Keep calm and think uniportal

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THE JOURNEY OF UNIPORTAL VATS

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THIS IS LIFE: THE JOURNEY OF UNIPORTAL VATS (FIRST EDITION)

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Foreword: uniportal VATS, more than an approach, a philosophy of life

This book is about a scientific, personal and cultural journey built upon many personal sacrifices and difficulties. But moreover, a journey which has gifted me with gratifying and unique experiences, the luck to have met many worthy people, discover cultures and do activities in many remote corners of the world…This is life.

Uniportal has given me the opportunity to operate in places where I would've never imagined I could do it. With different resources available, sometimes very scarce, but which have led to creativity and open mindedness when facing numerous challenges or extreme situations. This has enriched me both at a personal level as well as from a surgeon's perspective and I realized that nothing is impossible, if you really want to achieve something.

I am pleased to have been able to provide my humble contribution to bring a less invasive thoracoscopic surgery to many different hospitals, even to somewhere it had never been done before.

In my opinion, uniportal has achieved what no other surgical technique development in medical history has ever obtained; to bring together a group of very different people around the world with different backgrounds and mentalities but with at least a single common thing. A philosophy to do better every day. And day by day throughout this journey a group of friends (which almost every day increases) has been created. This is a group of friends and virtual family that share the same ideal and stimulus to advance, improve and get better. In definitive, uniportal has led to good friendships and a large group of like-minded people where everything can be done with care, passion, enthusiasm and dedication.

Sometimes when we get confronted with different cultures or people with different backgrounds we may think we cannot learn anything, but there is always something that you can take away. You can always learn with or without resources. Travelling extensively has helped me be consistently aware of this and has allowed me to form ideas to continue evolving. If I would have stayed comfortably in my hometown the evolution and adoption of uniportal would have probably not spread so quickly and consistently. At the same time, my travels enable me to take bits and pieces from each place and person and direct them into further improvements to the uniportal approach. This is the reason why in only 6 years there has been such a development and quick adoption rate of a surgical technique in the history of medicine.

It is also important to surround yourself of the best, at what they may be. Extract the positive and the best in their fields of each person or group whether surgeons, physicians, nurses, companies, friends or family and use it to continue improving. The key of success is sacrifice, persistence and hard work.

The industry has also been taken by the uniportal approach by being stimulated to innovate less invasive thoracic devices. During the last years, uniportal VATS has created new opportunities to push the boundaries on minimally invasive surgery, allowing a rapid progress in instrument design and technology.

Uniportal is thus, not only one incision less or a progress to less invasiveness but also a way of living life by constantly evolving and getting better at what we do. From there the ramifications of uniportal. Think of non-intubation, subxiphoid, subcostal, single port robotics…i.e., the least invasive surgical approach for our patients. We will continue to make our lives just a tad more difficult every time by stepping out of our comfort zone. This is where the magic and evolution of medicine happens…An open door to the future, because less is more.

So remember:

(I) "The beauty of life begins when you are out of your comfort zone" (*Figure 1*);

(II) "You must know the past to understand the present and guide your future" (*Figure 2*);

(III) "Don't limit your challenges; challenge your limits" (*Figure 3*);

(IV) "Surround yourself of the best people in their fields and learn from the positive they have to offer. You never stop learning" (*Figure 4*);

(V) "There is only one person who can prevent you from reaching the top, and he looks back at you everyday from the mirror" (*Figure 5*);

(VI) "Do not follow where the path may lead. Go instead where there is no path and leave a trail" (*Figure 6*).

Finally I would like to thank the many people who have contributed to the uniportal way of life, whether supporting me

Figure 1 Skydiving in Namibia, Swakopmund, Namibia. August 2016.

Figure 2 Petra, Jordan. February 2016.

Figure 3 Mentawai Islands. Sumatra, Indonesia. May 2005.

Figure 4 With the NBA basket player Pau Gasol. Coruña, Spain. June 2016.

Figure 5 Everest base Camp, 5300 meters altittude. Tibet, January 2016.

Figure 6 Great wall. Beijing, China. October 2014.

as a person or as a surgeon, but above all thank you to those who have caught on with the enthusiasm of this philosophy. Timmy, Alan, Dani, Marc, Raul.

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Keep calm and think uniportal

After many years of no evolution in our specialty, momentum is again with us, thanks to the explosion of minimally invasive techniques making our specialty more interesting than ever. The future offers many changes for thoracic surgery, and the forces in play are complex and myriad. The modern technology and recent innovative techniques make this an incredibly exciting time for our specialty.

One of the most significant of these advances from the patient's perspective is the development of minimally invasive thoracoscopic surgery. For the past several decades, the thoracotomy was considered the gold standard approach to primary non-small cell lung cancer. But this procedure was too aggressive: big incision spreading the ribs, anesthetic control with a double lumen tube, epidural, central venous catheter, arterial line and urinary catheter.

Thanks to the improvements in technology and surgical instruments. Most of the thoracic surgical procedures can be performed by video-assisted thoracoscopic surgery (VATS), therefore resulting in less pain, shorter hospital stay and with excellent surgical outcomes.

The progress of VATS is an ongoing development and challenges to the role of a VATS major resections will never cease to emerge. The information available on Internet, live surgery events and experimental courses has contributed to the rapid learning of minimally invasive surgery during the last decade. While initially slow to catch on, the traditional multi-port approach has evolved into a single incision approach (uniportal VATS) that mimics open surgical vantage points while utilizing a non-rib-spreading small incision. The early period of uniportal VATS development was focused on minor procedures until the second phase uniportal VATS started in 2010 with the development of the technique for major pulmonary resections. The creation of specific uniportal VATS programs in high volume centers, like the Shanghai pulmonary hospital (the biggest thoracic program in the world with more than 8,000 major resections per year, *Figure 1*) has contributed to spread out the technique to a large number of surgeons from all over the world in a short period of time.

Nevertheless our speciality must continue looking for the way to offer our patients the least invasive approach possible for removing the lung cancer. Improvements in anaesthetic techniques such as non-intubated uniportal VATS, may further quicken postoperative recovery allowing the tumor resection to be performed in an ambulatory setting. Furthermore, the need to reduce the risk of intercostal nerve damage associated with the transthoracic incision has led to the recent development of uniportal subxiphoid VATS technique for major pulmonary resections.

It is interesting to note that in only a period of 6 years, uniportal VATS has further evolved into a sophisticated technique capable of performing the most complex thoracic procedures, including bronchovascular and carinal resections. Additionally, a rapid progress in instrument design and technology have brought developments of ultrahigh definition cameras, narrower and more angulated endostaplers, sealing devices for vessels, and adapted and refined thoracoscopic instruments.

Figure 1 The Shanghai Pulmonary Hospital has performed more than 8,000 cases of thoracic surgery in 2015.

We need to assume an active role in both pursuing education in emerging technologies and fair and practical utilization of scarce healthcare resources. However, we also need to temper the desire to control costs with the real benefits that technology brings. Rationing surgical care among a faceless statistic group is very different from applying it to a living breathing patient, even when the application criteria are exactly the same. The successful marriage of cost-containment and surgical advancement is not unobtainable. In fact, Uniportal surgery is an excellent example of this. Unlike other areas of emerging technology in thoracic surgery like robotic surgery, uniportal surgery does not require a huge upfront expense for additional equipment, nor does it require expensive upkeep. There are a handful of useful surgical tools that facilitate the conversion to uniportal VATS but the procedure otherwise builds on existing technology, allowing surgeons to use existing equipment.

We truly believe in future ultramodern technology including naked 3D image systems, wireless cameras and improved uniportal robotic arms. Even though nowadays most of the surgeries can be performed by uniportal VATS, subxiphoid or awake techniques (in expert hands), the further development of technology will be crucial to facilitate the uniportal worldwide adoption and improve safety for the patient and the surgeon.

This book offers a comprehensive compilation of recent uniportal VATS articles authored by the pioneers of the technique and by some of the most experienced specialists in this field.

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Of luck and inspiration

Many of you see Diego Gonzalez Rivas as a maverick pioneer in Minimally Invasive Thoracic Surgery, a masterful educator in operative technique, or simply the rock-star of Thoracic Surgery. I happen to know him as one of my best friends inside and outside the world of surgery. And I am luckier than you because I have seen some sides of this man that you may never see. Let me share just four of these sides of 'xiao gan' (little Gonzalez) with you.

Diligence

Diego did not become a superstar surgeon through luck or serendipity. He did it the old-fashioned way through lots of hard work. Many evenings in Shanghai, as other colleagues succumb to fatigue and even after the legions of his fans have left, Diego remains keen to operate more and gladly takes on cases when others can barely stand. Even between his many operations during the day, he does not rest. Immediately on coming out of the operating room, he is already editing videos or planning his next paper. And no matter how late he leaves work, he always turns up on time the next morning—eager for more work and more opportunities to improve himself. During the early days of developing Uniportal VATS, Diego and his team would even work long after hours in the animal lab, honing the skills which would later go on to benefit so many patients. This tireless drive to practise his art, and then practise some more, is not often seen by others, but it is one of the keys to his prolific success. Those who envy him should try spending a day in his shoes, and see if they don't end up completely exhausted.

Never self-satisfied

It is easy for anyone achieving the success he has to be complacent, but Diego is never content to rest on his laurels. It was his relentless pursuit to find a better way to perform thoracic surgery that drove him around the world to learn from some of the greatest practitioners of VATS: McKenna, D'Amico, Walker, Rocco, and others. Not satisfied with conventional VATS, he went on to perfect Uniportal VATS. But even with that, he was not fulfilled. He pushed the envelope with complex sleeve resections using this technique, and today he remains keen to explore the possibilities of non-intubated surgery and subxiphoid VATS. These techniques may or may not succeed, but it takes surgical pioneers willing to try them to find out the answer. This seeking to always improve oneself is a fine example for all surgeons to follow, and great news for our patients of tomorrow.

Sensibility

Advocates of a new approach are often criticized as being reckless or acting like 'cowboys'. Although some have viewed Diego in this way, this could hardly be further from the truth. Even though he is an avid adventurer and sportsman, when he realized that motorcycle racing could jeopardize his surgical career—he simply quit. When he realized that his health depended on it, he immediately went on a super-healthy diet, lost weight, and never put it back on—something the rest of us only think about but never do. Most astonishingly, when he embarked on these resolutions, he always kept himself committed and dedicated to the program, exercising a level of self-discipline most people can only marvel at. This sensible approach to life extends to his surgery. Despite his obvious enthusiasm for advanced VATS techniques, he has never failed to draw the line for himself and those he teaches on when to fall back on conventional approaches, on when to convert. He is unafraid to admit that even he needs to abandon the Uniportal approach on occasion, and cautions that what he demonstrates may not be suitable for everyone.

Generosity

On a recent trip to his hometown of A Coruna, I (or actually my airline) lost a couple of posters I was bringing to a major conference. In the midst of his own busy clinical schedule and his running of an amazing surgical workshop, he went far out of his way to personally help me get the posters reprinted—almost missing a very important meeting of his own to ensure his friend (me) got what was needed. Those posters that he 'saved' eventually won a major prize at the conference I was going to, and this would not have been possible without Diego's selfless generosity with his time and effort. I am happy to say that Diego's big-heartedness is not limited to his friends. While some artists may jealously keep their skills to themselves, Diego has enthusiastically broadcast his techniques to the world. Whether it is through his online videos, the countless training programs he organizes, or his personally proctoring colleagues in centres on every continent, he generously shares all his experience so that everyone has a chance to do exactly what he does. Why wouldn't we all welcome Kasparov coaching us on how to play chess? Or Eddie Van Halen giving private lessons to budding rock guitarists? But how many stars like that would give up their own time to teach?

Diego's diligence, never being self-satisfied, sensibility and generosity are often unfairly overshadowed by his technical wizardly and his (dare I say it) celebrity. But the sum total of these characteristics means one thing for me. They add up to him being an inspiration for fellow surgeons. I have often told him that if it were not for these qualities of his that inspired me forwards, I would have been quite content to perform 2- or 3-port VATS for the rest of my own career. Knowing him personally has spurred me to also do better and I credit him for making me Keep Calm and Think Uniportal all these years.

I shall remain luckier than most of you. But the fact that you are holding this book and are about to read it means that you will also have a chance to get closer to my dear brother Diego. In these collected papers of his, you will find his diligence, never being self-satisfied, sensibility and generosity shining through. You will learn about Uniportal VATS from the master. But more than that, I hope you will be as inspired as I am.

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Preface to the book *This is life: the journey of uniportal VATS*

Uniportal video-assisted thoracic surgery (VATS), also known as single port VATS or single incision VATS has taken the world of minimally invasive thoracic surgery by storm. The technique originated more than a decade ago for minor procedures and stood still, until recent developments in surgical technique and instrumentation allowed the most complex of thoracic procedures to be performed by the uniportal approach. However, it is also the determination, courage, skill and unshakable belief of an individual, Dr Diego Gonzalez-Rivas that has shaped the uniportal world as we all know it today.

Armed with a rough drawing of port placement in 2-port VATS from Duke University Medical Centre, Diego returned to his home town of a Coruna, and started performing 2-port VATS major lung resections in 2007. Realizing the inferior camera port can be omitted, he performed the first uniportal VATS major lung resection for a left lower lobe cancer in 2010. His path has not always been plain sailing, and perhaps few people are aware that his first hurdle, apart from convincing his immediate colleagues (some of whom are more senior) of the feasibility and safety of the technique, was to get his case report accepted in mainstream academic literature. One of the journal reviewers of his initial work, who also happen to be my mentor, Prof. Anthony Yim was sceptical and rejected the article. Subsequently, Yim has become an advocate of the uniportal approach, realizing that Diego's experience is akin to a reflection of his own when he was struggling to convince the thoracic community to embrace VATS in the mid-1990s. From his first publication in 2011, Diego's has not looked back, showing the world the uniportal approach can be safely performed for bronchoplastic sleeve, vascular sleeve, double sleeve, lung with chest wall resection, post neo-adjuvant therapy lung cancers, and even in non-intubated patients.

My first encounter with Diego was in Hong Kong for the 1st Asian Single Port VATS Symposium and Live Surgery event in March 2013. I remember fondly his immediate email reply to my invitation, and for a nobody like myself, I was surprised and touched by his generosity and enthusiasm. Over the years, it is clear to me that these characteristics of his, as well as his humanity, loyalty and integrity have been the cornerstone of his success. Perhaps this is the temperament and behaviour of a man who has survived a surfing accident that very nearly took his live, or who was just seconds from a terrorist bomb detonation in Bali Indonesia that destroyed many other people's lives. From some of the most war torn countries in the Middle East to the resource stricken countries of Cuba and Eastern Europe, he has unreservedly travelled to demonstrate and preach the uniportal approach. Through lectures, workshops, surgical models, animal carcasses, cadavers, live animal models of sheep, goats, dogs and pigs, and live surgery, Diego has dedicated his career to share with others his knowledge and skill. His obsession has led him to record for teaching purposes videos of every lobectomy performed by uniportal VATS in a sheep and pig. No doubt, his charisma and enthusiasm have infected everyone he has touched and everywhere he has been, to follow his teaching of uniportal VATS.

Many will notice that this preface has deliberately neither commented on the evidence for the benefits and efficacy of uniportal VATS, nor discussed the technique or its future. I believe this book should focus on celebrating Diego's achievements and inspirational journey, as well as provide reflection upon the influence this gentleman has had on our surgical practice all over the world. I once hypothetically asked, "what would you do after you have visited and conquered every country and hospital in the world with uniportal VATS?" Diego jokingly replied, "There are many more lives to be saved in the veterinary world", as he showed me his latest video recording of uniportal subxiphoid porcine lobectomy! An important lesson I learnt from Diego comes from an ancient Chinese saying, "*Wherever you go, go with all your heart.*" (*Confucius, 551-479BC*).

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Preface to the book *This is life: the journey of uniportal VATS*

Thoracoscopic lobectomy was introduced without the support of prospective randomized trials; however, the advantages of thoracoscopic lobectomy were demonstrated through multi-institutional and propensity-matched studies, proving the quality of life advantages, safety advantages, and cost advantages, compared to thoracotomy. Prospective randomized trials would now be difficult to complete to due lack of equipoise. Thoracoscopic lobectomy has emerged as the standard of care for early stage lung cancer and is utilized extensively for locally advanced lung cancer in centers of excellence. Throughout the investigation of the potential for thoracoscopic lobectomy to improve outcomes, the focus on technical aspects centered on limiting the size of the access incision, but more importantly, avoiding rib spreading with a retractor. Surgeons may have used 4 ports, or 3 ports or 2 ports, and robotic procedures may have employed with up to 5 ports, but the difference in the number of ports was never considered in assessing outcomes.

Is there a difference in outcomes based on the number of ports? Is an approach using 3 ports better than one using 4 ports? If minimally invasive approaches improve outcomes, would the most minimally invasive approach incrementally improve outcomes compared to other approaches? It is unlikely that this hypothesis will ever be tested in a prospective randomized trial, and it is possible that there are other considerations that are more important than the number of incisions, including the location of the incisions, avoidance of local trauma, and other strategies to reduce surgical stress. Yet the quest to improve outcomes by minimizing the number of incisions has been completed with the development of the uniportal thoracoscopic lobectomy.

This volume, “Uniportal Thoracoscopic Surgery” presents to most up to date data available regarding the use of uniportal approaches for early stage as well as locally advanced pulmonary malignancy. It is interesting to note that transition to a uniportal approach seems to have evolved relatively rapidly compared to the adoption of other minimally invasive approaches. The current evidence, relevant controversies, regional experience and results, and future directions are critically discussed by an international panel of experts, from Asia, Europe, and North America. This compilation is especially useful as the emphasis on minimally invasive approaches increases in the wake of lung cancer screening with low dose computed tomography, as more and more patients with early stage lung cancer will be treated and surgical approaches will be compared to non-surgical ablative approaches. Furthermore, as robotic technology evolves, a uniportal robotic platform may also emerge. It may not be possible to demonstrate that one incision is better than other minimally invasive approaches, but it is more likely that one and two port approaches will be considered preferable to ablative techniques than other multiport strategies.

The text is well-written and well-edited, providing relevant information for experienced uniportal surgeons as well as others interested in adopting the uniportal approach. This is an outstanding reference, one that will be extremely useful for the modern management of lung cancer in the era of lung cancer screening, as there will be an increased focus on optimizing the advantages of minimally invasive strategies.

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Preface to the book *This is life: the journey of uniportal VATS*

It is my great pleasure to recommend this important book written by well-known and widely respected authors, including my long-term friend Dr. Diego Gonzalez-Rivas.

I met Diego for the first time many years ago when I was his teacher in the notable European School for Cardio-Thoracic Surgery in Bergamo, which became the forge of many future world's leaders in thoracic surgery. I was immensely privileged to lecture there a group of several young and enthusiastic adepts of our specialty from all over the world.

One word of explanation—the European School for Cardio—Thoracic Surgery in Bergamo was not an ordinary school, it was a center of excellence and the teaching was dynamic, as the masters were able to oversee the content personally. The masters' adepts were continually being trained and thus there was the power of tradition combined with the flamboyance of the creative newcomer. However, this prestige was for me not only limited to lecturing.

Students were living in the old monastery, in very simple rooms like former monks and we all spent long hours together both in lecture halls and outside—discussing, provoking new ideas and points of views, quarrelling sometimes, and on top of that dining in many fantastic Italian restaurants carefully selected by our hosts. It was a fantastic time—I hope for both sides.

Diego was one of my students and I immediately noticed him as a natural leader, inventor and extremely vivid young man, who was working hard and seemed to be interested in all details of thoracic surgery, but also finding time to have some fun and relax.

Albert Einstein famously said that "Everyone knows that something cannot be done until someone comes along who doesn't know that it's impossible, and does it"—with this in mind we can make progress not only in medicine. Diego is actually a perfect example of such approach, but with one important difference—he knew what he wanted to invent and he did it on a basis of solid theoretical and laboratory background.

This was my dream as an academic teacher in Bergamo to inspire a bunch of young men and women to move our specialty forward, and to be able to outgrow their teachers and mentors and surpass them in their skills, because only such condition provides steady development. My dream came true. Many years later, as an experienced open access thoracic surgeon (making incisions smaller and smaller but still with retractors) I felt obliged to start anatomic videothoracoscopic resections. Believe me—it is not easy at the age of 50 but I was smart enough to reach the acceptable level of skills. Nevertheless, I still remained not completely comfortable with all those triangles, axes etc. Then, I met Diego again (knowing about his technique from medical literature of course) who—with his elegant, calm and delicate way—showed me all the secrets, tricks and shortcuts of the uniportal VATS. It was like enlightenment for me—experienced, traditional thoracic surgeon well accustomed to small but open thoracotomy. Suddenly, everything became clear and simple again—just mimicking open surgery, but performed in a modern and minimally invasive fashion.

As a result, I started to make my incisions even smaller (4 cm instead of 8–10 cm), stopped using retractors and began my uniportal VATS career at the age way above 50. Believe me, it works! Now, I stopped to count my uniportal VATS lobectomies, because I perform them regularly and I feel almost as comfortable as during open thoracotomy. I am pretty much convinced it would not be so easy without patient education by Diego.

He changed our thoracic world forever. I know that my feelings about this new technique are shared by many younger and older thoracic surgeons. Diego's endless efforts to show his magic skills to the thoracic community, and to share his enormous knowledge about uniportal VATS are priceless and—despite his relatively young age—position him among the greatest giants of thoracic surgery.

Dear Diego Gonzalez Rivas, thank you for all you are doing for us. You are a great man, a great thoracic surgeon and—last but not least—a great friend.

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Go on the journey of VATS with more stamina and collaboration

I would first like to congratulate my dear friend Diego and the relevant colleagues on making "*the journey of uniportal VATS*" in reality and even a revolution. Excitingly, the book '*this is life and the journey of uniportal VATS*' will usher you into the kaleidoscopic world of uniportal VATS and refresh your knowledge about it.

My first encounter with Diego was dated back in 2012 in Edinburg during the European 20-year Anniversary on VATS Lobectomy & consensus conference. At the time, I have had been impressed by his talk and his effort in bringing uniportal VATS into a potential vitality.

I always believe one-minor-port incision is an ultimate goal for minimally invasive surgery. Yet, given the discomfort of operation under one port for the surgeon and camera-holder and its limitation by instrument, not many thoracic surgeons can accept it at the very first beginning. But things change rapidly and tremendously, with the improvement of the technique and advancement of related instrument made possible by Diego. He makes this procedure not only applicable but with higher and higher proficiency. All these effort later facilitates the development of thoracic surgery.

Diego and I have kept a good relationship between each other since we met and we shared experience and lessons learned from daily practice. He knew I am well versed in VATS under spontaneous respiratory anesthesia and advanced surgeries, so he looked for a chance to learn the technique.

In 2013, I invited Diego to give a presentation in the Asia-Pacific Minimally Invasive Thoracic Surgery Conference, where I introduced to him the technique of VATS under spontaneous respiratory anesthesia. I am soon impressed (again) that he is so good at observing and achieve mastery of the technique. Meanwhile, he became adept to performing complicating thoracic surgeries with uniportal VATS such as Sleeve lobectomy, chest wall surgery etc.

Furthermore, Diego successfully completed uniportal VATS under spontaneous respiratory anesthesia, maximizing the benefit of both single port incision and anesthesia without intubation by combining these two techniques. We talked about how to practice "Tubeless VATS" and how to make VATS surgery easier and simpler, even simplest. Actually, witnessing unique advantage of spontaneous respiratory anesthesia with large amount of clinical experience, I had been working hard to spread this technique. Recently, in the first Pan-Asian Forum on Cooperation in Thoracic Surgery, after hearing my presentation about the Tubeless VATS technique, Dr. Toriaki Morikawa commented this technique as "your tubeless method is revolutionary since thoracotomy was established for 100 years". That is both of our effort.

Diego was then able to deliver the technique to more and more countries and cities, further opening the gate of innovation and inspiration. To me, what Diego has done also serve to inspire the collaboration between thoracic surgeons, let along he is a very preferable collaborator and an upright and considerate friend.

Personally, I was deeply touched by Diego's perseverance and diligence. He is a true 'matador' and fighter in the history of thoracic surgery. Diego has the Stamina to make the surgical technique more easy and practical, which march the technique towards a great step. I think from the association with Diego, one can easily feel the charm of a surgeon and may even get obsessed to surgery for beginner.

There is still much work to do in thoracic surgery. *The journey of uniportal VATS* is no doubt a significant and glorious part of the journey of thoracic surgery in history. To keep up with the journey, we need more stamina and collaboration.

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Preface to *Uniportal VATS Journey*

"Innovation, tenacity and a master technician are words I would use to describe my friend Diego Gonzalez-Rivas. We met for the first time in Berlin at the ISMICS meeting in 2010. At that time a few pioneers such as Gaetano Rocco had reported initial forays into the world of uniportal VATS, but no-one was using this approach as a standard for lobectomy. The standard approach for VATS lobectomy then was a multiport approach, however the adoption of VATS lobectomy was also still relatively small.

Although not sold at that time, I was impressed by Diego's tenacity and sprit for innovation that drove him to keep refining this approach. A few months later Diego visited Boston University and gave a splendid lecture to our residents, showing videos that demonstrated not only the successes but the technical pitfalls of this approach.

I was then honored to be part of the faculty for the first course for uniportal lobectomy that he held in La Coruna. What impressed me then, was Diego's technical skills, but again I was not sold on the technique. What truly were the advantages of a uniportal lobectomy over a well performed multiport lobectomy? Secondly, this seemed to me an operation that perhaps could only be performed by a technically gifted surgeon such as Diego, and not the average thoracic surgeon.

However as Diego continued to publish his outcomes as well as a combination of his infectious enthusiasm and drive, I have seen a tide change in thoracic surgery. Surgeons who previously have been performing open operations have been able to adopt this technique and made it their standard approach. Perhaps it is that the camera views are similar to what is seen with open surgery, so that there is less need to learn to mirror image? Regardless, my initial thoughts that this was an operation limited to a select few have been proven wrong countless times as I see more and more surgeons around the world adopt uniportal lobectomy.

This really came hope to me when I visited Shanghai Pulmonary hospital this year, and on an average day of a "mind-boggling" fifty operations saw surgeons performing uniportal resections in several different operating rooms. Never one to rest on his laurels and always looking to innovate, it was fun to watch Diego learn from his Chinese colleagues, as he takes on other challenges such as mastering sub-xiphoid lobectomy.

Although my first question about which is better for the patient (uniportal or multiportal) remains to be answered, these are exciting times for thoracic surgery. Through the efforts of pioneers such as Diego, surgeons around the world, and ultimately our patients will benefit from the increased adoption of minimally invasive lung resection. What comes next remains to be seen…

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Preface to the book *This is life: the journey of uniportal VATS*

This book is not only a scientific one but it is a demonstration of a successful story in the world of thoracic surgery. It is difficult to describe and talk about the thoracic surgeon behind this story, the reason is that I cannot add anything: every thoracic surgeon in the world knows him and he has visited him or vice versa. Diego Gonzalez-Rivas is not only a colleague he is my best friend and brother.

I can write many things about the story of uniportal, but I will restrict it to few stories and facts. I can remember the talk of Diego at ISMICS 2010 in Berlin where he represented his innovations (by the way his talk was the only one with music during the meeting). At that time it was clear for everyone that he will make a big explosion in the history of thoracic surgery.

"Mahmoud I did the first single incision lobectomy" this was his original message after ISMICS 2010 to me. I was very proud of him, and I hoped that he would develop this technique further and further. And he did it, he was not only developing it in his hospital but he was spreading it all over the world. I invited him and his colleague Ricardo in June 2012 to our hospital "Charité Berlin" and we performed with them the first German uniportal lobectomies. After that I went and visited him at his hospital and stayed at his beautiful house and get to know his family. His days were long working days but effective and with a perfect team. During one uniportal operation came the resident in her second year and was watching the operation and suddenly she gave Diego one remark during the procedure, and of course he followed her advice, this is the proper way how great surgeons with self-confidence behave. It was the inspiration he gave me in the world of thoracic surgery. Since that I started performing uniportal procedures, which changed my whole thinking, minimal than that you will never be in thoracic surgery.

In February 2014 was the first "International Uniportal VATS Course and Live Surgery" in A Coruña, and since that Diego and me decided to make it in Berlin which continued the success which was started in A Coruña. It was the start in Germany, the start of a new era of thoracic surgery, the Uniportal thoracic surgery.

According to me, the uniportal technique is not an adventure but it is a reality: "if you start preforming it you will love it and you will never change".

Dear Diego, my colleague, friend but overall my brother, thank you for your continuous support. I wish you a lot of success with this book. Readers of this book should be sure that through reading this book they will have a journey to the world of uniportal VATS, the world of Diego Gonzalez-Rivas and his friends, the world of thinking how to help our patients with minimal surgical trauma to give them the hope of fast healing and recovery.

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Table of Contents

Segmentectomy

Advanced Resections: Pneumonectomy, Chest Wall and Sleeve

Uniportal VATS Experience from Different Countries

Meet the Professor

Video-assisted thoracoscopic surgery versus stereotactic radiotherapy for early stage lung cancer: what is the best treatment?

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Anatomic major pulmonary resection has long been considered the standard of care for Stage I with cure rates of 50–90% (1). Traditionally, the standard treatment was too agressive: open approach by means of thoracotomy, anesthetic control with a double lumen tube, epidural, central venous catheter, arterial line and urinary catheter.

Stereotactic body radiation therapy (SBRT) has evolved over the past 20 years and revolutionized the management of early stage NSCLC. Compared to conventional radiation therapy, SBRT offers superior outcomes, lower costs and greater patient convenience (2). The role of minimal invasive surgery and stereotactic body radiation therapy in stage I NSCLC are evolving, particularly for marginally operable patients and the elderly population. SBRT is generating promising results in inoperable patients, with local control rates of 90% or higher in Stage I of the disease.

The management of Stage I NSCLC has now developed into a focus of intense debate between surgeons and radiation oncologists. Thoracic surgeons argue that SBRT does not provide adequate pathological staging and that it is a local treatment only, without the removal of the tumor. This is in contrast to many radiation oncologists who argue that surgery has a higher morbidity while SBRT offers local control and cancer outcomes approaching surgical resection, but with a lower risk of treatment-related morbidity, thus making SBRT the treatment of choice for medically inoperable and many high-risk surgical candidates.

However, in the most critical issue of cancer therapy, the literature comparing VATS and SBRT has suggested that survival data may not be entirely in favor of SBRT (3). For example, one recent study suggested that stereotactic body radiotherapy (SBRT) offers lower immediate mortality and toxicity. Over the longer term, however, there was more benefit with surgery over SBRT (4). These findings highlight the importance of looking at the long-term benefit to patient life expectancy rather than to the short-term benefits of a treatment when reviewing and interpreting future comparisons of SBRT and surgery. In another recent propensity matched study of 117,618 patients, it was demonstrated that there was improved survival with surgery compared with SBRT. However, rigorous prospective studies are needed to optimize the patient selection criteria for SBRT in the high-risk surgical population (5). It was further reported that VATS lobectomy offers better results than SBRT in the treatment of patients with pathologically confirmed early stage NSCLC (6).

Perhaps the road ahead may be determined by defining an appropriate role for SBRT vis-a-vis surgery. Today, with the very rapid advances in medical oncology through the development of new chemotherapy with less toxicity and major effectiveness, as well as SBRT, the role of a thoracic surgeon is to offer the patient the best oncologic procedure with the least surgical invasiveness and anaesthetic such as uniportal VATS and non intubated techniques. The combination of radiology and thoracic surgery techniques within the hybrid operating theater may open doors to new surgical and ablative radiation techniques that can be potentially safer, more effective and more economical for our patients. The comparative mortalities and toxicities of these treatments for patients of different life expectancies are unknown. We are expecting in the future that well designed and large randomized trials will be conducted comparing sublobar resection and SBRT for local control, quality of life and overall survival.

In the meantime, thoracic surgeons are continually aiming to find the way to offer our patients the least invasive approach possible for removing the lung cancer. Improvements in anaesthetic techniques such as non-intubated uniportal VATS,may further quicken postoperative recovery allowing the tumor resection to be performed in an ambulatory setting. Over the past 2 decades VATS has further evolved into a sophisticated technique capable of performing the most complex thoracic procedures. Additionally, a rapid progress in instrument design and technology have brought developments of narrower and more angulated endostaplers, sealing devices for vessels, and adapted and refined thoracoscopic instruments (7). Furthermore the surgery is evolving more and more to segmental and sublobar resections for early stages of NSCLC, preserving lung parenchyma and offering similar oncological results when compared with lobectomy. Evidence from current literature, suggests that VATS segmentectomy could be equivalent to VATS lobectomy in terms of overall and disease-free survival, postoperative complications and mortality (8). The development of future technology such as wireless remote camera systems, subxiphoid approach, embryonic natural orifice transluminal endoscopic surgery (e-NOTES) or nanorobotic surgical techniques will help to reduce surgical access trauma and allow a faster recovery to our patients.

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Footnote

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Uniportal thoracoscopic surgery: from medical thoracoscopy to non-intubated uniportal video-assisted major pulmonary resections

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The development of thoracoscopy has more than one hundred years of history since Jacobaeus described the first procedure in 1910. He used the thoracoscope to lyse adhesions in tuberculosis patients. This technique was adopted throughout Europe in the early decades of the 20th century for minor and diagnostic procedures. It is only in the last two decades that interest in minimally invasive thoracic surgery was reintroduced by two key technological improvements: the development of better thoracoscopic cameras and the availability of endoscopic linear mechanical staplers. From these advances the first video-assisted thoracic surgery (VATS) major pulmonary resection was performed in 1992. In the following years, the progress of VATS was slow until studies showing clear benefits of VATS over open surgery started to be published. From that point on, the technique spread throughout the world and variations of the technique started to emerge. The information available on internet, live surgery events and experimental courses has contributed to the rapid learning of minimally invasive surgery during the last decade. While initially slow to catch on, the traditional multi-port approach has evolved into a uniportal approach that mimics open surgical vantage points while utilizing a non-rib-spreading single small incision. The early period of uniportal VATS development was focused on minor procedures until 2010 with the adoption of the technique for major pulmonary resections. Currently, experts in the technique are able to use uniportal VATS to encompass the most complex procedures such as bronchial sleeve, vascular reconstructions or carinal resections. In contrast, non-intubated and awake thoracic surgery techniques, described since the early history of thoracic surgery, peaked in the decades before the invention of the double lumen endotracheal tube and have failed to gain widespread acceptance following their re-emergence over a decade ago thanks to the improvements in VATS techniques.

Keywords: Thoracoscopy; advances in video-assisted thoracic surgery (VATS); minimally invasive surgery; uniportal VATS; surgical improvements

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Background

The uniportal approach to diagnosing and treating thoracic disease has existed for much longer than most thoracic surgeons care to acknowledge. Under the umbrella of pleuroscopy and thoracoscopy, physicians have been using scopes and a single port incision to inspect, biopsy and perform thoracic procedures since Hans Christian Jacobaeus first described this procedure (1) in 1910 to treat pleural adhesions (2,3), calling it thoracoscopy. While there are anecdotal reports of thoracoscopy use as early as 1866, Jacobaeus is widely acknowledged as the inventor of this technique. Notably, the pioneers of this approach usually performed thoracoscopy or pleuroscopy in spontaneously breathing patients using a local anesthetic (4).

Around the world, under the terminology of 'pleuroscopy', many thoracoscopic procedures often fall under the domain of pulmonologists, away from the supervision of thoracic surgeons (5,6). This does not lessen the importance of this technique to the development of current advancements in the uniportal approach (7).

The development of medical thoracoscopy

Jacobaeus continued his work using thoracoscopy, i.e., the "Jacobaeus Operation", to treat adhesions, infections and effusions in addition to diagnosing tuberculosis, tumors and other pathology well into the 1920s. To perform thoracoscopy, he developed both a dedicated cystoscope and a dual port approach for visualization (8). His diagnostic thoracoscopies aided in our understanding of the normal and diseased appearances of the lung and pleural cavity (4). His counterparts in the 1920s, mainly Cutler, Davidson, Friedel and Drash, focused on uniportal techniques. Drash and others published data based on large patient studies in the 1930's (3). Others, such as Sattler, Kux and Roche, expanded the use of thoracoscopy to include treatment of spontaneous pneumothorax, sympathectomy and talc pleurodesis (5).

Even after the advent of antibiotics resulted in therapeutic thoracoscopy largely falling from favor, advances in anesthesia and intra-operative oxygenation made thoracoscopic biopsy an invaluable tool before falling into disuse (4).

The emergence of modern thoracoscopy was just beginning to revive these forgotten techniques. Upon rediscovery, many thoracic surgeons were readily embracing thoracoscopy, especially with the advent of modern technology, such as video displays, which allowed the surgeon to see through the thoracoscope as never before.

Evolution to video-assisted thoracoscopic surgery

Interest in minimally invasive thoracic surgery was rekindled in the last few decades by two key technological breakthroughs: (I) the development of video-assisted cameras offering a panoramic view of the hemithorax instead of the previous tunnel-like view with direct vision and (II) the availability of new endoscopic instruments like the linear mechanical stapler. From these advances, video-assisted thoracic surgery (VATS) was born (9). Since the first VATS major pulmonary resection was reported in in 1992 (10), thoracoscopy has regained its relevance to thoracic surgery. While the adoption of VATS was initially slow, it has now become the standard of care for many procedures (11).

With the re-emergence of thoracoscopy, surgeons utilized a multi-port approach, like Jacobaeus, with one port used for visualization and additional ports for instrumentation. As this technique was further developed for more complex operations, the initial port configurations were further refined for better ergonomics, visualization and access to anatomical structures (7). Later, as VATS became more popular within thoracic surgery, further development brought two-port configurations, robotic assisted surgery and needlescopic approaches. VATS was also introduced into use for increasingly complex operations including mediastinal masses, large resections and cases with chest wall involvement (12). The old rules regarding absolute contraindications for VATS and the standard indications for open thoracotomy were broken with excellent results. Eventually, as the nature of the evidence changed from case reports, to retrospective studies, to randomized trials, and finally to large scale meta-analyses, VATS began to replace the open thoracotomy as the standard approach in international guidelines and day-to-day practice (13).

The rise of uniportal VATS (Video 1)

Uniportal VATS started from humble beginnings, with an initial report of uniportal VATS thoracic sympathectomy in 2000 (14). By pushing the boundaries of what might be possible with a uniportal approach, this initial publication was the stimulus for the development of more complex uniportal procedures to treat an ever-increasing range of thoracic conditions.

The results of the first prospective trial reporting the method to perform several thoracic procedures through a uniportal VATS technique was published in 2000, 2001 and 2003 (15-17).

Rocco was one of the first thoracic surgeons to break through the remaining barrier to bring thoracic surgery almost full circle, back to the uniportal approaches of the 1920s to the time of Drash, Cutler and Freidel. Advances in visualization with the use of large sized monitors and high performance fiber-optics have now made earlier challenges with this technique easily surmountable. Rocco popularized the approach, utilizing a uniportal approach for minor procedures such as pneumothorax and wedge resections and reported it in several publications in the early 2000s (18-20). The work of Rocco was further enhanced by our team with the development of the uniportal approach for lobectomy (21). Initially the technique was described only for lower lobes but it was rapidly improved and developed for upper lobes, segmentectomy and pneumonectomy (22-25). In quick succession, more difficult cases were reported including bronchial sleeve resection, pulmonary artery resection and reconstruction, and then, in 2014, a double sleeve resection (26-30). As the uniportal approach was successfully applied to more and more complex cases, the contraindications for the uniportal approach changed. Tumors with chest wall involvement slipped out of absolute contraindication to become more of a general surgical consideration after multiple chest wall resection cases were successfully performed (31). The same expansion occurred with the patient selection criteria as it quickly become apparent that general anesthesia was one of the most limiting factors for surgery. This led to the development of a non-intubated protocol that has allowed the uniportal approach to be used for patients who were otherwise ineligible or in a high risk category for thoracic surgery (32-34).

The speed of the adoption of uniportal VATS

As previously mentioned, the early period of uniportal VATS development was focused on minor procedures (from 2000 to 2010). The second phase of uniportal VATS began in 2010 with the development of the technique for major pulmonary resections (35,36). In only a period of five years, experts have been able to apply the uniportal VATS technique to encompass more complex procedures such as bronchial sleeve, vascular reconstruction and carinal resection. The information available on the Internet, at live surgery events and experimental courses all contributed to the rapid development of uniportal minimally invasive surgery during the last decade (37).

The sheer volume of publications and the variety of increasingly complex uniportal procedures performed by the pioneers has brought this technique to the forefront of modern thoracic surgery. This, combined with a very active lecture circuit and numerous YouTube surgical publications, hands-on wet lab courses and documentary films have advanced the popularity and adoption of this uniportal approach at a speed unheard of in modern medicine. Part of the rapidity of the progression of minimally invasive surgery in an age of internet and global connectivity can be attributed to enhanced collaborative efforts within the international thoracic community. In today's thoracic surgery, developments and accomplishments can be shared in an instant, with on-line video demonstrations. No longer is the majority of information shared via paper publications or at annual conferences. On-line journal editions now allow interested readers to comment and question the authors weeks before the paper journal is mailed out to subscribers.

Philosophical shift

The development and adoption of uniportal VATS on a widespread scale globally requires a shift in current philosophies and treatment algorithms for common thoracic conditions. Empyema, for example, has traditionally been treated according to guidelines that were developed when open thoracotomy was the standard of care. The morbidity and mortality associated with this approach relegated surgical intervention to the last line of treatment after the failure of less effective and less invasive treatments (38). In an era when open thoracotomy has become a rare exception, rather than the rule, the application of “surgery as a last resort” leads to unnecessary delays that increase the morbidity, mortality and suffering of our patients (39). In the treatment of lung cancer, this has been addressed to some extent within thoracic surgery and pulmonology with the most recent clinical guidelines (40). However, the terminology and use of non-thoracic surgeons as the decision-maker for determining the patient’s eligibility for surgery may require re-exploration now that uniportal and related non-intubated anesthetic approaches have been used safely and effectively on even the frailest patients (32,41).

Non-intubated and awake thoracic surgery techniques, described since the early history of thoracic surgery, peaked in the decades before the invention of the dual lumen endotracheal tube and have failed to gain widespread acceptance following their re-emergence over a decade ago (42).

A discussion of non-intubated thoracic surgery and minimally invasive VATS surgery is a discussion involving two distinct phenomena: anesthetic technique and surgical technique. Despite this, both surgical and anesthetic advances share commonalities, particularly from a historical perspective. Both suffer from the phenomenon of forgotten knowledge, having been initially discovered and used successfully before being forgotten and subsequently rediscovered, advanced and readopted several decades later. Both techniques have also suffered from significant skepticism upon their re-emergence, which has hindered rapid widespread adoption.

Recently the aim to avoid intercostal nerve damage incurred by the transthoracic incision during VATS has led to the development of a novel procedure entitled the uniportal VATS subxiphoid approach. To attempt the subxiphoid approach, it is mandatory to have both a previous experience in uniportal VATS lobectomy and a skilled assistant. The subxiphoid approach technique has several limitations such as the difficulty of controlling major bleeding and performing a complete oncologic lymph node dissection. The access for the view of the posterior mediastinum is challenging, which makes the complete dissection of the subcarinal space very difficult to accomplish. Despite these disadvantages, this novel approach has the potential for widespread use in the future after the development of new technology such as wireless cameras, better instruments or single port robotic technology adapted to the subxiphoid approach.

While common philosophical approaches to thoracic disease have changed within the thoracic surgical specialty, the paradigm shift has not yet made its way to general medicine and to the general practitioners who still serve as the gatekeepers to our patient populations. Too often, referrals for curative surgeries are delayed or omitted while general practitioners mull over whether frail or debilitated patients are eligible surgical candidates. When this surgical candidacy is weighed against open thoracotomy or sternotomy, patients with significant co-morbidities such as oxygen-dependent chronic obstructive pulmonary disease or coronary artery disease, who are likely to have been successfully treated with minimally invasive techniques, are instead shunted to less effective therapies such as chemotherapy, radiation or even palliative therapies. They are thus are more likely to suffer adverse outcomes.

Therefore, it is incumbent among the practitioners within the thoracic surgical specialty to make special efforts to educate practitioners in other specialty areas, through the publication of clear treatment algorithms and evidence-based practice guidelines.

Basic principles of the uniportal technique

Uniportal VATS represents a drastic change in the approach to lung resection compared to conventional multi-port VATS as the placement of the surgical instruments and the camera are both done through the same incision. Recent industry improvements such as the specifically designed instruments with double articulation, ultra high definition video-camera systems, new energy devices and narrower and more angulated staplers, have made uniportal VATS for major lung resections easier to learn and safer.

The spread of uniportal VATS oncologic surgery has been possible because it has been shown that oncologic principles can be achieved by this approach without compromising the safety of the patient (43,44). It is essential that during the dissection of structures, the basic principles are respected and followed when performing individual dissection of veins, arteries and bronchus, as well as completion of an appropriate lymphadenectomy (45,46).

During the uniportal VATS procedure, both the surgeon and the assistant are usually positioned in front of the patient in order to have the same thoracoscopic vision throughout the procedure. Even though the field of vision can only be obtained through the anterior access site, movement of a 30-degree thoracoscope along the incision allows for different angles of vision. The role of the camera assistant is important during any VATS procedure but it is specially demanding during uniportal VATS because this technique lacks the dedication of one port for the camera that is usual for multiport VATS techniques. The advantage of using the thoracoscope in the same port and in coordination with the instruments is that vision is directed to the target tissue. By doing this, we are lining up the instruments to address the target lesion from a direct, sagittal perspective (43). Optimal exposure of the lung is vital in order to facilitate the dissection of structures and to avoid any instrument interference.

Uniportal VATS is performed with the patient positioned in a lateral decubitus position that is the same as for a conventional multiport VATS procedure. The access incision, about 3–4 cm long, is preferably made in the anterior fifth intercostal space. This incision location provides better angles for hilar dissection and insertion of staplers. It is helpful to rotate the surgical table away from the surgeon during the hilar dissection and division of structures and towards the surgeon for the subcarinal lymph node dissection. We always recommend inserting the staplers, with angulation, through the anterior part of the incision. The use of curved-tip stapler technology allows for improved placement around the superior pulmonary vein and bronchus through a single incision, which is very helpful as these are the most difficult structures to divide through a single port. It is important to dissect the vessel as distal as possible in order to achieve better angles for the stapler insertion. When the angle is difficult for stapler insertion, we either use polymer vascular clips or ligate the vessels by using sutures.

It is crucial that the thoracoscope remains positioned in the posterior part of the incision at all times and the instruments in the anterior part as this positioning provides the best view and functionality. In the case of upper lobectomies, the pulmonary artery is normally divided first, followed by the vein. When the lobectomy is completed, the lobe is removed in a protective bag and a systematic lymph node dissection is accomplished. At the end of the surgery, the intercostal spaces are infiltrated with bupivacaine under thoracoscopic view and a single-chest tube is placed in the posterior part of the incision.

The role of the uniportal technique for advanced cases

With experience, skilled uniportal VATS surgeons can perform the most complex cases in the same manner as surgeons using a double or triple port approach (47,48). Previous experience in VATS is necessary to perform these advanced cases with success. The experience acquired with minimally invasive techniques such as uniportal VATS and improvements in surgical instruments, high definition cameras and recent three-dimensional systems have greatly facilitated the adoption of uniportal VATS techniques for complex cases and sleeve reconstructions. We believe it is important to minimize the surgical aggressiveness, especially in advanced stage lung cancer patients where the immune system is weakened by the disease or by induction treatments. The thoracoscopic surgical approach represents the least invasive technique to operate on lung cancer and the uniportal technique is the final stage in the evolution of these minimally invasive surgical techniques. The geometrical concept of the uniportal approach, i.e., the ergonomy obtained with the direct view and bimanual instrumentation could explain the excellent results that we have obtained with this technique for sleeve procedures (49,50). Moreover, this geometric ergonomy also contributes to the easy learning of the technique by numerous surgeons, many of them directly transitioning from open surgery to the uniportal VATS technique.

However, despite the multiple advantages of conventional multiport or uniportal VATS compared to thoracotomy such as decreased postoperative pain, decreased hospitalization, diminished inflammatory response or faster access to chemotherapy, the uniportal VATS approach for advanced stages of lung cancer is still infrequently undertaken (41). The main reasons for this low adoption of the technique are concerns about an intraoperative thoracoscopic major bleeding event or the technical challenges of performing a radical oncologic resection by uniportal VATS in advanced cases (51).

The majority of the complications that occur during VATS can be minimized with correct preoperative planning of the case as well as a careful pulmonary dissection. Coordination of all the surgical team is essential when confronting a challenging case or an emergency such as major bleeding (52). This is particularly important during the VATS learning curve, where the occurrence of intraoperative complications, particularly significant bleeding, usually ends in a conversion to open surgery. The conversion to open surgery should never be considered as a failure of VATS but rather as a form of guaranteeing the oncologic principles and the safety of the patient, especially for inexperienced thoracoscopic surgeons. It is essential to know at which moment the surgery should be converted and this will greatly depend on the experience of each surgeon (53). The advantage of the uniportal approach is the speed at which it can be converted to an open thoracotomy. Since the incision is in the anterior fifth intercostal space, it just needs to be enlarged posteriorly and a rib spreader introduced. When converting to a thoracotomy for bleeding, it is important to always maintain compression and the thoracoscopic view while performing the thoracotomy in order to avoid situations of massive bleeding.

Further studies will be necessary to evaluate the long term results of a large series of complex resections performed by uniportal VATS (41,54).

Conclusions

The rapid rise of uniportal VATS is over a century in the making. Dr. Jacobaeus and his counterparts provided the foundations from what later become VATS and uniportal surgery. Without the advent of both video fiber optics and the Internet, modern uniportal surgery might still be taking baby steps on to the surgical stage. Now that uniportal surgery has progressed beyond its infancy, it is time to propose changes in existing treatment algorithms to reflect its existence. To do so, thoracic surgery needs to generate additional publications beyond the level of case reports and retrospective review.

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Footnote

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Uniportal VATS—a new era in lung cancer surgery

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"*To improve is to change; to be perfect is to change often.*"
Sir Winston Churchill

It is perhaps surprising that this quotation comes from a gentleman of tradition and conservatism. However, even one of the greatest prime ministers of Great Britain recognized that we live in a constantly evolving world and adaptation is the key to survival. In surgery for lung cancer, we are witnessing a significant revolutionary change in approach that has not been witnessed since the 1990's when major lung resection became possible through minimally invasive "key-hole" surgery in the form of video-assisted thoracic surgery (VATS) instead of through a large open thoracotomy. In 2011, as we recognized the 20th anniversary of VATS lobectomy (1), another promising major advance in lung surgery, uniportal (single port) VATS lobectomy, was developed that has subsequently been more rapidly adopted than its parent procedure (2,3).

VATS lobectomy has been most commonly performed through several incisions or ports, usually three or four. Rocco was the first to challenge this by performing the first uniportal VATS lung resection (4). In 2006, the team from Duke University Medical Centre published their experience of performing almost 500 cases of VATS major lung resection using only two ports (5). To many surgeons, this was another big leap towards an even less invasive VATS approach. The article inspired Gonzalez-Rivas, a skeptical thoracic surgeon from Spain to visit Duke University, and who in his own words once said "it is impossible to perform lobectomy with only two ports". It was perhaps ironic that in 2010, Gonzalez-Rivas successfully performed the first uniportal VATS lobectomy for treatment of early stage lung cancer. Since then he and his team have enthusiastically championed and refined this approach, with subsequent publications of the first pneumonectomy, sleeve lobectomy and vascular sleeve lobectomy all performed by uniportal VATS. In the present era, even complex major lung resections that can be challenging through an open thoracotomy can now be performed by minimal invasive VATS using a single small incision of 5 cm or less. Furthermore, advances in uniportal technique and equipment allow for straight forward uniportal lobectomy procedures to be performed through an ultra-mini 2.5 cm single incision (6).

As with any novel technique, particularly one which is mostly used for the treatment of an oncological disease, safety and efficacy is paramount. Studies have shown the uniportal VATS approach to be at least as safe as conventional VATS (7,8). Post-operative pain has been shown to be less following uniportal VATS when compared with conventional 3-port technique in certain procedures. Furthermore, data have so far shown at least equivalent disease-free survival at intermediate follow-up for patients with early stage non-small cell lung carcinoma who received uniportal VATS surgery, although long term outcomes are still pending (8).

Apart from weighing the success of a new technique by purely clinical outcomes, rarely is one able to assess a modification of surgical approach by its wider impact on the whole specialty. The introduction and evolution of uniportal VATS has driven thoracic surgeons to reconsider alternative access routes to operate inside the chest. Furthermore,

Figure 1 Non-intubated hybrid operating room image-guided uniportal VATS wedge resection of lung nodule using 3-dimensional variable angle thoracoscope. VATS, video-assisted thoracic surgery.

the success of the uniportal strategy has reignited interest by industry to design instruments and equipment to facilitate this procedure. The development of subcostal single incision access to the thoracic cavity to avoid intercostal nerve injury, "scarless" embryonic natural orifice transumbilical endoscopic thoracic surgery (e-NOTES), and robotic thoracic surgery through a single incision have all at least in part been fueled by the uniportal VATS evolution. Angulated and narrower instruments and thoracoscopes, as well as remote wireless instrument platforms are rapidly being developed and introduced into minimal invasive thoracic surgery, which will further facilitate uniportal VATS procedures (9). Furthermore, the spirit for reinvention has extended into multidisciplinary collaboration with the anesthetists in the form of non-intubated uniportal VATS lung resection to achieve quicker postoperative recovery (10), and also with radiologists in the hybrid operating theatre using cone beam CT for guided uniportal VATS procedures to improve surgical accuracy (11). Our experiences so far on the non-intubated single port VATS approach to major lung resections have been encouraging with earlier resumption of normal diet and less nausea following surgery, as well as improved postoperative mobility allowing for shorter hospital stay (*Figure 1*). The approach has also been modified to retain the single interspace philosophy and to improve the ability to train residents (12).

In the same way that when conventional VATS was introduced more than two decades ago, uniportal VATS for major lung resection also have its sceptics, some of whom are immediately dismissive. As a Chinese Philosopher, Confucius (551-479 BC) once said, "*I hear and I forget. I see and I remember. I do and I understand*". For thoracic surgeons who have experienced and converted to uniportal VATS, they fully understand the potential impact of this new era in thoracic surgery on lung cancer management.

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Footnote

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Evolving from conventional video-assisted thoracoscopic lobectomy to uniportal: the story behind the evolution

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Diego Gonzalez-Rivas personal experience: how the idea of uniportal VATS lobectomy was born

"Humans are allergic to change. They love to say, we've always done it this way. I try to fight that. That's why I have a clock on my wall that runs counter-clockwise."

—Grace Hopper

When I started my training in thoracic surgery in 1999, I realized that the post-operative period for patients were very painful and hard because the incision we used to operate was very large, about 15 cm with rib spreading. So very often I thought of ways on how to improve this post operational period of our sick patients. In short, what could we do to reduce this pain and facilitate a better quality of life?

"There is always a way to do it better, so find it."

—Thomas Edison

So I started to study the origins of thoracoscopic surgery and this approach started to fascinate me. In the year 1910, Jacobaeus, described the first thoracoscopy to release adherences in patients suffering from tuberculosis. Before him, Kelling had done this in 1901 in dogs but not in humans. He did not publish this though and therefore Jacobaeus is claimed to be the first surgeon to use thoracoscopy in 1910. For many years this procedure was relegated to diagnostics and therapeutic procedures up till 1992 when Giancarlo Roviaro decides to do the first lung resection to surgically treat lung cancer through small incisions, looking at a screen and no rib spreading. He went from an aggressive open surgery to a minimally invasive surgery by using only three small incisions enabling the patient to a better postoperative recovery. This revolutionized the world of thoracic surgery. He was criticized for many years by the more traditional surgeons who considered themselves more prestigious than him by claiming that this procedure was not a total oncological procedure.

Time proved him right. Giancarlo Roviaro believed in his idea that the post-operative period of his patients could be improved by doing surgery with small incisions. His experience doing surgery through small incisions showed him this was not only possible but that his patients had much less pain and faster recovery after surgery.

The medical community did not see it this way and many years had to go by before he was recognized for his work. This is the story of medicine and in general of mankind.

I decided I had to learn this technique so I searched which hospital in the world had the most video surgery experience. So, in 2007 I went to Los Angeles in the United States and learned the surgical technique through 3-4 incisions with one of the most expert surgeons of the world (Dr. Robert Mckenna) and I put to it practice at my hospital. When we gathered enough experience I decided I had to improve my technique further, so I went back again to New York. By chance, I met a person there who changed my way of thinking. I had gone to New York to improve my three incisions technique and this person told me they were doing two incisions at Duke University Medical Center in North Carolina. This thought really confused me as I couldn't understand how surgery could be done through

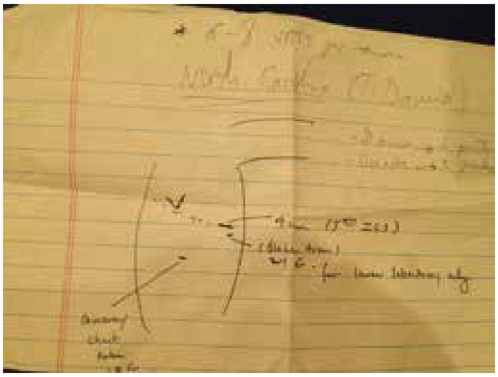

Figure 1 Drawing showing the double port technique from Duke medical center, US.

two incisions only. In my head I had the concept that three incisions were necessary: utility incision for instrumentation, inferior port for the camera and posterior incision for holding the lung. I wasn't able to think differently so I asked this person to draw it on a piece of paper (*Figure 1*).

After I returned to Spain this piece of paper kept me thinking and rethinking about how this could be done. I couldn't understand it. I decided then to go to Duke. I contacted the chief surgeon at Duke and he answered that he didn't accept people whom he did not know so you can imagine my disappointment. I couldn't accept a "no" for an answer so I persisted. I had to meet him. I decided to go to a congress that he would attend so I could meet him in person. I attended the annual meeting of the American Thoracic Society to meet Dr. Damico, and after an unforgettable conversation I asked him about the possibility to visit his institution and then I was accepted. Thanks to persistence Dr. D'Amico and I are very good friends and we organize courses together. Thanks to the persistence of an idea. If I wouldn't have believed in this I would've never met him and I wouldn't be where I am nowadays.

So it is important to never stop thinking and to never let your ideas go if you believe they are important.

However, thinking differently has produced a lot of troubles to those who came up with new ideas or innovations. A clear example of this was Galileo—Galileo during his time dared to say that the world was round and as a consequence was sentenced to be arrested for a long time at home. In order escape from this punishment he had to reject his idea and say all was a lie.

Another example of innovation and ideas, this time in relation to medicine, was Semmelweis. This person discovered asepsis. He tried to convince his colleagues that if people washed their hands their patients would have less post-operative infections. He was expelled from the international scientific community and finally died from an infection (after cutting himself during an autopsy).

Obviously, people who think differently, who are visionaries are the ones who change the world. The founder of Apple, Steve Jobs was a visionary and he became a genius. He pronounced these words:

"Here's to the crazy ones, the misfits, the rebels, the troublemakers, the round pegs in the square holes the ones who see things differently—they're not fond of rules. You can quote them, disagree with them, glorify or vilify them, but the only thing you can't do is ignore them because they change things, they push the human race forward, and while some may see them as the crazy ones, we see genius, because the ones who are crazy enough to think that they can change the world, are the ones who do".

But think differently especially in the medical world can be very risky because we are affecting the most valuable asset human beings have, health. I knew though, that I had to think differently because I was a restless person and I liked to innovate.

During the double port technique I was working most of the time with the camera located through the utility incision because I realized that I had a better direct view. So I thought: for lower lobes, all instruments and staplers are inserted through the utility incision but the view came from another perspective, not anatomic. Why not have the same view as we have during an open thoracotomy approach? Thus, in June 2010 after thinking a lot I decided to do the first lobe resection through one single port. I placed all instrumentation and the camera through the same utility incision. I realized during the surgery that I felt comfortable, with a better view and was able to finish it completely very fast. The evolution of the patient was excellent, discharged on the second postoperative day with no pain. This motivated me to continue further with this approach. When I first published it in an international journal the conclusion I drew was that this surgery was only meant for tumors in the lower lobes. For the upper lobes I thought we needed new technology to access them due to angulation a physical problem. Nothing further from reality. In time, with the evolution I realized that if we thought differently and we exposed the lung in a different way, no new technology was needed. Thus, all surgery could be done, and so we did. We published all our cases and results in the most important journals and textbook of thoracic surgery. Thanks to team work, we could teach our technique to our colleagues and residents who were starting.

In 2012, in an international congress, an Italian surgeon

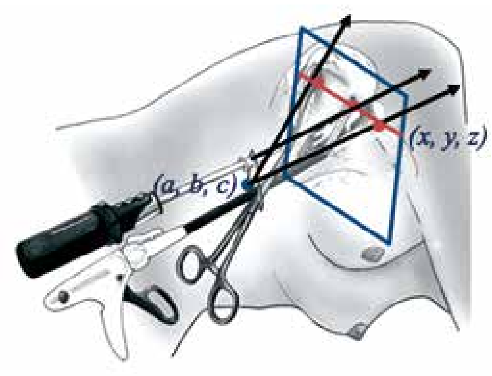

Figure 2 Geometric concept of uniportal VATS. VATS, video-assisted thoracoscopic surgery.

called Luca Bertolaccini with a background in physics and fascinated by our technique made a physical and mathematical demonstration with equations of why our uniportal technique (through one incision) was better than other techniques which were being used by some of the best surgeons in the world. The advantage of using the camera in coordination with the instruments is that the vision is directed to the target tissue, bringing the instruments to address the target lesion from a straight perspective, thus we can obtain similar angle of view as for open surgery (*Figure 2*). Conventional three port triangulation makes a forward motion of video-assisted thoracic surgery (VATS) camera to the vanishing point. This triangulation creates a new optical plane with genesis of dihedral or torsional angle that is not favorable with standard two-dimension monitors. Instruments inserted parallel to the videothoracoscope also mimic inside the chest maneuvers performed during open surgery. This mathematic explanation made me understand many things, such as why I felt so comfortable that first time, why were we able to teach the technique and reproduce it successfully in other parts of the world.

We were invited to many different countries to give conferences: China, Taiwan, Korea, Rusia, Israel, Indonesia, Brazil, Chile, Colombia, Turkey, United States, France, Italy, Germany. What first started as a curiosity, a special ability of one surgeon—I heard this thousands of times—in time it became a reproducible technique which all members of my department performed. This created even more interest. The uniportal technique was adopted in other parts of the world and we received even more demand. It's not because the technique was interesting for being a unique thing, but it's being applied all over the world and its expansion continues.

During all this time we've had many obstacles. It hasn't been a walk through the park. Because when you're doing a new technique, you need to design many new things in your head. You need to learn how to expose the lung properly, you need to search for strategies, how to teach these and not only that—the obstacles posed by people, surgeons of prestige who see themselves threatened by this novel technique because they are unable to learn it. Then critics and envies happen opposition takes place.

Because every innovation comes with restriction. Therefore, these obstacles made us grow and all critics from other colleagues we heard predicting the future such as: you're not going to reach anywhere; this technique doesn't have any future ended in nothing.

Life is full of erroneous predictions—In 1913 the president of the Michigan bank advised Henry Ford's lawyer not to invest in Ford Motor Company arguing that the horse was here to stay and the automobile was just a fad. Luckily this person didn't listen to the advice. He invested and became a multimillionaire.

We've always followed the philosophy of never be intimidated by the obstacles and be always open to progress. Because we never know what the future will bring. The next generation will be with the robotic technology, single port devices, wireless cameras. We are sure of this because the future will be the minimum invasiveness. This is why we believed in our idea. Who knows if in the future we will have devices of robotic surgery at home? What we can't do is close ourselves to evolution and make predictions on things that won't work.

I've learned that in life if you walk alone, you will get there faster but if you walk in company you will get further. And without the support of the people who love you and a good team, we would've never been able to reach where we are now. Who would've told us that from a small corner of Spain, with the several colleagues against our innovation, after a lot of work, dedication and confidence we would do something that was going to bring revolution to surgery in the world.

This is why the key is to think differently, measure risks, be innovative, believe in an idea, fight for it and overcome obstacles, because "*Impossible is nothing*".

"Intelligence is the ability to adapt to change."

—Stephen Hawking

Figure 3 Video-Conference during international symposium on uniportal VATS held in Coruña (7). VATS, video-assisted thoracoscopic surgery.
Available online: http://www.asvide.com/articles/317

Coruña University and Minimally Invasive Thoracic Surgery Unit (UCTMI) experience: a coordinated teamwork

We started to perform VATS lobectomies in our department in 2007 after learning the technique at Cedars Sinai, LA (1). After performing over 80 lobectomies with three ports, we eliminated the posterior incision, and subsequently performed most lobectomies through only two ports according to the technique described by D'Amico (2). But the final step of the surgical evolution in our unit, to minimize chest wall trauma, was the uniportal approach for major lung resections.

We developed the technique to perform major pulmonary resections by uniportal approach in June 2010 (3) thanks to the previous experience in double-port VATS for lobectomy and single-port technique for minor procedures (wedge resections, pneumothorax, etc). Initially only lower lobes cases were selected.

This evolution in the approach from three ports to single port technique required a new learning curve: different lung exposure and learning how to coordinate the instruments and the camera with no interference during surgery. As with all new surgical procedures, there was a certain learning curve component but not comparable to the one experienced when starting a VATS program (4).

For double port VATS lower lobectomies all the instrumentation and stapler insertion are performed through the utility incision. Therefore we decided to insert the optic through the utility incision working in coordination with instruments to perform a single incision lobectomy. The first case we performed was accomplished in 90 minutes and the patient was discharged on the second postoperative day with no complications (3). When several lower lobes cases were performed with good results, the upper lobes were attempted (5). With gained experience the more complex resections were accomplished (6) (*Figure 3*).

Results (4 years' experience)

- June 2010-April 2014: 362 uniportal lobectomies (>900 total uniportal VATS);
- 2.4% conversion rate;
- Most frequent resection: RUL;
- Mean surgical time: 150.62 [40-310] min;
- Mean number of lymph nodes: 14.8 [5-38];
- Mean nodal stations: 4.7 [3-8];
- Median chest tube: 2 days;
- Median hospital stay: 3 days;
- Complications: 69 patients.

Tips and tricks: the uniportal approach can be adopted following two different ways

(I) Learning from conventional VATS to uniportal (our evolution)
  - Remove the posterior port;
  - Adopt the double port technique;
  - For lower lobectomies place the camera at the posterior part of utility incision;
  - Use bimanual instrumentation with curved instruments;
  - For upper lobectomies place the camera through utility incision and use inferior port only for stapler insertion or for instrumentation;
  - Use the inferior port only to expose the lung (camera, staplers and instrumentation through the incision);
  - Remove the inferior port;
  - Use vascular clips when no angle for staplers;
  - Always insert the staplers with angulation for vascular division;
  - Start with lower lobectomies (female and thin patients preferably).

(II) Learning from open approach to uniportal (uniportal mimics the open maneuvers)
  - Adopt the Anterior small thoracotomy approach (10-12 cm incision);

- Add the thoracoscope to thoracotomy (use monitor view and open direct view during surgery);
- Remove rib spreader (same incision). Move instruments and camera along the 10 cm incision;
- Reduce progressively the size of incision after gained experience.

Future

The future of the thoracic surgery is to reduce the surgical and anesthetic trauma. We truly believe on the use of the single port technique for major pulmonary resections because we understand that the future goes in that direction, i.e., robotics and single-port. We expect further development of new technologies like sealing devices for all vessels and fissure, robotic arms that open inside the thorax and wireless cameras, which will probably allow the uniportal approach to become the standard surgical procedure for major pulmonary resections in most thoracic departments. The combination of nonintubated or awake thoracoscopic surgery and single-port VATS technique is promising because it represents the least invasive procedure for pulmonary resections (8). Thanks to avoidance of intubation, mechanical ventilation and muscle relaxants the anesthetic side effects are minimal allowing to most of the patients to be included in a fast protocol avoiding the stay in an intensive care unit.

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Footnote

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Evolving thoracic surgery: from open surgery to single port thoracoscopic surgery and future robotic

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Thoracic Surgery is a continuous evolving specialty. In the past, thoracic surgeons had to make large incisions in order to operate any pathology inside the chest. This often meant big, painful and ugly scars and long recovery times after surgery. But he history of thoracic surgery changed since the begining of video-assisted thoracoscopic surgery (VATS).

Hans Christian Jacobaeus provided the first description of a thoracoscopy in 1910 (1). During decades the role of thoracocopy was only related to diagnostic and minor therapeutic procedures. Since the past two decades, thoracoscopic procedures have increasingly gained acceptance specially with the introduction of VATS major pulmonary resections (2).

Although there is no standardised technique for the thoracoscopic approach used in this type of procedure, most groups use a utility incision of about 4-6 cm, and add between 1-3 ancillary incisions, i.e., there is variability in the number of incisions used, depending on the centre in question. The most common approach comprises a utility incision plus two supporting incisions, i.e., three ports, and a very important consideration is the obviation of rib-spreading (3).

The use of multiple ports seems to entail more facilities for performing VATS lung resection and provides different angles for hilar dissection and lymphadenectomy. However, the performance of a lobectomy can be accomplished by only one incision with similar results (4). With increased experience in VATS lobectomy, we have gradually improved less invasive techniques and thanks to the advances in the field of thoracoscopic surgery the indications and contraindications for lung cancer treatment have been changed overtime.

We evolved from the conventional VATS to a single incision approach after gained experience via three ports. The first step was to avoid the posterior incision to perform cases by the double port technique (5), and the second step was avoid the inferior incision and insert the camera and the instruments through the utility incision (*Figure 1*).

We started to perform major pulmonary resections by uniportal approach in 2010 in our department (6). No other reports were described in the literature before. Actually we apply the single-port technique for most major resections including advanced and complex cases (7). To date we have performed 430 single-port VATS pulmonary resections (140 were lobectomies) through a single-incision (*Figure 2*) with excellent postoperative results.

The advantage of using the camera in coordination with the instruments is that the vision is directed to the target tissue, bringing the instruments to address the target lesion from a straight perspective, thus we can obtain similar angle of view as for open surgery (*Figure 3*). Coventional three-port triangulation creates a new optical plane with genesis of dihedral or torsional angle that is not favorable with standard two-dimension monitors. Instruments inserted parallel to the videothoracoscope also mimic inside the chest maneuvers performed during open surgery. There is a physical and mathematical demonstration about better view and instrumentation obtained in the uniportal VATS over conventional approach. Other potential advantage could be less postoperative pain: only one intercostal space is involved and avoiding the use of a trocar could minimize the risk of intercostal nerve injury. Further studies will be required to demonstrate other geometric aspects like ergonomy and that there is less pain with single incision techniques, compared to conventional VATS for lobectomy.

On the other hand technology improves and there is

Figure 1 Surgical instrumentation (camera placed in the posterior part of the incision)

Figure 2 Postoperative result with chest tube placed through the incision

Figure 3 Surgeons position (anterior location)

no question that robotic surgery has an important role in the future of thoracic minimally invasive surgery. Over the past 10 years, robotics have revolutionized surgery, and new innovations are continuing to push the boundaries of surgery (8). We are currently in a phase of rapid growth and dissemination of the applications for robotic surgical technology within thoracic surgery (9).

The first generation of robotic technology appeared twenty years ago (10). The robot lets surgeons carry out keyhole surgery remotely, allowing them to control robot arms from a console that also provides a three-dimensional image of the proceedings. The idea to develop robotic surgery platforms evolved from the need to improve the precision of surgical techniques. There is no doubt that robotics will be always more precise than even the most skilled surgeon with the steadiest hand. This development is growing and probably will allow surgeons to perform extremely complex surgical procedures using a minimally invasive approach through a small single hole in a near future.

Anyway nowadays, in my opinion, there are several disadvantages with robotic pulmonary resection: still is a hybrid procedure (robot makes the dissection and VATS is used for staplers) high cost, the need of 3-4 incisions, time-consuming procedure, difficulties to detect nodule lesions and to solve a major bleeding event. However, several advantages of the robot over VATS are clear: instrumentation with more degree of motion and perfect 3D view, specially to achieve a radical lymph node dissection and teaching residents (robotic lobectomy can be performed with no previous VATS experience) (11).

Therefore the adoption of new emergent robotic technology and the minimization of surgical aggression is a recommendable way to follow (12,13). We truly believe on the use of the single port technique for major pulmonary resections because we understand that the future goes in that direction, i.e., robotics and single-port. The instruments that would be necessary develop in the next future for single port robotic surgery should be vessel and bronchus sealer devices, snake-like arms inside the chest for instrumentation, wireless cameras and feedback robotic tactile Systems. We have to be open to the new therapies and the next robotic era because the future of lung cancer treatment probably will be related to genetic, selective molecular chemotherapy and microrobotic technology.

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Is uniportal thoracoscopic surgery a feasible approach for advanced stages of non-small cell lung cancer?

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Objectives: Conventional video-assisted thoracoscopic (VATS) lobectomy for advanced lung cancer is a feasible and safe surgery in experienced centers. The aim of this study is to assess the feasibility of uniportal VATS approach in the treatment of advanced non-small cell lung cancer (NSCLC) and compare the perioperative outcomes and survival with those in early-stage tumors operated through the uniportal approach.

Methods: From June 2010 to December 2012, we performed 163 uniportal VATS major pulmonary resections. Only NSCLC cases were included in this study (130 cases). Patients were divided into two groups: (A) early stage and (B) advanced cases (>5 cm, T3 or T4, or tumors requiring neoadjuvant treatment). A descriptive and retrospective study was performed, comparing perioperative outcomes and survival obtained in both groups. A survival analysis was performed with Kaplan-Meier curves and the log-rank test was used to compare survival between patients with early and advanced stages.

Results: A total of 130 cases were included in the study: 87 (A) *vs.* 43 (B) patients (conversion rate 1.1 *vs.* 6.5%, P=0.119). Mean global age was 64.9 years and 73.8% were men. The patient demographic data was similar in both groups. Upper lobectomies (A, 52 *vs.* B, 21 patients) and anatomic segmentectomies (A, 4 *vs.* B, 0) were more frequent in group A while pneumonectomy was more frequent in B (A, 1 *vs.* B, 6 patients). Surgical time was longer (144.9±41.3 *vs.* 183.2±48.9, P<0.001), and median number of lymph nodes (14 *vs.* 16, P=0.004) were statistically higher in advanced cases. Median number of nodal stations (5 *vs.* 5, P=0.165), days of chest tube (2 *vs.* 2, P=0.098), HOS (3 *vs.* 3, P=0.072), and rate of complications (17.2% *vs.* 14%, P=0.075) were similar in both groups. One patient died on the 58th postoperative day. The 30-month survival rate was 90% for the early stage group and 74% for advanced cases

Conclusions: Uniportal VATS lobectomy for advanced cases of NSCLC is a safe and reliable procedure that provides perioperative outcomes similar to those obtained in early stage tumours operated through this same technique. Further long term survival analyses are ongoing on a large number of patients.

Keywords: Advanced lung cancer; uniportal; thoracoscopy; video-assisted thoracoscopic(VATS) lobectomy; minimally invasive surgery; non-small cell lung cancer (NSCLC)

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Introduction

Despite the multiple advantages of video-assisted thoracoscopic (VATS) compared with thoracotomy (1) as decreased postoperative pain, decreased hospitalization, diminished inflammatory response or faster access to chemotherapy, the thoracoscopic approach for advanced stages of lung cancer is still infrequent. The concern about an intraoperative thoracoscopic major bleeding or the technical complication of performing a radical oncologic resection by VATS in advanced cases are the main reasons for the low adoption.

There are few studies reporting perioperative results and survival of patients with advanced disease operated by thoracoscopic approach (2,3). These cases are operated by using conventional VATS. However the same procedure can be performed by using a single incision approach. Since we developed our uniportal technique for VATS lobectomies in 2010 (4) we have increased the application of this technique to more than 90% of cases in our routine surgical practice. The experience we acquired with the uniportal technique during the last years (5), as well as technological improvements in high definition cameras, development of new instruments, vascular clips and more angulated staplers have made this approach safer, incrementing the indications for single-port thoracoscopic resections. We believe it is important to minimize the surgical aggressiveness especially in advanced stage lung cancer patients where the immune system is weakened by the disease or by neoadjuvant treatments. The minimally invasive surgery represents the least aggressive form to operate lung cancer and the single-port or uniportal technique is the final evolution in these minimally invasive surgical techniques.

The objective of this study is to assess the feasibility of uniportal VATS approach in the treatment of advanced non-small cell lung cancer (NSCLC) and to compare the perioperative outcomes and overall survival with early-stage tumors.

Methods

A retrospective descriptive prevalence study was performed on patients undergoing single-port approach for major pulmonary resections at Coruña University Hospital and Minimally Invasive Thoracic Surgery Unit (UCTMI) between June 2010 and December 2012. This study was approved by the review board at Coruña University Hospital and UCTMI. All patients were informed and had a written consent before surgery. A total of 163 surgical interventions (major pulmonary resections) were performed using this technique during the study period. Most were conducted by surgeons experienced with the uniportal approach for minor and major resections.

Only NSCLC were included in the study. Advanced clinical stage NSCLC were considered as tumors bigger than 5 cm, T3 or T4 and/or tumors that received neoadjuvant chemotherapy or radiotherapy. Most of the patients underwent routine preoperative pulmonary function testing, bronchoscopy, computed tomography, and fused positron emisión tomography-computed tomography.

Patients were divided into two groups: (A) early stage (T1 and T2) and (B) advanced clinical stages. A descriptive and retrospective study was performed, comparing perioperative outcomes and survival obtained in both groups.

Thanks to our previous VATS experience with conventional and double-port VATS (6), the indications and contraindications have changed overtime. The only absolute contraindication considered was surgeon discomfort and huge tumors impossible to remove without rib spreading.

Variables studied in each patient were age, sex, smoking habits, COPD, pulmonary function (FEV1 and FVC), presence of associated comorbidities, how the lesion is presented, tumor type and location, type and duration of surgical intervention, surgery-associated adhesions, stage, histology, tumor size, lymph nodes affected (number of lymph nodes retrieved and number of nodal stations explored), duration of chest tube, length of hospital stay, postoperative complications, 60-day mortality and survival.

Statistical analysis

A descriptive analysis of the variables studied was carried out. The quantitative variables are expressed as mean ± standard deviation, median and range. Qualitative variables are expressed by means of frequencies and the corresponding percentages. SPSS 17 for Windows for statistical analysis.

To compare the postoperative course according to perioperative characteristics, the Mann Whitney test was used for quantitative variables and Chi square test or Fisher exact test was used for qualitative variables.

A survival analysis was performed with Kaplan-Meier curves and the log-rank test was used to compare survival between patients with early and advanced stages.

Surgical technique

All patients in both groups were operated by using a single-incision VATS approach with no rib spreading and no wound protector (7). No epidural catheter was used. The 4-5 cm incision was placed in the fifth intercostal space. Anatomic major pulmonary resections were performed in all patients. Following anatomical resection, a complete mediastinal lymphadenectomy was performed in the patients with a diagnosis of malignancy. Instruments used were long and curved with proximal and distal articulation to allow the insertion of 3 or 4 instruments simultaneously and the camera used was 10 mm HD scope 30 degree. Intercostal infiltration was performed at the end of the

Table 1 Patient characteristics

	Mean ± SD [range] or No. (%)	
	A	B
Age	64.87±10.41 [38-84]	65.05±8.99 [47-81]
Sex		
Male	61 (70.1)	35 (81.4)
Female	26 (29.9)	8 (18.6)
Smoking history		
Yes	68 (78.2)	68 (78.2)
No	19 (21.8)	19 (21.8)
Comorbidity		
COPD	34 (39.1)	34 (39.1)
Cardiovascular risk factor	73 (83.9)	73 (83.9)
Cardiac disease	21 (24.1)	21 (24.1)
Previous cancer	22 (25.3)	22 (25.3)
Symptoms		
Casual finding	58 (66.7)	58 (66.7)
Hemoptysis	8 (9.2)	8 (9.2)
General syndrome	7 (8.0)	7 (8.0)
Cough	5 (5.7)	5 (5.7)
Pneumonia	6 (6.9)	6 (6.9)
Chest pain	1 (1.1)	1 (1.1)
Endobronchial tumor	6 (6.9)	6 (6.9)
Preoperative histology	13 (13.8)	13 (13.8)
Neoadyuvant treatment	0	29 (67.4)
Chemotherapy alone		24 (55.8)
Chemo-radiotherapy		5 (11.6)
Pulmonary function		
FEV1	89.06±25.35 [27-134]	79.56±19.87 [45-126]
FVC	94.24±21.04 [57-139]	90.62±14.75 [67-121]

surgery under thoracoscopic view and only one chest tube was placed in all patients.

We always start all lung operations with uniportal VATS to assess the extent of the disease and to rule out any pleuro-pulmonary metastasis. Conversions were defined as operations that began with a thoracoscopic dissection-division of hilar structures and were concluded as ribspreading thoracotomies. The cases that required conversion to open surgery were performed by extending the existing incision and continuing surgery through an

Table 2 Anatomic pulmonary resections (n=130)

	No. (%)	
	A	B
Right upper lobectomy	26 (29.9)	17 (39.5)
Right middle lobectomy	5 (5.7)	3 (7.0)
Right lower lobectomy	11 (12.6)	7 (16.3)
Left upper lobectomy	26 (29.9)	4 (9.3)
Left lower lobectomy	13 (14.9)	5 (11.6)
Typical segmentectomy	4 (4.6)	0
Right pneumonectomy	0	1 (2.3)
Left pneumonectomy	1 (1.1)	5 (11.6)
Bilobectomy	1 (1.1)	1 (2.3)

anterior minithoracotomy with rib spreading and support of optics (like hybrid VATS).

Results

Since the start of the Uniportal VATS program in June 2010 until December 2012, we have performed 163 major lung resections using this technique (That is now, December 2013, a total of 323 major resections). Only NSCLC cases were included in this study so a total of 130 cases were studied: 87 (group A) *vs.* 43 patients (group B). The demographic characteristics of the patients in both groups are described in *Table 1*. There were no significant differences in terms of patient age, sex, smoking status, past medical history or associated comorbidity between the two groups. The lesions were most often casual findings (66.7% in group A and 37.2% in B). From the patients in group B, 67.4% of them received chemo or chemo-radiotherapy induction treatment before surgery.

The types of resection performed and their frequency are shown in *Table 2*. Upper lobectomies (A, 52 *vs.* B, 21 patients) and anatomic segmentectomies (A, 4 *vs.* B, 0) were more frequent in group A while pneumonectomy was more frequent in B (A, 1 *vs.* B, 6 patients).

In group A, 68.3% of the patients and 40% of those in group B showed no adherences following lung collapse. In contrast, significant adherences complicating surgery were recorded in 15.4% of the cases in group A and 28.9% in group B.

The advanced group included very complex cases like bronchial sleeve resections, lobectomies with vascular reconstruction, chest wall resection, lobectomies after high

Table 3 Intraoperative data

	Mean ± SD; median [range]		P
	A	B	
Surgical time (minutes)	144.94±41.34; 140.0 [60-300]	183.26±48.97; 180.0 [100-310]	<0.001
Number of lymph nodes	14.36±6.71; 14.0 [5-38]	16.52±6.16; 16.0 [7-29]	<0.001
Number of explored nodal stations	4.76±1.11; 5.0 [3-7]	4.97±1.31; 5.0 [1-8]	NS
Tumor size (cm)	2.55±1.02; 2.5 [0.5-4.8]	3.92±2.38; 4.0 [0-9]	NS

Table 4 Postoperative results

	Mean ± SD; Median [range] or No. [%]		P
	A	B	
Days of chest tube	2.92±2.4 2.0 [1-16]	3.42±2.66 2.0 [1-14]	NS
ICU	2.0±6.54 1.0 [0-54]	1.15±0.36 1.0 [1-2]	NS
HOS	4.45±7.27 3.0 [1-58]	4.26±2.87 3.0 [2-14]	NS
Rate of complications	15 [17.2]	6 [14.0]	NS
Prolonged air leak (>5 days)	3	2	
Atelectasis	1	0	
Wound problems	3	0	
Atrial fibrillation	3	2	
Respiratory failure/SIRS	1/1	0	
Postoperative bleeding requiring reoperation	2	2	
Reinsertion of chest tube	1	2	

Table 5 Concordance between clinical and pathological staging (NSCLC)

	Preoperative No. (%)			
	A		B	
Stage				
IA	59 (67.8)	50 (57.5)	1 (2.3)	6 (14.0)
IB	15 (17.2)	16 (18.4)	4 (9.3)	5 (11.6)
IIA	6 (6.9)	7 (8.0)	7 (16.3)	9 (20.9)
IIB	1 (1.1)	2 (2.3)	1 (2.3)	4 (9.3)
IIIA	3 (3.4)	9 (10.3)	26 (60.5)	9 (20.9)
IIIB	0	0	0	0
IV	0	0	2 (4.7)	2 (4.7)
pT0N0M0				6 (14.0)
Concordance N (%)	74 (85.1)		20 (46.5)	
Downstaging chemo N (%)			16 (55.2)	

NSCLC, non-small cell lung cancer.

doses of chemo-radiotherapy, redo-VATS, completion pneumonectomy or sulcus tumor after induction treatment.

The intraoperative results are described in *Table 3*. Conversion rate was higher in group B (1.1% *vs.* 6.5%, *P*=0.119). Also in group B, surgical time was longer (144.9±41.3 *vs.* 183.2±48.9, *P*<0.001) and median number of lymph nodes (14 *vs.* 16, *P*=0.004) was statistically higher in advanced cases.

The postoperative results are described in *Table 4*. There were no significant differences in terms of days of stay in the intensive care unit, days of chest tube, HOS and rate of complications. One patient died on the 58th postoperative day due to a respiratory failure (group A).

In both groups the majority of the patients (A, 82.8% and B, 86%) suffered no postoperative complications. From the patients in group A, 65.5% of them were discharged in the first 72 hours versus 51.2% of patients in group B. All patients (100%) were discharged without any nursing assistance at home.

The most common histological type in group A (48, 55.1%) was adenocarcinoma while in group B (24, 55.8%) it was squamous cell carcinoma. The concordance between clinical and pathological stages is described in *Table 5*. A total of 85.1% of patients (A) and 46.5% (B) presented concordance between preoperative and postoperative staging. From the patients receiving chemotherapy 55.2% (16 patients) were pathologically downstaged (six of them were down-staged to pT0N0M0, total tumoral regression).

The survival rates are described in *Table 6*. The 30-month survival was 90.4% for early stages (group A) and 73.7% for advanced cases (group B). The 30-month overall survival of the 130 pacients was 85% (Kaplan-Meier).

Discussion

Since the first lobectomies using VATS were reported 20 years ago (8), the thoracoscopic approach has experienced an exponential increase for lung cancer treatment, especially

Table 6 Survival data (n=130)

	Mean ± SD (range) or No. (%)	
	A	B
Postoperative mortality	1 (1.1)	0
Actual survival		
Alive	82 (94.3)	33 (76.7)
Deceased during following	5 (5.7)	10 (23.3)
Estimated survival (months)	39.02±1.02 (37.02-41.01)	25.25±1.48 (22.34-28.16), *P*<0.002
30 months-estimated survival (Kaplan-Meier)	90.4%	73.7%

for early stages. The majority of publications on VATS lobectomy focus on patients with early stages of NSCLC, showing less postoperative pain, lower stress responses and improved outcomes, when compared with thoracotomy (9). However the role of VATS for treatment of advanced stages of lung cancer is not clear and has been questioned.

Thanks to the advances in the field of thoracoscopic surgery the indications and contraindications for lung cancer treatment have been changed overtime. Initially only early stages were considered for VATS approach and advanced NSCLC tumors were considered a contraindication for thoracoscopic surgery (10). Several concerns regarding the radicality of oncologic resection, technical challenges, and safety has reduced the incorporation of VATS for more advanced stages of lung cancer. In cases of extended resections such as vascular or bronchial sleeve, chest wall resection or tumors after high doses of induction chemo-radiotherapy; the VATS approach is even less frequent. However, thoracoscopic major lung resection for advanced stage lung cancer is now gaining wide acceptance in experienced VATS departments (11). Skilled VATS surgeons can perform 90% or more of their lobectomies thoracoscopically, reserving thoracotomy only for huge tumors or complex broncho-vascular reconstructions.

Despite the increasing implementation of the techinque by experienced surgeons to deal with advanced tumors, the number of publications showing results is still insignificant. Hennon and colleagues, showed similar outcomes of advanced cases performed by VATS when compared with open surgery (2). In this study the perioperative complications were equal in patients undergoing thoracoscopic resection when compared to those having a thoracotomy. No difference was observed for disease-free and overall survival.

In another multi-institutional experience, more than 400 patients with stage III or IV disease were treated with a VATS approach over a period of 8 years. The preliminary analysis indicate no significant difference in overall survival between VATS and open thoracotomy groups, with a conversion rate of approximately 5% in the cohort of patients with advanced stage NSCLC (12).

The incidence of surgical complications after neoadjuvant therapy has been reported in the literature to be high (13). VATS lobectomy has been usually avoided in patients undergoing preoperative chemotherapy or radiotherapy due to concerns regarding the propensity of induction therapy to increase the difficulty of hilar and mediastinal dissection, especially around vessels. In our series of patients the induction treatment increased the complexity of hilar and lymph node dissection but these were performed successfully, most likely due to our previous thoracoscopic experience (5,6). There are publications reporting that pulmonary resection may be performed safely after induction chemo or high doses of radiotherapy (14,15). However, recent publications showed prior chemotherapy as one of the significant predictors of morbidity in a multivariable analysis (16). The rate of complications in our study in patients receiving induction treatment had not increased, being similar to perioperative results in early stage tumors.

Recently, Huang J and colleagues published a study of 43 locally advanced NSCLC patients (including nine sleeves and four pneumonectomies) undergoing VATS following neoadjuvant therapy with good posotperative results (3). Lee and colleagues report that thoracoscopic pulmonary resection for NSCLC showed better compliance with adjuvant chemotherapy, allowing to apply the thoracoscopic procedure not only to patients with early stage NSCLC but also to patients who need adjuvant chemotherapy (17).

Uniportal VATS has become an increasingly popular and effective approach in our unit to manage early and advanced stages of NSCLC, because of the reduced access trauma, advantages in view and more anatomic instrumentation and good perioperative results. The success in performing uniportal complex VATS lobectomies is a result of skills and experience accumulated over time from performing uniportal VATS surgery (5). With gained experience with the uniportal VATS technique the most complex cases can be performed in the same manner as with double or triple port approach. We have performed advanced NSCLC cases via single-port VATS including lobectomies with chest wall resection (18), redo-VATS and completion pneumonectomies, cases after high doses of chemo-radiotherapy, vascular reconstruction (19), bronchial sleeve lobectomies (20) and complex pneumonectomies (21).

Mean operation time for advanced uniportal VATS resections was higher than for early stage tumors (188 *vs.* 141 m), as expected. However our surgical time is less than other authors by using more number of thoracoscopic incisions (11). We found several advantages of the single incision technique especially for advanced cases. The geometrical explanation of the approach could explain our results (22). The advantage of using the camera in coordination with the instruments is that the vision is directed to the target tissue, bringing the instruments to address the target lesion from a straight perspective, thus we can obtain similar angle of view as in open surgery. Bimanual instrumentation also facilitates the surgery for complex cases. Conventional three port triangulation makes a forward motion of VATS camera to the vanishing point. This triangulation creates a new optical plane with genesis of dihedral or torsional angle that is not favorable with standard two-dimension monitors. Instruments inserted parallel to the videothoracoscope also mimic inside the chest maneuvers performed during open surgery. There is a physical and mathematical demonstration about better geometry obtained for instrumentation and view in the uniportal VATS over conventional approach (22). This fact in combination with the expierence obtained so far as well as recent improvements in surgical instruments, new energy devices and modern high definition cameras enable us to be very confident with the instrumentation and the manipulation of tissue even in very complex and advanced procedures.

The rate of pneumonectomies was logically higher in patients with advanced stages.

Pneumonectomy is only considered in cases where it is not possible to perform a sleeve resection. In our unit it is mandatory to do a careful assessment of the location of the tumor in order to proceed with a uniportal VATS pneumonectomy. Sleeve resections are also performed via single-incision VATS with no need to convert to thoracotomy allowing patients a better postoperative recovery (23). This is especially important in patients receiving induction chemo-radiotherapy as performing a pneumonectomy would increase the rate of postoperative complications. The uniportal thoracoscopic resection of the whole lung is technically easier to perform than a lobectomy because the fissure doesn't need to be managed. However extra care must to be taken during dissection and division of the main artery and transection of the main bronchus (21). There are several studies reporting that pneumonectomies performed thoracoscopically or via thoracotomy resulted in equivalent survival rates (24). Further studies and follow-up is needed to verify the benefits of VATS pneumonectomy for lung cancer.

From the literature, conversion rates from VATS lobectomy to open surgery have been reported to be from 2% to 23%, with these higher rates coming from patients with more advanced tumors (2). Most frequently the conversion to thoracotomy was considered necessary because of bleeding during dissection or oncological reasons, such as centrally located tumors requiring sleeve resection, or unexpected tumors that infiltrate the mediastinum or chest wall. In our series, the rate of conversion for advanced cases is low (only 6.5%) compared with other series (2,3). Furthermore, no patient was converted to conventional thoracotomy in our study (enlarged incision to antherior thoracotomy and Hybrid VATS).

Also in our study, the incidence of postoperative complications in early stages and advanced stages were similar. The uniportal technique was developed in 2010 by one of the surgeons of the department and sequentially taught to a total of four consultant surgeons and two trainees. Most of the advanced cases were performed by the surgeon who developed the technique, and with more thoracoscopic experience. This surgeon's experience in managing complex and highly difficult procedures under uniportal VATS and the advantages of the minimally invasive approach (small incision, no rib retractor and only one intercostal space opened) is also important to reduce the prevalence of postoperative complications, especially in the advanced group.

We believe that minimize the surgical aggression is particularly important given the large number of frail patients with advanced stage disease who require multimodality therapy, sometimes being difficult to tolerate in older patients or patients with severe comorbidity. Several articles in the literature suggest that the immune response is better preserved after VATS surgery than thoracotomy (1). Given that immune function is an important factor in controlling tumor growth and recurrence, we have hypothesized that the reduced inflammatory response associated with thoracoscopy, especially with uniportal VATS (which represents the minimal invasive approach) may be associated with improved long-term survival. Further studies to analyze inflamatory response and long term survival on uniportal VATS are ongoing.

This study is limited by its retrospective design and absence of comparative subjects with open approach. Most of the data except on present survival were collected from chart review, with the limitations accompanying a retrospective study. Also, the follow-up duration was relatively short, and the free-disease period was not studied making it difficult to conclude whether survival rates were favorable for patients undergoing uniportal VATS lobectomy.

Another limitation of the study is the absence of an analysis of the results based on the cases performed by surgeons with a greater experience in the technique (those who have performed most operations), compared to those surgeons who started the technique later.

There are few reports regarding perioperative results and survival of advanced cases of NSCLC operated by thoracoscopic approach. According to the VATS Consensus Statement (agreement among 50 international experts to establish a standardized practice of VATS lobectomy after 20 years of clinical experience), eligibility for VATS lobectomy should include tumour size ≤7 cm and N0 or N1 status. Chest wall involvement was considered a contraindication for VATS lobectomy, while centrality of tumour was considered a relative contraindication when invading hilar structure (25). The Consensus Group acknowledged the limitations of VATS lobectomy based on their individual experiences with a recommendation to convert to open thoracotomy in cases of major bleeding, significant tumour chest wall involvement and the need for bronchial and/or vascular sleeve procedures. However, these recommendations are directed at the general thoracic surgical community, and indications for VATS lobectomy and conversion to thoracotomy should depend on each surgeons experience.

In conclusion, Uniportal VATS lobectomy for advanced cases of NSCLC is a safe and reliable procedure that provides perioperative outcomes similar to those obtained in early stage tumours operated through this same technique. Our 30-month survival rate is acceptable and similar to survival rates reported in other studies performed by conventional VATS. Further analyses of long term survival for advanced cases operated by uniportal VATS needs to be performed with a large number of patients to validate the oncologic outcomes of the technique.

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Multivariate analysis in thoracic research

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Abstract: Multivariate analysis is based in observation and analysis of more than one statistical outcome variable at a time. In design and analysis, the technique is used to perform trade studies across multiple dimensions while taking into account the effects of all variables on the responses of interest. The development of multivariate methods emerged to analyze large databases and increasingly complex data. Since the best way to represent the knowledge of reality is the modeling, we should use multivariate statistical methods. Multivariate methods are designed to simultaneously analyze data sets, i.e., the analysis of different variables for each person or object studied. Keep in mind at all times that all variables must be treated accurately reflect the reality of the problem addressed. There are different types of multivariate analysis and each one should be employed according to the type of variables to analyze: dependent, interdependence and structural methods. In conclusion, multivariate methods are ideal for the analysis of large data sets and to find the cause and effect relationships between variables; there is a wide range of analysis types that we can use.

Keywords: Multivariate analysis; statistics; research

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Introduction

With the development of information technology and communication, it is now easier to make processes of collection, storage and transportation of large—both in volume and complexity—databases from observation or experimentation. A multivariate approach will help to illuminate the inter interrelatedness between and within sets of variables.

Definition

Multivariate analysis in a broad sense is the set of statistical methods aimed simultaneously analyze datasets. That is, for each individual or object being studied, analyzed several variables. The essence of multivariate thinking is to expose the inherent structure and meaning revealed within these sets if variables through application and interpretation of various statistical methods.

There are two determining factors that have to take into account when doing a multivariate approach (1): (I) the multidimensional nature of the data matrix and (II) the purpose of trying it, preserving its complex structure. This is based on the belief that the variables are interrelated, so that only the set of the same test may provide a better understanding of the studied object obtaining information univariate and bivariate statistical methods are unable to achieve. The joint treatment of the variables will faithfully reflect the reality of the problem addressed (2).

Types of multivariate methods

Multivariate methods can be classified based on the types of variables (3) (*Figure 1*):

(I) According to the methods of dependency: Analyzed variables are divided into two groups: dependent and

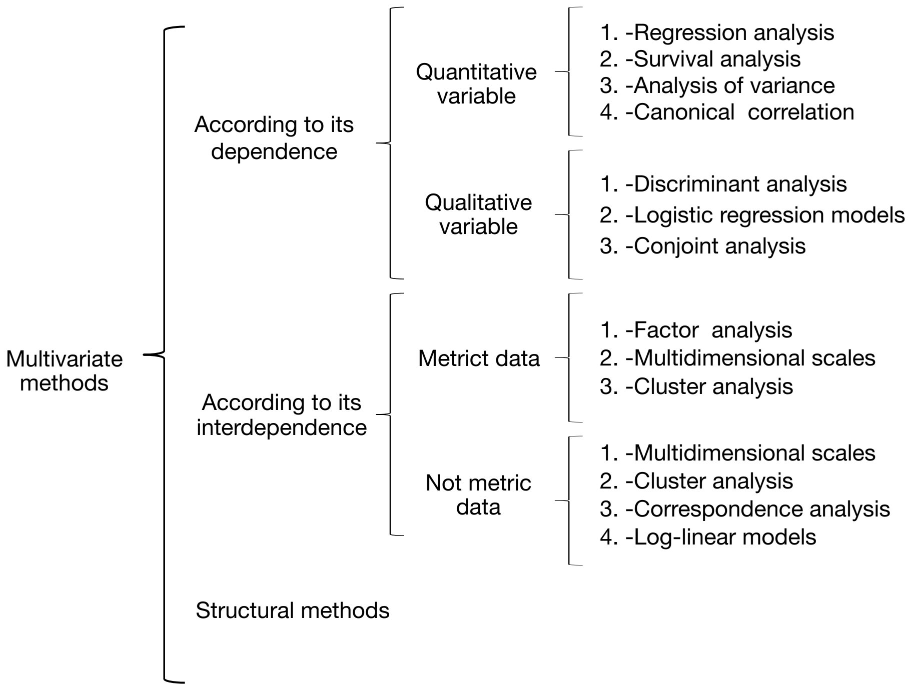

Figure 1 Classification of multivariate methods.

independent variables. The aim is to determine whether the set of independent variables affects all dependent variables and how. They develop a hypothesis that attempts to validate empirically are explanatory or predictive techniques.

They can be classified according to if the dependent variable or variables are quantitative or qualitative (4).

(i) If the dependent variable is quantitative, we can use different multivariate models such as:

a) Regression analysis: It is typically used to predict the behavior of certain variables from others. Generally, it does not describe the relationship between variables because it ignores the possible random variations in the value of the independent variable and they are not derived from the variation of the dependent variables. An example would be to analyze a sample of 500 smokers aged 50 years and establish the relationship between lung cancer (outcome or dependent variable) and some of its basic characteristics and habits: number of cigarettes per day, number of years of smoking, forced expiratory volume at first second (FEV1), etc.

b) Survival analysis: It consists of a set of appropriate statistical techniques where each subject is followed for a certain period. Here the independent variable is the time to the event (time to death for survival analysis, but also can be time to recurrence, time to discharge, etc.). This model will allow us to study the relationship between a set of explanatory variables and the incidence of the event of interest and also to predict the survival chances of a given subject from the pattern of values taken in the predictors. The most widely used model in health sciences is the proportional hazards model of Cox. An example would be a study for ex-smokers relapse (outcome variable) in their consumption according to their employment status, the presence of mental illness, if they have other toxic habits and years of smoking (explanatory variables).

c) Analysis of variance: a method for comparing various measures in different situations that is used when the full sample is divided into several groups based on one or more non-metric independent variables and the dependent variables analyzed are metric. An example could be to evaluate the efficacy of different drugs to control dual bronchodilator chronic obstructive pulmonary disease (COPD), compared with inhaled corticosteroid and a bronchodilator drug in a population of patients with COPD; these patients were randomly distributed. The first group would be provided a placebo, the second an inhaled corticosteroid and a bronchodilator; the third, it would be administered twice bronchodilator therapy and the results are evaluated.

d) Canonical correlation: it is based on to try to analyze simultaneously multiple dependent and independent metric variables by calculating linear combinations of each set of variables, looking for the possible existence of relationship between two sets of variables. Its objectives are to determine whether two sets of variables (measurements on the same objectives) are independent from each other or, conversely, to determine the magnitude of the relationships that may exist between the two sets. A possible example would be to determine if lifestyle and dietary habits have an effect on health by measuring different variables such as weight, blood pressure and dyslipidemia.

(ii) If the dependent variable is qualitative:

a) Discriminant analysis: it provides rules for classifying new observations of their group of origin, based on the information provided by the values it takes the independent variables. In other words, it indicates which variables differentiate the groups. The objective of this analysis is to find the linear combination of independent variables that best differentiate the groups. We would establish which patients would benefit and which lung cancers are not of a formal lobectomy—versus atypical resection—in stage I.

b) Logistic regression models: Logistic regression measures the relationship between a categorical dependent variable and one or more independent variables, which are usually (but not necessarily) continuous, by using probability scores as the predicted values of the dependent variable (5). The aim would be to explore a set of possible predictors to define those that are important in explaining a particular dependent variable and build a prognostic index to predict response or outcome (Y) from a set of explanatory variables (X), help control the effects of confounding variables to estimate the specific effect of one or more factors (Xi) on a variable (Y), detect and assess interaction effects between two or more explanatory variables. The regression analysis may be applied for example in a study of lung cancer [dependent variable (Y)] from studying snuff consumption (X1), asbestos exposure (X2) and exposure to radon (X3).

c) Conjoint analysis: It is a method that analyzes the effect of non-metric independent variables in metric or non-metric variables. Unlike the analysis of variance, the dependent variables may be non-metric and the analyst sets non-metric values of the variables. The goal is to understand how individuals form their preferences for objects or stimuli, estimating the relative importance attached to each of the attributes or characteristics of it. This model would explain the preferences of patients with lung cancer when choosing a treatment.

(II) According to the methods of interdependence: It is based in to do a reality approach without specific hypotheses and try to describe reality by synthesizing the relevant information; they are descriptive or reductive techniques. They can be classified into two groups based on whether the data analyzed are metric or non-metric.

(i) If the data are metric:

a) Factor analysis and principal component analysis: this technique allows to analyze interrelationships among a large number of metric variables explaining these relationships in terms of a smaller number of variables called factors if they are unobservable or components if they are observable. It removes existing redundancies between the initial set of observed variables. A possible example would be to study a group of items from a scale and label them under a single dimension or factor assessment.

b) Multidimensional scales: It transforms judgments of similarity or preference distances represented in multidimensional space. The objectives are: proximity between objects used to perform a spatial representation of them and identify the underlying dimensions. An example is the spatial representation of the similarities between the various chemotherapy treatments lung cancer in order to know the relative positioning of each of them.

c) Cluster analysis: This is a method for ranking entities; whether individuals or variables in a small number of groups so that the observations within a group are very similar and very different from the rest. Unlike discriminant analysis, the number and composition of these groups is unknown. This method could build a sanitary map in Spain according to the incidence of the different types of lung cancer.

(ii) If the data are not metric:

a) Multidimensional scales.
b) Cluster analysis.
c) Correspondence analysis: It is applied to multidimensional contingency tables and pursues a similar multidimensional but simultaneously representing the rows and columns of the contingency tables scales goal. Its goals are to reduce the data (non-metric variables); from the relationship between observed variables, identifying dimensions or latent variables; deepen the relations established between two or more categorical variables. A possible example would be to get a perceptual positioning map showing the association between lung cancer and the underlying dimensions.
d) Log-linear models: It is based on applying to multidimensional contingency tables and multidimensional relationships modeled dependence of the observed variables that seek to explain the noted frequencies. They allow the researchers to test different models that posit types of relationships between two or more categorical variables.
e) Structural methods: These methods assume that the variables are divided into two groups: the dependent variables and the independent. They aim to analyze how the independent variables affect the dependent variables and the relationships of the variables in the two groups together. For example, consider how the resources of the fast lane of lung neoplasms with perceptions that patients have of it are used.

Stages of realization of a multivariate analysis

The steps (I) to perform a multivariate analyze can be summarized in:

(I) State the objectives of the analysis. Define problem in its conceptual terms, objectives and multivariate techniques that are going to be employed.
(II) Design analysis. To determine the sample size and estimation techniques those are going to be employed.
(III) Decide what to do with the missing data.
(IV) Perform the analysis. Identify outliers and influential observations whose influence on the estimates and goodness of fit should be analyzed.
(V) Interpret the results. These interpretations can lead to redefine the variables or the model which can return back to steps (III) and (IV).
(VI) Validate the results. At this point, we must establish the validity of the results obtained by analyzing other results obtained with the sample is generalized to the population from which it comes.

Multivariate analysis example

Wells *et al*. (6) published in New England Journal of Medicine a study were they hypothesized that a computed tomographic (CT) metric of pulmonary vascular disease [pulmonary artery enlargement, as determined by a ratio of the diameter of the pulmonary artery to the diameter of the aorta (PA: A ratio) of >1] would be associated with previous severe COPD exacerbations . A univariate logistic regression was used to determine the associations between patient characteristics (including the PA: A ratio) and the occurrence of a severe exacerbation of COPD in the year before enrollment. Variables showing a univariate association with severe exacerbations (at $P<0.10$) were included in stepwise backward multivariate logistic models to adjust for confounders. These models included also variables previously reported to be independently associated with acute exacerbations of COPD in the ECLIPSE study as gastro-esophageal reflux disease (GERD), lower values for the forced expiratory volume in 1 second (FEV1), a history of acute exacerbations of COPD within the previous year, increased white-cell count, and decreased quality of life as measured by the St. George's Respiratory Questionnaire (SGRQ) score (which ranges from 0 to 100, with higher scores indicating worse quality of life and with a minimal clinically important difference of 4 points). Authors found significant univariate associations between severe exacerbations and younger age, black race, use of supplemental oxygen, congestive heart failure, sleep apnea, thromboembolic disease, GERD, asthma, chronic bronchitis, employment in a hazardous job. Thanks to the development of a multivariate model, it will not only let to handle many covariates, it will let to asses potential confounders and also test for interaction or effect modification. Multiple logistic-regression analyses showed continued significant independent associations between severe exacerbations and younger age, lower FEV1 values, higher score on the SGRQ, and a PA: A ratio of more than 1.

Conclusions

This article provides a brief overview of the importance of using multivariate studies in the health sciences and the different types of existing methods and their application depending on the type of variables to deal with. In addition, it described the steps to follow to design a multivariate study.

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Video-assisted thoracoscopic lobectomy versus stereotactic radiotherapy for stage I lung cancer

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With great interest we read the study of Hamaji *et al.* (1) entitled "Video-Assisted Thoracoscopic lobectomy Versus Stereotactic Radiotherapy for Stage I Lung Cancer" which was recently published in *Annals of Thoracic Surgery*. With a mean follow-up of 48 months, the authors show that lobectomy performed by video-assisted thoracoscopic surgery (VATS) offers better results than stereotactic radiotherapy (SBRT) in the treatment of patients with pathologically proved non-small cell lung cancer (NSCLC) in early stages.

Nowadays and according to current guidelines the surgery is the best therapeutic option for the treatment of early stages NSCLC (2-4); being the inoperability secondary to the high surgical risk the SBRT main indication. However, they have shown comparable results with VATS/SBRT in retrospective studies with matching cases (5) including studies with patients who were medically operable but refused surgery (6).

The study has been conducted exclusively in patients with NSCLC stage I and IIa potentially resectable who met adequate standards of operability. The paper attempts to analyze if the SBRT can be an elective valid therapeutic option comparable with the surgery and not as alternative when the patient's general conditions pose an unacceptable surgical risk. Theoretically the SBRT can provide many advantages to the patients: it's a treatment that doesn't require hospitalization, preserves more the lung function, could shortened waiting times and recovery of daily life, and the satisfaction degree and acceptance of the patient is greater. It can be especially useful in older patients who often tend to refuse surgery and who are more difficult to cooperate with postoperative rehabilitation measures.

Although at work the VATS group results are clearly better in both overall survival and cause specified as the recurrence rates, we consider the probability of lymph node involvement, not objectified in the SBRT group, could be adversely affected the results in this treatment group.

This is particularly important especially considering that different pathological strains are included, and some of them have specially propensity for lymphatic spread. For that reason it may be useful for futures studies include a systematic lymph node biopsy by endobronchial ultrasound (EBUS).

We have observed that in the VATS group they included some patients who had undergone chemotherapy, so it's difficult to know what is the impact of this factor about the results of this specific group of the study.

Similarly, the fact of the close monitoring of SBRT group was based on a TAC realization while in the VATS group was based on a simple physical examination, makes us think which could be underestimated the recurrence time in the operated patients.

As is the case with sublobar resections, it is difficult to compete with the anatomical lobar resection for obtaining good long-term results. Perhaps the SBRT is the ideal alternative to such resections and could support on similar inclusion criteria.

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Recent advances in uniportal video-assisted thoracoscopic surgery

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Abstract: Thanks to the recent improvements in video-assisted thoracoscopic techniques (VATS) and anesthetic procedures, a great deal of complex lung resections can be performed avoiding open surgery. The experience gained through VATS techniques, enhancement of the surgical instruments ,improvement of high definition cameras and avoidance of intubated general anesthesia have been the greatest advances to minimize the trauma to the patient. Uniportal VATS for major resections has become a revolution in the treatment of lung pathologies since initially described 4 years ago. The huge number of surgical videos posted on specialized websites, live surgery events and experimental courses has contributed to the rapid learning of uniportal major thoracoscopic surgery during the last years. The future of the thoracic surgery is based on evolution of surgical procedures and anesthetic techniques to try to reduce the trauma to the patient. Further development of new technologies probably will focus on sealing devices for all vessels and fissure, refined staplers and instruments, improvements in 3D systems or wireless cameras, and robotic surgery. As thoracoscopic techniques continue to evolve exponentially, we can see the emergence of new approaches in the anesthetical and the perioperative management of these patients. Advances in anesthesia include lobectomies performed without the employment of general anesthesia, through maintaining spontaneous ventilation, and with minimally sedated patients. Uniportal VATS resections under spontaneous ventilation probably represent the least invasive approach to operate lung cancer.

Keywords: Uniportal surgery; awake lobectomy; single-port robotic; non-intubated; lung cancer

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Thanks to the recent improvements in thoracoscopy, a great deal of complex lung resections can be performed without performing thoracotomies (1,2). During the last years, experience gained through video-assisted thoracoscopic techniques, enhancement of the surgical instruments and improvement of high definition cameras have been the greatest advances. The huge number of surgical videos posted on specialized websites, live surgery events and experimental courses have contributed to the rapid learning of minimally invasive surgery during the last years. Nowadays, complex resections are being performed by thoracoscopic approach in experienced centers (3). Additionally, surgery has evolved regarding the thoracoscopic surgical approach, allowing us to perform difficult procedures by means of a small single incision, with excellent postoperative results (4,5).

Uniportal video-assisted thoracic surgery (VATS) has a history spanning over more than 10 years and, more recently, has become an increasingly popular approach to manage most of the thoracic surgical diseases (6). The potential advantages of reduced access trauma, less pain and better cosmesis, together with patient demand, have seen uniportal VATS spread across the world (7). Since we developed the uniportal technique for VATS major pulmonary resections in 2010, we have increased the application of this technique to more than 95% of cases in our routine surgical practice (8,9). The experience we acquired with the uniportal technique during the last years, as well as technological improvements in high definition cameras, development of new instruments, curved tip appliers for vascular clips and more angulated staplers have made this approach safer, incrementing the indications for single-port thoracoscopic resections. We believe it is important to minimize the surgical aggressiveness especially in advanced stage lung cancer patients where the immune system is weakened by the disease or by induction treatments. The minimally invasive surgery represents the least aggressive form to operate lung cancer and the single-port or uniportal technique is the final evolution in these minimally invasive surgical techniques (10).

The future of the thoracic surgery is based on evolution of surgical procedures and innovations to try to reduce even more the surgical and anesthetic trauma. We truly believe on the use of the uniportal technique combined with future 3D image systems or robotic technology for major pulmonary resections. We understand that the future goes in the direction of digital technology which will facilitate the adoption of single port technique worldwide in the next coming years. The current DaVinci robotic technology has been around for over a decade (11). Despite offering excellent visual feedback and robotic arm dexterity and precision, several ports are still required for the lobectomy (12). Although performing robotic surgery through specialized single-incision laparoscopic surgery (SILS) ports is possible with computer-compensated movements to overcome the difficulties associated with instrument crossover, robotic SILS is probably the limit for the current system design in terms of minimizing surgical access trauma. The main reason for this limitation is simple; essentially the robot is ‘outside’ of the patient. To move forwards into a higher realm, the whole robotic approach needs to be revised. To perform complex robotic thoracic surgery through a single small incision, the robot’s ‘shoulders’, ‘arms’ and ‘head and eyes’ must move inside the thoracic cavity with parallel instrumentations, making the procedure more anatomic and easy.

Recent innovations in single-incision approach are the use of subxyphoid technique for major resections and the thoracoscopic lobectomy in non-intubated patients. Liu *et al.* from Taiwan successfully performed the first cases of uniportal VATS lobectomies via a subxyphoid approach, which might reduce the risk of intercostal nerve injury and avoids the limitations imposed by narrow rib spaces (13). One of the limitations of this approach are the transmitted pulsation from the heart to the VATS instruments and the difficulties to control a bleeding from upper lobe tumors. Interestingly, an additional advantage of the subxyphoid approach is the ability to gain access to bilateral thoracic cavities to perform bilateral lung resections through a single incision (14). Avoiding the incision through the intercostal space could be another potential advantage to reduce postoperative pain but further studies will be required to demonstrate that this approach is less painful. Currently, the evolution of the thoracoscopic surgery to less invasive techniques, such as the uniportal VATS allows us to considerer the possibility of avoiding intubation and general anesthesia. The choice of a single incision technique in an awake or non intubated patient could minimize even more the invasiveness of the procedure. We consider it very important in high risk patients for general intubated anesthesia such as elderly patients or those with poor pulmonary function (15,16). We recently introduced in our department the uniportal VATS lobectomy technique in non-intubated patients. To date we have performed 30 non-intubated uniportal VATS major pulmonary resections with excellent postoperative results (no mortality, 6.6% conversion rate to intubation). The combination of nonintubated or awake thoracoscopic surgery and single-port VATS technique is promising because it represents the least invasive procedure for pulmonary resections (17,18). Thanks to avoidance of intubation, mechanical ventilation and muscle relaxants the anesthetic side effects are minimal allowing to most of the patients to be included in a fast protocol avoiding the stay in a intensive care unit. Moreover, the perioperative surgical stress response could be attenuated in non-intubated patients undergoing uniportal VATS as a result of the reduced postoperative stress hormones and proinflammatory mediators related to mechanical ventilation (19,20). Given that only one intercostal space is opened, the use of local anesthesia and blockade of a single intercostal space is enough for pain control at the beginning and during the surgery (no epidural and no vagus blockade is necessary in the single port approach). We use no trocar and during instrumentation we try to avoid pressure on the intercostal nerve so we reduce the risk of intercostal bundle injury. Oxygen (6-9 L/min) is supplied via facial mask. Standard monitoring must include electrocardiogram, non-invasive blood pressure, pulse oximetry, and respiratory rate, along with an approximation of the end-tidal carbon dioxide with a catheter placed in one nostril. The pharmacological management is based on a target-controlled infusion of remifentanyl and propofol, with a premedication of midazolam (0.15-0.25 mg/kg) and atropine (0.01 mg/kg) 15 min before anesthesia, adjusting real-time rate of infusion with the aggressiveness of each period during the surgery. The use of a nebulization of 5 mL of lidocaine 2% 30 min before helps to avoid coughing that could troublesome when performing lung traction and hiliar manipulation during dissection. These non-intubated major pulmonary resections must only be performed by experienced anesthesiologists and uniportal thoracoscopic surgeons (preferably skilled and experienced with complex or advanced cases and bleeding control through VATS). However, intraoperative conversion to general anesthesia is sometimes necessary and the surgical team must have a plan to minimize the risk of the patient. The anesthesiologist must be skilled in bronchoscopic intubation, placing a double-lumen tube or an endobronchial blocker in a lateral decubitus position

One of the criticisms of uniportal VATS approach is the difficulty in palpating small lesions through a single incision. The recent development of advanced multimodality image-guided operating room (AMIGO) in combination with the uniportal approach has opened up new possibilities. The hookwire insertion and uniportal VATS surgery can now be performed in the same room and for those lesions for which it might not be feasible to insert a hookwire, a real-time on-table scan can be performed to localize the tumor for resection and potentially provide additional information on surgical margins (21).

In conclusion, the uniportal approach has created new opportunities for collaboration with the industry to develop new technology and to push the boundaries on the minimal thoracic invasive surgery (22). We expect further development of new technologies like narrower endostaplers, sealing devices for all vessels and fissure, refined thoracoscopic instruments, improvements in 3D systems or wireless cameras, and robotic surgery, which will probably allow the uniportal approach to become the standard surgical procedure for major pulmonary resections in most thoracic departments.

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Opportunities and challenges for thoracic surgery collaborations in China: a commentary

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Abstract: Through a unique combination of factors—including a huge population, rapid social development, and concentration of resources in its mega-cities—China is witnessing phenomenal developments in the field of thoracic surgery. Ultra-high-volume centers are emerging that provide fantastic new opportunities for surgical training and clinical research to surgeons in China and partners from other countries. However, there are also particular shortcomings that are limiting clinical and academic developments. To realize the potential and reap the rewards, the challenges posed by these limitations must be overcome. Thoracic surgeons from Europe may be particularly well-placed to achieve this through multi-dimensional exchanges with their Chinese counterparts.

Keywords: China; Europe; collaboration; clinical research; training; thoracic surgery

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"Ici repose un géant endormi. Laissez le dormir, car quand il s'éveillera, il étonnera le monde."
"Here lies a sleeping giant. Let him sleep, for when he wakes up, he will shock the world."
—Napoleon Bonaparte on China [1803]

This is not a scientific paper. This is an opinion piece discussing a personal perspective on one of the potentially most important trends emerging in thoracic surgery today. However, this trend is not about an exciting new operative technique, or a mind-boggling technological breakthrough. It is about the ascent of a continent in general: Asia, and of China in particular.

It is impossible today to go through a single day without reading or hearing about the growing influence China now has on the world. This ranges from its massive industrial capacity to its ambitious economic ambitions (1-3). It encompasses its impact on international security as well as its influence on global environmental issues (4-6). It should therefore come as no surprise that China is also progressively demonstrating to the world that it has a presence in medical practice worldwide that cannot be ignored.

China's "coming of age" in thoracic surgery is already being felt in Europe (7). At the 23rd European Conference on General Thoracic Surgery held in June 2015 in Lisbon, Portugal, there were more attendees from China than from any other single country—including every European country. Over the last two years, there were more submissions from China to the *European Journal of Cardio-Thoracic Surgery* than from any other single country on the planet (8).

So what does this growing Chinese presence in international thoracic surgery circles mean for Europe and the world? Perhaps it means the same as any new development in our specialty—whether it is the latest minimally invasive surgical approach, or an expensive new instrument. Perhaps it means that there are exciting new opportunities and challenges for those intrepid enough to seek them.

What China offers

If what China had to offer the medical world needed to be summed up in one word, then that word would be: people.

It may seem tedious to repeat the cliché that China is the world's most populous country (9). Nonetheless, the fact that one in every five people on earth lives in China remains a very important statistic. The sheer volume of humanity that experiences disease and requires healthcare in this country means that the lessons learned here can have far-reaching implications for the rest of the world (7,10).

Furthermore, it is not just the numbers alone that are noteworthy. China is undergoing a rapid urbanization, with an internal migration of people moving from a rural environment to an urban one happening at a rate unprecedented in human history (11,12). This has several implications.

First, the risks to health that they are exposed to are becoming ever closer to those seen in the "developed" Western world. Unlike fellow population giant India where thoracic surgery is overwhelmingly a specialty involved with managing inflammatory (rural) conditions, China has a pattern of thoracic surgical disease that closely matches that in the West (lung cancer predominates) (13-15). The experiences learned in China are therefore much more relatable to Western surgeons than those gained in other non-Western countries.

Second, the urban environment fosters better education and access to information (11,12). The burgeoning middle class in China—even larger than that of the United States—is very knowledgeable about basic healthcare essentials and has easy access to both healthcare information (via the internet) and medical facilities at very low cost (by Western standards) (16). It is not a wonder that the rate of detection of lung cancer at an early stage in this supposedly "developing" country already rivals that in many economically more advanced countries in the West (17,18). Often it is simply a matter of a well-informed populace having access to CT scanning that they can afford. The knock-on effect is that patient demand and expectations are also more likely to mirror those seen in Europe and the West (11,12).

Thirdly, the concentration of patients in large conurbations lead almost inevitably to the major healthcare institutions in these mega-cities accumulating vast clinical experience and expertise (11,15). They quickly become centers of excellence with clinical volumes equalling or surpassing those anywhere else in the world, and clinical skillsets become world-class (15,19,20). For the thoracic surgery world, that means that their clinical research output can no longer be dismissed and much can be learned from their achievements. For folk within China, that means that even more patients are increasingly attracted to seek treatment in those major centers (11,12). In the two largest thoracic surgery units in Shanghai, the number of major lung resections performed annually has effectively doubled in the space of the last 2 years alone (14,15,19,20). This positive feedback loop of excellence attracting every greater case numbers which further drives improvements shows no signs of abating at the time of this writing.

The net result of the above factors means that China has now much to offer Europe and the rest of the world in the field of thoracic surgery. These can broadly be categorized into two areas: surgical training, and clinical research.

Opportunities in training

The Shanghai Pulmonary Hospital now has a fairly legitimate claim to be possibly the largest thoracic surgery unit in the world (15,20). In 2015, 8,320 thoracic surgical operations were performed there. Of these, around 80% are performed using video assisted thoracic surgery (VATS), and around half of those are performed using a Uniportal approach. This equates on average to 30–40 operations on every working day of the year. The Shanghai Chest Hospital, a cross-town friendly rival, also boasted of over 8,000 thoracic surgical operations in 2015 (19). On top of that, a good number of other major hospitals in Shanghai also offer thoracic surgery, often with volumes unimaginable in Europe. And all that is just in one city: Shanghai. Huge volumes of operations are also being performed in the other Chinese mega-cities, including Beijing, Guangzhou, Chengdu and others (14). It has been estimated that over 700,000 patients from across the country enter Beijing every day to seek medical care of one sort or another.

While such staggering numbers may create headaches for healthcare administrators, they are a delight for another group: those wishing to train in thoracic surgery. When a single hospital can provide up to 40–50 operations a day to observe, assist in, or perform, a trainee can gain an incredible amount of live experience in a very short period of time (15,20). Moreover, because so many operations are being simultaneously performed by different surgeon teams in different operating rooms, the trainee can see not just one style or approach, but a variety—allowing a much, more balanced perspective of thoracic surgery than

Figure 1 Thoracic Surgery experts have been welcomed to China for years to share their experiences. From left to right: Chia-Chuan Liu (Taiwan); Diego Gonzalez Rivas (Spain); Gening Jiang (Shanghai Pulmonary Hospital); Alan D. L. Sihoe (Hong Kong); Chang Chen (Shanghai Pulmonary Hospital)—taken at the Shanghai Pulmonary Hospital, Oct 2013.

would normally be possible just shadowing a single surgeon mentor.

The emergence of these ultra-high volume units in China is therefore opening up a modality of surgical technique training hitherto not seen in traditional training in the West (21-23). Namely, it is now possible to offer short-duration, high-volume, clinical immersion training. Traditionally, a clinical attachment in the Western setting may involve an attachment at a renowned hospital for weeks to months, during which a trainee may hope to see zero to a few operations each day (21-23). What is demonstrated is often simply whatever patients happen to come in requiring operation that day. In a center offering dozens of operations each day, the variety of pathologies and of surgical approaches demonstrated becomes much greater (15,19,20). Furthermore, within a short attachment of simply a couple of weeks, it is possible to see a number of operations only possible after months of attachment elsewhere. Having such intensive attachments benefits not only the trainee (who doesn't have to take so much leave) but also the trainee's parent unit (which doesn't have to cope with one less staff member for quite so long) (23).

A large unit such as the Shanghai Pulmonary Hospital would be running such short-duration, high-intensity courses on a very regular basis for thoracic surgeons from across China (20,24). Almost every month, trainees and even more senior surgeons from across the country could come to learn the latest VATS and uniportal techniques. Because the attachment duration is short thanks to the high daily volumes, new trainees can be brought in frequently, ensuring that training can reach as many centers across the country in as time-efficient a manner as possible.

In recent years, this concept has expanded across national borders. Units such as the Shanghai Pulmonary Hospital are now welcoming foreign trainees and surgeons from across the globe to come to learn the latest minimally invasive techniques (15,20,24). Over the past 2 years, over 100 surgeons and trainees from across Europe, the Americas, Africa, the Middle East, and all of Asia have come to Shanghai for immersion training in VATS. Many come for a couple of weeks, but some stay for up to half a year or more (25). For the latter, the hands-on surgery they are allowed to experience exceeds what they would have gotten in their parent units in Europe. Moreover, the surgical training is now often supervised by internationally recognized experts (*Figure 1*). Dr. Diego Gonzalez Rivas—world-famous for the uniportal VATS approach—is now the Course Director for a number of Uniportal VATS Training Courses held each year at the Shanghai Pulmonary Hospital (24,25). Each course lasts 2-weeks and includes wetlab hands-on experiences at the world-class clinical training facilities available in Shanghai (*Figure 2*). These courses are invariably popular and over-subscribed.

The success of the Uniportal courses raises another very important concept: that of "modular" training in thoracic surgery (26). Traditionally, a trainee would attach to a large unit in the West to learn "thoracic surgery" in general for many months, hoping to see a wide range of pathologies

Figure 2 Surgeons and trainees from around the world visit a state-of-the-art critical care training facility during their Uniportal VATS Training Course at the Shanghai Pulmonary Hospital. VATS, video assisted thoracic surgery.

and management in that time (21-23). However, with short-duration, high-intensity immersions, it now becomes possible for a surgeon to take maybe a couple of weeks off from work and go to a single ultra-high-volume center to learn just one specific item that that center specializes in or is most famous for. A surgeon may choose to spend 2 weeks in hospital A learning uniportal VATS, then 4 weeks later in the year in hospital B learning tracheal surgery, then maybe another 2 weeks in hospital C learning about non-intubated thoracic surgery (26). The large volumes in these large Chinese centers allows a surgeon to potentially select "modules" of training in specific areas, tailoring the training to suit his/her own practice needs and time available off work at the parent unit.

Another upshot of the sheer patient volumes in China is the rapid accumulation of a vast video library of operations (25,27). It is an undeniable trend around the world that many surgeons now learn or refresh their memories about certain operations through watching videos online. The pros, cons and potential hazards of this practice are beyond the scope of this article, but there hardly exists a thoracic surgeon today who has not watched an online surgical video at one time or another. With the large video libraries now building up in China from the large numbers of operations, the "Chinese style" of VATS is now increasingly spreading in influence (25,27).

So what does all of the above mean for thoracic surgeons in Europe?

For young trainees in Europe, it obviously means there are now great opportunities to come to train in China (21-23). They can observe more in a shorter space of time, and they can tailor their training more specifically to suit their needs and schedule (26). This is on top of gaining and invaluable exposure to Thoracic Surgery overseas in a foreign land—that still has recognizable patterns of disease not unlike those in Europe. There is an added bonus for the younger surgeon in the fact that costs of living in China are generally lower than in Europe, and many doctors in the larger cities can speak quite good English.

For more experienced surgeons, there is the chance to come to China for a relatively short time to learn a specific skill or technique—such as uniportal surgery, for example (26). The other potential opportunity for the avid teacher is perhaps to partner with a Chinese hospital to run advanced training courses in China (28). The marriage of local patient volumes with international expertise promises to make available very attractive training opportunities for trainees in China and overseas.

Opportunities for research

Having large patient numbers also means "big data". A great volume of clinical information can potentially be collected in a relatively short space of time. This is invaluable for clinical research (29-31).

Retrospective studies should theoretically be easy. Even in a single institute in China, accumulated data for more common diseases (for example lung or esophageal cancer) can number into hundreds or thousands. The opportunity to identify broad demographic or clinical trends is tremendous (29,30). With such a large catchment of cases, the chance to find a substantial series of rarer diseases also increases greatly. This would potentially allow ready analysis of uncommon conditions that would have taken many years or many centers to gather sufficient information about in other countries.

Prospective studies are of course where the greatest interest lies. With so many operations being performed every year, there are a number of great opportunities (31). First, clinical trials can be completed in a much shorter time than possible elsewhere. Second, in a given study period, greater numbers of subjects can be recruited allowing a study even greater power and accuracy. Third, it is possible to run trials with more concurrent study arms for even more detailed analyses.

As mentioned above, having many operations in a single hospital in a single day also means that there is potentially more variation in surgical approaches being used (29-31). This further gives a natural advantage if different study approaches need to be compared, as experts of different techniques are readily available and yet perioperative management within a single institute can be kept relatively homogeneous to minimize other confounding variables.

The large operation volumes not only provide data, but if the proper mechanisms and infrastructure are established, the prospects for developing very powerful tissue banks are also tremendous (32,33). Many of the larger hospitals in China are already banking tissue. However, the challenge would to systematize the collection and regulate the storage and access protocols. Considerable work remains to be done in many Chinese hospitals in order to make tissue banks a strong, viable producer of research output.

To support the above potential for research, China also has advantages beyond sheer patient numbers.

The first is the staff. China produces a remarkably high proportion of frontline clinicians with academic postgraduate degrees (14,34). This may be partly due to the perceived career structure within China for doctors, and the phenomenon has also raised issues in surgeon training that have not yet been fully reconciled within the country (34,35). For example, after receiving an academic degree, many young surgeons go on to pursue clinical service exclusively in their careers and neglect research in comparison. Nevertheless, the upshot of having many scientifically trained academics who are now surgeons means that there is a hypothetically large talent pool whose potential to produce good research is still not fully realized. The staffing advantage is not only in terms of doctors. Nurses are also well-trained and many also have academic degrees (36). Each of the larger hospitals also maintains relatively large teams of research staff—both in terms of post-graduate fellows and also research assistants. The availability and quality of Chinese research personnel is well recognized internationally, with many Chinese scientists now working in major laboratories around the world. Within China, research staffs in the hospitals are on hand, managing everything from running sophisticated experiments to simply phoning patients to check on follow-up status. Having well-qualified staffs at all levels means that any collaboration with European and other foreign colleagues will be much smoother.

The other key advantage is that China's enormous national resources are being mobilized to boost medical research (11,37,38). China's investments in medical research are growing at a pace that far outstrips that in the West. There have been estimates that medical research spending in China could soon overtake that in the United States within the coming 10 years (37). What this means for European partners is that any collaborations will be supported on the Chinese side by well-funded departments, well-equipped state-of-the-art laboratories and facilities, and political backing. Lack of material resources is unlikely to be a limiting factor for any planned project.

What China needs

Having outlined the bright prospects China has to offer, it is time to return to a starker reality. Although China offers fantastic promises in terms of quantity, in clinical medicine it sometimes fails to deliver in terms of actual quality.

This is especially easy to demonstrate in terms of scientific research. Chinese authors have published 230,000 medical papers in the leading scientific journals included in the Scientific Citation Index (SCI) from 2010 to 2014, ranking second in the world in this statistic (38). However, when one scratches beneath the surface, problems appear. Of the many paper published by China in scientific journals, only 0.56% were amongst the top 1% of most-cited papers—an indicator of the quality of the papers (39). This percentage was less than half of what was achieved by Western countries, such as the United States (1.19%), the United Kingdom (1.44%), or Germany (1.21%). In Cardiothoracic Surgery specifically, the situation is similar. Chinese authors submitted more papers to a leading cardiothoracic surgery journal than any other country, accounting for over 16% of all submissions in 2014 (8). However, Chinese-authored papers only ended up accounting for barely 10% of all papers ultimately published by that journal. In other words, the rate of rejection of Chinese papers was proportionately higher than most other countries. This again reflects a simple truth: quantity does not always equate with quality.

It is conceivable that this suspicion of disappointing quality can be extrapolated from clinical research to clinical practice. Do all those claims of vast patient numbers being operated on in China really mean that all the operations were being done well? Certainly, foreign attendees of the training courses in Chinese hospitals mentioned above virtually all attest to the very high standard of technical skill in the operating room (15,24,25). But this is subjective, anecdotal evidence. For objective evidence, one must look at published clinical data. When one reads the results from China, they again almost invariably paint a very rosy picture with great outcomes (14,38). However, is this publication bias? Moreover, are the publications plagued by the inadequate quality as suggested above, and are they believable?

There are obviously many quality issues that must be addressed in China in the realms of both clinical research and clinical practice. Until these are addressed, it is difficult for Chinese thoracic surgery to become fully established on the international stage and gain the recognition it hopes for. Until these are addressed, it is difficult for European surgeons wishing to work with or in China to find common ground for collaboration. The following are a few of those issues that observers from within and without China most commonly identify as limitations to the quality of thoracic surgery in China.

Guidelines and auditing

Clinical guidelines exist in China—as they do in Europe and elsewhere in the Western world (14). Chinese society as a whole does respect such guidelines. However, one of the key differences with the West is that the concept of auditing is not well ingrained (40). Clinical audit is defined as "a quality improvement process that seeks to improve patient care and outcomes through systematic review of care against explicit criteria and the implementation of change" (41). While guidelines containing criteria as set by "experts" exist, mechanisms for comparing practice against those guidelines generally do not. The reasons why this is so are complex and beyond the scope of this simple article. It may have something to do with the political history of modern China: where official targets and directives are set for the economy and units across the country, and those units in the past have reported "compliance"—even when those targets were ultimately not met in reality (42).

Regardless of the reasons, it is common to find Chinese clinical reports stating that "all operations were completed successfully with no complications", in a similar fashion as a work unit would report to the party commissar. What is less easy to find are establishment of quantified benchmarks for clinical practice, and systematic comparison of achieved outcomes against those benchmarks. This is a standard practice in Europe, but conspicuously rare in China (43). The lack of a culture of objective auditing of clinical performance in China is a weakness, and it undermines efforts to portray the quality of surgery and to improve it. It also adds difficulty to collaborations between surgeons in Europe and China by obscuring assessment of clinical quality.

Patient follow-up

Most Chinese thoracic surgeons recognize that one of the main sources of criticism of their publications in the West has been the lack of good clinical follow-up. In the West, a patient typically is followed up regularly after any thoracic operation by the operating unit or by other primary care physicians (43). This follow-up is often systematic, and involves recognized steps to exclude morbidity and recurrence of disease. For example, a lung cancer patient may be followed up with routine schedule imaging at intervals defined by guidelines to rule out recurrence.

In China, however, this is often not possible (44,45). As noted above, many patients receiving surgery in a hospital often come from very far away. It is often not convenient to journey across the country to attend a follow-up. Furthermore, given that many patients are relatively poor, they may often refuse the travel back for follow-up because of the costs involved. Primary care is also under-developed in China, and sharing of clinical information between hospitals in the big city (where the operation was performed) and in the provincial town (where the patient lives) is also limited. This means that any follow-up in the patient's place of residence is also often unreliable or of inconsistent quality.

For clinical studies, most major big city institutes can only rely on calling patients by phone as the primary (or only) means of follow-up (44,45). Cellular telephone communication is actually well developed in China, and claims of "100% follow-up" of all patients may actually be true as they can often be readily reached. However, a telephone conversation is never the same as a proper clinical evaluation. Other than ascertaining that the patient is still alive, relatively little useful or reliable clinical information can be obtained. For example, how can a patient tell his telephone interviewer whether or not he/she has an asymptomatic recurrence of cancer? The telephone follow-ups also tend to be conducted only when it is decided to perform a "study". Hence, those telephone interviews do not occur at regular scheduled intervals after surgery, but only at a fixed time—giving rise to a cross-sectional survey that includes patients at very different intervals after their operation.

The lack of good clinical follow-up is a major weakness in clinical studies in China, and seriously restricts the ability of many Chinese units to look at longer-term clinical outcomes. That is one of the reasons why many papers from China can still only focus on immediate postoperative outcomes (7). To improve the situation, however, is no easy task. Developing a system like those in many European countries to allow patients to have regular specialist follow-up would require a massive overhaul of the healthcare system—and that may be a prohibitively big step to currently undertake.

A possible interim solution may be to establish better prospectively collected clinical databases in China (46). Even if patients cannot physically return for follow-up, at least the telephone interviews can be conducted at defined intervals, and data collection could be conducted systematically according to the data field requirements in the database.

Over-reliance on reporting bland data

In many Chinese publications in thoracic surgery, the results section is often blandly formulaic. The mortality and morbidity rates are reported, as are distribution of surgical indications, operating times, blood loss, lengths of stay, and a vague claim that 'all patients were satisfied' with their operations. The conclusion is therefore that surgical approach "X" is "safe and feasible". For thoracic surgeons in China, this is a perfectly reasonable article because that is how most clinical papers in Chinese medical journals are written up. However, for Western readers, reviewers and editors, such writing is painfully boring (7,8,47). Worse, such papers often appear to be little more than a boastful advertisement of what operations have been done in the authors' own unit. The papers may get published because of the sheer size of the cohorts involved—including surprising numbers of rare diseases, for example. However, they report little that is novel or "interesting". It is often not surprising that—as alluded to earlier—citations of Chinese papers are often relatively few (47). It needs to be appreciated that readers are simply not that excited by "look at what I did" papers.

In contrast, many Chinese authors remain envious of how European authors appear to easily publish clinical papers in the best journals despite often small case numbers. The key to success was not in relying on large volumes alone, but in delivering an important message (48-51). To make a study appeal to readers, reviewers and editors, it must say something that is clinically relevant, intellectually interesting, and/or practically useful. This can be achieved without lots of patients. What is does require, however, is to ask the right question (48). If the authors ask a question that many readers have wondered about, and then they set about providing the answer through a well-designed study, the chances are that the results will be relevant, interesting and/or useful. This is something that European surgeons have been doing very well, producing high-quality, frequently-cited papers (23,50,51). They seem to better understand that readers are more excited by papers that say: "You know that problem we all had? I think I may have found a solution!"

To improve Chinese papers, one key step is to stop the over-reliance on sheer volume of data alone. The study should never be to start with the intention of "getting an SCI publication". It should also not start with the intent to simply advertise their own unit's prowess. Instead, it is necessary to look at what unanswered clinical questions there may be, and using their clinical data to answer it (48,49). In this regard, European surgeons have many things to teach their Chinese counterparts (50,51).

Cultural misunderstandings, not linguistic deficiencies

A common belief among authors whose native language is not English is that when their papers are rejected, it is because of poor English. This is actually not true. Most—if not all—good journal editors can see past linguistic deficiencies and identify whether the science behind the words is worthy of publication. Nonetheless, this misconception is often held in China. The problem with this misconception is that by blaming their own poor English (or the reviewers' intolerance of it), the authors fail to see that it is the deficiencies within the paper that led to the rejection. In turn, this means that the authors may not realize where they need to improve.

However, although language is not the barrier, there is a chasm between Western and Chinese authors that is relevant to whether a paper is accepted (7). That chasm is not linguistic, but cultural. Western peoples (including surgeons) have some deeply held beliefs and conventions that an Asian author may not understand, and vice-versa (7,52,53). When the misunderstanding appears in a medical paper or in the way an operation is performed, then it is easily misconstrued as a lack of quality (instead or a difference in beliefs or conventions). To illustrate this, one commonly encountered example is in surgery for primary pneumothorax. In most European countries, bullectomy is almost invariably accompanied by pleurodesis (either mechanical or chemical) (54). However, in East Asian countries like Japan, Korea and China, bullectomy alone is commonly done and pleurodesis omitted (55). A Chinese author may write about bullectomy only as a matter of course as it is the norm in his/her country, but a Western reviewer not familiar with this would be aghast at this “inadequate” surgery and be inclined to reject the paper out of hand. Another example is when an Asian author writes about the cosmetic result from minimally invasive surgery, and claims that the improved appearance may appeal especially to “female patients” because they “care more about appearance” (56). This kind of writing may actually be quite normal and innocent in East Asian cultures, even amongst female authors and readers. However, in the eyes of a Western reviewer, this would be blatantly sexist and could be reason alone to reject the paper outright (57).

The solution is quite simple: the chasm can be bridged through more cross-cultural exchanges. If the aim is for Chinese surgeons to publish in SCI journals, then the onus is certainly on the Chinese authors learning more about Western and European conventions. They must leave behind the notion that writing a paper for an SCI journal is simply a matter of translating a Chinese medical journal paper into English. Instead, they need to realize that writing for an international journal often requires a completely different set of rules to appeal to the different culture of international reviewers and readers. That can only be done through getting to know European counterparts better (7).

There is one further, more sinister, aspect of the cultural gap between East and West in academic medicine. In 2014, *BioMed Central* retracted 42 papers submitted by medical researchers from China (58,59). This was an unprecedented move, and was a humiliation for many major institutes in China. The retractions, it turned out, were almost entirely due to a systematic abuse of the peer-review system. *BioMed Central* explained the retractions by saying that: “a systematic and detailed investigation suggests that a third party was involved in supplying fabricated details of potential peer reviewers for a large number of manuscripts submitted to different journals” (58,59). In China (as in some other Asian countries), a number of third party agencies have thrived by selling language-editing and manuscript “preparation” services to clinician authors. It appears that these agencies have often “suggested” reviewers to journals for the papers they submit—a practice normally welcome by some journals. Regrettably, the reviewers suggested by the agencies were sometimes fraudulent or fabricated. The shocking issue in this episode is that so many different institutes across China were involved (even though they may not have known of the action by the agencies). In a landmark Editorial, *The Lancet* commented that: “This episode suggests that misconduct might not be limited to isolated individuals or institutions, but rather that it could have infiltrated the country’s research culture more widely” (59). This editorial clearly locates a serious problem at the fundamental level of national culture. A major change in that culture is a pressing necessity, and that may certainly require assistance through greater exchanges with Europe and the West (59).

How Europe can play a key role

The above discussions identify what colleagues in Europe may gain by interacting with China in the field of thoracic surgery. China offers incredible opportunities in surgical training, and exciting prospects for clinical research. However, the situation in China is not perfect, with major deficiencies also as considered above. Therefore, to access the potential rewards in China, colleagues in Europe may be invited to assist in solving some of the deficiencies. There appear to be three broad categories where Europe can play a very substantial role in this.

Systemizing clinical practice

While Chinese surgeons are proud of their operative skills, their experience in regulating perioperative practices lags far behind Europe. Europe has many years’ of experience honing authoritative practice guidelines, designing effective clinical pathways, and performing objective clinical auditing (43,46,52,54,60-62). These are driven at the institute level, but also but national authorities. More importantly, this systemization of practices has often been supervised or guided by international professional bodies, such as the European Society of Thoracic Surgeons (ESTS) (52,62). The concentration of expertise in bodies such as the ESTS means that access to it is readily available. The authority of the European organizations means that their experience and guidance are well respected in China. They are therefore ideal vehicles to aid Chinese Thoracic Surgeons in designing and maintaining their own clinical systems. These would include:

(I) Setting up clinical pathway algorithms for perioperative care (54);
(II) Regulation of surgical training (including standard setting) (23,28);
(III) Accreditation of thoracic surgery units (63);
(IV) Establishment of clinical practice benchmarks on a national (not institutional) level (43,64);
(V) Auditing of clinical performance against those benchmarks (60);
(VI) … and others.

Europe is perhaps better suited to assist in the process of refining clinical systems in China than other places, including the United States. Although both Europe and America possess outstanding experience in the items mentioned above, Europe may prove more accessible to surgeons in China. American guidelines and benchmarks are usually framed around the homogenous healthcare system of a single nation (the United States). However, American measures of performance are not always directly compatible with Asian ones (65,66). For example, the importance of remuneration considerations and urgency of discharge away from the surgical ward that are ubiquitous in American practices are relatively minor issues in East Asian practices. In Europe, practices do tend to match American practices more than Asian ones. However, the need to accommodate the many differences between the constituent nations within Europe gives bodies such as the ESTS considerably greater powers of inclusiveness and understanding of foreign cultures (64). It is no accident that European conferences in Cardiothoracic Surgery attract more delegates and speakers from Asia than equivalent American ones. The bridge between China and Europe may possibly prove an easier one to cross for all parties than a bridge across the Pacific.

Raising the academic standard

As discussed above, there are many shortcomings with Chinese academic medicine (despite its many strengths). The good news is that those shortcomings all have potential solutions. These solutions in turn can be greatly aided by having input from European colleagues.

The issues of auditing and lack of follow-up, for example, may be addressed by establishing world class clinical databases. In this area, Europe has a huge experience. The ESTS database is a paragon for being comprehensive, stringent, and accessible, and has acted as the cornerstone for many important clinical studies over the years (61,62). The experience from Europe would be invaluable in helping set up similar databases in China. Individual centers in China already have their own databases, but occasionally suffer from some flaws. The databases are sometimes institution-specific and exchange of data for collaborations may be difficult. Also, many Chinese clinical computer systems still rely on Chinese language syntax entry of information, making extraction of information subsequently very tedious if not impossible. European experience could help in linking databases, standardizing definitions and data quality across institutes—possibly leading to an eventual national database. The European experience working across many nations may also prove important in transforming data from a language-syntax form to a digitalized format that facilitates data retrieval and inter-institutional collaborations (61,62).

The Chinese issues of uninteresting studies and cultural misunderstanding would also be perfectly addressed by greater exchanges with European friends. The European flair for identifying stimulating clinical questions, and the European code of strict adherence to the highest standards of professionalism and ethics in research are all things which Chinese surgeons should learn and embrace (28,48,52,59). These qualities can be taught. The ESTS, for example, conducts highly successful workshops in Medical Writing to instill in young surgeons the skillsets and principles needed to craft good scientific papers (28). Although some Chinese workshops do exist, it would be perhaps more productive for Chinese surgeons to attend those taught by European experts so that European research culture can rub off on them. Ideally, European friends could come to China to help in this. The above qualities could also be shared outside the classroom. Simply by engaging in collaborative research efforts with Chinese counterparts, European surgeons can already demonstrate many aspects of good academic practice (66). This is the classic 'win-win' situation: where European friends stand to gain access to Chinese patient volumes for research, and Chinese clinicians can learn from some of the best academic surgeons in the world.

Figure 3 The 23rd European Conference on General Thoracic Surgery, held by the ESTS in June 2015 in Lisbon, Portugal was well attended by some of the leading thoracic surgeons in China. This was a valuable opportunity for Chinese and European experts to learn from one another. From left to right: Diego Gonzalez Rivas, Jianxing He, Toni Lerut, Haiquan Chen, Gonzalo Varela, Gening Jiang, Lunxu Liu, Alan Sihoe, Long Hao, Frank Detterbeck, Keneng Chen. ESTS, European Society of Thoracic Surgeons.

Providing the platforms for exchange

One of the best aspects of the thoracic surgery community in Europe is that it already contains many platforms for international exchanges between surgeons of different countries in Europe. Bodies such as the ESTS and others offer a wide range of platforms, including: annual meetings; technical and academic skills workshops; educational courses; specialty examinations and credentialing; research collaboration hosting; and so on (52,64). Professional bodies like the ESTS also provide sponsorships for trainees to travel to learn in different centers, and serve to facilitate such training exchanges (23). The ideal is therefore to explore if these opportunities can be opened to surgeons and trainees from Asia. As said, the inherent inclusive nature of Europe may help it to better accommodate partners from Asia. For years, prominent European thoracic surgeons have travelled to China on an individual basis, helping the development of the specialty there (67). More recently, there is a growing trend for exchanges at an institutional and professional society level—as exemplified by the ESTS-Chinese Association of Thoracic Surgeons Joint Session during the 23rd European Conference on General Thoracic Surgery in June 2015 in Lisbon (68) (*Figure 3*). Perhaps in future, it is not just a matter of Chinese surgeons travelling to Europe to learn at the above platforms, but European teachers coming more and more to China (20,24,25).

Of course, the bridge does work in both directions. It is hoped that more European trainees may also have the opportunity to come to train in China. As already said, they have much to gain from the unique training opportunities in China. However, there presence in China will also help greatly in demonstrating European perspectives on clinical and academic practice to Chinese colleagues around them. Any attachment has the opportunity of allowing a very fruitful bi-directional cultural exchange.

Conclusions

Napoleon's famous quote about China being a sleeping giant is prescient. This famous European foresaw long ago the great potential in the Middle Kingdom that waited to be realized. Over the past few decades, European industrialists, financiers, and traders can confirm that China has indeed arisen in economic terms—and many have thrived on the collaborations between East and West. Today, it is perhaps the turn of European surgeons to experience the unique opportunities that modern China brings.

The sheer scale of surgical practice in China opens up unprecedented prospects for training and research collaborations. To tap into these, however, requires facing up to the challenges that also hinder clinical and academic practices in China. Nevertheless, Europe is in an ideal position to work with thoracic surgeons in China, providing invaluable experience and guidance but potentially reaping rich rewards. The giant has awakened, but shocking the world is better achieved with good partners.

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Footnote

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Systematic review and meta-analysis of uniportal versus multiportal video-assisted thoracoscopic lobectomy for lung cancer

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Background: Uniportal video-assisted thoracoscopic surgery (VATS) has emerged as a less invasive alternative to the conventional multiportal approach in the treatment of lung cancer. The benefits of this uniportal technique have not yet been characterized in patients undergoing VATS lobectomy. This meta-analysis aimed to compare the clinical outcomes of uniportal and multiportal VATS lobectomy for patients with lung cancer.

Methods: A systematic review was conducted using seven electronic databases. Endpoints for analysis included perioperative mortality and morbidity, operative time, length of hospital stay, perioperative blood loss, duration of postoperative drainage and rates of conversion to open thoracotomy.

Results: Eight relevant observational studies were identified and included for meta-analysis. Results demonstrated a statistically significant reduction in the overall rate of complications, length of hospital stay and duration of postoperative drainage for patients who underwent uniportal VATS lobectomy. There were no significant differences between the two treatment groups in regard to mortality, operative time, perioperative blood loss and rate of conversion to open thoracotomy.

Conclusions: The present meta-analysis demonstrated favourable outcomes for uniportal VATS lobectomy in the treatment of lung cancer compared to the conventional multiportal approach. However, long-term follow-up data is still needed to further characterize the benefits of the uniportal approach.

Keywords: Uniportal; video-assisted thoracoscopic surgery (VATS); lobectomy; lung cancer; meta-analysis

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Introduction

Over the past two decades, surgical management of lung cancer has been characterized by the emergence of novel minimally invasive surgical techniques. Video-assisted thoracoscopic surgery (VATS) has been shown to be associated with superior perioperative outcomes when compared to open thoracotomy, with numerous meta-analyses demonstrating reduced complication rates, shorter hospital stay and improved long-term survival (1-3). In recent years, a uniportal VATS technique has emerged as an even less invasive alternative to the conventional multiportal approach (4,5). Since its adoption by thoracic surgeons, there have been numerous reports on the feasibility of this approach in the surgical management of lung and mediastinal tumors (5-7).

In addition to the reduced number of surgical incisions, institutional reports have demonstrated a number of potential advantages of the uniportal VATS technique. These included a significant reduction in postoperative pain (8,9), paresthesia (10-12) and improved patient satisfaction (11,13,14). Despite these encouraging results, comparative clinical outcomes of uniportal versus multiportal VATS remain uncertain. The present systematic review and meta-analysis aimed to compare uniportal VATS to conventional multiportal VATS in the context of lobectomy for lung cancer. Endpoints included mortality, operative time, length of hospital stay, perioperative blood loss and duration of postoperative drainage, as well as complication rates and rates of conversion to open thoracotomy.

Methods

Search strategy and selection criteria

Electronic searches were performed using Ovid Medline, Embase, PubMed, the Cochrane Central Register of Controlled Trials (CCTR), Cochrane Database of Systematic Reviews (CDSR), ACP Journal Club and Database of Abstracts of Reviews of Effects (DARE) from their inception date to January 2016. In order to maximize the sensitivity of the search and identify all relevant studies, we used the terms 'uniport*' or 'single-port' or 'single port' or 'single-incision' or 'single incision' combined with 'VATS' or 'thoracosp*' or 'video-assisted' or 'video assisted', either as key words or MeSH terms. Following initial screening based on abstracts, the full texts of potentially relevant articles were obtained. The reference lists of all retrieved articles were examined in order to identify additional potentially relevant studies.

Eligible comparative studies for the present systematic review and meta-analysis included those in which survival data was available for patients with a diagnosis of lung cancer treated by lobectomy in uniportal and multiportal VATS cohorts. Indications for surgery other than for lung malignancy, such as mediastinal tumors, primary spontaneous pneumothorax and hyperhidrosis, were excluded. In cases where institutions have published duplicated trials with accumulating patient cohorts, only the most recent and complete study was included for appraisal. All studies were limited to human subjects. Case reports, conference abstracts, editorials, expert opinions and commentaries were excluded. Review articles were also excluded due to possible duplication of results and publication bias.

Data extraction and critical appraisal

All data were extracted from article texts, tables and figures. Two investigators (C.G.H. and R.S.J.) independently reviewed each retrieved article. Any inconsistencies between the two reviewers were resolved by discussion and consensus. The final results were reviewed by the senior investigators (T.D.Y. and C.C.).

Statistical analysis

Meta-analysis was performed by combining the results of outcome variables. Data were summarized as standard mean difference, with overall weighted mean presented where appropriate. I^2 statistic was used to estimate the percentage of total variation across studies, due to heterogeneity rather than chance. An I^2 value of greater than 50% was considered substantial heterogeneity. If there was substantial heterogeneity, the possible clinical and methodological reasons for this were explored qualitatively. In the present meta-analysis, the results using the random-effects model were presented to take into account the possible clinical diversity and methodological variation amongst studies. Specific analyses considering confounding factors were not possible because raw data were not available. All P values were 2-sided. A significant difference was defined as $P<0.05$. Statistical analysis was conducted with Review Manager Version 5.3 (Cochrane Collaboration, Software Update, Oxford, UK).

Results

Quantity and quality of trials

A total of 1,051 references were identified by the electronic search strategy. After excluding duplicate or irrelevant articles, 38 references were retrieved for further evaluation. Manual searching of the reference lists of these retrieved articles did not identify any additional relevant studies. After applying the selection criteria and excluding studies that compared uniportal and multiportal VATS for indications other than lung cancer, eight studies remained for assessment. All of these studies were observational studies and deemed suitable for quantitative meta-analysis. The study selection process is summarized in *Figure 1* according to the PRISMA statement (15). A summary of the study characteristics is presented in *Table 1*. Overall, a total of 1,850 patients were compared, including 627 patients who underwent uniportal VATS and 1,223 patients who underwent multiportal VATS. Three studies reported propensity-matched data (20-22). Two of these studies presented data from both unmatched and propensity-

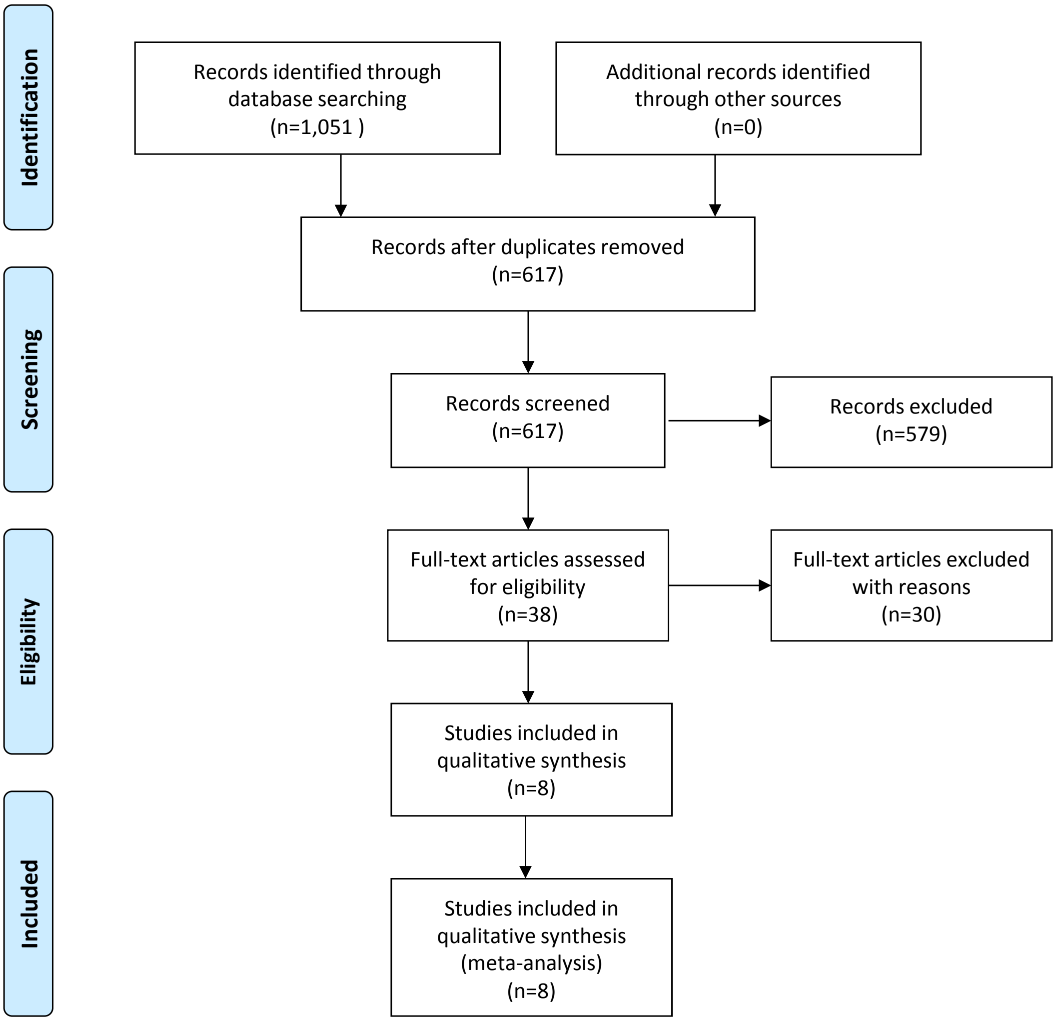

Figure 1 PRISMA flow chart for literature search.

Table 1 Summary of all studies comparing uniportal and conventional multiportal lobectomy in for management of lung cancer

Authors	Publication	Study period	Indication	Uniportal (n)	Multiportal [n]
Chung (16)	2015	2013–2014	Lung cancer	90	60 [2–3]
Hirai (17)	2016	2011–2014	Lung cancer	60	20 [3–4]
Li (18)	2013	2011–2013	Lung cancer	87	75 [3]
Liu (19)	2016	2005–2014	NSCLC	149	389 [NR]
Mu (20)	2015	2014–2015	NSCLC	58	347 [3]
Shen (21)	2016	2013–2014	Lung cancer	100	100 [3]
Wang (22)	2015	2005–2013	Lung cancer	50	183 [2–3]
Zhu (23)	2015	2014–2014	NSCLC	33	49 [3]

NSCLC, non-small cell lung cancer. Number in square brackets indicates number of ports used. NR, not reported.

Table 2 Summary of baseline patient operative characteristics in all studies comparing uniportal and conventional multiportal lobectomy in lung cancer treatment

Paper	Operative procedure		Age		Male gender		FEV1		No. of lymph nodes retrieved	
	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi
Chung	L	L	60.5±11.4	63.3±9.3	50 (56%)	34 (57%)	NR	NR	13.6±7.2	15.8± 8.7
Hirai	L	L	72.5 [64–82]	65.5 [60–86]	33 (57.5%)	12 (60%)	2.0 (1.4–2.7)	2.0 (1.4–2.5)	13.6 [6–24]	12.8 [5–25]
Li	L	L	63.9±12.1	66.2±8.7	65 (75%)	52 (69%)	NR	NR	13.06±1.36	12.6±1.6
Liu^	L (67%); S (33%)	L (88%); S (12%)	NR	NR	39 (39%)	150 (44%)	NR	NR	28.47±11.77L	25.2±11.3L
Mu	L (53%); S (16%); W (31%)	L (78%); S (6%); W (16%)	55.8±12.2	59.6±10.0	32 (55%)	174 (50%)	2.4±0.6	2.4±0.7	7.0± 8.6	13.3±9.3
Shen	L	L	61.5±7.9	60.9±7.8	56 (56%)	55 (55%)	2.3±0.3	2.3±0.6	21.4±5.6	20.9±5.2
Wang	L (70%); S (30%)	L (87%); S (13%)	58.2±10.5	62.2±11.2	16 (32%)	77 (42%)	2.3±0.5	2.2±0.6	27.3±12.2	25.2±11.4
Zhu	L	L	62 [25–79]	59 [31–81]	11 (33%)	19 (39%)	NR	NR	23.6±11.2	25.4±7.3

^Data presented are for lobectomy patients unless otherwise stated. Continuous variables presented as mean ± SD or median (range). Uni, uniportal group; Multi, multiportal group; FEV1, forced expiratory volume in 1 second (liters); L, lobectomy; S, segmentectomy; W, wedge resection; NR, not reported.

matched cohorts (20,22) and unmatched data from these studies is presented in *Tables 1-3*.

Patient operative and histopathological details

A summary of the patient operative details is presented in *Table 2* and a summary of patient histopathological details is summarized in *Table 3*. See *Table S1* for a summary of patient comorbidities in all included studies.

Assessment of operative outcomes

There was a statistically significant reduction in the length of hospital stay for patients who underwent uniportal VATS lobectomy compared to the multiportal approach (6.2±2.6 *vs*. 6.7±3.4 days, $P<0.0001$, *Figure 2*). There was also a statistically significant reduction in the duration of postoperative drainage for the uniportal group (4.5±2.2 *vs*. 5.4±2.9 days, $P=0.0006$, *Figure 3*). In regard to overall morbidity as reported by the included studies, there was a statistically significant reduction in the incidence of overall morbidities for patients undergoing uniportal VATS lobectomy compared to the multiportal approach (12.0% *vs*. 13.7%, $P=0.009$, *Figure 4*).

There were no significant differences between uniportal versus multiportal VATS in regard to operative time (155.8±53.8 *vs*. 167±64.6 minutes, $P=0.69$), perioperative blood loss (86.3±76.2 *vs*. 82.4±74 mL, $P=0.63$) or rate of conversion to open thoracotomy (3.6% *vs*. 2.6%, $P=0.83$). It should be noted that there were no perioperative mortalities in any patients who underwent uniportal VATS and only one patient who underwent the multiportal approach (16). Long-term clinical outcomes were not reported in any of the studies.

When propensity-matched data were analyzed, there were no statistically significant differences in operation time, length of hospital stay, perioperative blood loss, duration of postoperative drainage, rate of conversion to thoracotomy or overall morbidity. A summary of these findings is presented in *Table 4* for all included studies and *Table 5* for the studies with propensity-matched data.

Discussion

The present systematic review demonstrated that uniportal VATS was associated with a statistically significant shorter duration of chest tube drainage (4.5±2.2 *vs*. 5.3±2.9 days), shorter hospital stay (6.2±2.6 *vs*. 6.7±3.4 days) and lower

Table 3 Summary of patient histopathological characteristics in all studies comparing uniportal and conventional multiportal lobectomy in lung cancer treatment.

Paper	Stage I (n)		Tumor size (cm)		Histology								Tumor location (n)											
					Adeno-carcinoma		SCC		Metastasis		Other		RUL		RML		RLL		LUL		LLL			
	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi		
Chung	60 (67%)	39 (65%)	NR	NR	55 (61%)	45 (75%)	15 (17%)	8 (13%)	13 (14.4%)	5 (8.3%)	7 (7.8%)	2 (3.3%)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR		
Hirai	60 (100%)	20 (100%)	2.4 (1.1–3.5)	1.8 (0.8–3.2)	NR	NR	NR	NR	NR	NR	NR	NR	18 (30%)	6 (30%)	4 (7%)	0 (0%)	12 (20%)	5 (25%)	14 (23.3%)	5 (25%)	12 (20%)	4 (20%)		
Li	31 (36%)	30 (40%)	NR	NR	48 (55.2%)	33 (44%)	39 (45%)	42 (56%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	32 (37%)	18 (24%)	8 (9%)	8 (11%)	13 (15%)	18 (4%)	23 (26%)	16 (21%)	11 (13%)	15 (20%)		
Liu^	38 (38%)	112 (33%)	NR	NR	82 (82%)	271 (79%)	NR	NR	NR	NR	NR	NR	33 (33%)	141 (41.2%)	15 (15%)	34 (10%)	23 (23%)	66 (19%)	11 (11%)	61 (18%)	18 (18%)	39 (11%)		
Mu	36 (62%)	279 (80%)	2.2±1.6	2.2±1.2	45 (78%)	308 (89%)	2 (3%)	35 (10%)	2 (3.4%)	0 (0%)	0 (0%)	0 (0%)	16 (28%)	106 (31%)	5 (9%)	23 (7%)	12 (21%)	67 (19%)	11 (19%)	94 (27%)	14 (24%)	57 (16.4%)		
Shen	NR	NR	2.5±0.9	2.5±0.9	80 (80%)	84 (84%)	20 (20%)	16 (16%)	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR		
Wang	NR	NR	2.3±1.1	2.8±1.5	45 (90%)	151 (82.5%)	NR	NR	NR	NR	NR	NR	14 (28%)	68 (37%)	6 (12%)	20 (11%)	7 (14%)	32 (18%)	16 (32%)	38 (21%)	7 (14%)	25 (13.7%)		
Zhu	NR	NR	NR	NR	26 (79%)	35 (71%)	5 (15%)	11 (22%)	NR	NR	2 (6%)	3 (6%)	9 (27%)	10 (20%)	3 (9%)	5 (10%)	7 (21%)	14 (29%)	8 (24%)	9 (18%)	6 (18%)	11 (22.4%)		
Mean	55.0%	64.4%	2.4±1.1	2.4±1.3	75.0%	80.0%	22.0%	17.7%	6.4%	1.0%	3.4%	0.9%	29.5%	33.2%	9.4%	8.5%	19.7%	19.6%	25.4%	23.7%	17.2%	14.9%		
P value	0.51		0.89		0.75		0.36		0.22		0.12		0.45		0.25		0.71		0.18		0.18			

^Data presented are for lobectomy patients. Continuous variables presented as mean ± SD or median (range). Uni, uniportal. Multi, multiportal. SCC, squamous cell carcinoma. RUL, right upper lobe. RML, right middle lobe. RLL, right lower lobe. LUL, left upper lobe. LLL, left lower lobe. NR, not reported.

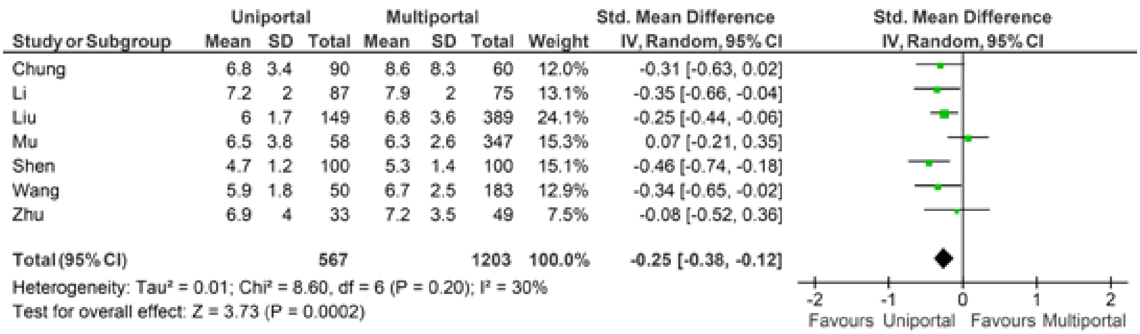

Figure 2 Forest plot of length of stay for uniportal and multiportal groups. The estimate of the mean difference of each study corresponds to the middle of the squares and the horizontal line shows the 95% confidence interval (CI). On each line, the mean and standard deviations are shown for both treatment groups. The sum of the statistics, along with the summary standardized mean difference, is represented by the middle of the solid diamonds. A test of heterogeneity between the trials within a subgroup is given below the summary statistics.

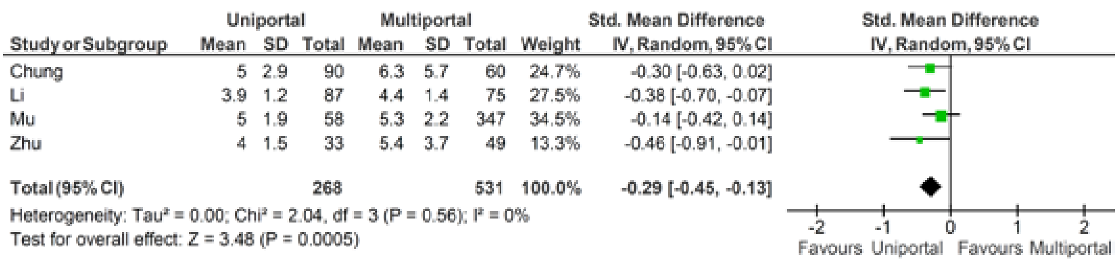

Figure 3 Forest plot of duration of postoperative drainage for uniportal and multiportal groups. The estimate of the mean difference of each study corresponds to the middle of the squares and the horizontal line shows the 95% confidence interval (CI). On each line, the mean and standard deviations are shown for both treatment groups. The sum of the statistics, along with the summary standardized mean difference, is represented by the middle of the solid diamonds. A test of heterogeneity between the trials within a subgroup is given below the summary statistics.

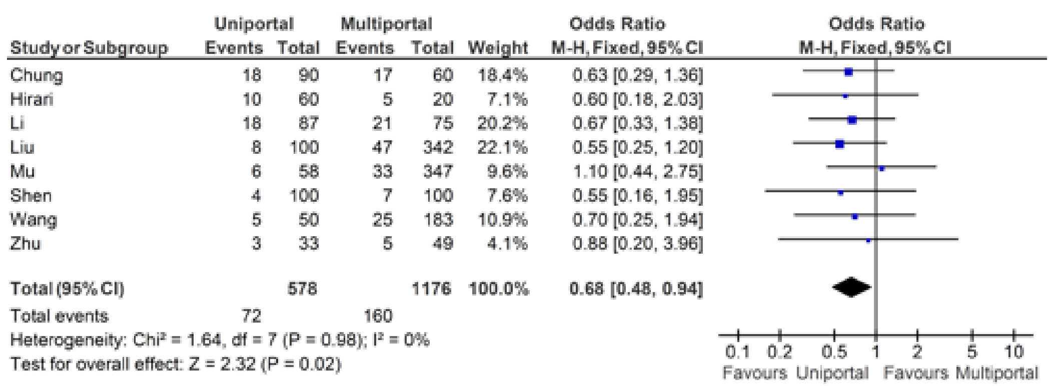

Figure 4 Forest plot of overall morbidity for uniportal and multiportal groups. The estimate of the mean difference of each study corresponds to the middle of the squares and the horizontal line shows the 95% confidence interval (CI). On each line, the mean and standard deviations are shown for both treatment groups. The sum of the statistics, along with the summary standardized mean difference, is represented by the middle of the solid diamonds. A test of heterogeneity between the trials within a subgroup is given below the summary statistics.

Table 4 Summary of perioperative outcomes in all studies comparing uniportal and do not delete multiportal. Leave heading as is lobectomy in lung cancer treatment

Paper	Operation time (min)		Length of stay (days)		Blood loss (mL)		Duration of postoperative drainage (days)		Conversion to thoracotomy		Overall morbidity		Mortality	
	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi
Chung	159.2±53.1	166.2±49.5	6.8±3.4	8.6±8.3	NR	NR	5.04±2.9	6.3±5.7	10/90 (11%)	9/60 (15%)	18/90 (20%)	17/60 (28%)	0/90 (0%)	1/60 (2%)
Hirai	168 [95–276]	155 [105–225]	7.2 [5–14]	7.4 [5–15]	95 [15–475]	85 [14–435]	NR	NR	1/60 (2%)	0/20 (0%)	10/60 (17%)	5/20 (25%)	0/60 (0%)	0/20 (0%)
Li	151.0±26.0	156.3±26.5	7.2±2.0	7.9±2.0	188.6±47.0	156.3±26.5	3.9±1.2	4.4±1.4	NR	NR	18/87 (21%)	21/75 (28%)	NR	NR
Liu^	179.4±52.2	208.2±63.6	6.0±1.7	6.8±3.6	55.7±52.8	78.3±85.0	NR	NR	NR	NR	8/100 (8%)	47/342 (14%)	NR	NR
Mu	138.8±63.6	135.6±55.5	6.5±3.8	6.3±2.6	73.6±51.5	74.1±64.5	5.0±1.9	5.3±2.2	2/58 (3%)	8/347 (2%)	6/58 (10%)	33/347 (10%)	0/58 (0%)	0/347 (0%)
Shen	95.3±16.9	98.8±15.3	4.7±1.2	5.3±1.4	55.1±9.0	58.7±7.1	NR	NR	1/100 (1%)	2/100 (2%)	4/100 (4%)	7/100 (7%)	0/100 (0%)	0/100 (0%)
Wang	165.9±41.7	192.5±55.2	5.9±1.8	6.7±2.5	50.8±45.9	87.4±85.4	NR	NR	0/50 (0%)	1/183 (1%)	5/50 (10%)	25/183 (14%)	0/50 (0%)	0/183 (0%)
Zhu	181.3±27.5	149.5±30.9	6.9±4.0	7.2±3.5	90.6±49.3	79.5±45.2	4.0±1.5	5.4±3.7	0/33 (0%)	0/49 (0%)	3/33 (9%)	5/49 (10%)	0/33 (0%)	0/49 (0%)
Mean	155.8±53.8	167.9±64.6	6.2±2.6	6.7±3.4	86.3±76.2	82.4±74.0	4.5±2.2	5.3±2.9	3.6%	2.6%	12.0%	13.7%	0.0%	0.1%
P value	0.69		<0.0001		0.63		0.0006		0.83		0.009		NA	

^Data presented are for lobectomy patients. Continuous variables presented as mean ± SD or median (range). Uni, uniportal; Multi, multiportal; NR, not reported.

Table 5 Summary of perioperative outcomes in studies with propensity-matched patient cohorts comparing uniportal and do not delete multiportal. Leave heading as is lobectomy in lung cancer treatment

Paper	Operation time (min)		Length of stay (days)		Blood loss (mL)		Duration of postoperative drainage (days)		Conversion to thoracotomy		Overall morbidity		Mortality	
	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi
Mu	145.0±65.8	130.9±46.9	6.8±4.2	5.4±1.9	79.8±56.4	72.8±28.5	5.17±2.09	4.56±1.71	1/47 (2%)	1/47 (2%)	4/47 (9%)	5/47 (11%)	0/47 (0%)	0/47 (0%)
Shen	95.3±16.9	98.8±15.3	4.7±1.2	5.3±1.4	55.1±9.0	58.7±7.1	NR	NR	1/100 (1%)	2/100 (2%)	4/100 (4%)	7/100 (7%)	0/100 (0%)	0/100 (0%)
Wang	169.9±39.6	191.2±51.8	5.8±1.8	6.50±2.4	53.0±47.1	95.3±107.0	NR	NR	0/46 (0%)	0/46 (0%)	4/46 (9%)	8 (17%)	0/46 (0%)	0/46 (0%)
Mean	125.2±51.1	128.6±51.9	5.5±2.6	5.6±1.9	60.6±38.2	70.9±56.3	NR	NR	1.0%	1.6%	6.2%	10.4%	0.0%	0.0%
P value	0.42		0.64		0.16		NR		0.65		0.14		NA	

Continuous variables presented as mean ± SD. Uni, uniportal; Multi, multiportal; NR, not reported.

overall morbidity (12.0% *vs*. 13.7%) compared to multiportal VATS. However, these findings must be considered in the context of their clinical relevance, as the improvements were only minor. Furthermore, the benefits of uniportal VATS were even less significant when propensity-matched data were meta-analyzed. Results also demonstrated that there were no significant differences between the two treatment modalities in regard to the number of lymph nodes dissected, operative time or rates of conversion to open thoracotomy. Overall, these findings suggested that uniportal VATS can be performed with relatively similar or improved perioperative outcomes without compromising safety or oncologic principles. However, there was a paucity of long-term clinical data and equivalent oncologic efficacy cannot be ascertained based on the existing literature.

Improved pain management has been a frequently claimed benefit to the uniportal VATS approach. However, the evidence for this was limited, with only one study in the present review reporting patient pain outcomes (23). Although this study demonstrated a reduction in pain scores, as measured by Visual Analogue Score (VAS) of 1–10 on day 1 postoperatively, a recent Best Evidence Topic review of uniportal and multiport VATS surgery concluded that the single port approach made little difference in pain outcomes for patients undergoing minor thoracic surgeries (24). Based on these findings, it is clear that further studies with standardized pain management protocols are required to determine benefits of the uniportal approach for pain management. Opponents of uniportal VATS have voiced concerns that this approach may be associated with longer operative duration, worse safety outcomes and higher likelihood of conversion to open thoracotomy. However, results of the present meta-analysis have refuted these concerns, at least in the context of selected patients treated in specialized centers.

It is important to acknowledge a number of limitations when considering the results of the present systematic review. Of the eight observational studies included for meta-analysis, one was prospective (20) and all others were retrospective in design. Wang and colleagues noted that a randomized control trial could not be easily performed in this setting, but suggested further prospective studies in the future (22). In order to minimize patient selection bias due to the non-random allocation of treatment, three studies performed propensity-matched analyses to improve the matching of patients according to relevant prognostic factors (20-22). Other limitations of the systematic review included the variable reporting of conversions in different studies and variable grading of postoperative morbidities. Whilst most studies included conversion rates (from single port to multiportal VATS or from VATS to open thoracotomy) in their analysis of surgical outcomes, Wang and colleagues used conversion as one of their exclusion criteria for statistical analysis (22). Furthermore, some studies accounted for a learning curve period by excluding the initial patients who underwent uniportal VATS from analysis in order to exclude the learning curve (21). These arbitrary exclusions may have had an impact on the surgical outcomes of the uniportal VATS treatment arm.

In conclusion, the present study was the first to meta-analyze clinical outcomes of uniportal VATS versus multiportal VATS in the treatment of lung cancer. Results suggested that uniportal VATS was associated with a statistically significant reduction in the duration of chest tube drainage, in-hospital stay and overall morbidity, but these improvements may only be minor in the clinical setting. Future studies should aim to standardize clinical outcomes with longer follow-up to assess the oncologic efficacy of the uniportal approach.

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Footnote

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Technique of uniportal VATS major pulmonary resections

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Abstract: The surgical approach to lung resections is evolving constantly. Since the video-assisted thoracoscopic surgery (VATS) anatomic lobectomy for lung cancer was described two decades ago, many units have successfully adopted this technique. The VATS lobectomy can be defined as the individual dissection of veins, arteries and bronchus, with a mediastinal lymphadenectomy, using a videothoracoscopic approach visualized on screen and involving 2 to 4 incisions or ports, with no rib spreading. However, the surgery can be performed by only one incision with similar outcomes. Since 2010, when the uniportal approach was introduced for major pulmonary resections, the technique has been spreading worldwide. This technique provides a direct view of the target tissue. The parallel instrumentation achieved during the single-port approach mimics the maneuvers performed during open surgery. It represents a less invasive approach than the multiport technique, and minimizes the compression of the intercostal nerve. As the surgeon's experience with the uniportal VATS lobectomy grows, more complex cases can be performed by using this approach, thus expanding the indications for single-incision thoracoscopic lobectomy.

Keywords: Minimally invasive surgery; video-assisted thoracic surgery (VATS); single-port lobectomy; uniportal video-assisted thoracic surgical resections

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Introduction

The uniportal access was initially described by Rocco *et al.*, firstly for the management of minor procedures (1). Since 2010, when the uniportal approach was introduced for major pulmonary resections, the technique has been spreading worldwide.

This technique provides a direct view of the target tissue. The parallel instrumentation achieved during the single-port approach mimics the maneuvers performed during open surgery (1-3).

It represents a less invasive approach than the multiport technique, and minimizes the compression of the intercostal nerve.

The aim of this chapter is to establish the most important steps of the uniportal lobectomy and to reveal some useful tricks to perform the technique.

Operative technique

General aspects

Single-incision video-assisted thoracic surgery (VATS) lobectomy follows the oncological principles of major pulmonary resections by VATS: individual dissection of veins, arteries and lobar bronchus, likewise complete mediastinal lymphadenectomy with a video-assisted thoracoscopic approach, with no rib spreading (2-4). The procedure is performed by video-visualization.

The utility incision is usually placed in the 5th intercostal space. The proper placement of the incision is crucial for good access to upper hilar structures and lymph node stations. No trocar and no rib spreader are required.

One of the key points is the adequate exposure of the lung, which is mandatory for every step. Also, the rotation

Figure 1 Uniportal instrumentation. Camera location (6).
Available online: http://www.asvide.com/articles/327

Figure 2 Video describing the use of energy devices, vascular clips and curved-tip staplers during the uniportal technique (7).
Available online: http://www.asvide.com/articles/328

Figure 3 Video describing the technical aspects of the left lower lobectomy: fissureless technique (8).
Available online: http://www.asvide.com/articles/329

of the surgical table and the correct retraction of the parenchyma are essential to improve the exposure and to obtain different angles of view. Another key point is the bimanual instrumentation.

This approach provides a direct visualization of the target tissue (5). In addition, the surgeon and the assistant are placed in front of the patient, so they have the same field of vision and the coordination is better.

For most of the surgical steps, the thoracoscope is usually placed at the posterior part of the utility incision, working with the instruments in the anterior part (*Figure 1*).

Finally, the use of specific equipment (such as a 30º thoracoscope, instruments with proximal and distal articulation, energy devices, articulated staplers or vascular clips) is recommended (2,3). In fact, the use of vascular clips for proximal vascular control and energy devices for distal division of small vascular branches is recommended (*Figure 2*).

Lower lobectomy

The technique is different depending on whether the fissure is complete or not:

(I) If the fissure is complete, the sequence is as follows: artery, pulmonary ligament, vein, bronchus and fissure;

(II) In the fissureless-technique, the sequence could be: pulmonary ligament, vein, bronchus, artery and fissure. Another way would be starting the procedure by dividing the anterior portion of the fissure from the hilum, after the identification of the interlobar artery (the anvil of the stapler should be placed over the surface of the artery).

In the video, there is an example of the fissureless technique performing a left lower lobectomy, from down to up (*Figure 3*). After retracting the lower lobe posteriorly and superiorly, the vein can be dissected using the right angle clamp, so the stapler goes easily into place.

The most difficult step during this lobectomy is the dissection of the bronchus; care must be taken in order to avoid injuries in the basilar artery. An optimal plane must be created between the bronchus and the artery, to staple without tractions. Once the bronchus is transected, the artery can be divided. The last step is to complete the fissure.

On the right side, the right lower lobectomy is very similar. As in this video (*Figure 4*), firstly the pulmonary ligament is cut and the vein is dissected and stapled. In this case, the fissure is complete, so the artery can be easily exposed and divided. Sometimes, it is easier to divide the artery into basilar and superior segmental branches. Then the bronchus can be stapled; the last step is the fissure.

The sequence is different if a fissureless technique is performed: starting the procedure by cutting the pulmonary ligament and dissecting the vein. When the vein is divided,

Figure 4 Video describing technical aspects of the uniportal VATS right lower lobectomy (9).
Available online: http://www.asvide.com/articles/330

Figure 5 Technical aspects of the right lower lobectomy: fissureless technique (10).
Available online: http://www.asvide.com/articles/331

Figure 6 Video describing the technical aspects of the uniportal VATS left upper lobectomy (11).
Available online: http://www.asvide.com/articles/332

the bronchus is exposed and transected. Care must be taken to avoid injuring the bronchus or the artery of the middle lobe. After the section of the lower bronchus, the artery is identified and stapled. The fissure is the last step (*Figure 5*).

Figure 7 Technical aspects of the management of the left upper bronchus during the uniportal VATS left upper lobectomy (12).
Available online: http://www.asvide.com/articles/333

Left upper lobectomy

Probably, this is the most difficult lobectomy using the uniportal approach, especially when the fissure is not complete (*Figure 6*). We recommend dividing the arterial trunks before dissecting the vein. Once the artery is divided, the vein can easily be exposed. It is very important to dissect the vein as distal as possible to improve the angle for the insertion of the stapler.

During the management of the upper vein, we recommend stapling the anterior portion of the major fissure. At this point, the camera is placed in the anterior portion of the utility incision to provide a better view of the hilum. The use of tip-curved staplers is also recommended, to avoid major tractions.

When the remaining arterial branches are divided, the bronchus can be dissected. It can be transected at this point or left for the final step. In this video (*Figure 6*), we were able to identify the interlobar artery in the fissure; so the anvil of the stapler is placed over the surface of the interlobar artery and the fissure can then be stapled; it is the safest management of the fissure, avoiding vascular events. After this step, the fissure is completed and the bronchus divided.

Focusing on the management of the left upper bronchus, there are four different approaches to the bronchus transection (*Figure 7*):

(I) When the fissure is complete or the artery can be easily exposed, we recommend dividing the lingular artery in the fissure, and then the bronchus;
(II) If the fissure is not complete or the artery is hidden, a TA stapler can be used to divide it;
(III) Another way is the use of scissors and to close it later (using a stapler or manual suture);

Figure 8 Video describing the uniportal VATS right upper lobectomy performed on a patient with previous thoracotomy and chemotherapy (13).
Available online: http://www.asvide.com/articles/334

Figure 9 Technical aspects of the uniportal VATS middle lobectomy (14).
Available online: http://www.asvide.com/articles/335

(IV) Finally, during the fissureless-technique, when the arteries and the vein have been stapled, the bronchus can be transected using an Endostapler. We only recommend this way for experienced VATS surgeons.

Right upper lobectomy

The steps for this lobectomy are very similar to those on the left side (*Figure 8*).

We recommend starting the procedure by dividing the anterior arterial trunk and then the vein. If the angle is no good, stapling the anterior portion of the minor fissure can provide a better retraction of the lobe, thus improving the angle.

When the artery and the vein are transected, the bronchus is divided and stapled and finally, the fissure. This last step is performed by placing the anvil of the stapler over the surface of the interlobar artery.

During the approach to the minor fissure, the camera is placed in the anterior portion of the utility incision and the instruments at the posterior. Perhaps, this is the only step in which the camera position is changed, but it provides a direct view of the hilum.

Middle lobe lobectomy

This lobectomy is usually performed from bottom to top. The sequence is as follows: anterior portion of the major fissure, vein, bronchus, artery and finally, the remaining fissure. Only when the fissure is complete or the artery can be easily exposed, the artery can be divided before the bronchus (*Figure 9*).

Due to the smaller branches, vascular clips are often used to divide the arterial branches in the middle lobectomy.

Comments

The uniportal lobectomy is a feasible, safe and an oncologic procedure in expert hands (4). To date, we have performed about 400 uniportal major pulmonary resections with good postoperative outcomes. Only one incision is used, which is less invasive than the multiportal technique. No trocar is used, so there could mean less compression to the intercostal nerve. The instrumentation is more anatomic and the visualization of the target is direct (5).

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Footnote

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Uniportal video-assisted thoracoscopic lobectomy

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Abstract: Over the past two decades, video-assisted thoracic surgery (VATS) has revolutionized the way thoracic surgeons diagnose and treat lung diseases. The major advance in VATS procedures is related to the major pulmonary resections. The best VATS technique for lobectomy has not been well defined yet. Most of the authors describe the VATS approach to lobectomy via 3 to 4 incisions but the surgery can be performed by only one incision with similar outcomes. This single incision is the same as we normally use for VATS lobectomies performed by double or triple port technique with no rib spreading. As our experience with VATS lobectomy has grown, we have gradually improved the technique for a less invasive approach. Consequently the greater the experience we gained, the more complex the cases we performed were, hence expanding the indications for single-incision thoracoscopic lobectomy.

Keywords: Video-assisted thoracic surgery (VATS); left lower lobectomy; right lower lobectomy; left upper lobectomy; right upper lobectomy; middle lobectomy; lymphadenectomy; lobectomies; less invasive approach

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Introduction

Video-assisted thoracic surgery (VATS) anatomic lobectomy for lung cancer was initially described two decades ago (1). Since then, many units have successfully adopted this technique, albeit its precise definition and description greatly vary between them (2).

The final step in the evolution of the technique is the use of a single-port approach. The uniportal access was described initially by Rocco and colleagues for minor thoracic and pulmonary procedures (3). The development of articulated staplers and purposely-designed instruments has helped to perform major pulmonary resections through a single incision approach. The first uniportal VATS lobectomy was described by Gonzalez-Rivas and colleagues, from Coruña University Hospital in 2010 (4). This chapter describes the technique for VATS single-port lobectomies.

Material

Although uniportal VATS lobectomy can be performed with conventional instruments, the use of especially adapted conventional material (such as instrumentation with both proximal and distal articulation, *Figure 1*), modern articulated staplers, vascular clips, high definition 30° cameras (The use of videolaparoscope with the distally mounted CCD design facilitates the instrumentation, *Figure 2*) and energy devices seems to be more fitted for successful single-incision lobectomy.

General aspects

The surgeon and the assistant must to be positioned in front of the patient in order to have the same thoracoscopic vision during all steps of the procedure and experience more coordinated movements (*Figure 3*).

Even though the field of vision is only obtained through the anterior access site, the combined movements of the thoracoscope along the incision will create different angles of vision (in this context, a 30 degree thoracoscope is recommended to achieve a panoramic view). The advantage

Figure 1 Adapted instruments with proximal and distal articulation.

Figure 2 High definition 30° thoracoscope.

Figure 3 Surgeons positioned in front of the patient watching the same monitor. The scrub nurse is located on the opposite side.

of using the thoracoscope in coordination with the instruments is that the vision is directed to the target tissue, bringing the instruments to address the target lesion from a direct, sagittal perspective.

Instruments must preferably be long and curved to allow the insertion of 3 or 4 instruments simultaneously (*Figure 4*).

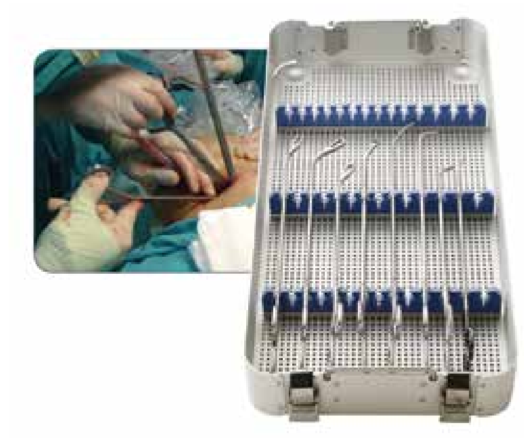

Figure 4 Uniportal set of specific adapted instruments.

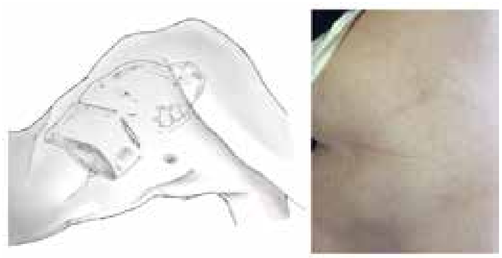

Figure 5 Drawing showing the placement of incision.

Optimal exposure of the lung is vital in order to facilitate the dissection of the structures and to avoid instrument interference.

Under general anesthesia and double lumen intubation, the patient is placed in a lateral decubitus position as usual for a conventional VATS. The incision, about 4-5 cm long, is performed preferably in the 5^{th} intercostal space in the anterior position (*Figure 5*). This location of the incision provides better angles for hilar dissection and insertion of staplers (*Figure 6*). This incision is the same size as the utility incision we use for double or triple port VATS technique to allow removal of specimen (*Figure 7*). There is no need to use a trocar for the thoracoscope.

It is helpful to rotate the surgical table away from surgeons during the hilar dissection and division of structures, and towards the surgeons for the lymph node dissection.

The vessels are usually divided by staplers but when the angle for vascular division is difficult for stapler insertion, the use of vascular clips (click aV, Grena®) or sutures is recommended (*Figure 8*).

For most of the surgical steps the thoracoscope is usually

Figure 6 Insertion of staplers during upper lobectomies (5). Available online: http://www.asvide.com/articles/34

Figure 7 Incision for left upper lobectomy (6). Available online: http://www.asvide.com/articles/35

Figure 8 Use of vascular clips during lobectomy (7). Available online: http://www.asvide.com/articles/36

placed at the posterior part of the utility incision working with the instruments in the anterior part.

For lower lobectomies the normal sequence of dissection is as follows: inferior pulmonary ligament, inferior pulmonary vein, pulmonary artery, bronchus and finally completion of the fissure. In case of upper lobectomies, the pulmonary artery is normally divided first, followed by vein, bronchus and fissure.

Figure 9 Single-chest tube placed in the posterior part of the incision.

When the lobectomy is completed, the lobe is removed in a protective bag and a systematic lymph node dissection is accomplished. The intercostal spaces are infiltrated with bupivacaine at the end of the surgery under thoracoscopic view. A single-chest tube is placed in the posterior part of the incision (*Figure 9*). We do not routinely employ epidural or paravertebral catheters.

Indications and contraindications

The indications and contraindication for uniportal VATS are similar as proposed by authors with experience in double or triple-port technique VATS (8).

The only absolute contraindications we consider are surgeon discomfort and huge tumors are not possible to be removed without rib spreading.

Surgical technique

Left lower lobectomy

The lobectomy may be technically different depending on whether the fissure is complete or not. If fissure is complete we try to dissect and staple the artery in the fissure. Sometimes, it is easier to individually divide the arterial branches of the superior and basilar segments. Upon retracting the lobe with a long curved grasper, we cut the pulmonary ligament to find the vein. The vein is dissected free and divided. Then, the lower lobe bronchus is exposed, dissected and stapled the same way as mentioned for the vein. The last step is to staple the fissure and remove the lobe in to a protective bag (*Figure 10*).

Figure 10 Left lower lobectomy (artery exposed in the fissure) (9). Available online: http://www.asvide.com/articles/37

Figure 11 Left lower lobectomy from bottom to top (10). Available online: http://www.asvide.com/articles/38

Figure 12 Right lower lobectomy with artery exposed in the fissure (11). Available online: http://www.asvide.com/articles/39

In the presence on an incomplete fissure or no visible artery, the technique may change. The preferred method does not involve dissection within the fissure in order to avoid postoperative air leaks. In this case, the lobectomy must be performed from caudal to cranial leaving the fissure stapling as the last step (fissureless technique). Once the lobe is retracted cranially, the sequence of the dissection should be as follows: inferior pulmonary ligament; inferior vein; inferior bronchus. Subsequently, a plane is created between the bronchus and the artery; the artery is taken thus leaving the fissure to be developed last (*Figure 11*).

Figure 13 Right lower lobectomy from down to up (12). Available online: http://www.asvide.com/articles/40

Right lower lobectomies

The strategy for right lower lobectomy is similar as for the left side but when the artery is exposed in the fissure, the origin of superior segmental artery must to be dissected in the posterior and superior portion of the fissure. The sequence is similar to left lower lobectomy (*Figure 12*).

For lobectomies when performed along a caudo-cranial axis, care must be taken to identify and avoid the damage of the bronchus or artery of the middle lobe. Once the inferior pulmonary vein has been stapled, the lower lobe bronchus is exposed, dissected and divided from its inferior aspect to its bifurcation with the middle lobe bronchus. Dissection of the bronchus with development of the plane between the bronchus and artery is performed leading to the visualization of the artery. We recommend removal of the interbronchial lymph nodes to better define the anatomy. Once identified, the segmental arterial branches to the lower lobe (basilar artery and superior segmental artery) are divided leaving the fissure to be finally stapled (*Figure 13*).

Left upper lobectomy

The operative sequence for left upper lobectomies is similar to conventional VATS. However, we recommend, when feasible, to divide the upper lobe truncus anterior first in order to facilitate division of the upper lobe vein (*Figure 14*).

Figure 14 Division of upper arterial trunk as first step.

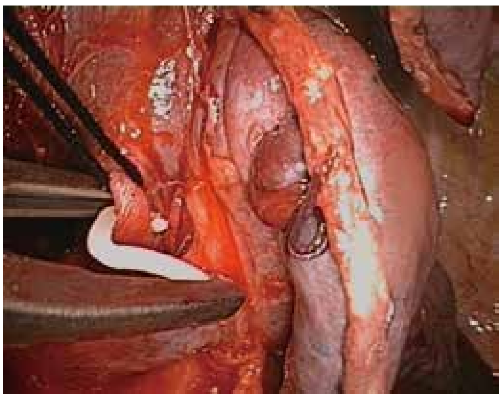

Figure 15 Use of vascular clips when the angle for staplers is not optimal.

Figure 16 Left upper lobectomy (fissureless technique) (13). Available online: http://www.asvide.com/articles/41

As a rule, for upper lobes we try to use staplers for all hilar structures. However, when there is no angle for stapler insertion or is difficult from the incision, we either use clips for vascular control (click aV, GrenaR) (*Figure 15*) or doubly

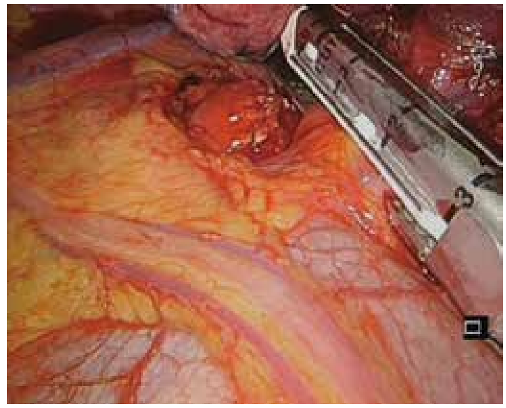

Figure 17 Division of the left superior pulmonary vein after division of truncus anterior.

ligates the vessels. We recommend to staple the fissure as the last step of the procedure, after dividing the hilar structures, from anterior to posterior (fissureless technique) (*Figure 16*).

The uniportal view facilitates the dissection and division of upper anterior and apical segmental trunks which are usually hidden by the superior vein when we use a conventional thoracoscopic view. We recommend to first divide the upper anterior and apical segmental trunk in order to facilitate the insertion of the endostaplers in the upper lobe vein. Once this arterial branch is stapled, the vein is easily exposed (*Figure 17*). It is important to dissect the vein as distal as possible for optimal stapler insertion. The use of curved-tip stapler technology facilitates improved placement around superior pulmonary vein and bronchus through a single incision (*Figure 18*). Another interesting option for management of the upper lobe vein is to open the fissure as the first step, from a hilar view and then dissect the plane between upper and lower vein, with identification of the bronchus and artery. The stapler is inserted over the artery, thereby dividing the fissure, and the lobe is mobilized to allow stapling of the vein from a different angle (*Figure 19*).

The management of bronchus during left upper lobectomies is more difficult because care must to be taken with lingular artery which lies usually behind the bronchus. We have 4 different forms to manage the upper lobe bronchus (*Figure 20*). The first option consists of exposing the lingular artery and subsequently dividing it in the fissure. At this point, the insertion of an endostapler for the bronchus is easy. In the second option a TA stapler is used for division of the left upper lobe bronchus in certain cases of incomplete fissure to avoid injury of the lingular artery (*Figure 21*). The third option entails dividing the bronchus with scissors

Figure 18 Use of curved tip stapler to facilitate division of upper vein (14). Available online: http://www.asvide.com/articles/42

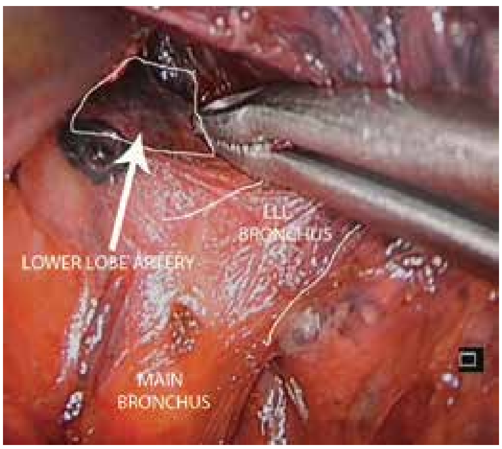

Figure 19 Division of anterior portion of fissure from a hilar view.

Figure 20 Different options for bronchus transection (15). Available online: http://www.asvide.com/articles/43

and closing it at the end of the surgery (by manual suture or by using a stapler). The final and fourth option focuses on inserting an endostapler after division of superior trunk (and optionally posterior ascending artery) and vein. This last option must be pursued only by experienced uniportal VATS surgeons.

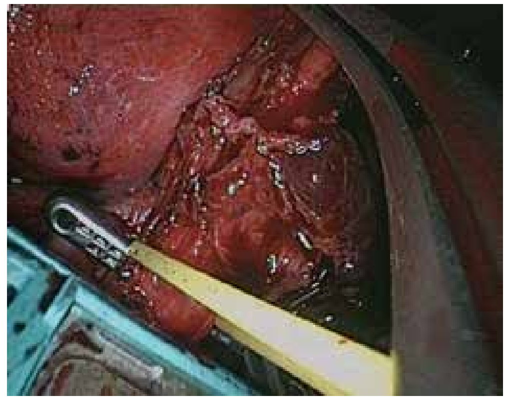

Figure 21 Use of TA linear stapler to transect the bronchus is case of complex fissure.

Figure 22 Division of boyden trunk as first step.

Right upper lobectomy

The surgical steps are similar to left upper lobectomy: anterior and apical segmental trunk, upper vein, posterior segmental artery, upper bronchus, fissure. We prefer to divide first the upper apico-anterior arterial trunk when possible (*Figure 22*) to help the insertion of staplers to the upper vein as described in the left upper lobe (*Figure 23*).

Sometimes it is helpful to partially divide the minor fissure as the first step (anvil of the stapler placed between the upper and middle lobe vein pulling the parenchyma into the jaws of the stapler) in order to get a better angle for the insertion the staplers to the upper vein. This maneuver will provide us with a much better field of vision to dissect and transect the RUL bronchus (*Figure 24*) or the ascending arteries.

The last step would be to complete the fissure (anvil of the stapler placed over the artery). After transecting the

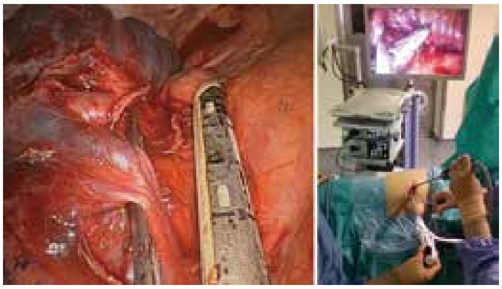

Figure 23 Division of upper lobe vein after arterial trunk is divided.

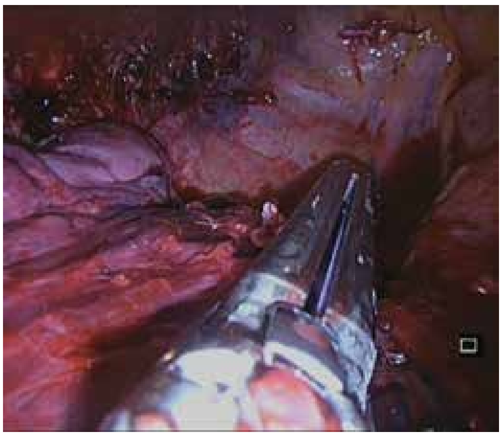

Figure 24 Division right upper lobe bronchus.

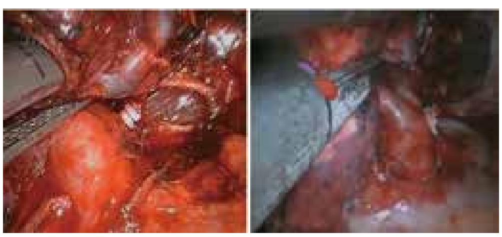

Figure 25 Division of the fissure in a right upper lobectomy from anterior to posterior as the last step of the lobectomy (fissureless technique).

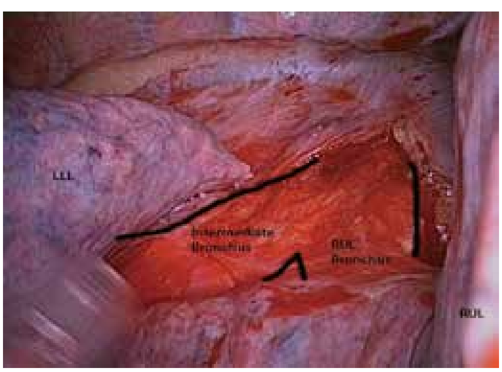

Figure 26 Exposure of posterior division of main right bronchus.

vein, artery and bronchus and after identifying the artery for the middle lobe, we can continue to divide the fissure by placing the stapler over the interlobar artery, pulling the parenchyma anteriorly making sure that the middle lobe artery is left out to the left side of the stapler. The vascular and bronchial stumps are kept out from the staplers jaws (*Figure 25*).

Occasionally, it is better to divide the bronchus after the division of the Boyden trunk to facilitate stapling of the upper lobe vein. We recommend first to expose the posterior bifurcation between the upper lobe and intermediate bronchus by dividing the posterior pleural reflection (*Figure 26*). This maneuver facilitates the following anterior bronchial dissection and subsequent insertion of staplers to divide the vein.

The use of vascular clips or tie off the vessels is helpful in the division of segmental branches of the pulmonary artery and vein. Except for the management of the bronchus, all vascular branches could be divided using clips rather than staplers.

Middle lobectomy

We recommend to perform the middle lobectomy from caudal to cranial: anterior portion of major fissure, vein, bronchus, artery, anterior portion of minor fissure and finally the posterior portion of fissure. The identification of medium (MLV) and lower lobe vein (LLV) indicates the location to place the stapler to divide the anterior portion of major fissure (the anvil of the stapler is placed between the MLV and LLV, and we pull the parenchyma into the jaws of the stapler). This maneuvre facilitates the dissection and insertion of stapler to transect the vein.

Once the vein is divided, the middle lobe bronchus is exposed, dissected and stapled. A ring forceps is then placed to exert traction onto the middle lobe, thereby exposing the middle lobe artery (medial segmental artery), which is then divided. Finally, the fissures are stapled (*Figure 27*).

Lymphadenectomy

A complete lymph node dissection can be performed with similar results as conventional VATS. For paratracheal dissection it is very helpful the anti-trendelenburg position because it naturally makes the lung “fall down”. For subcarinal dissection the trendelenburg position and the anterior table rotation facilitate the exposure. Preliminary division of the pulmonary ligament gives us a better access to the subcarinal space.

Figure 27 Middle lobectomy (16).
Available online: http://www.asvide.com/articles/44

Figure 28 Aortopulmonary window lymph node dissection (17).
Available online: http://www.asvide.com/articles/45

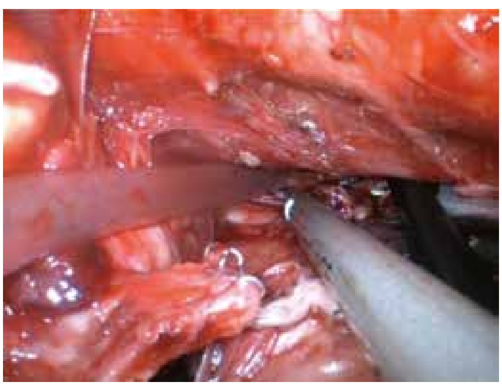

Figure 29 Left subcarinal lymph node dissection after left lower lobectomy.

The best location is to place the camera in the upper part of the incision. We can insert 3 or 4 instruments below the camera to complete the systematic dissection of the subcarinal space and paratracheal on the right side and

Figure 30 Left subcarinal lymph node dissection (18).
Available online: http://www.asvide.com/articles/46

Figure 31 Right subcarinal lymph node dissection (19).
Available online: http://www.asvide.com/articles/47

subcarinal and aortopulmonary window on the left side (*Figure 28*).

For left subcarinal dissection, it is helpful to insert two 10 mm endopeanuts in the lower part of the utility incision to retract the aorta, esophagus and lung (*Figure 29*). This operation facilitates the dissection with instruments placed above the peanuts and below the camera (*Figure 30*).

For right subcarinal lymph node dissection, the esophagus and the intermediate bronchus must be separated to facilitate the procedure (*Figure 31*).

For paratracheal lymph node dissection, we recommend to carry out the procedure by opening the pleura inferiorly to the azygos vein, lifting the azygos vein and retracting the superior vena cava to the right side with an endopath instrument (*Figure 32*). This technique will create a plane that will allow us to successfully dissect the paratracheal space from an inferior approach (*Figure 33*).

For hilar and N1 station lymphadenectomy, it is

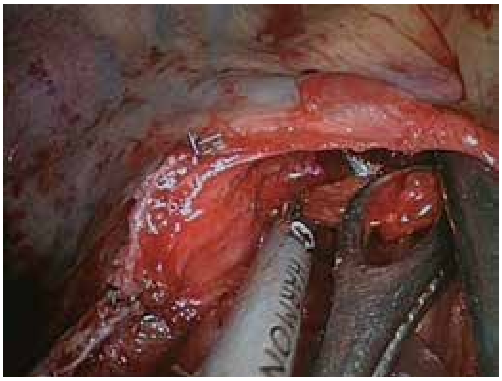

Figure 32 Surgical image of instrumentation during right paratracheal lymph node dissection.

Figure 33 Paratracheal lymph node dissection (20). Available online: http://www.asvide.com/articles/48

Figure 34 N1 station lymph node dissection after left upper lobectomy (21). Available online: http://www.asvide.com/articles/49

important to move and rotate the operating table posteriorly in order to place the lung in the back position. Bimanual instrumentation is crucial to achieve an accurate N1 radical lymph node dissection (*Figure 34*).

Results

Since June 2010, we have performed 222 uniportal VATS major pulmonary resections. All cases were performed by surgeons with experience in VATS surgery, especially in double-port technique for major pulmonary resections and single-port technique for minor procedures (wedge resections, pneumothorax, etc.). This series of patients included advanced NSCLC and complex major resections after chemo-radiotherapy induction treatment.

The overall conversion rate was 3.6%. The most frequent resection was right upper lobectomy (29.4%). The mean surgical time was 151.7±76 minutes (range, 60-310 minutes). After anatomical resection, a complete mediastinal lymphadenectomy was performed in patients with diagnosis of malignancy according to the oncological criteria already adopted in open surgery. The mean number of nodal stations explored was 4.4±1 (range, 3 to 7) with a mean of 14.6±6 (range, 5 to 38) lymph node resections. The mean tumor size was 3±2 cm (range, 0 to 9.8 cm).

The median chest tube duration was 2 days (range, 1 to 16 days) and the median length of stay was 3 days (range, 1 to 58 days).

Discussion

The VATS approach to lobectomy is not standardized. Although 3 to 4 incisions are usually made, the operation can be successfully carried out using only one incision.

Single-port pulmonary resections were initially described by Rocco and colleagues in 2004 (4). Since then they have published different articles on the single-port VATS technique (22,23) for diagnostic and therapeutic procedures, though not including lobectomies. We have adopted this single-incision technique and performed the initial major pulmonary resections by this approach (24,25). Currently we apply the single-port technique for most major resections including complex cases and advanced tumors (26).

The size of the utility incision performed is comparable to the ones commonly used for double (27) or triple-port approach (28). It is essential to accompany the movement of the camera in coordination with the surgical instruments. The use of high definition 30° thoracoscope with the distally mounted CCD design facilitates the instrumentation. The single-port technique provides a direct view to the target tissue. In comparison we feel that the conventional three-port creates an optical plane which requires a torsional angle that is not favorable with standard

Figure 35 View of the single incison wound in a patient with a previous thoracothomy and double-port VATS. The patient was initially operated years ago by thoracotomy (wedge resection of a lower lobe metastasis). He was reoperated 3 years later by VATS 2 ports (atypical segmentectomy) and now reoperated by single incision to complete a lower lobectomy.

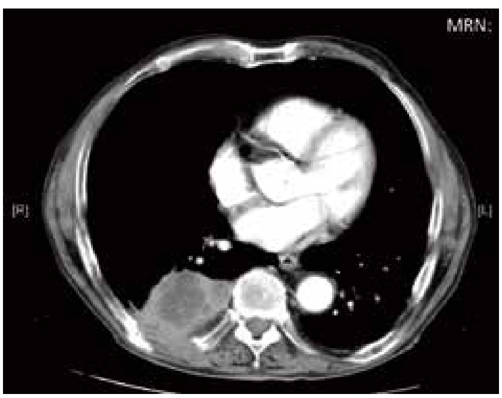

Figure 36 Lower lobe tumor with chest wall involvement operated by uniportal VATS for lobectomy and posterior incision for chest wall resection and reconstruction.

two-dimension monitors. The parallel instrumentation achieved during the single port approach mimics inside the maneuvers performed during open surgery. The uniportal view facilitates the dissection and division of the upper arterial trunk which is usually hidden by the superior vein when we use a conventional thoracoscopic view. For upper lobectomy, we recommend first dividing the upper lobe truncus anterior to facilitate dividing the upper lobe vein with an endo-stapler. Once the arterial branch is divided the division of the vein is much easier using the single-port approach. It is important to dissect the vein as distal as possible to optimise the passage of the stapler.

An advantage we have noticed is that we don't need the camera trocar to introduce the lens. By separating the soft tissue we can introduce the camera without trocar allowing us to have more flexibility and obtaining bigger and better angles of vision. Furthermore, we believe that by avoiding the use of the trocar the possibility of an intercostal nerve injury could be minimized. During the instrumentation we always try to avoid putting pressure over the intercostal bundle, putting it over the upper edge of the lower rib to avoid any contact with the nerve. We have the impression that our patients refer less pain when using this approach but we will try to demonstrate it in a further research with a larger patient population. Some authors have reported less postoperative pain and fewer paresthesias in patients operated for pneumothorax through a single incision, in comparison to the classical multiport approach (29).

Single-incision VATS is not only indicated to initial stages or easy cases. With gained experience the most complex cases can be performed in the same manner as with double or triple port approach (30). The previous experience in VATS is important to perform these advanced cases with success. We have performed lobectomies with strong adherences, re-VATS after thoracotomy (*Figure 35*), tumors with chest wall involvement (*Figure 36*) (31), cases after induction or radical chemo-radiotherapy, sleeve lobectomies (*Figure 37*) (32), vascular reconstruction (*Figure 38*), pancoast tumors, and huge tumors (*Figure 39*).

Recently, we have analysed our results comparing early stages of NSCLC with advanced tumors (>5 cm, T3-T4 or after induction therapy) operated by uniportal VATS (87 early stage tumors *vs.* 47 advanced tumors). Surgical time and number of lymph nodes were higher in advanced tumor group but postoperative outcomes were similar in both groups (chest tube duration, hospital stay and complications). Further analysis of survival for uniportal VATS lobectomy of advanced stage tumors is ongoing.

Despite the increasing adoption of the uniportal VATS approach worldwide, the technique for major lung resections should be learned by implementing dedicated educational pathways inclusive of wet labs and hands on courses as well as visiting experienced VATS centers. We expect further development of new technologies like electrosealing devices for all pulmonary structures, robotic arms that open inside

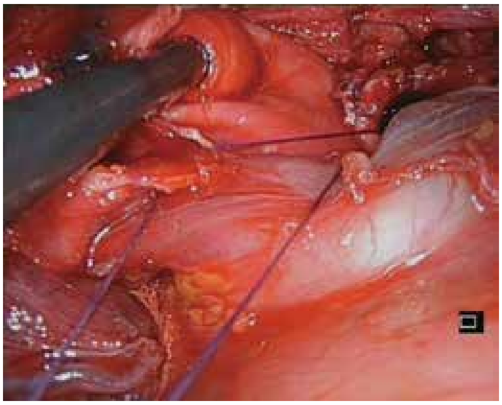

Figure 37 Sleeve anastomosis after left lower lobectomy.

Figure 38 Surgical instrumentation during vascular reconstruction.

the thorax and wireless cameras, which may allow the uniportal approach to become a standardized addition to the thoracic surgical armamentarium for major pulmonary resections in most thoracic departments.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Figure 39 Huge tumor operated by uniportal VATS: bilobectomy and anatomic segmentectomy S6 (right upper lobe, middle lobe and superior segment of lower lobe were involved).

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Technical steps in single port video-assisted thoracoscopic surgery lobectomy

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Abstract: Video-assisted thoracoscopic surgery (VATS) has transformed the way of treating patients with lung diseases over the past two decades and this is particularly true referred to patients with lung carcinoma. The indication for surgical treatment could be extended to those patients that were functionally unable to receive a thoracotomy and overall this approach shortened the length of stay in hospital and improved the quality of life of these patients postoperatively. The best VATS technique for lobectomy has not been well defined yet. The VATS approach to lobectomy can be performed via 1–4 incisions without rib spreading with similar outcomes. Over the last few years the single port VATS approach has generated a growing interest in the scientific thoracic surgery community as less invasive for the patients and comfortable for the performing surgeon. The aim of this video-article is to show the different steps of this technique and to provide some tips and tricks to improve and facilitate the execution of the uniportal VATS lobectomy.

Keywords: Uniportal video-assisted thoracoscopic lobectomy; single port minimally invasive thoracic surgery

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Introduction

Video-assisted thoracoscopic surgery (VATS) has transformed the way of treating patients with lung diseases over the past two decades. This is particularly true referred to patients with lung carcinoma. The VATS approach has proven to be superior to thoracotomy in many regards, in particular regarding the treatment with patients with lung cancer (1). The best VATS technique for lobectomy has not been well defined yet. The VATS approach to lobectomy can be performed via 2–4 incisions without rib spreading with similar outcomes. The final step in the evolution of the technique is the use of a single-port approach. Gonzalez-Rivas *et al.* described the first uniportal VATS lobectomy in 2010 (2). The development of angulated instruments and articulated staplers has helped to perform lobectomies and other major pulmonary resections through a single incision approach.

Patient selection and workup

The VATS lobectomy technique is considered nowadays the standard treatment for early stage of lung cancer (3), but there are still some uncertainties in relation to the potential difficulties and complications regarding thoracoscopic major pulmonary resections in patients with advanced lung cancer. Recent studies showed that it is feasible to perform these kind of procedures safely and reliably, providing perioperative outcomes similar to those obtained in early stage tumours operated through this same technique (uniportal or not) (4,5). In this context it is possible to extend the indication for VATS also in those patients who previously would have undergone a thoracotomy, upon the appropriate expertise of the surgeon (6). An appropriate preoperative workup and patient selection is mandatory in order to avoid complications and to maintain a low conversion rate (7).

Figure 1 Specific adapted instrumentation with distal articulation and articulated staplers.

Figure 2 Dissection of the fissure and of the lower lobe pulmonary artery using the Harmonic® Unltrasonic Device (9).
Available online: http://www.asvide.com/articles/843

Figure 3 Incision in the 5th intercostal space anterior axillary line (12).
Available online: http://www.asvide.com/articles/844

Pre-operative preparation

Planning for a VATS resection as safely as possible involves the consideration of the patient's characteristics and the anticipated technical aspects of the case. The patients can be included in an enhanced recovery pathway, that refers to a combination of perioperative interventions designed to minimise the impact of surgery on patients' recovery in order to reduce postoperative complications (8).

Equipment preference card

Single port VATS lobectomy can be performed with conventional instruments, but the use of especially adapted instrumentation with distal articulation (*Figure 1*), articulated staplers, vascular clips, modern energy devices (*Figure 2*) and high definition 30° cameras can facilitate the surgeon in performing a successful uniportal VATS lobectomy (10).

Role of team members

The modern thoracic surgical team includes one surgeon who operates together with the first assistant who holds the camera and a scrub nurse (11). The surgeon and his assistant should be positioned in front of the patient in order to have the same thoracoscopic vision during all steps of the procedure for more coordinated movements. The scrub nurse is located on the opposite side of the operating table. An experiences anaesthetist should also be present in case of complications.

Procedure

General aspects

The uniportal VATS lobectomy technique follows the oncological principles of major pulmonary resections by VATS (individual dissection of veins, arteries and lobar bronchus combined with complete mediastinal lymphadenectomy). The procedures are performed under video-assisted visualisation and with no rib spreading.

Under general anesthesia and double lumen intubation, the patient is placed in a lateral decubitus position as usual for a conventional VATS. The 4–5 cm long incision is usually placed in the 5th intercostal space anterior axillary line to get access to the hilar structures and lymph node stations (*Figure 3*). This location also allows a good angle for hilar dissection and insertion of staplers. The proper

Figure 4 Use of 45° applier for polymer clips to divide the vessels (13).
Available online: http://www.asvide.com/articles/845

Figure 5 Use of the stapler to avoid traction (14).
Available online: http://www.asvide.com/articles/846

placement of the incision is crucial in order to have an adequate exposure to ease the dissection and to avoid instrument interference. The size of the incision will allow removing the specimen without performing any further utility incision. A wound retractor can be used, a trocar for the thoracoscope is not needed. The thoracoscope is usually placed at the posterior part of the incision, so that the surgeon can work with the instruments in the anterior part. It is helpful to rotate the surgical table away from surgeon during the hilar dissection and towards the surgeons for the lymph node dissection. The use of vascular clips for proximal vascular control and energy devices for distal division of small vascular branches is recommended.

The field of vision is only obtained through the anterior access site but the movements of the 30-degree thoracoscope along the incision will create different angles of vision. Using the thoracoscope in coordination with the instruments allows the direct vision of the target tissue, thus we can obtain similar angle of view as for open surgery. Instruments should be long and curved to allow the insertion of 3 or 4 instruments simultaneously. The dissection can be performed with energy devices.

For upper lobectomies, the pulmonary artery is normally divided first, followed by vein, bronchus and fissure. In case of lower lobectomies the normal sequence of dissection should be as follows: inferior pulmonary ligament, inferior pulmonary vein, pulmonary artery, bronchus and finally completion of the fissure. When the lobectomy is completed, the lobe is removed in a protective bag and a systematic lymph node dissection is performed. The intercostal spaces are infiltrated with local anaesthetic at the end of the surgery under thoracoscopic view. A single-chest tube is placed in the posterior part of the incision.

Right upper lobectomy

The surgical steps for the right upper lobectomy are very similar to conventional VATS. It is recommended starting the procedure by dividing the anterior arterial trunk in order to facilitate the insertion of the staplers in the upper lobe vein. Once this arterial branch is stapled, the vein is easily exposed. As a rule, for upper lobes ideally staplers should be used for all hilar structures, but the use of vascular clips or tie off the vessels can be very helpful in the division of segmental branches of the pulmonary artery and vein (*Figure 4*). If the angle is no good, stapling the anterior portion of the minor fissure (anvil of the stapler placed between the upper and middle lobe vein pulling the parenchyma into the jaws of the stapler) can provide a better retraction of the lobe, thus improving the angle for the insertion the staplers to the upper vein. It is important to dissect the vein as distal as possible for optimal stapler insertion. The use of tip-curved staplers is also recommended to avoid major tractions (*Figure 5*).

When the remaining arterial branches are divided, the bronchus can be dissected. The last step would be to complete the fissure from anterior to posterior. After identifying the artery for the middle lobe, we can continue to divide the fissure by placing the stapler over the surface of the interlobar artery, pulling the parenchyma anteriorly making sure that the middle lobe artery is left out to the left side of the stapler. The vascular and bronchial stumps are kept out from the staplers' jaws. During the approach to the minor fissure, the camera is placed in the anterior portion of the utility incision and the instruments at the posterior. This is the only step in which the camera position is changed, but it provides a direct view of the hilum.

Figure 6 Difficult bronchus dissection during left upper lobectomy (15).
Available online: http://www.asvide.com/articles/847

Figure 7 Division of the anterior portion of major fissure and of the main for the middle lobe (16).
Available online: http://www.asvide.com/articles/848

Left upper lobectomy

The surgical steps for this lobe are similar to right upper lobectomy: anterior and apical segmental trunk, upper vein, posterior segmental artery, upper bronchus and fissure. Probably, this is the most difficult lobectomy using the uniportal approach, especially when the fissure is incomplete. It is recommended starting the procedure by dividing the anterior arterial trunk and then the vein, in order to help the insertion of the stapler to the upper vein as described in the right upper lobe. Prior to the management of the upper vein, the anterior portion of the major fissure should be stapled.

Another option for the management of the upper lobe vein is to open the fissure as first step and dissect the plane between upper and lower vein with the identification of bronchus and artery. The stapler is then inserted over the artery to divide the fissure and the lobe is mobilized to allow the stapling of the vein from a different angle.

When the remaining arterial branches are divided, the bronchus can be dissected. It can be transected at this point or left for the final step. The management of the bronchus during left upper lobectomies is more difficult because it must be taken with the lingular artery, which usually lies behind the bronchus. We have four different forms to manage the upper lobe bronchus. The first option consists of exposing the lingular artery and subsequently dividing it in the fissure (when the fissure is complete or the artery can be easily exposed). At this point, the insertion of an endostapler for the bronchus is easy. In the second option, if the fissure is not complete or the artery is hidden, a thoracoabdominal (TA) stapler can be used to divide it in order to avoid injury of the lingular artery. The third option entails dividing the bronchus with scissors and closing it at the end of the surgery (by manual suture or by using a stapler) (*Figure 6*). The final and fourth option focuses on inserting an endostapler after division of superior trunk (and optionally posterior ascending artery) and vein. This last option must be pursued only by experienced uniportal VATS surgeons.

Right middle lobectomy

This lobectomy is usually performed from caudal to cranial: anterior portion of major fissure, vein, bronchus, artery, anterior portion of minor fissure and finally the posterior portion of the major fissure. The identification of middle and lower lobe veins indicates the location to place the stapler to divide the anterior portion of major fissure (the anvil of the stapler is placed between the two veins and the lung parenchyma is pulled into the jaws of the stapler). This manoeuvre facilitates the dissection and insertion of stapler to transect the vein (*Figure 7*). Only when the fissure is complete the artery can be easily exposed, dissected and divided before doing the same with the bronchus. Finally, the minor fissure and the posterior part of the major fissure are stapled and the lobe can be removed.

Right lower lobectomy

The technique for lower lobectomies may be different depending on whether the fissure is complete or not. If fissure is complete, the artery in the fissure should be dissected and stapled. Sometimes it is easier to individually divide the arterial branches of the superior and basilar

Figure 8 Fissureless technique in left lower lobectomy (17). Available online: http://www.asvide.com/articles/849

Figure 9 Dissection on the paratracheal lymph nodes (18). Available online: http://www.asvide.com/articles/850

segments. Upon retracting the lobe, the pulmonary ligament should be resected in order to find the vein. Then the vein is dissected and divided. After the exposure of the lower lobe bronchus, this should be dissected and stapled as well. The last step is to staple the fissure and remove the lobe.

In the presence on an incomplete fissure or no visible artery, the technique may change. The best method does not involve the dissection within the fissure in order to avoid postoperative air leaks. Once the lobe is retracted cranially, the sequence of the dissection should be as follows: inferior pulmonary ligament, inferior vein and inferior bronchus. Care must be taken to avoid injuring the bronchus or the artery of the middle lobe. After the section of the lower bronchus, the artery is identified and stapled. The fissure is the last step (fissureless technique). The removal of the intrabronchial lymph nodes is recommended to better define the anatomy.

Left lower lobectomy

The technique for this lobectomy is very similar to right lower lobectomy. The most difficult step during the left lower lobectomy is the dissection of the bronchus so that a particular care should be taken in order to avoid injuries in the basilar artery. An optimal plane must be created between the bronchus and the artery to staple without traction. Once the bronchus is transected, the artery can be divided. The last step is to complete the fissure (*Figure 8*).

Lymphadenectomy

The anti-Trendelenburg position can be very helpful for paratracheal dissection because it naturally allows the lung to "fall down". It is recommended to carry out the procedure by opening the pleura inferiorly to the azygos vein, lifting the vein and retracting the superior vena cava to the right side, allowing a successfully dissection of the paratracheal space from an inferior approach (*Figure 9*).

The Trendelenburg position and the anterior table rotation facilitate the exposure for subcarinal dissection and the preliminary division of the pulmonary ligament gives us a better access to the subcarinal space. For left subcarinal dissection, it is helpful to insert two 10-mm endopeanuts in the lower part of the utility incision to retract the aorta, esophagus and lung. This operation facilitates the dissection with instruments placed above the peanuts and below the camera. For right subcarinal lymph node dissection, the esophagus and the intermediate bronchus must be separated to facilitate the procedure.

For hilar and N1 station lymphadenectomy, it is important to move and rotate the operating table posteriorly in order to place the lung in the back position.

Post-operative management

A recent review suggests that except for pain score the uniportal VATS reveals no differences in most postoperative outcomes in minor or major thoracic procedures (19).

Currently, the evolution of the thoracoscopic surgery to less invasive techniques, such as the uniportal VATS allows us to considerer the possibility of avoiding intubation and general anesthesia. The combination of non-intubated thoracoscopic surgery and single port VATS technique represents the least invasive procedure for pulmonary resections. Due to avoidance of intubation, mechanical ventilation and muscle relaxants, the anesthetic side effects are minimal allowing patients to be mobilized right after surgery and to be discharged faster (20).

Figure 10 Dissection of the superior pulmonary vein using the curved sucker (22).
Available online: http://www.asvide.com/articles/851

Tips and tricks

Complications can be around the corner, particularly early in the surgeon's learning curve. The best strategy for facing complications of VATS lobectomy is to prevent them from happening. Awareness of the possibility of intraoperative complications of VATS lobectomy is mandatory to avoid them, and the development of management strategies is necessary to limit morbidity if they occur (21). A very helpful trick in finding the artery in the fissure in case of fissureless lobes consists in identifying the superior pulmonary vein. This should be dissected until the partial exposure of the bronchus, normally located behind it. Then a stump dissection of the tissue should be performed in the direction of the fissure, until the artery can be seen and identified. Finally, the fissure can be divided positioning the stapler in the dissected tunnel, on top of the artery. In case of difficult isolation of the vein, the sucker can be used to facilitate the insertion od the stapler to divide it (*Figure 10*). To facilitate the assistant in the use of the scope, a sling can be applied to the upper part of the incision in order to hold the camera.

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Footnote

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Uniportal video-assisted thoracoscopic left upper lobectomy under spontaneous ventilation

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Abstract: Intubated general anesthesia with one-lung ventilation was traditionally considered necessary for thoracoscopic major pulmonary resections. However, non-intubated thoracoscopic lobectomy can be performed by using conventional and uniportal video-assisted thoracoscopic surgery (VATS). These non-intubated procedures try to minimize the adverse effects of tracheal intubation and general anesthesia but these procedures must only be performed by experienced anesthesiologists and skilled thoracoscopic surgeons. Here we present a video of a uniportal VATS left upper lobectomy in a non-intubated patient, maintaining the spontaneous ventilation.

Keywords: Non-intubated patient; single-port video-assisted thoracoscopic surgery (VATS); awake surgery; lobectomy; uniportal; spontaneous ventilation

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Intubated general anesthesia with one-lung ventilation was traditionally considered necessary for thoracoscopic major pulmonary resections. However, non-intubated thoracoscopic lobectomy can be performed by using conventional and uniportal video-assisted thoracoscopic surgery (VATS). Here we present a video of a uniportal VATS left upper lobectomy in a non-intubated patient.

A 73-year-old female, non-smoker, was admitted to our department for surgery. A control CT scan revealed a mass in the left upper lobe. The patient was proposed for non-intubated VATS surgery. A facial mask was used to have control of the airway. Propofol and continued perfusion of remifentanil were administered for sedation. No epidural catheter was placed. The skin and the intercostal space were infiltrated with levobupivacaine. A 3-cm incision was made in the 5th intercostal space. A 3-cm adenocarcinoma was detected in the left upper lobe so a left upper lobectomy and lymph node dissection was performed. The total surgical time was 90 minutes (*Figure 1*).

The patient was sent to a recovery room for 1 hour and then to the ward. The patient was discharged home on the second postoperative day with excellent recovery. The final pathological result revealed a 3.5-cm adenocarcinoma with no lymph node involvement.

Discussion

The first non-intubated VATS for lobectomy was initially described in 2007 (2). Since then, only three groups have published major pulmonary resections by VATS in non-intubated patients (3-5).

The non-intubated procedures try to minimize the adverse effects of tracheal intubation and general anesthesia such as intubation-related airway trauma (6), ventilation-induced lung injury, residual neuromuscular blockade (7) and postoperative nausea and vomiting. Avoidance of general anesthesia also results in a faster recovery with immediate return to daily life activities.

We consider this procedure feasible for selected patients with no difficulties for intubation, with no obesity and good cardiopulmonary function. In addition, this surgery should only be performed by experienced anesthesiologists and

Figure 1 Uniportal VATS left upper lobectomy under spontaneous ventilation (1).
Available online: http://www.asvide.com/articles/468

thoracoscopic surgeons (preferably skilled and experienced with complex or advanced cases and bleeding control through VATS).

In this video we show the technique for lobectomy by using a 3 cm single incision approach with no intubation, no vagus blockade, no central vein, no epidural and no urinary catheter. The future of the thoracic surgery is to reduce the surgical and anesthetic trauma. The combination of nonintubated or awake thoracoscopic surgery and the single-port VATS probably represents the least invasive procedure for pulmonary resections. Thanks to avoidance of intubation, mechanical ventilation and muscle relaxants, the anesthetic side effects are minimal allowing to most of the patients to be included in a fast protocol avoiding the stay in an intensive care unit.

The success in performing lobectomies by a single incision approach in non-intubated patients is a result of skills and experience accumulated over time by performing many uniportal VATS surgeries (8,9).

In conclusion, uniportal video-assisted thoracoscopic lobectomy in patients under spontaneous ventilation is a feasible and a safe procedure in expert hands. It represents a good option for high risk patients for intubated general anesthesia such as elderly patients. This procedure should only be performed by experienced anesthesiologists and skilled single-port thoracoscopic surgeons.

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Uniportal video-assisted thoracoscopic lobectomy in the animal model

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Abstract: We introduce the training on uniportal video-assisted thoracoscopic (VATS) lobectomy in sheep. This animal model is helpful to learn the different view, the importance of lung exposure and the key points of the instrumentation. In this article we present three videos with the left upper lobectomy, the left lower lobectomy and the right upper lobectomy in the sheep.

Keywords: Video-assisted thoracoscopic lobectomy (VATS lobectomy); uniportal VATS; VATS training; VATS animal model

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Introduction

Video-assisted thoracoscopic (VATS) lobectomy in the animal model is very helpful in surgeons training, particularly in a new approach as the uniportal. It allows to know the different visualization with the camera through the same incision and learning the keypoints of the instrumentation (1,2).

The best animal model in our experience is the sheep, due to its anatomy.

The technological center

Our technological center is located near to the hospital and is managed by a veterinarian, with great experience in training courses, not only for thoracic surgery, but also general surgery, vascular surgery, microsurgery.

The training hall has eight surgery tables with a ventilator and monitorization. The vet is helped by another two vets and two assistants. They are responsible for the general anesthesia, selective intubation of the sheep, and the posterior control during the surgery. The center has also simulators to practise sutures in artificial tissues or animal tissues (*Figure 1*).

The animal model

The anatomy of the sheep is in our opinion the most similar to the human model. We use adult sheep, six months old and with an average weight of 25-28 kg.

We recommend starting with the left upper lobe, because it is a small lobe, and so the exposure is easier. The lingula is long, needing frequently to be positioned in the posterior part of the hemithorax.

After the upper lobectomy, the left lower lobectomy is easier because the artery and the bronchus are exposed in the fissure. For this reason, we suggest the students to try to do the lobectomy from the inferior aspect of the lung, after dividing the pulmonary ligament.

In the right side, the anatomy is a little different from human. The cava vein is bigger, and the pulmonary arterial branches are behind it. The upper lobe has a tracheal bronchus. The upper and lower veins are hidden behind the cava vein too.

The sheep is positioned in the lateral decubitus with a rol or a small pillow under the thorax (*Figure 2*).

The uniportal utility incision

The best place is in the fourth intercostal space, in the lateral part of the hemithorax and in front of the tip of the scapula. Three or four centimeters are enough.

Instruments

We use a 30º-10 mm camera and most of the time we place

Figure 1 Surgery hall in The Technological Center.

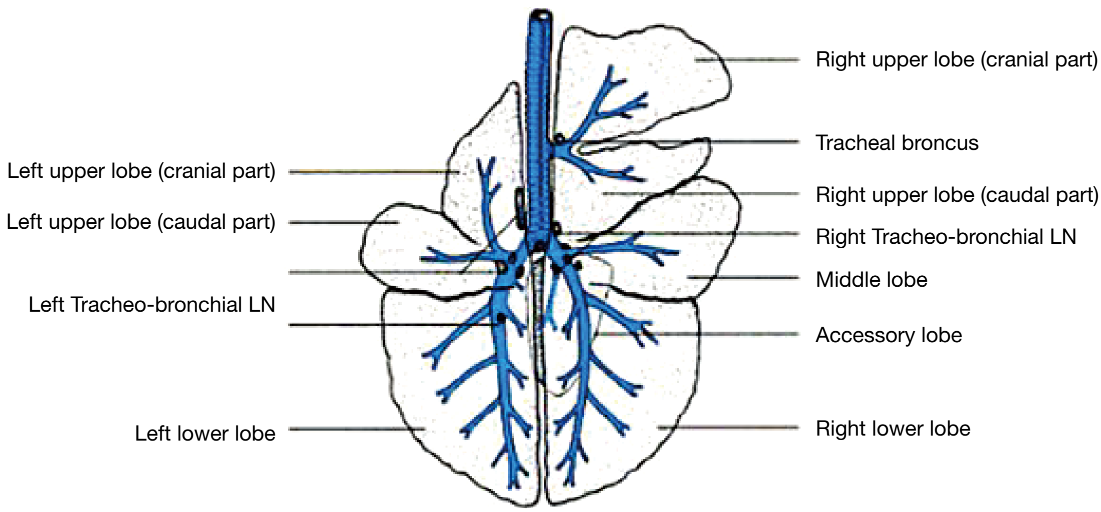

Figure 2 Lung's anatomy in the sheep.

it in the posterior angle of the incision.

For the dissection we recommend Scanlan instruments, with proximal and distal articulation: thin lung grasper, dissector, scissor. The long curved suction is helpful to expose and sometimes to dissect the hilar structures.

The staplers are the same as in human surgery, and frequently they are too big to divide the vessels. In this case the vascular clips are the solution.

Energy devices are helpful to divide the mediastinal pleural, the hilar tissue around the bronchus and the pulmonary ligament.

The left upper lobectomy (*Figure 3*)

The surgeon is positioned in the upper part of the thorax.

The camera is introduced through the incision and placed in the posterior angle.

The upper lobe is retracted to posterior with a lung grasper by the assistant, and then the hilar structures are visible.

The mediastinal pleura is opened.

The upper vein is dissected and divided with vascular clips, because the angle for a stapler is not good. The lingular vein is dissected and divided too.

It is important to be careful with this dissection because these vessels are thin and fragile.

The next step is to open the mediastinal pleura up to the posterior aspect of the arterial trunk. Now we can dissect and divide the artery or the lobar bronchus. We recommend to use a silk for the reference of the bronchus, to make the introduction of the stapler easier. This avoids the lesion of the lingular artery, located behind the bronchus.

The final step is the fissure (Fissure-less technique), that is divided with one or two staplers. The lobe is removed and you can use a protective bag.

Figure 3 Left upper lobectomy in the sheep (3).
Available online: http://www.asvide.com/articles/324

Figure 4 Left lower lobectomy in the sheep (4).
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Figure 5 Right upper lobectomy in the sheep (5).
Available online: http://www.asvide.com/articles/326

The left lower lobectomy (*Figure 4*)

The surgeon is positioned in the inferior part of the thorax, because the camera must be directed to the pulmonary ligament.

The lung is exposed to the upper part of the hemithorax with one or two lung graspers, since it is a big lobe.

The pulmonary ligament is very long. It is divided with the electronic devide or the cautery up to the lower vein.

This vein is then easily dissected and divided with a vascular stapler.

Many adhesions to the esophagus are divided up to the bronchus.

The basilar arterial trunk is dissected and divided with big vascular clips or a vascular stapler.

The final step is the dissection of the bronchus, that it is divided with a stapler.

The lobe is removed.

The right upper lobectomy (*Figure 5*)

The anatomy of the right lung is different from humans and the pulmonary resections are more difficult. One problem is the big cava vein.

The surgeon is positioned in the upper part of the thorax.

After opening the utility incision, the camera is placed in the posterior angle.

The upper lobe is retracted to the back.

The mediastinal pleura is opened.

Two or three veins are dissected separately and divided with vascular clips, because they are small.

Then you can find two arteries. They are dissected and divided with vascular clips.

The trachea is exposed and we recommend dividing first the fissure with two staplers.

The posterior mediastinal pleura and tissues are divided and the tracheal bronchus is exposed. It is dissected and transected with a stapler.

The lobe is removed.

The right lower lobectomy

It is the most difficult. The cava vein is big and the lower pulmonary vein is hidden behind it.

The lobe is retracted to the upper part of the pleural cavity with one or two lung graspers.

The long pulmonary ligament is divided with the energy device or the cautery. It is helpful to separate the cava vein with a small sponge stick.

The lower vein is then dissected and transected with a stapler.

The arteries are located in the anterior aspect of the lobe and they can be divided with vascular clips.

The tissue in the posterior face of the lobe is dissected and divided to expose the bronchus.

The bronchus is divided with a stapler. The lobe is removed.

Discussion

Although VATS lobectomy has been demonstrated to be safe and effective, the technique is not widely. This may, in part, reflect difficulty in acquiring appropriate skills (6).

This minimally invasive technique places special demands on the surgeons. Using simulation-based training on artificial models or animals has been proposed to overcome the initial part of the learning curve (7,8).

Surgical simulation may be able to facilitate a more rapid and safe introduction into surgical practice without exposing the patient to unnecessary risk. There are number of relevant issues regarding simulation in thoracic surgery: computer-based, animal or tissue block (9,10). The virtual reality platform would be a good starting point for novice thoracic surgeons (11,12). The porcine model can then be used once surgeons gain some operative experience and will facilitate the development of fine dissection skills of hilar vessels (13).

Simulation may be able to replace some of the case numbers required to achieved proficiency in a complex operation, but this requires that the simulation environment have high fidelity and be challenging, constantly testing the learner's growing cognitive an technical skills (14).

Our experience with five courses in The Technological Center allows us to affirm that the sheep is an excellent model in VATS lobectomy training.

Summary

The uniportal VATS approach is the most ergonomic approach and it provides you a direct view to the hilar structures and the fissure (15). But you must be confident with the lung exposure and the instrumentation. The bimanual instrumentation is very helpful and to define every step is the key.

The practice in the animal model is a good option to acquire these skills.

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Footnote

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Techniques and difficulties dealing with hilar and interlobar benign lymphadenopathy in uniportal VATS

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Background: Surgical treatment of lung cancer has evolved to a minimally invasive approach and currently is recognized as an acceptable treatment for resectable non-small cell lung cancer (NSCLC). As the volume and complexity of cases has increased technical difficulties had arisen. Hilar and sublobar lymph nodes can represent a challenge for video-assisted thoracoscopic surgery (VATS) surgeons in order to complete a safe dissection of vascular and bronchial structures without complications or conversion. It is not unusual the patients with smoking history or benign infections in the past present with enlarged calcified nodes that are fused to the hilum, fissure and specially the bronchus which can lead to an accident during the procedure if the surgeon has no experience handling this issue. As the amount of surgeons carrying out VATS lobectomies grows it is very important for them to know what to do in this specific case so the completion of the procedure can be achieved safely.

Methods: The coordination between the surgeon and the assistant is very important in order to carry out the procedure without discomfort positions and good visualization, the use of energy devices in expert hands can help considerably during the dissection of lymph nodes in the hilum and fissure reducing the bleeding, which provides a clean operative field. It is a necessary maneuver during the dissection to find the correct adventitial plane between the lymph node and the structure before passing it.

Results: The videos in this article show the different maneuvers a VATS surgeon can implement when facing enlarged fussed lymph nodes in the hilum, fissure or mediastinum. Improving exposure, opening the fissure, using energy and carrying out the dissection through the correct plane are keys to complete the procedure successfully.

Conclusions: With growing experience in uniportal VATS and advances in surgical technology, enlarged or fussed lymph nodes are no longer a contraindication to complete a VATS lobectomy, experience VATS surgeons have a repertory of options in order to perform a safe and effective dissection.

Keywords: Uniportal video-assisted thoracoscopic surgery (VATS); lymph node dissection; lymphadenectomy; minimally invasive

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Introduction

Currently video-assisted thoracoscopic surgery (VATS) lobectomy is recognized as an acceptable option for resectable non-small cell lung cancer (NSCLC) (1). Minimally invasive approach in thoracic surgery offers a number of advantages for patients including less pain, faster recovery and better cosmesis.

Uniportal VATS lobectomy was first describe by González-Rivas in 2010 (2), and since then it has continuously been adopted by more and more surgeons around the world. This also has been possible thanks to numerous workshops and masterclass that teach the technique to willing surgeons.

As experience grows in uniportal VATS that complexity and technical difficulty of the cases approach become continuously more challenging for the VATS surgeon. One particular task in order to complete a uniportal VATS lobectomy is successfully carrying out the dissection of structures that are block by enlarged lymph nodes fussed to them.

A correct training following the steps necessary to acquire experience with the technique prepare the VATS surgeon to face this challenging cases and permits that the patient receive the advantages of a minimally invasive approach.

This article focus on the different options the surgical team has for the dissection of particularly difficult lymph nodes during uniportal VATS lobectomy.

Methods

Patient selection and workup

The steps for obtaining good results begin with patient selection through and adequate medical history and preoperative workup. Patients with past history of tuberculosis (TB) infection, heavy smokers or exposed to working places with hazardous environmental conditions like mining, constructions and factories tend to have enlarged, calcified lymph nodes that get severely stacked, so based on the patient medical history the surgeon can be prepared in advanced for this findings.

Preoperative CT is an important tool that can help the surgeon identify the specific anatomic location of enlarged lymph nodes. Usually they can be easily identified as a conglomerate in the hilum or in the fissure near the bronchus or vessels. Once the surgeon knows in advance in which moments of the dissection they will face this difficulty, they can use it to plan in advance how to deal with this issue during the dissection of structures in an anatomical lung resection.

Equipment preference

Although uniportal VATS can be perform with conventional VATS instruments, the use of special instruments can facilitate considerably the procedure. Longer instruments with distal and proximal articulation, high definition camera with 30 degree thoracoscope and distally mounted charge-couple device (CCD) facilitates instrumentation and reduce "fighting" between instruments (3,4). Recent advance in technology has contribute a lot in the simplification of dissection, with energy devices that permit precise dissection between lymph nodes, sealing small vessels around them avoiding bleeding that can obscure the field and compromise the visualization during the rest of the step or even the procedure. Sometimes when the plane between the lymph nodes and structures is difficult to identified, having the proper uniportal VATS forceps can help to reach the correct adventitial plane, which is the key for successful dissection (5).

Procedure

During single-incision video-assisted surgery there are many considerations that will make the procedure more comfortable and fluent for the surgeon and the team involved in the surgery. The surgeon and the assistant should be position in the same side, allowing them to share the same thoracoscopic view and improve coordination between the surgeon and the camera assistant (3,4). The role of the camera assistant is important during any VATS procedure but is specially demanding during uniportal VATS since it lacks the fixation of one port for the camera only that is usual during multiport VATS. This requires that the assistant is always focused in keeping the camera in the posterior part of the incision (4). A learning curve is also necessary to get the right view angles, usually through the rotation of a 30-degree lens camera that permits a target visualization during complex dissection steps, such as vascular dissection between enlarged and fixated lymph nodes. When the assistant is position in the other side of the operating table it is usual that they end up adopting uncomfortable positions to get the right view, which ends up being very exhausting for them.

The consolidation of uniportal VATS oncologic surgery has been possible because it has shown that transoperative

Figure 1 Uniportal video-assisted right upper lobectomy (9). This video shows a case of benign (TB) lymphadenopathy blocking the bronchus and the space between the pulmonary artery and upper pulmonary vein. It demonstrates the relevance of finding the correct adventitial plane to dissect away the lymph nodes. TB, tuberculosis.

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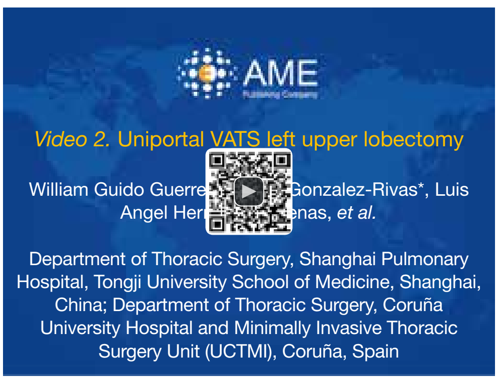

Figure 2 Uniportal VATS left upper lobectomy (12). This video shows lymphadenopathy blocking the left upper bronchus and the pulmonary artery in the fissure. It shows how to improve exposure by opening the fissure and finding the correct adventitial plane to dissect the lymph nodes. VATS, video-assisted thoracoscopic surgery.

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oncologic principles can be achieve by this approach without compromising safety of the patient (6). It is of most relevance that during the dissection of structures, oncologic principles must be respected and follow, accomplishing individual dissection of veins, arteries and bronchus, as well to complete an appropriate lymphadenectomy (3).

The procedure must be carried out with safety and this requires to maintain always a correct exposure through retraction and bimanual instrumentation that allows good visualization of the operation field you are working on (7,8). For example, when dealing with hilar lymph nodes, an adequate retraction of the lung can help to expose to superior, posterior and inferior part of the hilum, so it allows the surgeon to dissect all around the lymph nodes that are blocking the structures, making it easier to identify the correct plane and remove the lymph nodes exposing completely the hilum for dissection and subsequent individualization and division of the vessels and bronchus.

When the hilar lymph nodes are between vascular structures such as the pulmonary artery and vein, and they are blocking the way between them, the key step is to identified the adventitial plane adjacent to the vessel and carry the dissection and individualization of the vessel thru that layer, avoiding the lymph node (5) (*Figure 1*). Forcing the dissection thru the lymph node is a mistake frequently made, it usually leads to bleeding from the lymph node which obscures the operative field and can result in applying excessive force in order to pass across the lymph node, which at the same time could lead to injure the vessel the surgeon is trying to dissect or even injure other structures around like bronchus, lung parenquima or nearby vessels.

There are maneuvers that can be made in order to avoid undesirable injures during dissection of the interlobar pulmonary artery or lobar bronchus in the fissure when they are obstructed by enlarged and fused lymph nodes. When the fissure is complete, if it's possible, avoid the lymph node blocking the structure and dissect proximally or distally to it, where the planes are more preserve and safer, and after doing so, dissect the lymph nodes away using blunt dissection or pulling them carefully away to get enough space to divide the structure with a stapler if necessary. If the fissure is incomplete is very important to open the fissure and complete it through the fissureless technique (10,11), doing it, allows a better visualization an optimized control (*Figure 2*), because it lets the surgeon see the other side of the pulmonary artery and bronchus when dissecting and passing them, making it a safe maneuver. The second maneuver the surgeon can make is to dissect the adventitial tissue on top of the structure the lymph node is blocking, and use this plane to easily dissect and remove the lymph node. After removing the lymph nodes the structures usually become apparent very easily and facilitates subsequent steps of the procedure. This option is better than trying to remove the lymph node by grasping directly to it, because frequently leads to fragmentation and bleeding from it.

Figure 3 Uniportal VATS radical lymph node dissection (14). This video shows how energy devices can help during lymph node dissection in complex cases with big lymph nodes reducing bleeding and facilitating the procedure. VATS, video-assisted thoracoscopic surgery.
Available online: http://www.asvide.com/articles/796

Another consideration to be made during VATS uniportal procedures is that to improve the visualization in a specific step of the procedure, changing the position and orientation of the operating table improves the exposure and minimize the retraction that is necessary to see the surgical field. For example, rotating the table anteriorly when the surgeon is dissecting station 7 or putting it in anti-Trendelenburg position when dissecting station 2 and 4 (4).

It is important to keep in mind that in difficult cases with enlarged lymph nodes that are severely pasted to vascular structures, in spite of all the measures that are carried out by the surgical team to avoid complications they can still happen. Complications such as bleeding from branches of the pulmonary artery during the dissection should be anticipated and the surgeon must be ready to deal with them. In case that they present it is crucial to remain calm, use a sponge stick to compress the bleeding site and in that moment decide is the bleeding can be controlled through the VATS approach or if it is necessary to convert to open surgery. Usually experience surgeons are able to control the bleeding under VATS maneuvers, using energy devices, clips or suturing the injury. All of the steps are carried out after adequate exposure and control of the bleeding site (13).

Results

Tips and tricks

- High definition cameras and appropriate uniportal VATS instruments facilitates considerably the procedure for the surgeon.
- The use of energy devices during the dissection helps minimized the bleeding, permitting a more clean operative field (*Figure 3*).
- Maximize exposure of the operative field by adequate retraction of the lung and opening the fissure when needed.
- Avoid dissecting through the lymph node, instead find the correct adventitial plane of the structure being dissected, it facilitates the dissection and avoids bleeding from the lymph node.
- Use the adventitial plane of the structure being dissected to remove and pull away the lymph node obstructing it, instead of grasping it directly.
- Surgeon always must anticipate possible complications in order to be ready to handle them.

Conclusions

Benign lymphadenopathy that are fussed to vascular or bronchial structure do not contraindicate uniportal VATS lobectomy in the hands of experience surgeons. Conversion and complications can be avoided by dealing with the lymph nodes with a careful surgical technique that avoids injury to surrounding structures. The surgeon that face this kind of cases should be experience in handling bleeding through a VATS approach and has the support of an team (assistant, anesthesiologist and nurses) prepare to face such situations.

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Footnote

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Informed Consent: Written informed consent was obtained from the patient. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

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Total anatomic vascular dissection for lobectomy by using only energy devices

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Background: The introduction of ultrasonic energy into surgical dissecting devices was a technological breakthrough in minimally invasive surgery in the 1990s.

Methods: Nowadays, the energy devices are used very often during video-assisted thoracoscopic surgery (VATS) especially for lymph node dissection and for transection of small pulmonary vessels. However these devices can be used for hilar anatomic dissection in expert hands.

Results: In this video we show a right lower lobectomy performed by uniportal VATS in where the anatomic dissection of artery, vein and bronchus was performed by only using an ultrasonic energy device (Harmonic scalpel). The total surgical time for lobectomy was 30 minutes and 20 minutes for lymph node dissection.

Conclusions: The use of energy devices for vascular and bronchial dissection during lobectomy is feasible and safe when performed by expert thoracoscopic surgeons.

Keywords: Energy devices; anatomic dissection; lobectomy; uniportal video-assisted thoracoscopic surgery (VATS); vascular dissection

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The introduction of ultrasonic energy into surgical dissecting devices was a technological breakthrough in minimally invasive surgery in the 1990s. Nowadays, the modern ultrasonic coagulation shears are used very often during video-assisted thoracoscopic surgery (VATS). The most frequent use is for the lymph node dissection but these devices can be used even for vascular dissection. Some authors recommend avoiding the use of ultrasound energy near vascular structures to prevent thermal injuries from ultrasonic coagulation shears. However, energy devices are very safe in expert hands and the vascular dissection can be performed safely. These devices offer cutting, coagulation, dissecting, and grasping all in a single system. The versatility and safety profiles make ultrasonic energy a compelling technology to consider for VATS lobectomy.

In this video we show an uniportal VATS right lower lobectomy in where the total anatomic hilar dissection was performed by using only ultrasound energy devices (*Figure 1*).

Figure 1 Total anatomic vascular dissection for lobectomy by using only ultrasound coagulation shears (1).
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Management of complications by uniportal video-assisted thoracoscopic surgery

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Abstract: Since the video-assisted thoracoscopic surgery (VATS) anatomic lobectomy for lung cancer was described two decades ago, many units have successfully adopted this technique. VATS lobectomy is a safe and effective approach for the treatment not only of early stage lung cancer but also for more advanced disease. It represents a technical challenge. As the surgeon's experience grows, more complex or advanced cases are approached using the VATS approach. However, as VATS lobectomy has been applied to more advanced cases, the rate of conversion to open thoracotomy has increased, particularly early in the surgeon's learning curve, mostly due to the occurrence of complications. The best strategy for facing complications of VATS lobectomy is to prevent them from happening. Avoiding complications is subject to an appropriate preoperative workup and patient selection. Planning for a VATS resection as safely as possible involves the consideration of the patient´s characteristics and the anticipated technical aspects of the case. Awareness of the possibility of intraoperative complications of VATS lobectomy is mandatory to avoid them, and the development of management strategies is necessary to limit morbidity if they occur.

Keywords: Complications; uniportal; video-assisted thoracic surgery (VATS); bleeding; lobectomy

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Introduction

The video-assisted thoracoscopic surgery (VATS) lobectomy is a safe and effective approach for the treatment, not only of early stage lung cancer but also for more advanced disease.

It represents a technical challenge, perhaps due to perceived technical challenges when compared to the more conventional open approach and because of the intraoperative complications, particularly early in the surgeon's learning curve.

The best strategy for facing the complications of VATS lobectomy is to prevent them from happening. Avoiding complications is subject to an appropriate preoperative workup and patient selection (1).

Planning for a VATS resection to be as safely as possible involves the consideration of the patient's characteristics, the radiographic appearance of the area of the lung to be removed and the anticipated technical aspects of the case (1).

Our objective is to describe how to solve intraoperative complications and avoiding catastrophic complications. Catastrophic complication is defined as an event that results in an additional unplanned major surgical procedure other than the intended lobectomy (2).

Operative technique

There are different causes of complications that could lead us to convert to open thoracotomy. Generally, we can classify the reasons for conversion into four categories:

- ❖ Technical problems;
- ❖ Bleeding;
- ❖ Airway injury;
- ❖ Oncological reasons.

Technical problems

These are some of the technical problems that can lead us to have intraoperative complications.

A fused or complex fissure or true pleural symphysis present a technical challenge to VATS lobectomy. The key to an adequate detachment is to find the correct plane in the pleural cavity and to create a space; then we can perform the adhesiolysis using a combination of sharp and blunt dissection (1). With the uniportal approach we have the advantage in visualizing, with high resolution for details, the apex and the base of the hemithorax (*Figures 1,2*).

Complex artery/vein or bronchus dissection or a difficult anatomy can also lead to abandonment of the VATS approach, although with improving surgeon experience and comfort with VATS lobectomy, these cases can be accomplished. The presence of calcified hilar and/or periarterial lymph nodes can likewise complicate vascular dissection. Regarding complex hilar structures dissection, the key is to find the adventicial plane (*Figure 3*). In the video, we see an artery fused to the vein and to the lymph node. Note the utility of the bimanual instrumentation and how we can perform the dissection with simple instruments (curved ring forceps, long scissors, suction and a conventional dissector).

A previous ipsilateral surgery is also no longer a contraindication as Redo-VATS surgery had been reported.

Another reasons for conversion could be emphysematous lung or the absence of lung collapse, due to the small space available to perform the surgery. The difficulty for digital palpation or identification of the target lesion (mostly, small nodules) is another cause of conversion.

The uses of high doses of prior chemo-radiotherapy have previously been considered a relative contraindication, but VATS lobectomy can be performed safely and effectively for these patients (1).

Finally, chest involvement requires thoracotomy for resection, but VATS can be used to perform the lobectomy and allow placement of the better incision to the chest wall removal.

Bleeding

Without doubt the most dangerous intraoperative complication is major bleeding. The uniportal VATS approach usually offers excellent visibility of the operative field, thus intrathoracic hemorrhage is rare.

If bleeding occurs, a sponge stick should be available to apply pressure immediately to control the hemorrhage; it is always important to remain calm and not to panic. With the bleeding temporarily controlled, a decision must be made promptly as to whether thoracotomy is needed (3) or if it can be solved through the VATS approach. This will depend mostly on the surgeon's experience.

Focusing on the artery bleeding, care must be taken during the vascular dissection as well as to the lung traction, especially if an advanced case is performed. Dissection of the vessels can be difficult due to a wide variety of causes and bleeding can be high even by thoracotomy depending on the complexity of the procedure. For example, during the approach of the artery from the hilum, a bleeding can occur (*Figures 4,5*). In this case, we did not know exactly where it was coming from. So, the first step in order to achieve any bleeding control was made: compression with a sponge stick and consideration of the appropriate strategy. Then, the anterior arterial trunk was divided and the anterior portion of the minor fissure completed; these steps allowed us to reduce tractions and improve the vascular control. Then the posterior ascending arterial branch to the right upper lobe could be identified and also another arterial branch (which probably was the one that caused the bleeding). At last, the bleeding was controlled with a proximal vascular clip.

Regarding the correct planning of the VATS lobectomy, consideration of the patient's characteristics is very important. Furthermore, certain vascular anomalies resulting in conversion are often visible on preoperative enhanced CT. Care must be taken to avoid injuring unexpected small branches (*Figure 6*). In this case a left upper lobectomy was performed. After the bronchus transection, a bleeding was caused. Again, the first step must be to remain calm and think of a new strategy. "Are we able to control the bleeding?" "Is the bleeding very important?" Once these questions were answered, we placed a vascular clip using bimanual instrumentation and the complication was solved through VATS.

Nevertheless, the use of several developments to avoid the bleeding problems or even to the vascular division can also be the cause of bleeding. For example, an unexpected displaced clip can cause a bleeding (*Figure 7*). Looking at the top left corner we can identify the source of the bleeding: an accidental displacement of the proximal vascular clip during the lung retraction. We proceed to stem the bleeding with compression. Then, the change of the lung exposure allowed us to identify the source of the bleeding and finally reclipping the artery.

Another key point to take into consideration occurs

Figure 1 Adhesiolysis (3).
Available online: http://www.asvide.com/articles/341

Figure 2 Adhesiolysis (4).
Available online: http://www.asvide.com/articles/342

Figure 3 Complex hilar structures dissection (5).
Available online: http://www.asvide.com/articles/343

Figure 4 Arterial branch bleeding (7).
Available online: http://www.asvide.com/articles/344

Figure 5 Arterial branch bleeding (8).
Available online: http://www.asvide.com/articles/345

Figure 6 Unexpected bleeding (9).
Available online: http://www.asvide.com/articles/346

during the lymphadenectomy, due to the major vascular structures nearby. As in this situation, while the right paratracheal lymphadenectomy was being performed (*Figure 8*), the azygos vein was injured in its proximal aspect without us noticing. The bleeding was controlled with a vascular clamp and by stapling the azygos vein.

With advanced skill and experience in VATS surgery, in the event of minor to moderate bleeding, conversion can

Figure 7 Bleeding after unexpected displaced clip (10).
Available online: http://www.asvide.com/articles/347

Figure 8 Azygos vein bleeding (11).
Available online: http://www.asvide.com/articles/348

Figure 9 Bleeding control with suture (12).
Available online: http://www.asvide.com/articles/349

often be avoided. For example, during the performance of an upper lobectomy, one of the branches can be injured (*Figure 9*). After compression, the mediastinal trunk was dissected and controlled, so the tear was sutured.

Figure 10 Left upper lobectomy. Bleeding control (13).
Available online: http://www.asvide.com/articles/350

Figure 11 Airway injury (14).
Available online: http://www.asvide.com/articles/351

Finally, the last example of bleeding control: a left upper lobectomy performed on a patient who had received prior induction chemotherapy. During the arterial dissection, a branch was damaged. Then we dissected one of the branches of the vein in order to get obtain a good angle to control the mediastinal trunk of the artery. Once the mediastinal trunk was controlled, the arterial branch was clipped in the proximal and distal aspect (*Figure 10*).

Airway injury

Although this is not the most common cause of conversion, it has to be taken into consideration. The failure of the stapler or a major air leak after performing a lobectomy on a patient with severe emphysema or a complex/fused fissure, can lead to conversion in order to repair the air leak.

Another cause would be the bronchus or trachea injury by the endotracheal tube. As in the video (*Figure 11*), after a uniportal VATS left lower lobectomy, small bubbles were identified deep down in the subcarinal space during the dissection of the subcarinal station. Also, mediastinal emphysema and air leak from the aortopulmonary window were noticed. There was no air leak from the bronchus stump, nor at the anesthetic monitor, so the patient was extubated. When the patient was at the ICU, a CT scan was performed due to subcutaneous emphysema, where a right tracheal wall disruption caused by the double lumen tube was observed. Suturing the wall of the trachea through a right thoracotomy repaired the problem.

Comments

During VATS lobectomy the most important aspect is to prevent complications. Avoidance is enhanced by a solid knowledge of the anatomic relationships, careful dissection, awareness of the potential complications and the judicious conversion to thoracotomy when appropriate (2). If a complication occurs, we have to consider the management strategy. It is essential to have a good preoperative workup, the bimanual instrumentation and a good exposure of the lung or the target area. Ultimately, the decision for conversion is left to each surgeon's skills and patience. The surgeon has to feel comfortable with the approach, whatever it is. Finally the most important consideration above all is never panic and always keep calm.

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Footnote

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Uniportal video-assisted thoracoscopic major pulmonary resections

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Abstract: Uniportal thoracic surgery is being continuously adopted by thoracic units around the world. Growing interest in the procedure is demonstrated by numerous workshops and training programs along every continent. The success of the technique lies in that it does not compromise oncologic principles and be carried out safely when proper training is acquired. For a surgeon to be able to perform a uniportal lobectomy successfully and safely proper steps must be ensuring. Multiple key maneuver and tricks are inherent to the uniportal approach. This article summarizes the equipment and key steps necessary to do a uniportal lobectomy.

Keywords: Uniportal; video-assisted thoracic surgery (VATS); lobectomy; single-port; single incision

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Introduction

One of the most important breakthroughs in thoracic surgery has been the development of video-assisted thoracic surgery (VATS) (1). It has revolutionized how surgeons treat thoracic diseases (2). In the early 1990s, it began to be used to perform major lung resections (3), starting an era of continuous growth in minimally invasive thoracic surgery (MITS).

The last stop in the quest for a better minimally invasive procedure is the single port approach or uniportal VATS. Rocco was the first one to describe the approach for minor thoracic procedures (4) González-Rivas and colleagues were the first team to perform an uniportal VATS lobectomy in La Coruña in 2010 (5) Since then, the technique has had an exponential widespread around the world, being performed by more and more units every year thanks to numerous workshops and training programs. (6)

Technology improvement in high definition cameras, instrumentation, staplers and energy devices has allowed that uniportal VATS can also be implemented as an approach not only for standard cases but for advance tumors and for vascular and bronchial reconstruction (7).

Uniportal VATS lobectomies can be perform safely by thoracic surgeons around the world as long as they follow the proper steps in order to learn the technique, gain experience with it and carried it out in their own units.

Patient selection and workup

When it comes to patient selection there are two scenarios, one is for the experience uniportal VATS surgeon in a high volume center and the other is for the surgeon in the learning curve or that has just surpass it.

For the experience surgeon, very complex and technically difficult cases can be done successfully, including sleeve lobectomies, vascular reconstruction or tumors invading the chest Wall (8). With exception of tumor size (tumors bigger than 8 cm are difficult to take out without rib spreading) (9), patients that are candidates for a major lung resection with an open approach should be eligible for a single port approach. And this is one of the key things to keep in mind about this technique, it does not compromise oncologic principles and basically carry out the same procedure as in open surgery but through a minimally invasive approach with VATS instruments. The complexity of the case although may be challenging, does not mean a

Figure 1 Uniportal VATS equipment (instruments with proximal and distal articulation). VATS, video-assisted thoracic surgery.

contraindication in this scenario.

VATS surgeons that are inexperience or just surpass the learning curve should focus on early stage lung cancer lobectomies and avoid complex cases like reinterventions, sleeve resections, big tumor or cases with lots of benign lymphadenopathy around the hilum or fissure in order to avoid complications such as bleeding during the surgery.

During the work up, there are two very important aspects that will inform the surgeon of potential difficulties in a particular case. First patient previous history of tuberculosis, bronchiectasis or previous surgery should prepare the surgeon for adhesions and lymphadenopathies that will make dissection especially difficult. Second the CT image will show big lymph nodes in the probable site of dissection, big lung tumors or anatomical relations that will make the procedure especially difficult to finish without conversion (7).

Timely conversion should never be considered a complication but an appropriate step during a VATS procedure.

Pre-operative preparation

Patients that are candidates for a uniportal VATS lobectomy can undergo the same institutional protocols as other approaches lobectomies (multiport or open lobectomies) and the patient has to know that conversion to an open procedure is a possibility during the procedure as a step to avoid complications or risky situations.

It is appropriate to accompany single port MITS with fast track protocols that should began when the surgeon interview the patient in the outpatient clinic managing patient expectations and addressing their concerns. An educational program of respiratory exercises and smoke cessation will be helpful for the postoperative recovery (10).

When the surgeon is experience to do so, a pre-operative conference with the anesthesiologist discussing the possibility of a non-intubated uniportal VATS lobectomy is important for a good coordination and safe planning for the surgery.

Equipment preference

Optimal equipment can facilitate and made more comfortable the procedure for the surgeon. The ideal equipment necessary to perform a major lung resection includes:

- 30-degree lens high definition camera thorocoscope: provides a very detailed image and permits the assistant to move the angle of the camera to obtain the appropriate visualization around structures during visualization;
- Distally mounted charge couple device (CCD): it reduces the fighting between the surgeon and the assistant (11);
- Instruments with distal and proximal articulation: a complete set of instruments such as the one show in *Figure 1* allows the surgeon to do the surgery without having troubles with the incision, since only the fixed part of the instrument is in contact with it during dissection (*Figure 1*);
- Wound retractor: it is not always necessary, although it might help to prevent camera smearing in fat patients or with inexperience assistants;
- Reticulated staplers: the angulation of the staplers makes it easy to pass the structure, avoiding tension and unnecessary risks during this step;
- Vascular clips (click a-V Grena): for vessel when the angle for vascular division is difficult, also for small segmental branches of the pulmonary artery that can be safely divided using this clips;
- Energy devices: they permit to keep the operative field clean and avoid unnecessary bleeding from small vessels in fatty tissues or around lymph nodes. During lymph node dissection can avoid lymph leaking after the surgery.

Although the equipment mentioned above is the ideal one in the present to perform and uniportal VATS lobectomy it is not mandatory, the surgery can be performed with conventional VATS instruments (6), but with more technical difficulty.

Figure 2 Surgeon and assistant located at the same size of the table.

Role of team members

The surgeon and the assistant must be positioned in the same side, in order for them to share the same view and work in coordination (*Figure 2*). The surgeon should be position in front of the incision, with the monitor directly in front, at the level of the eyes. In this way the surgeon avoids to take uncomfortable positions during the whole surgery. The assistant has to be much focused in keeping the camera in the posterior part of the incision and avoid lens smearing. During the surgery the assistant can change position between the left and right side of the surgeon in order to get the best angle of visualization.

The nurse should be placed in the other side of the patient, taking care not to obscure the visualization of the monitor.

The anesthesiologist has to be communicating with the surgeon during the procedure, in order to avoid unexpected movement (cough) during critical dissection of vessels. When it is a non-intubated procedure, the coordination during the surgery is mandatory and requires for a very close control of the condition of the patient.

Procedure

In uniportal VATS, is important that the surgeon maintain comfortable positions during the surgery in order to avoid fatigue. The best way to achieve this is in a way remembering that the surgeon is mimicking open surgery and should reproduce this condition. For example, is better to position the monitor in front of the surgeon at the level of his eyes, instead of putting it in near the head of the patient, because that will make the surgeon keep his head turn to this side during the entire procedure. The assistant should be positioned at the same side of the surgeon so they will share the same vision and coordinate better their movements.

The patient is position in lateral decubitus, and the procedure can be done under general anesthesia with double lumen intubation or without intubation (only by expert uniportal surgeons). The surgical table can be move away or to the surgeon in order to help in the exposure of structures and lymph node stations, since by gravity the lung is pull away from the operative field.

The incision is located at the 5th intercostal space, in the anterior position of the mid axillary line, although sometimes the 4th intercostal space can be used for upper lobes. Trocar is not needed for uniportal VATS, so nerve damaged by compression is minimized and space available in the incision maximized.

The role of the camera man is very important and difficult, because in order for the surgeon to be comfortable the assistant has to sometimes take positions that are demanding and at the same time get the right view of the surgical field, which requires a learning curve also and a lot of team work to be correct.

It is also important to remember that the camera should always be in the posterior part of the port, and the instruments enter the thoracic cavity from below, in this way resembling the eye and hand configuration as open surgery.

The approach to the target lesion is very similar as the one use in the open technique, because the visualization occurs along the same axis (12) and the angles of vision require performing a safe and detailed dissection can be obtained by moving the angle of the 30-degree lens camera (5,6).

During the entire procedure the surgeon must perform bimanual instrumentation, making the exposure and dissection better and easier. The retraction has to be carried out by the assistant, allowing the surgeon to use both hands and instrument for dissection.

The technique for upper lobectomies usually begins by dividing the first branches of the pulmonary artery, creating space and avoiding obstruction for the stapler for the vein division that comes afterwards. Then the bronchus as dissected and divided and the fissure is usually complete at last. For lower lobectomies the procedure usually begins with the pulmonary ligament, the inferior pulmonary vein, then the pulmonary artery, bronchus and fissure at last.

Vessels are usually divided with stapler, but vascular clips can also be used. For bronchus and fissure division staplers are routinely the choice.

The specimen can be remove using and endo-bag or even a glove, taking care not rupture it in order to avoid spilling of the specimen that could compromise oncologic results. If a wound retractor was used for the surgery is better to removed it prior to take out the specimen in a bag, because to keep it in place could make this step more difficult since it can reduce the space or flexibility of the tissues in the wound.

At the end of the procedure the three intercostal spaces are infiltrated with bupivacaine under direct vision, usually the space of the incision and the one below and up from it.

Surgical steps for each lobe

Right lower lobectomy

The procedure usually begins with the dissection of the inferior pulmonary ligament, the lobe can be retracted upwards by the assistant and the surgeon use the sucker to put aside the diaphragm and the ligament divide with energy devices or cautery. Then posterior mediastinal pleura can be divided up until the fissure; this step will help make easier to pass the vein and to dissect the artery and separate it from lung parenchyma in fissure less technique. After the posterior pleura is dissected the vein is dissected and divided using a vascular stapler with a reticulation, a tie or the sucker can be used to help the anvil of the stapler pass the structure.

The next step is to dissect the artery that is done from anterior to posterior. It is not difficult when the fissure is complete because the surgeon just have to divide the visceral pleura from the artery, but when the fissure is incomplete it has to be perform with the fissure less technique. The dissection has to begin in the space between the inferior and medial pulmonary vein, then go upwards to encounter the bronchus, and just above it find the artery. Dissection above the artery will create the plane to put the stapler and complete the fissure (care must be taken to avoid injury to middle lobe artery). The artery can be divided after in one step if it can be pass easily or first dividing the basilar branch will allow a better exposure of sixth segment artery(can be divided using a clip). The last step of the lobectomy is dividing the bronchus in which is important a good retraction and correctly identifying the middle lobe bronchus to avoid damage to it during transection of the lower lobe bronchus.

In cases of very difficult fissures, such as bronchiectasis or thick incomplete fissures the best way is to perform a fissure less technique, starting with the ligament, then the inferior pulmonary vein, bronchus, artery and at last the fissure. Correctly identifying middle lobe structures would avoid injuries to them during transection.

Middle lobectomy

This lobectomy can be technically difficult in uniportal VATS, since the angles for division and dissection of the structures can be tricky. The lung must be retracted up and backwards by the assistant. The procedure began by identifying the middle lobe vein, dissecting it. When the major fissure is incomplete, the stapler can be put in the space between the middle and lower lobe vein, which would facilitate passing the middle lobe vein after with the stapler. If a safe angle cannot be obtain with the stapler a vascular clip (a-V Grena) can be used to divide the vein. The next step is to divide the bronchus taking care not to injure the artery that is just behind. The artery is staple next and at last the anterior portion of the minor fissure and the posterior portion of the major fissure.

Right upper lobectomy

The dissection usually begins with the artery, identifying the anterior arterial trunk and then dividing it with the stapler. This step facilitates to divide the vein after since it helps to obtain a better angle by removing the obstruction of the artery. The right upper bronchus will be expose along with the posterior ascending artery, so the surgeon can choose to divide the one that is better exposed in that moment. The posterior ascending artery can be stapled or divided using a clip and the bronchus divided using a stapler. Care must be taken when passing the bronchus to avoid damage to the azygos vein. At last the fissure can be divided using a stapler, always being sure that the stumps are not in the jaws of the stapler but in the lobe that is going to be resected. When the artery is occult because of an incomplete fissure the best way to expose it is to dissect between the middle and upper lobe vein, the bronchus will be expose and just above it the artery can be identified. It is safe to dissect above the plane between the artery and lung parenchyma, and to staple above the artery would avoid injuries to other structures and permit to complete the fissure. It is important to avoid vigorous retraction of the lobe before dividing the posterior ascending artery, because it might rupture and is not and unusual cause of bleeding and conversion when performed by inexperience surgeons.

Left lower lobectomy

The steps to complete a left lower lobectomy are very similar as those uses to complete a right lower lobectomy. The surgery begins by dissecting the pulmonary ligament and continues to dissect the posterior visceral pleura until the fissure, the plane should be close to the lung parenchyma to avoid injury to surrounding structures. The next step is to

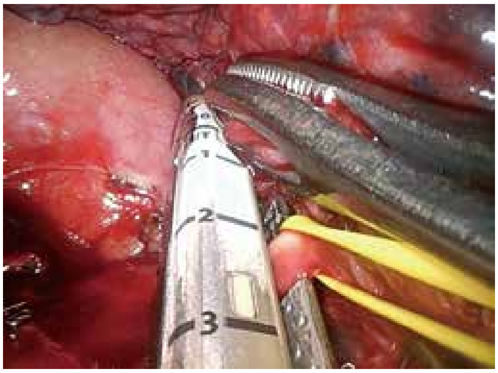

Figure 3 Retraction with a rubber band of the vascular structure that facilitates the insertion of the stapler.

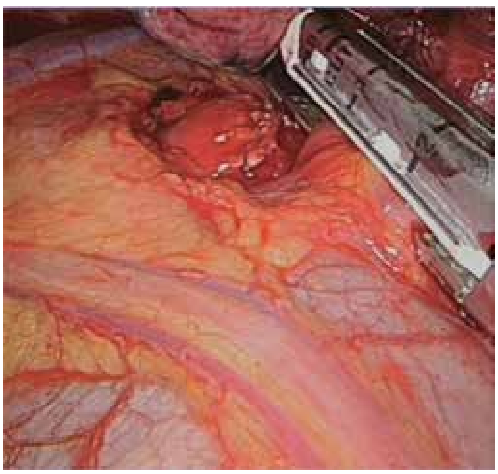

Figure 4 Vascular stapler passing the vein after the anterior trunk has been divided.

divide the lower lobe vein. When dissecting the artery care must be taken to identify the lingular artery so it will not be injure when the lower lobe artery is stapled. In case of incomplete fissure the surgeon can use the same maneuver to find the artery as in the right lower lobe. Dissect the space between the upper and lower vein, the artery will be just above the bronchus. The staple can be safely placed just above the artery to divide the lung in the fissure.

Left upper lobectomy

The left upper lobectomy should be carried out by a surgeon that has prior experience with uniportal vascular dissection, stapling, ligation and that has successfully performed other uniportal lobectomies, specially a right upper lobectomy.

This lobectomy, along with the middle lobe lobectomy are perhaps the most difficult ones to perform in uniportal VATS, but the risk of bleeding secondary to vascular injury is more frequent an important in the left upper lobectomy. This is especially true in two steps, when dissecting the anterior trunk an injury can be done to the base of the artery by traction and when passing the stapler through the vein, without good exposure and traction the anvil can injure the pulmonary artery behind, causing a major bleeding. A tie can be used to retract the vein or the sucker pass through the space in order to facilitate the step and avoid this injury (*Figure 3*).

The dissection begins with the anterior trunk, a key maneuver is to expose to posterior part of the trunk before trying to pass it, because it avoids unnecessary traction to the vessel. After dividing the trunk the vein can be dissected ant then staple with a reticulated endostapler, avoiding injury to the pulmonary artery behind with the anvil of the stapler (*Figure 4*). To facilitate this step is important to dissect the vein as distally as possible. The next step is to dissect the fissure, which can be easy when is complete or requires identifying the artery between the upper and lower lobe vein in order to complete it. Lingular artery and the rest of the branches can be ligated, staple or divided using a vascular clip. The last step is the bronchus, which is easy if all the vascular structures are divided, but is more difficult if the lingular artery is not divided, because is just behind the bronchus. Dividing the bronchus with scissors or using a TA are maneuvers needed to complete this task. When cut the bronchus can be closed with sutures or staplers.

Lymphadenectomy

A complete lymph node dissection that follows the same oncologic principles as conventional VATS or open surgery can be performed. In block resection of the lymph nodes must be pursued and energy devices are especially helpful to maintain a clean operative field.

The surgical table can be move in order to facilitate visualization of lymph node stations. When dissecting station 7, the table can be moved anteriorly, and sponge stick can be use by the assistant to retract the lung and expose station 7. This will provide and excellent visualization and allow the surgeon to use both hands to remove the lymph nodes. In the right side care must be taken to retract away the esophagus in order to avoid injury to it.

For paratracheal lymph node dissection, the patient should be placed in anti-trendelenburg position, and the pleura below the azygos vein dissect, then remove the lymph nodes and fatty tissue in block by dissecting it away from the superior vena cava, vagus nerve. The lymph nodes then can be finally removed from remaining attachments by opening the pleura above and pulling them up.

For the aortopulmonary window, exposure is also improved in anti-trendelenburg position, dissection should avoid injury to the recurrent laryngeal nerve.

Post-operative management

Fast track protocols are important in order to maximize the benefits of a uniportal VATS approach. The patient can resume oral feeding the same day of the surgery and can initiate walking with help. The chest tube can be removed in absence of bleeding and air leak. Respiratory rehabilitation should start from the same postoperative day and incentive in spirometry must be reinforced. In case of no intubated lobectomies studies suggest patients can recover faster and resume ordinary activities sooner.

Tips and tricks

- Maintain always ergonomic positions in order to avoid fatigue;
- Keep the camera in the posterior part of the incision;
- The assistant must perform the retraction of the lobe so that the surgeon perform bimanual instrumentation;
- To optimized exposure, the surgical table can be move in some steps of the surgery, especially in lymph node dissection;
- In upper lobectomies dividing the anterior trunk first helps to facilitate the division of the vein;
- Using a tie or the sucker to facilitate the passing of the stapler when dividing the vein are key maneuvers to avoid injury to the artery in upper lobes;
- In incomplete fissures the artery can be located by dissecting upwards from the space between lobes veins, creating a safe plane top putt he staple and complete the fissure.

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Non-intubated (tubeless) uniportal video-assisted thoracoscopic lobectomy

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During the last decade, there have been important developments in new minimally invasive surgical techniques for major pulmonary resections (1). Advances in anesthesiology include a lack of general anesthesia in thoracic operations, by maintaining spontaneous ventilation, and minimal sedation of patients. The choice of a single-incision technique combined with the lack of general anesthesia further minimize the invasiveness of the procedure (2). Moreover, a 'tubeless' concept can be perfectly applied to these procedures. This involves the complete absence of a tracheal tube or even laryngeal mask, central line, urinary catheter or epidural. We present a video showing three cases of non-intubated (tubeless) uniportal video-assisted thoracoscopic surgery (VATS) major pulmonary resections (*Video 1*).

Clinical vignettes

First case

The patient is a 50 year-old female with a 4 cm adenocarcinoma located on the right upper lobe (RUL) with no lymph node involvement. The video shows a right upper lobectomy.

Second case

The patient is a 60 year-old male with a 3 cm tumor on the RUL. After a right upper lobectomy, a complete paratracheal lymph node dissection was performed, as shown in the video.

Third case

The patient is a 68 year-old male with a 4.2 cm non-small cell lung cancer in the left upper lobe with adhesions to the chest wall. The video shows a left upper lobectomy and lymph node dissection.

Clinical preparation

All patients underwent standard monitoring including electrocardiography, non-invasive blood pressure, pulse oximetry and respiratory rate measurements, with an approximation of the end-tidal carbon dioxide with a catheter placed in one nostril. The adequacy of ventilation and depth of sedation was monitored by using bispectral index or entropy.

The pharmacological management was based on a target-controlled infusion of remifentanyl and propofol, with a premedication of midazolam (0.15–0.25 mg/kg) and atropine (0.01 mg/kg) 15 minutes before anaesthesia, adjusting real-time rate of infusion with the aggressiveness of each period during the surgery.

As an intercostal nerve block, local anesthetic was administered at level T4–T5, in order to avoid any reaction of the patient due to the surgical incision (cases 2 and 3). For case 1 we only used a thoracoscopic intercostal block infiltration mixture of lidocaine 1% and levobupivacaine 0.2% to ensure fast onset of action and prolonged analgesia. We performed intrathoracic vagal blocks to inhibit visceral irritation and to minimize unwanted cough responses during nonintubated VATS (levobupivacaine 2 mL, 0.25%). Oxygen (6–9 L/min) was supplied via facial mask during the surgery. No central line, urinary catheter or epidural were used during the procedures.

Clinical results

All patients had an excellent recovery and were discharged home on the third, second and fourth postoperative days respectively with no complications.

Advantages

One of the major advantages of non-intubated VATS is to offer surgical opportunities for patients who are too risky for intubated general anesthesia A permissible transitory hypercapnia was usually noted in patients with severe emphysema but resolved after procedures

The quality of the pulmonary collapse obtained by iatrogenic pneumothorax via VATS under spontaneous breathing is excellent, or at least as good as in mechanical ventilation using a double-lumen endotracheal tube or bronchial blocker. The mechanism of performing this lung collapse is more physiological via a small intercostal incision than via one-lung ventilation (OLV), resulting in less lung inflammation and stress with the possibility of a faster and improved postoperative recovery and outcome (3).

Single-lung ventilation under spontaneous breathing also preserves a better match of ventilation and perfusion in the surgical position and avoids intubation-related airway trauma, mechanical ventilation-induced lung injury, residual muscular blockade and postoperative nausea and vomiting. Respiratory efficiency is increased by diaphragmatic function, which is maintained. Intrapulmonary shunting and hypoxemia are reduced compared to OLV intubated patients (4).

Another advantage of maintaining negative intrathoracic pressure due to spontaneous breathing is improved hemodynamic control, with no decrease in venous return related to the positive intrathoracic pressure generated during mechanical ventilation. Data from preliminary studies also suggest an attenuated stress response after awake VATS in comparison with equivalent procedures performed under general anesthesia and one-lung mechanical ventilation (3,4).

Caveats

Current reported studies support the contraindication of awake uniportal VATS in patients with anticipated difficulties in airway management, obesity (body mass index >30), dense and extensive pleural adhesions, hemodynamic instability, ASA classification over II and tumours greater than 6 cm (5). In order to ensure patient safety, a clearly defined protocol for elective or urgent intubation must be determined prior to the operation. Sometimes, intraoperative conversion to general anesthesia is inevitable and the surgical team must have a plan to minimize the risk of the patient. In case of complications such as major bleeding, strong adhesions, significant mediastinal movement or persistent hypoxaemia and tachypnea, it is suggested to make an early conversion to intubated general anaesthesia. We recommend the insertion of a double-lumen tube maintaining the lateral decubitus position for expert and skilled anaesthesiologists or, if it is not possible, intubation with a single-lumen tube followed by insertion of a bronchial blocker while trying to maintain the patient's position.

There is a risk of experiencing a hypercapnia-related rebreathing effect from the initial paradoxical respiration and hypoventilation due to collapse of the operated lung and sedation. However, it is rare to need support ventilation, which is only needed in patients with a severe restrictive or obstructive ventilatory defect. Ventilatory obstruction and hyperinflation in a dependent ventilated lung produce intrinsic positive end-expiratory pressure and decrease mediastinal shift, thus increasing functional residual capacity (FRC) and decreasing atelectasis. This reduces the risk of hypoxemia contrary to the restrictive ventilatory defect (4).

Conclusions

Nowadays, the evolution of video-assisted thoracic surgery to less invasive techniques, such as uniportal VATS (with only one incision of 3 cm) allows us to reconsider the possibility of avoiding intubation with general anesthesia for lobectomy. However, these non-intubated major pulmonary resections must only be performed by very experienced uniportal thoracoscopic surgeons, preferably skilled and experienced in complex or advanced cases and bleeding control through uniportal VATS. When there is a larger series of patients undergoing non-intubated VATS resections, a gold-standard technique may be defined. As a result, most patients could bypass intensive care units and be discharged home early, with a lower incidence of both surgical and anaesthetic complications. As Sir Winston Churchill said in 1942, "This is not the end. It's not even the beginning of the end… it's perhaps, the end of the beginning".

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Footnote

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Uniportal video-assisted thoracoscopic lymph node dissection

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Abstract: Lymphadenectomy is an important part of lung cancer surgery. At the moment, video-assisted thoracoscopic (VATS) is the most common approach to remove these tumors, when it is technically possible. With our current experience in VATS in major resections we have obtained a radical videothoracoscopic mediastinal lymphadenectomy, and single-port provides us with the best anatomic instrumentation and a direct view.

Keywords: Video-assisted thoracoscopic (VATS); lymphadenectomy; lung cancer; uniportal

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Introduction

Lymphadenectomy is important to identify the N, because it has a direct relationship to the prognosis after a lung tumor resection. For this reason, during the surgery, we have to be very careful with the N2 stations.

We have to distinguish between: (I) lymph node biopsy; obtaining a fragment (II) sampling: to obtain a node from each station and (III) the standard mediastinal dissection: which is to remove all the lymph nodes from at least three mediastinal stations from the affected side.

One of the principal concerns that appeared with video-assisted thoracic surgery (VATS) lobectomy was whether we could perform the same lymphadenectomy with VATS as we could perform with thoracotomy.

At present, with our current experience using VATS in many groups, we have achieved the same lymphadenectomy results with VATS as was previously obtained by a thoracotomy with even better results.

Thereby D'amico TA supports the view that videothoracoscopic mediastinal lymphadenectomy is just as feasable as conventional surgery, with similar results (1).

Watanabe A *et al*. analyzed a group of patients with lung tumor diagnosis and clinical N0, but with pathological N2 following lung resection by VATS or thoracotomy: they did not find any differences between groups in: (I) number of nodes, (II) number of nodal metastasis and (III) the 3- and 5-year recurrence-free survival. The authors concluded that it is unnecessary to convert the VATS approach to thoracotomy to do a radical mediastinal lymphadenectomy (2).

Wang W *et al.* compare the differences between VATS group and thoracotomy group in VATS lymphadenectomy results for 5,620 patients. They perform a systematic lymph node dissection with a greater number of nodes in VATS group, in addition to the known advantages of the VATS approach (3).

Figure 1 Paratracheal lymph node dissection (5). Available online: http://www.asvide.com/articles/336

Figure 2 Energy device for paratracheal lymph node dissection (6). Available online: http://www.asvide.com/articles/337

Operative techniques

We analyzed our experience in VATS for major resections for over a 3-year period [2007-2010] involving 200 cases, and we compared the differences between the three periods of time. We started performing VATS lobectomies with three ports (99 cases in the first year) and after that with only two ports or even the first single port lobectomy in the third year (4).

We observed improvements with the experience; we reduced the conversion rate, the mean surgical time, the number of lymph nodes as well as the explored nodal stations.

We must bear in mind the importance of the surgical material, which helps us to improve the lymphadenectomy. Especially with regards to:

(I) 10 mm thoracoscope (HD 30 degree);
(II) High definition monitor screen;
(III) Long, short and double-jointed curved ring forceps;
(IV) Long and double-jointed Metzenbaum scissors;
(V) Curved suction;
(VI) Long and double jointed thoracoscopic dissector;
(VII) Endopath 5 mm endoscopic peanut (×2);
(VIII) Energy devices;
(IX) Sponge stick.

Curved ring forceps are very useful to dissect and to pull the lymph nodes. We use the curved suction and sponge stick to dissect and to expose the structures. The Harmonic scalpel makes the haemostasis easier. To sum up, we give more than one use to the different instruments.

Instrumentation in VATS lymphadenectomy is vital because the surgeon works in a reduced space: in single port the camera goes into the posterior part of the incision. We obtain a direct view which makes the instrumentation easier since the view of the camera and the surgeon moving are in parallel.

The technical aspects in mediastinal spaces are:

(I) Right paratraqueal space: we remove all the mediastinal nodes and fat between trachea and cava vein (*Figure 1*). Usually it is not necessary to open the mediastinal pleura, we dissect going under the azygos vein, the result is a tunnel view (*Figure 2*). A long endothoracoscopic peanut is very useful to separate the join between azygos and cava vein. The use of energy devices facilitate the dissection and reduce the rate of postoperative bleeding.
(II) Subcarinal space: the most difficult lymphadenectomy is left subcarinal lymphadenectomy, because it is the deepest area. You have to retract the aorta on the left side and the oesophagus on both sides. That is possible with a sponge stick or another instrument like curved suction. With single port VATS you can even see the main contralateral bronchus, and the contralateral lower vein (*Figure 3*).
(III) Aortopulmonary window space: For this procedure lymph nodes should be removed from the aorta and the pulmonary artery and usually it is necessary to retract the phrenic nerve to better expose the prevascular area (*Figure 4*). Sometimes even with single port you can perform a left paratraqueal lymphadenectomy under the aortic arch (*Figure 5*).

The key for a correct lymphadenectomy in single-port VATS is good exposition and bimanual instrumentation. Moving the surgical table allows for better results thus improving the lung exposition; moving the table anteriorly

Figure 3 Left subcarinal lymph node dissection (7).
Available online: http://www.asvide.com/articles/338

Figure 4 Aortopulmonary window lymph node dissection (awake patient) (8).
Available online: http://www.asvide.com/articles/339

Figure 5 Left paratracheal lymph node dissection (9).
Available online: http://www.asvide.com/articles/340

exposes the subcarinal space and the anti-trendelenburg position which exposes the paratraqueal area.

Comments

We currently perform a complete and radical lymph node dissection by VATS. In our experience the lymphadenectomy achieved by uniportal VATS can be even better than open approach thanks to the high definition. As more cases are treated with the single-port approach, the number of lymph nodes removed increases—thus reflecting improvement in the surgical technique. In our uniportal series, the mean number of lymph nodes resected is greater than the mean number we reported by two or three port VATS (14.5±7 *vs.* 11.9±6.7) (10).

If we divide the period into two years, we observe more lymph node dissection performed during the second period: 12.2±4.7 *vs.*16±8 (*P*=0.055).

Conclusions

(I) Lymphadenectomy is an important part of the lung cancer surgery.
(II) To perform a standard lymphadenectomy by single port approach is possible and represents the best view if we compare with three and two ports.
(III) We can use conventional material, but it is easier with double-jointed and long instruments.
(IV) Do not forget the importance of the learning curve.

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Subxiphoid mediastinal lymphadenectomy

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Abstract: Video-assisted thoracoscopic surgery (VATS) has experience an exponential growth in lung anatomic resections. Since its beginnings in early 90s with the conventional multiport VATS to the more recent uniportal approach, a continuous search for a less invasive procedure has fueled the development of minimally invasive thoracic surgery. In this sense, subxiphoid uniportal VATS has surge as a uniportal option that avoids damage to the intercostal nerve created in a transthoracic approach. In order for this technique to become as an acceptable choice for lung cancer, oncologic principles must be respected, including a feasible and safe mediastinal lymphadenectomy. Although technically more difficult than other VATS approaches, a complete lymphadenectomy is possible in the hands of expert VATS surgeons through a subxiphoid approach.

Keywords: Uniportal video-assisted thoracoscopic surgery (VATS); lymph node dissection; lymphadenectomy; minimally invasive; subxiphoid; novel procedure

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Introduction

The surgical treatment of lung cancer has evolved considerably in the last two decades and video-assisted thoracic surgery has played a key role in this development. The first video-assisted thoracoscopic surgery (VATS) lobectomy was performed in the early 90s (1) starting the trend of VATS for the curative treatment of lung cancer. Initially the surgery was typically performed with three small incisions without rib spreading (2) and large case series were reported with good results last decade (3). Variations of the approach were made in the quest for a less invasive surgery and needlescopic and 2-port VATS were also performed successfully for anatomic lung resections. By 2010, the first uniportal VATS lobectomy was achieved by the team lead by Dr. Gonzalez (4), which started the era of uniportal VATS lobectomies. Since then large series with this approach has been reported by different groups around the world, establishing the safety and feasibility of the technique (5-7). As an alternative single port approach, a variety of thoracic procedures were performed through a subxiphoid incision, avoiding a transthoracic approach and preventing intercostal nerve damage. In 2016, the team from Shanghai Pulmonary Hospital published their results with more than 100 cases performed through a single port subxiphoid approach (8).

Some studies have suggested that avoiding a transthoracic approach could prevent nerve damage, resulting in less postoperative pain and neuralgia (9).

The consolidation of uniportal VATS surgery has been achieve since the oncologic principles of an anatomic lung resection are not compromise using this approach, and mediastinal lymph node dissection can be performed as efficient and safe as in other VATS approaches or open surgery. Mediastinal lymph node dissection in uniportal subxiphoid VATS is more demanding and technically difficult, so a lot of training and experience is necessary before attempting a lobectomy or segmentectomy for lung cancer (10).

Patient selection and workup

Uniportal subxiphoid VATS lobectomy is a novel technique, few cases are reported in the literature, and the experience performing these cases is limited to few groups (8-11). It is very important to select proper cases for this approach. Subxiphoid surgery is technically more difficult compared to intercostal VATS and has some limitations that are related to the site of the incision. Patients with obesity should not be selected for a subxiphoid approach since increased mediastinal and subcutaneous fatty tissue would increase the difficulty of the operation due to a larger tunnel and compromise exposure. A highly located diaphragm due to abdominal pressure in obese patients would obstruct maneuvering and also compromise adequate exposure for dissection, especially station 7.

Patients with cardiac comorbidities should also be avoided since heart compression and retraction is frequent during the surgery, especially in the left side and this can even be persistent when dissecting stations 2R, 4R, 5 and 6. Patients with suspected N2 disease should also be discard for this approach since the complexity and extension of the dissection could be very difficult to complete successfully with a subxiphoid approach, compromising oncologic results. In this stage of the evolution of the technique, complex cases such as an advance or centrally located tumors, patients with prior ipsilateral thoracic surgeries or severe adhesions should not be selected for a uniportal subxiphoid lobectomy.

Proper staging and preoperative workup is very important to select the correct candidate for this approach. The chest CT has to be examined carefully to detect enlarged interlobar or mediastinum lymphadenopathy. When documented in the preoperative CT a transthoracic approach should be preferred.

Equipment preference card

Special equipment is not mandatory but it does facilitate the procedure since there are some special considerations regarding the instruments. Since the distance from the incision to the thoracic cavity is longer and the ribs are not there to prevent the collapse of the tunnel, a wound retractor should be used to keep the incision tunnel open, prevent smearing of the camera and facilitate the introduction of the instruments. Instruments must be longer, thin and better angled (8). A 30 degree 10 mm camera provides a good visualization of the operative field, and is critical when performing station 7 dissection, since changing the angle of the lens can provide a good visualization in a very narrow field. Energy devices such as Ligasure or Harmonic Scalpel can help maintaining hemostasis during lymph node dissection, although sometimes, since they are not angled, the correct plane of dissection is difficult to achieve.

Procedure

Under general anesthesia, with double lumen endotracheal intubation, the patient is placed in 60–70 degree lateral decubitus position, elevating the side in which the surgery is going to be performed.

The monitor is usually placed at the head of the patient; the surgeon is located in front of the patient and the assistant holding the camera, in the opposite side. The role of the assistant is of key importance, it should have prior experience assisting in uniportal subxiphoid VATS and the surgeon should not attempt anatomic lung resections unless this is the case. Achieving the correct view of the surgical field is very difficult and more challenging in subxiphoid VATS than in any other VATS procedure. Constant communication and coordination between both is critical.

A 4–5 cm subxiphoid incision is made; the incision can be made in different ways according to the preference of the surgeon. It can be a vertical midline incision or a horizontal incision below the sternocostal triangle. A one sided, oblique incision from the xiphoid process and alongside the costal arch can be used also, and it diminishes compression to the heart (8) and facilitates the access to station 7 during lymph node dissection.

After completing the lobectomy, mediastinal lymph node dissection or sampling should be undertaken according to the case.

In the right side station 2 and 4 are dissected with the help of longer and more curve instruments that facilitates de exposure. Bimanual instrumentation and proper retraction of the lung facilitates exposure and visualization (*Figure 1*). When exposure is not ideal and dissection is technically difficult, the azygous vein can be transected with a stapler or separated with a silk. This would improve visualization of the operative field and can prevent bleeding from rupture of the azygous vein during dissection, since is in the path of the instruments in order to gain access to the paratracheal

Figure 1 Right paratracheal lymphadenectomy. The video shows a radical lymph node dissection, which is possible thanks to proper lung retraction and bimanual instrumentation (12). Available online: http://www.asvide.com/articles/1002

Figure 2 Subcarinal lymph node dissection. This video shows the difficulty and complexity of station 7 lymph node dissection, exposure and instrumentation is complicated by the diaphragm and heart (13). Available online: http://www.asvide.com/articles/1003

Figure 3 Aortopulmonary window. This video shows the use of long and curve instruments and the precision require to complete a radical lymph node dissection of station 5 and 6 (14). Available online: http://www.asvide.com/articles/1004

space. The next step is to remove the pulmonary ligament (in upper lobectomies) in order to expose the subcarinal space, the lower lobe must be retracted upwards and medially and the diaphragm pushed away with another instrument to facilitate exposure and visualization. After liberating the ligament, the lung must be retracted medially and the subcarinal space cleared. This is the most complex and difficult step of the lymph node dissection in both sides, because the access, instrumentation and dissection are very challenging. Radical lymph node dissection of station 7 should only be attempted by expert surgeon with experience in subxiphoid lobectomies in order to reduce the incidence of complications (*Figure 2*). A unilateral oblique incision can reduce heart compression and facilitate the access to the subcarinal space, making the dissection easier.

In the left side, retraction of the lung downwards and putting the patient in anti-Trendelenburg position improve the exposure of station 5 and 6. Care should be taken to avoid injury to the recurrent laryngeal nerve (*Figure 3*). The heart is in the path of the instruments in the left side, so care should be taken to avoid injury or minimized compression during dissection of station 5 and 6. As in the right side, the lower pulmonary ligament is divided in order to facilitate exposure of station 7 and 8. The subcarinal space is even more complicated in the left side, since the heart beating and compression becomes troublesome for the surgeon.

Only after acquiring considerable experience a surgeon is able to complete a mediastinal lymph node dissection in a uniportal subxiphoid lobectomy, the learning curve is very steep and caution is advice to avoid complications.

Role of team members

When performing a uniportal VATS subxiphoid lymph node dissection, it is important that every team member has previous experience in single port VATS, since it will smooth the learning process and technical challenges inherent to subxiphoid VATS (10).

The anesthesiologist should provide a good lung collapse and take care to avoid diaphragm movement, because in case the diaphragm starts to contract, the surgery through a subxiphoid approach, and specially the lymph node dissection would be impossible to perform.

The assistant has to keep a very good coordination and communication with the surgeon and be very focused in using the proper angulation of the camera to show clearly the structures the surgeon is dissecting. The assistant can also provide aid with retraction of the lung with another instrument, so that the surgeon can use both of his instruments in the dissection process.

The surgeon must be the leader of the procedure, addressing to the other team members about the steps ahead and letting the assistant know what is the vision angle needed and proper retraction in order to facilitate the step being performed in any moment of the surgery.

Post-operative management

The postoperative management should not differ from other VATS procedures. One 28F chest tube is placed in the thoracic cavity for unilateral resections and bilateral drainage is carried out, inserting both chest tubes through the same subxiphoid incision. Pain medication requirements may be lower, since less postoperative pain is expected as suggested by some studies (11), but more studies and randomized trials are needed to confirm this.

Tips, tricks and pitfalls

- Previous experience with transthoracic uniportal VATS is required, and only expert VATS surgeons should attempt uniportal subxiphoid VATS lymph node dissection;
- Placement of a wound retractor helps to maintain the subxiphoid surgical tunnel patent, simplifying instrument introduction and instrumentation during surgery;
- In paratracheal right side dissection, looping or dividing the azygous vein is needed in some cases for better exposure and retraction while removing lymph nodes;
- Lymph node dissection in station 7 is the most difficult step, and should only be performed by expert surgeons in subxiphoid VATS lobectomies;
- Proper traction of the lung and changes in bed positioning are required to access the subcarinal space.

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Footnote

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Uniportal video-assisted thoracoscopic anatomic segmentectomy

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Introduction

Anatomic segmentectomy was first described in 1939 for the treatment of benign lung conditions (1). The usual indications also include metastatic disease to the lung when ta parenchyma-sparing procedure is anticipated Nevertheless, anatomic pulmonary segmentectomy has been demonstrated to be effective in the resection of small primary lung cancers (2,3). Recently there has been a renewed interest in the use of anatomic segmentectomy, especially for patients unable to tolerate lobectomy because of poor cardiopulmonary function or severe comorbidities. Several recently published studies have shown that segmentectomy can be performed safely without compromising oncologic results (3-6).

Surgical technique

Single port VATS segmentectomy follows the principles of major pulmonary resections by VATS: individual dissection of segmental veins, segmental arteries and lobar segmental bronchus with a no rib spreading, video-assisted thoracoscopic approach. Radical mediastinal lymphadenectomy should complete the procedure (7).

The size of the utility incision is comparable to those commonly used for double-or triple-port approaches (8) and it is usually smaller than for a lobectomy, about 3-cm long. The incision is usually placed at the level of the 5th intercostal space (*Figure 1*) to get good access to upper hilar structures and lymph node stations. Adequate exposure of the lung is mandatory for successfully completion of the segmentectomy. The surgeon and the assistant must be positioned in front of the patient in order to have the some thoracoscopic vision during all these steps of the procedure and be more coordinated with the movements (*Figure 2*). Instruments must preferably be long and curved to allow the insertion of 3-4 instruments simultaneously (*Figure 3*). Optimal exposure of the lung is key to facilitate the dissection of the segmental structures and to avoid instrument interference. The HD 30° thoracoscope (the videolaparoscope with the distally mounted CCD design helps the instrumentation) is usually inserted in the posterior part of the incision and the instruments are placed below the camera. Bimanual instrumentation is crucial to achieve a successful segmental resection through a single incision VATS (*Figure 4*). A single chest tube is inserted through the same incision at the end of the procedure (*Figure 5*).

Different types of segmentectomies can be performed according the segment to be resected:

- ❖ RUL
  - Posterior segment
  - Apical segment
  - Anterior segment
  - Apico-posterior segmentectomy
- ❖ LUL
  - Lingulectomy
  - Apical trisegmentectomy (Lingula sparing)
- ❖ LLL/RLL
  - Superior segmentectomy
  - Composite basilar segmentectomy
  - Individual segments (7-8-9-10)
- ❖ RML
  - Medial
  - Lateral

The most frequent anatomic segmental resection is the

Figure 1 Incision for uniportal VATS segmentectomy.

Figure 2 Surgeons positioned in front of the patient watching the same monitor. The scrub nurse is located on the opposite side.

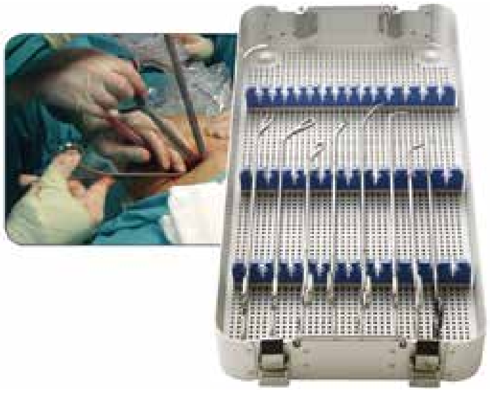

Figure 3 Uniportal of specific adapted instruments (proximal and distal articulation).

Figure 4 Bimanual Instrumentation during uniportal VATS segmentectomy (9).
Available online: http://www.asvide.com/articles/26

Figure 5 Single-chest tube placed in the posterior part of the incision.

superior lingulectomy and the superior segment of lower lobe (S6).

Left upper lobe (LUL)

A-lingulectomy (*Fgiure 6*-using staplers. *Fgiure* 7-using vascular clips)

The lingula is retracted laterally and posteriorly and the pleura overlying lingular vein (LV) is incised. The identification of LV and lower lobe vein (LLV) indicates the location to place the stapler to divide the anterior portion of major fissure (the anvil of the stapler is placed between the LLV and LV, and we pull the parenchyma into the jaws of the stapler). This maneuver facilitates the dissection and insertion of stapler to transect the vein (*Figure 6*). In some cases there is no angle for stapler insertion, then we use vascular clips, like click aV (Grena®) (*Figure* 7). Other option

Figure 6 Lingulectomy by using endostaplers (10).
Available online: http://www.asvide.com/articles/27

Figure 7 Lingulectomy by using vascular clips (Click aV) (11).
Available online: http://www.asvide.com/articles/28

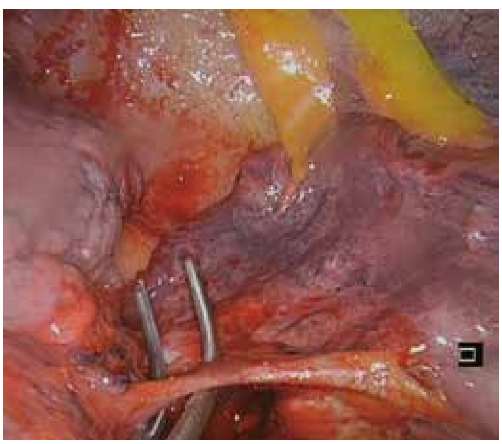

Figure 8 Dissection of lingular artery exposed in the fissure.

is to tie off the LV (the short distance from the incision facilitates this maneuver). Once the vein is divided, the lingular bronchus is exposed, dissected and stapled. When there is no angle for stapler we can transect bronchus by using scissors and close the stump at the end of the

Figure 9 Lef upper anatomic trisegmentectomy (12).
Available online: http://www.asvide.com/articles/29

Figure 10 Dissection of upper lobe vein for anterior, apical and posterior segment (13).
Available online: http://www.asvide.com/articles/30

procedure by using a stapler (*Figure 7*).

A ring forceps is then placed holding the lingula for traction, exposing the lingular artery which is then divided. Finally the intersegmental plane is divided (*Figures 6,7*). When the fissure is open, and the artery is visualized in the fissure, the dissection of the lingular artery can be performed from the fissure making easy the procedure (*Figure 8*).

B-apical trisegmentectomy (Lingula-sparing left upper lobectomy)-*Figure 9*

The anterior and apical arterial segmental branches are approached anteriorly, dissected and ligated by using stapler or vascular clips. The upper division of pulmonary vein is dissected and divided (anterior, apical and posterior veins) (*Figure 10*). The posterior artery is usually visualized after vein division and is divided by using vascular clips (we can use clips for proximal control and energy sealant devices for distal division)

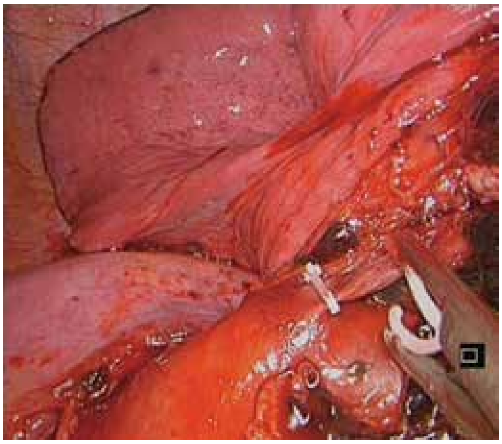

Figure 11 Division of posterior ascending artery during left upper lobe trisegmentectomy by using vascular clips.

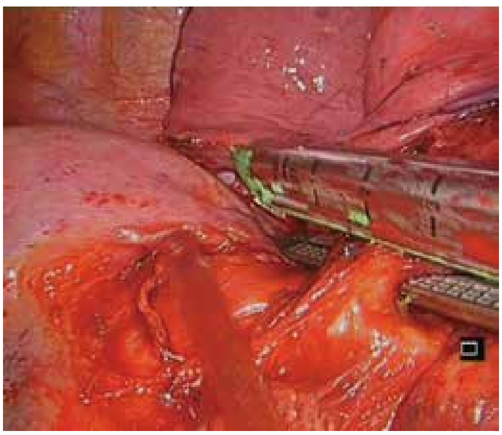

Figure 12 Division of segmental bronchus during left upper trisegmentectomy.

Figure 13 Superior segmentectomy left lower lobe (S6) (14). Available online: http://www.asvide.com/articles/31

Figure 14 Division of segmental artery during right lower lobe superior segmentectomy.

(*Figure 11*). The trisegmental bronchus is easily visualized after ligation of the segmental vein and arteries. Care must be taken during this dissection to avoid injury of lingular artery. After the bronchus is stapled (*Figure 12*) and divided the parenchymal resection is then completed through the segmental plane by using staplers (*Figure 9*).

Lower lobe (LLL-RLL)

A-superior segment lower lobe-*Figure 13*

The resection of the superior segment (S6) of lower lobe is easy because of the constant anatomical landmarks. The segmentectomy is done differently depending whether the fissure is complete or not. If fissure is complete we try to expose the superior segment artery in the fissure. To staple the artery we use a vascular clip (click aV, Grena®) or an endostapler (*Figure 14*) (7).

With a long ring forceps we retract the lower lobe and cut the pulmonary ligament to find the segmental vein (V6) for dissection and division by using a clip or a stapler. We dissect and expose the superior segmental bronchus and we staple it in the same way as mentioned for the vein (*Figure 15*). The last step is to divide the intersegmental plane (*Figure 16*) and remove the segment in to a protective bag (*Figure 13*).

Regarding segmentectomies with incomplete fissure or with no visible artery the procedure must be different. The preferred method does not involve dissection within the fissure in order to minimize postoperative air leaks. The resection must be performed from bottom to top, leaving the fissure stapling as the last step (fissureless technique). After cranial retraction of the lobe, the sequence of the dissection should be: inferior pulmonary ligament; segmental vein; segmental bronchus, segmental artery and intersegmental

Figure 15 Division of segmental bronchus during left lower lobe superior segmentectomy.

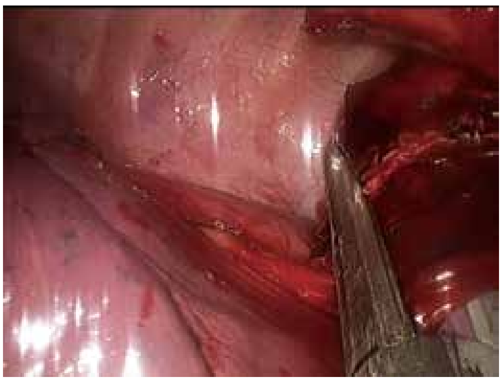

Figure 16 Intersegmental plane stapler division during left lower lobe superior segmentectomy.

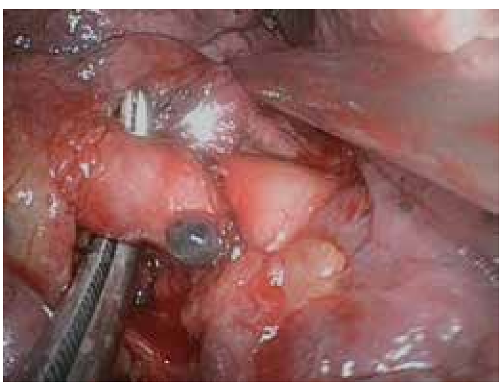

Figure 17 Division of basilar artery during right lower lobe basilar segmentectomy (artery exposed in the fissure).

plane. Once the segmental bronchus is stapled, the inflation of the lobe delimits the intersegmental plane.

B-basilar segmentectomy

Removal of 4 segments in the right lower lobe (S7-S8-S9-S10) or 3 segments in the left lower lobe (S7-S8-S9) sparing the apical segment (S6) is called basilar segmentectomy. These segments are usually removed together since they depend from a single bronchus.

Figure 18 Division of segmental vein and basilar artery during right lower lobe basilar segmentectomy (15).
Available online: http://www.asvide.com/articles/32

When the fissure is open the procedure is easy, and the basilar artery can be easily dissected in the fissure (*Figure 17*), and divided. After division of the basilar segmental vein (*Figure 18*), the basilar segmental bronchus (the most difficult part of the operation) is dissected and stapled. The intersegmental plane is completed last.

When performed stepwise in a caudo-cranial fashion, extra care must be taken to correctly identify the segmental structures. Once the inferior segmental vein has been divided, the lower lobe basilar segmental bronchus is exposed, dissected and divided from its inferior aspect to its bifurcation with the middle lobe bronchus on the right side or the upper lobe bronchus on the left side. Dissection of the bronchus with development of the plane between the bronchus and artery is performed with visualization of the artery. We recommend the removal of the interbronchial lymph nodes to better define the landmarks. The basilar segmental arterial branch to the lower lobe is identified (*Figure 19*) and divided and the intersegmental plane is stapled (*Figure 20*).

Other more complex segmentectomies

The anatomic resection of a single segment like the anterior, posterior or apical segment of RUL (*Figure 21*) (*Figure 22*), medial or lateral segment of RML and 7, 8 or 9 segment of lower lobe (*Figure 23*) is a complex procedure. The difficulty of thoracoscopic anatomic resection of a single segment is mainly based on the division of the segmental plane and the

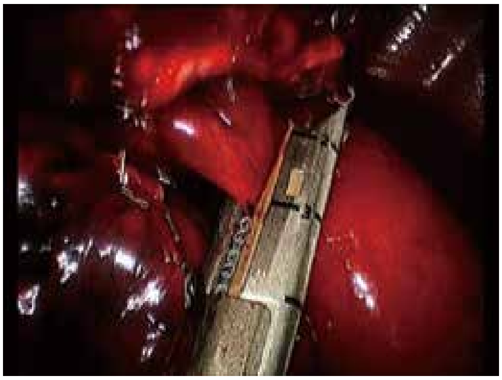

Figure 19 Division of basilar artery during left lower lobe basilar segmentectomy from down to up (fissureless technique).

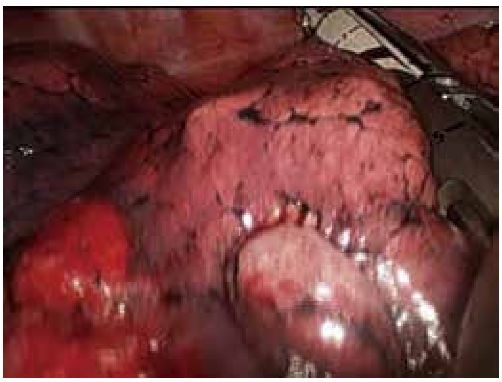

Figure 20 Division of intersegmental plane during left lower lobe basilar segmentectomy.

individual dissection of single segmental structures.

While the bronchial anatomy is very consistent, the arterial anatomy is variable. We always have to keep in mind that venous anatomy can drain multiple segments. It is very important to define the intersegmental plane. The ventilation of the lung delimitate the segmental plane once the segmental bronchus has been divided. To avoid collateral ventilation some authors have suggested following a reverse inflation-deflation technique, stapling the segmental bronchus once the whole lung is ventilated in order for the inflated segment to remain readily visible after deflation (6).

Discussion

Uniportal VATS segmentectomies are usually more difficult than lobectomies. Most of reported segmentectomies are related to segments that can be easily excised, such

Figure 21 Right upper lobe apical antomic segmentectomy (16). Available online: http://www.asvide.com/articles/33

as the lingular, superior, and basilar segments (1-3). In these segments the parenchyma can be separated by using staplers. To remove other segments via uniportal VATS, the procedure is more difficult but feasible. The preoperative evaluation of branches of pulmonary veins (8) or trans-bronchial indocyanine green injection and the use of infrared thoracoscope helps the intersegmental plane identification of complex segmentectomies (7). Since June 2010 we have performed 17 uniportal VATS anatomic segmentectomies. Lingulectomy for lung metastasis was the most frequent operation. The mean surgical time was 94.5±35 minutes (40-150 minutes). The mean number of nodal stations explored was 4.1±1 (range, 0-5) with a mean of 9.6±1.8 (range, 7-12) lymph node resections. The median tumor size was 2.3±1 cm (range, 1-4 cm).The median chest tube duration was 1.5 days (range, 1-4 days) and the median length of stay was 2 days (range, 1-6 days).

In our experience, there was no conversion of uniportal segmentectomy to conventional VATS or open and this outcome is a direct consequence of greater skills acquired with experience (17).

Compared to segmentectomy by thoracotomy, uniportal thoracoscopic segmentectomy was associated with a shorter length of stay and with equivalent morbidity and mortality (18). The procedure has some difficulties: it is technically demanding and more challenging than lobectomy, requiring a perfect knowledge of the bronchial and arterial relationships and possible anomalies of arterial branches. Once bronchovascular structures have been divided, the division of the intersegmental plane is the most difficult step.

The advantage of using the camera in coordination with the instruments is that the vision is directed to the target tissue, bringing the instruments to address the target lesion

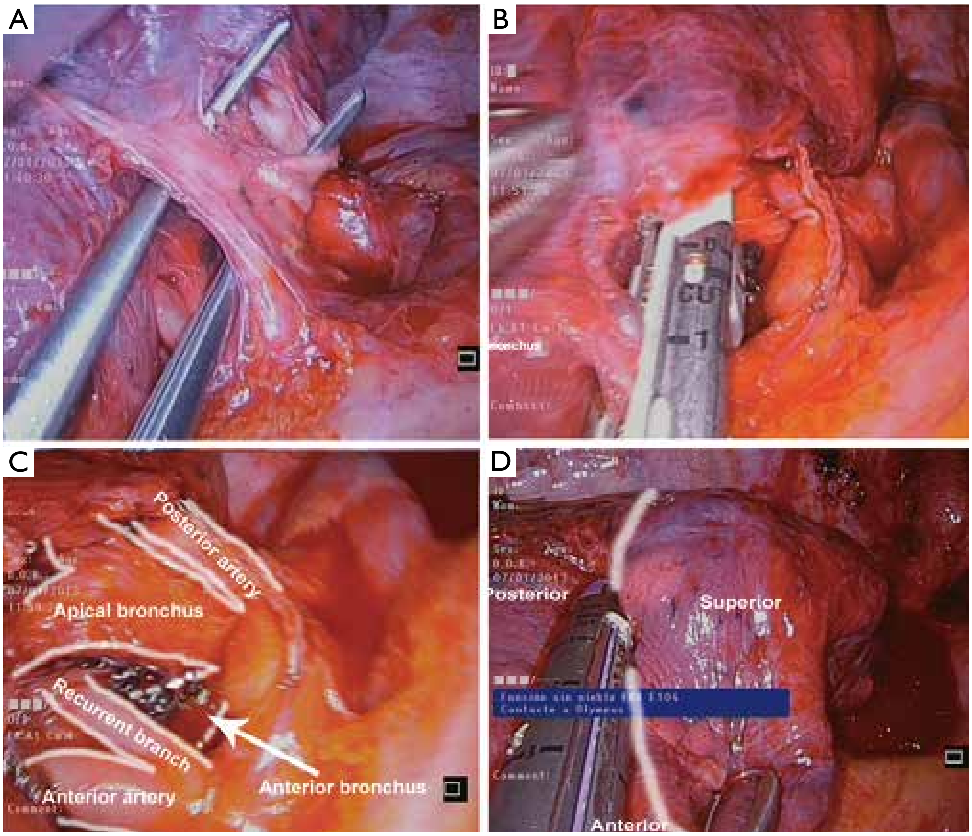

Figure 22 Right upper lobe apical segmentectomy. (A) Apical artery; (B) Apical vein; (C) Apical bronchus; (D) Intersegmental plane.

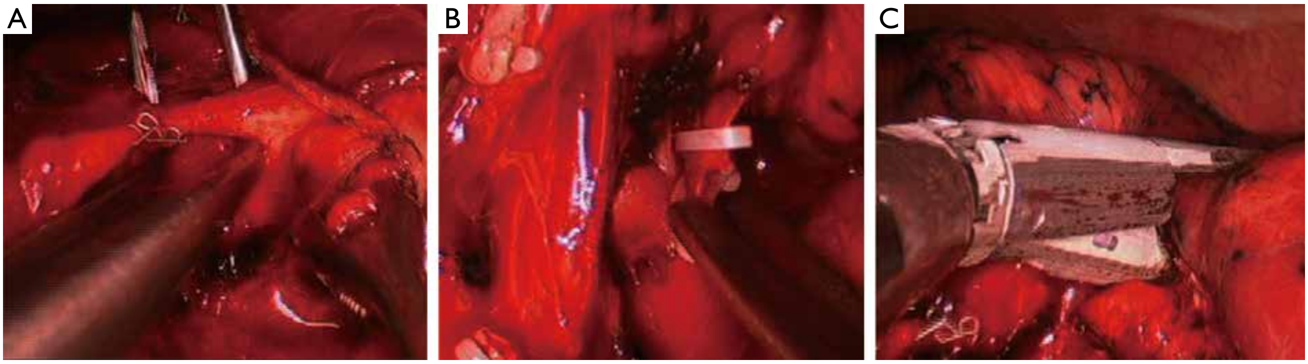

Figure 23 Segmentectomy of 7, 8 basal segments left lower lobe. (A) Segmental artery; (B) Segmental vein; (C) Intersegmental plane.

from a sagital perspective, thus we can obtain similar angle of view as for open surgery (19). Instruments inserted parallel to videothoracoscope mimic inside the chest maneuvers performed during open surgery.

Another potential advantage of this approach could be a reduction in post-operative pain. There could be several explanations for this issue: only one intercostal space is involved and avoiding the use of a trocar could minimize the risk of intercostal nerve injury (during instrumentation, we try to apply the force over the superior aspect of the inferior rib through the utility incision). We have observed that patients operated by conventional VATS sometimes refer their pain towards the posterior and inferior incision, and only a few times refer pain in the utility incision. We strongly believe that this pain could be explained by trocar compression over the intercostal nerve during camera movement. Some authors have reported less postoperative pain in patients operated on for pneumothorax through a single-incision, in comparison to the classical triple-port approach (20). Further studies will be required to demonstrate that there is less pain with single incision techniques, compared to conventional VATS for segmentectomy.

Conclusions

Single-port VATS segmentectomy is a feasible and safe procedure in experienced VATS centers. The uniportal thoracoscopic segmental resection should be performed by skilled VATS surgeons and is a good option for small primary tumors, metastasic lesions or benign conditions not suitable to be performed by wedge resection.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Single incision video-assisted thoracoscopic anatomic segmentectomy

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Introduction

Anatomic segmentectomy was first described in 1939 by Churchill and Belsey (1). Although segmentectomy is usually indicated for benign lesions or for metastasis when the goal is resecting the lesion while sparing parenchyma, anatomic segmentectomy has also been demonstrated to be effective in the resection of small lung cancers (2). Recently, due to the increasing incidence of small lung tumors, there has been renewed interest in the use of anatomic segmentectomy, especially for patients unable to tolerate lobectomy. Several recently published studies have shown that segmentectomy can be performed safely without compromising oncologic results (3,4). Video-assisted thoracoscopic surgery (VATS) is currently a better choice than thoracotomy for segmentectomy. Although most surgeons use three to four incisions, the surgery can also be performed using only one (5).

Surgical technique

Single-incision VATS segmentectomy follows the principles of major pulmonary resections by VATS: individual dissection of segmental veins, segmental arteries and the segmental bronchus, as well as complete mediastinal lymphadenectomy with a video-assisted thoracoscopic approach and no rib spreading.

The size of the incision is comparable to the utility incision commonly used in a double- or triple-port approach and is usually smaller than that for a lobectomy, approximately 3 cm long (6). The incision is usually made at the level of the 5th intercostal space to provide access to upper hilar structures and lymph node stations. Both the surgeon and assistant are positioned anteriorly to the patient in order to have the same thoracoscopic vision during all the steps of the procedure and be more coordinated with the movements. Instruments with a proximal and distal articulation are preferable as they reproduce the same experience as a conventional instrument but also allow the insertion and manipulation of three to four instruments simultaneously (Scanlan International, Inc., MN, United States).

Optimal exposure of the lung is crucial for facilitating the dissection of the segmental structures and to avoid instrument malposition. The 30º high-definition thoracoscope is usually placed in the posterior part of the incision and the instruments are placed below the camera. Bimanual instrumentation is crucial to achieve a successful segmental resection through a single port VATS. A single chest tube is placed at the end of the procedure through the same working incision.

In this video we show seven different anatomic segmentectomies performed through a single incision thoracoscopic approach, including: (I) Right upper lobe apico-posterior segmentectomy (S1-S2); (II) Right upper lobe apical segmentectomy (S1); (III) Left upper lobe trisegmentectomy (S1-S2-S3); (IV) Left lower lobe superior segmentectomy (S6); (V) Right lower lobe basilar segmentectomy (S7-S8-S9-S10); (VI) Anatomic lingulectomy using vascular clips (S4-S5); and (VII) Anatomic lingulectomy using endostaplers (S4-S5).

Right upper lobe apico-posterior segmentectomy (S1-S2)

Exposure of the vein is achieved by retracting the upper lobe posteriorly. The common apico-posterior segmental vein is dissected as distal as possible and divided with an endostapler.

The upper lobe is then retracted upward and forward in order to expose the apical artery which is dissected and divided using a stapler.

When the fissure is complete, the posterior ascending artery can be easily dissected and divided from the fissure. When the fissure is incomplete, a fissureless technique is performed in order to expose the posterior artery. The anterior portion of the intersegmental plane is divided using a stapler to expose the posterior ascending artery and the bronchus. A posterior segmental artery is then discovered. A vascular clip for proximal transection and ultrasonic energy device to do the distal division. Now the trifurcation of the upper lobe bronchus is exposed. The apical and posterior lobar bronchus are dissected separately and freed from its attachments to the upper lobe. A loop is passed around the two segmental branches and both bronchus are cut with an endostapler.

Finally, the parenchyma is divided by placing the stapler in the border between the apico-posterior and the anterior segment plane. The specimen is inserted into a protective bag and retrieved through the single incision.

Right upper lobe apical segmentectomy (S1)

The second video shows an apical segmentectomy of a 2.5 hilar tumor not possible to remove with a wedge resection. The first step is to identify the mediastinal trunk of the artery. Once the segmental vein for segment 1 is dissected we use a vascular stapler to divide it. We usually insert the staplers through the inferior part of the incision and the camera is normally placed above.

By using scissors we release the adherences of the anterior branch of the artery from the inferior portion of the tumor.

We divide the apical artery using vascular clips. The anterior portion of the intersegmental plane is divided by a 60 mm stapler. After identification of the branches for the anterior and posterior segment, we continue with the division of the parenchyma by placing the staplers above the stumps. In this particular case, the apical bronchus is divided through the intersegmental plane due to the benign nature of the tumor.

Left upper lobe trisegmentectomy (S1-S2-S3)

The third case shows a trisegmental resection of left upper lobe (also known as lingular-sparing lobectomy). The view of the apico-anterior arterial trunk is direct, and this branch is approached anteriorly, dissected and ligated by a stapler. The upper division of the pulmonary vein is dissected and divided [anterior, apical and posterior veins, preserving the lingular vein (LV)]. The trisegmental bronchus is easily visualized after ligation of the segmental vein and arteries, with care taken during this dissection to avoid injury of the lingular artery. After the bronchus is stapled, the posterior artery is usually visualized and is then divided by using vascular clips. The last step is to divide the parenchyma through the segmental plane by using staplers.

Left lower lobe superior segmentectomy (S6)

The resection of the superior segment (S6) of the lower lobe is straightforward as there are consistent anatomical landmarks. The conduct of segmentectomy will vary slightly depending on whether the fissure is complete or not. In this case, the fissure is complete so the superior segment artery is exposed through the fissure. The artery is easily divided by using an endostapler.

With a long lung grasper, the lower lobe was held and the pulmonary ligament was cut to find the segmental vein for dissection, followed by division by using a vascular stapler. We dissect and expose the superior segmental bronchus and it was stapled in the same way as mentioned for the vein. The last step is to divide the intersegmental plane and remove the segment using a protective bag.

Right lower lobe basilar segmentectomy (S7-S8-S9-S10)

Removal of four segments in the right lower lobe (S7-S8-S9-S10) while sparing the apical segment (S6) is called basal segmentectomy. These segments are usually removed together since they are dependent on a single bronchus.

After identification of the artery in the fissure, a stapler was placed above to better expose the artery. The anterior portion of the fissure is stapled, which allowed division of the basilar artery using a stapler.

The next step is dissection of the basilar segmental vein. The direct view provided by the single incision approach allows excellent visualization of the plane between the superior segmental vein and basilar vein. The basal vein was divided with a stapler. Once the inferior segmental vein has been divided, the lower lobe basilar segmental bronchus is exposed, dissected and divided from its inferior aspect to its bifurcation with the middle lobe bronchus on the right side or the upper lobe bronchus on the left side. Dissection of the bronchus with development of the plane between the bronchus and artery is performed with visualization of the artery. We recommend the removal of the interbronchial lymph nodes to better define the anatomy. The intersegmental plane is completed last. The lung is inflated to confirm an adequate ventilation of the superior segment of the lower lobe.

Anatomic lingulectomy using vascular clips (S4-S5)

The next video shows two different ways to perform an anatomic lingulectomy. In the first video we used vascular clips for vessels. The lingula is retracted laterally and posteriorly and the pleura overlying the LV is incised. In this particular case, the tumor was involving part of the lower lobe in the fissure, so the first step was to divide the anterior portion of the fissure from an anterior view.

The identification of the LV, lower lobe vein (LLV) and the artery indicates the location to place the stapler to divide the anterior portion of major fissure. The anvil of the stapler is placed between the LLV and LV, and above the upper part of the artery, and the parenchyma is retracted into the jaws of the stapler.

This maneuver facilitates the dissection of the LV. A ring forceps is then placed while holding the lingula for traction, exposing the small recurrent lingular artery which is then divided with clips. Once this small vessel is divided, the lingular bronchus is exposed. In this particular case there was no angle for the stapler, so the bronchus was transected using scissors and the stump was closed using a stapler at the end of the procedure. Subsequently the main lingular artery is exposed and divided by using vascular clips.

Finally the intersegmental plane is divided and the stump of the bronchus with is closed with an endostapler at the end of the procedure.

Anatomic lingulectomy using staplers (S4-S5)

The last segment of this video shows a non-edited lingulectomy using endostaplers. The fissure is complete so the lingular artery is easily exposed, dissected and divided in the fissure by using a vascular stapler. The LV is dissected and divided by using a 30 mm vascular stapler. Once the vein is divided, the lingular bronchus is exposed and transected using endostaplers. The last step is to divide the intersegmental plane.

Comments

Uniportal VATS segmentectomies are usually more difficult than lobectomies. From June 2010 to February 2014, we have performed 28 uniportal VATS anatomic segmentectomies. The mean surgical time was 89.5±3 minutes (range, 40-150 minutes). The mean number of nodal stations explored was 4.1±1 (range, 0-5) with a mean of 11.5±1.8 (range, 7-25) lymph node resections. The mean tumor size was 2.24±1 cm (range, 1-4 cm). The median chest tube duration was 2 days (range, 1-6 days) and the median length of stay was 2 days (range, 1-6 days).

None of these segmentectomy cases required conversion, which may be attributed to experience in uniportal lobectomy, including vascular dissection, the management of fissures, as well as experience in more complex cases (lobectomy after induction therapy, hilar calcification, and pneumonectomy) (7).

Comparing segmentectomies by thoracotomy with uniportal thoracoscopic segmentectomies, the latter was associated with a shorter length of stay and with equivalent morbidity and mortality (8).

The advantage of using the camera in coordination with the instruments is that the vision is directed to the target tissue, addressing the target lesion from a straight perspective and thus obtaining a similar angle of view as with open surgery. In standard three-ports VATS, the geometric configuration of a parallelogram generates interference with the optical source, creating a plane with a torsion angle not favorable on the flat two-dimensional vision of currently available monitors (9).

Another potential advantage of this approach could be a reduction in postoperative pain, although this has not yet been demonstrated. There could be several explanations for this issue: only one intercostal space is involved and avoiding the use of a trocar could minimize the risk of intercostal nerve injury. During instrumentation, force is applied only over the superior aspect of the inferior rib through the utility incision.

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Footnote

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Subxiphoid uniportal video-assisted thoracoscopic middle lobectomy and anterior anatomic segmentectomy (S3)

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Abstract: The video-assisted thoracoscopic surgery (VATS) approach for combined lobectomy and segmentectomy in the same lung is an infrequent procedure, rarely reported in the literature. Currently, Most of the surgeons still use 2–3 thoracic incisions for thoracoscopic anatomic resections. However, the uniportal approach is gaining worldwide acceptance in the recent years. The main advances of uniportal VATS during the last years are related to improvements in surgical technique by implementing new technology. The experience acquired with the uniportal technique allows expert uniportal VATS surgeons to explore new approaches in order to minimize even more the surgical invasiveness. Recently the aim to avoid the intercostal nerve damage created by the transthoracic incision has led to the creation of a novel procedure entitled uniportal VATS subxiphoid approach. Here we report the first case of a lobectomy combined with anatomic segmentectomy performed through a uniportal subxiphoid approach.

Keywords: Subxiphoid approach; uniportal VATS; segmentectomy; lobectomy; uniportal subxiphoid

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Introduction

The video-assisted thoracoscopic surgery (VATS) approach for combined lobectomy and segmentectomy is an infrequent procedure, rarely reported in the literature. There is no doubt that VATS is currently a better choice than thoracotomy for segmentectomies. However, anatomical segmental resections are more demanding procedures because they require a better knowledge of the distal lung anatomy (1). These lung sparing procedures are usually indicated for deeply located benign lesions, metastasis or early stage lung cancer such as ground glass opacities (GGO). Several studies recently published have shown that segmentectomies can be performed safely without compromising oncologic results in this group of patients (2).

Most of the surgeons doing segmentectomies implement a thoracoscopic approach through a transthoracic utility incision of 4–6 cm, with one to three additional ports in different positions (3). However, the anatomic resection can be performed by opening only one intercostal space, through a single utility incision. Since 2011, when the first uniportal VATS lobectomy was published (4), the single incision technique has been stablished as the approach of choice in many thoracic departments all over the world (5,6). Since then, a growing number of articles are available in the literature showing the feasibility, safety and good outcomes of this procedure for major pulmonary resections (7,8). Recently the aim to avoid the intercostal nerve damage created by the transthoracic ports has led to the creation of a novel procedure described in 2014 for lobectomy through a single subxiphoid incision (9). Here we report the first case of a lobectomy combined with anatomic segmentectomy performed through a uniportal subxiphoid approach (10).

Clinical case

A 53-year-old female was admitted to our department for surgery. The patient suffered from cough, and a CT

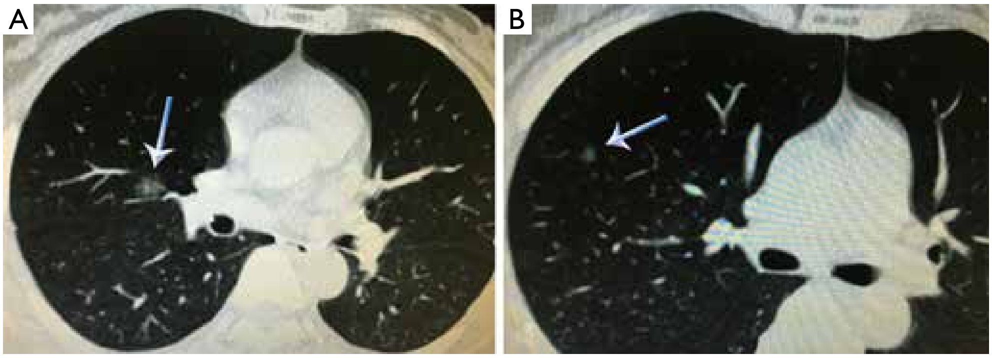

Figure 1 CT scan showing the GGO lesions located on the middle lobe (A) and on the anterior segment of the right upper lobe (B).

Figure 2 Subxiphoid uniportal video-assisthed thoracoscopic middle lobectomy and anterior anatomic segmentectomy (10). Available online: http://www.asvide.com/articles/904

scan revealed two GGO lesions located in the Middle lobe and anterior segment of RUL (S3) respectively (*Figure 1*). Pulmonary function tests were normal. The patient was proposed for uniportal VATS subxiphoid middle lobectomy and anterior anatomic segmentectomy of the right upper lobe.

Surgical technique (*Figure 2*)

The procedure was performed under general anesthesia and double lumen endotracheal intubation. The patient was positioned in lateral position with 60 degrees of inclination. The surgeon and scrub nurse were located in front of the patient and the assistant in the opposite side. A 3-cm midline vertical incision was made below the sterno-costal triangle, (longitudinal incision is made when the infrasternal angle is <70°). The rectus abdominis was divided and the xiphoid process was partially resected in order to have more space for instrumentation. Upon finding the infra-sternal angle between the xiphoid process and the subcostal margin, the right pleura was opened by finger dissection via the infra-sternal angle above the level of the diaphragm. The pericardial fatty tissue was removed and a wound protector was placed. The use of a wound protector helps the insertion of the camera and instruments, without the need of a sternal lifter. A 10-mm, 30-degrees video camera and double articulated instruments combined with several specific longer VATS instruments were used through the same subxiphoid incision. The lung was free of adhesions and a middle lobectomy and anterior anatomic segmentectomy of the right upper lobe (S3) were performed. The mean postoperative time was 70 minutes. A single chest tube was placed at the end of the operation through the subxiphoid incision.

Postoperative pain was managed with PCA (Patient-controlled analgesia) pump as required with sufentanyl citrate 1 mL: 50 mcg and regular medication with flurbiprofen 50 mg every 4 hours alternated with paracetamol 1 gr every 4 hours.

The postoperative course of the patient was uneventful, the chest tube was removed on the second postoperative day and the patient was discharged home on the 4^{th} postoperative day with no complications. The final pathology revealed the GGO located on the middle lobe as a 1.2-cm adenocarcinoma *in situ* and no malignancy was found in the anterior segment lesion of the RUL.

Discussion

The subxiphoid approach is a variant of uniportal VATS approach without opening the intercostal space. It has been employed during the last years for thoracic minor procedures such as thymectomies, pulmonary

Figure 3 Surgical photo showing bimanual instrumentation through the subxiphoid incision.

metastasectomies, pneumothorax (11,12).

However, this technique was recently introduced for major pulmonary resections in selected patients. After reviewing the literature, we have found few cases reporting about the subxiphoid approach incision for lobectomy (9) showing similar values to transthoracic uniportal VATS with regards to chest drain duration, hospital stay, operating time, rate of conversion and complications (8). Based on our previous experience with the uniportal VATS technique, we started to perform the subxiphoid approach for lobectomy with the potential advantage of decreased postoperative pain, better cosmesis and easier specimen retrieval compared to the transthoracic approach (13). Segmental anatomic resections are more complex procedures and require a perfect knowledge of the distal lung anatomy (14). The increased use of low-dose CT for screening will result in more diagnosed lung cancer in the early stage (15) therefore segmentectomy is being performing more frequently. For GGO lesions, anatomic segmentectomy should be sufficient for complete removal without risk of recurrence, and conserves an important amount of normal lung tissue in order to maintain better lung function (16).

To attempt the subxiphoid approach it is mandatory to have a previous experience in uniportal VATS lobectomies and a skilled assistant. As it happens with the transthoracic uniportal approach, bimanual instrumentation is crucial to achieve a good anatomic hilar dissection through a single incision (*Figure 3*). The view is caudal-cranial and anterior to posterior. The access for the view of the posterior mediastinum is difficult. Particularly challenging and difficult to accomplish is the need to apply traction to the lung in order to assess the lesions as well as the complete resection of subcarinal lymph node dissection. Moreover, this technique has several limitations such as the control of major bleeding and the performance of a complete oncologic lymph node dissection. When an emergent conversion to open surgery is necessary, an extension of the subxiphoid incision is unlikely to be useful and an additional thoracotomy must be performed. Despite these disadvantages, this novel approach has potential for widespread use after the developing of new technology, wireless cameras, instruments adapted to this approach or single port robotic technology also adapted to the subxiphoid approach (17).

Further studies are necessary to certify the feasibility and compare clinical outcomes of the subxiphoid versus other transthoracic approaches, in order to show the clear benefits from this technique.

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Uniportal video-assisted thoracoscopic pneumonectomy

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Abstract: Video-assisted thoracoscopic surgery (VATS) was introduced nearly 2 decades ago and has experienced an exponential increase for lung cancer treatment. A pneumonectomy can be performed by video-assisted thoracoscopic surgery and the lung usually fits through the incision as usually used for VATS lobectomy. The most common approach for pneumonectomy is undertaken with 3 or 4 incisions, including a utility incision of about 3-6 cm. However, this resection is amenable by using only a single utility-incision. This chapter describes the technique for pneumonectomies by single-incision thoracoscopic approach with no rib spreading.

Keywords: Video-assisted thoracoscopic surgery (VATS); right pneumonectomy; left pneumonectomy; intrapericardial pneumonectomy; completion pneumonectomy

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Introduction

During the past two decades, thoracoscopic procedures have increasingly gained acceptance specially with the introduction of video-assisted thoracoscopic surgery (VATS) major pulmonary resections. Since introducing the VATS programme at our hospital in July 2007, we have evolved from 3 ports to single-port technique (introduced in June 2010) for lobectomy and pneumonectomy (1). Recent studies have reported on the feasibility and safety of thoracoscopic pneumonectomy compared with conventional thoracotomy for lung cancer (2).

Surgical technique

The uniportal thoracoscopic resection of the whole lung is technically easier to perform than a lobectomy because the fissure do not need to be managed. However, extra care must to be taken during dissection and division of the main artery and transection of the main bronchus.

Once the lung is removed a radical mediastinal lymph node dissection is performed.

Right pneumonectomy

Initially, a 4-5 cm incision is made in the 5th intercostal space in the antero-lateral position (*Figure 1*). We introduce a 30 degree, high-definition, 10-mm thoracoscope in the posterior part of the incision and explore the chest cavity. Digital palpation confirms the need for a pneumonectomy. We only perform pneumonectomy when sleeve resection is not a feasible option. Optimal exposure of the lung is key to facilitate the dissection of the structures and to avoid instrument malposition (*Figure 2*).

On the right side the procedure is similar to that of the left, except for differences especially concerning the anatomy of the right pulmonary artery and its relationship to the main bronchus and superior vena cava.

The transection of azygos vein is not necessary but in some cases could help the mobilization of main pulmonary artery and paratracheal lymph node dissection. The lung is retracted posteriorly and the upper and inferior pulmonary vein are dissected and encircled. To dissect the main pulmonary artery we recommend to first divide the boyden trunk with vascular endostapler or vascular clips (click aV,

Figure 1 Incision on the right side.

Figure 2 Instrumentation during right pneumonectomy.

Figure 3 Right pneumonectomy (part 1) (3).
Available online: http://www.asvide.com/articles/50

Figure 4 Right pneumonectomy (part 2) (4).
Available online: http://www.asvide.com/articles/51

Grena). The uniportal approach provides a direct view to the artery. Once this branch is stapled, the lung is retracted caudally so as to havea good angle to staple the superior vein (*Figure 3*). The next step is the dissection and division of inferior vein. We retract the lung cranially, towards the apex of the chest, divide the pulmonary ligament and use an endostapler to divide the inferior vein (*Figure 4*).

Another option is to divide first the superior pulmonary vein by using 2 loads of (linear vascular stapler. and we could easily dissect the main pulmonary artery (therefore, the division of the boyden trunk is not necessary as the first step).

We dissect the main pulmonary artery with blunt dissection and the use of right angle clamp or thoracoscopic dissector. The removal of level 10 nodes and the previous posterior dissection of superior aspect of main bronchus help the dissection of the main artery. The pulmonary artery is encircled and divided by using a vascular endostapler.

Finally the main bronchus is divided by using a bronchial endostapler (a linear stapler is not usually needed on the right side) (*Figure 4*). Bronchial stump coverage with a vascularized flap is not usually performed. The lung is extracted in a protective bag. A systematic complete lymph node dissection is done upon completion of the procedure. A single chest tube is placed in the posterior part of the incision (*Figure 5*). If the tumor is too big to be removed by VATS, we enlarge de incision at the end of the surgery. In case of huge tumors we use a rib retractor to take out the specimen. In this unusual cases we recommend to perform another incision at the end of the surgery only to insert the chest tube (*Figure 6*).

Figure 5 Postoperative result of right pneumonectomy with chest tube placed in the posterior part of the incision.

Figure 6 Chest tube placed through additional incision in case of big tumors removed by using rib spreader (left pneumonectomy, 12 cm tumor).

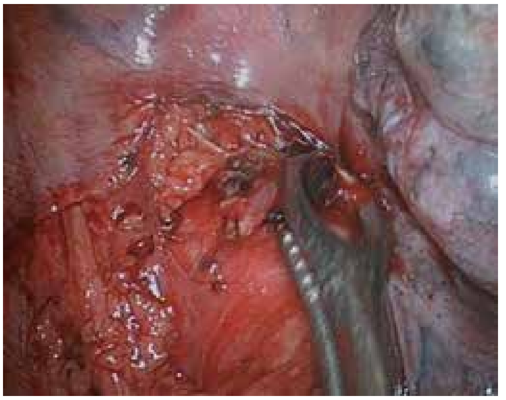

Figure 7 Aortopulmonary lymph node removal.

Left pneumonectomy

The incision is perfomed in the fifth intercostal space and is about 4-6 cm length. The thoracoscope is usually placed in the posterior part of the incision and the instrumentation is normally perfomed in the anterior portion of the incision. The staplers are also inserted through the anterior part of the incision.

The lateral aspect of the mediastinum is approached. The sequence for pneumonectomy on the left side could be different to the right side and includes the main pulmonary artery, superior pulmonary vein, inferior pulmonary vein, subcarinal lymph node dissection, and left mainstem bronchus.

We retract the lung posteriorly and inferiorly and we start the dissection by opening the mediastinal pleura to expose the pulmonary artery and the upper vein. It is important to remove the lymph nodes from the aortopulmonary window and divide the posterior pleura to better expose the artery (*Figure 7*). On the left side, the uniportal approach provides with an excellent and direct view to dissect and divide the main artery as the first step (*Figure 8*). The dissection and retraction of the upper pulmonary vein helps the exposure of the main artery. The dissection on the right side of the main pulmonary artery is very complex before the upper vein is transected). We divide the pulmonary artery by using a vascular endostapler (*Figure 9*). The superior pulmonary vein can then be divided with an endostapler. This is the most frequent sequence to divide the artery on the left side.

If the main pulmonary artery is not immediately accessible, our advice is to divide the superior pulmonary

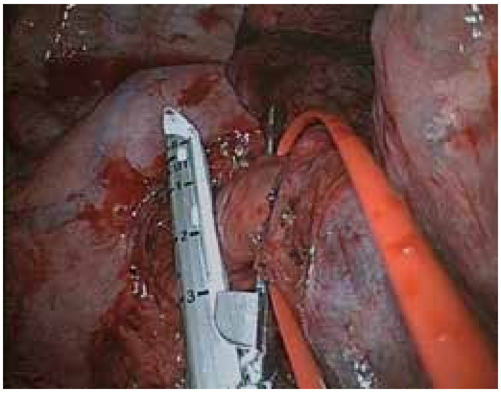

Figure 8 Division of left main pulmonary artery.

Figure 9 Division of left main pulmonary artery by using an endostapler (5). Available online: http://www.asvide.com/articles/52

Figure 10 Division of left inferior pulmonary vein (6). Available online: http://www.asvide.com/articles/53

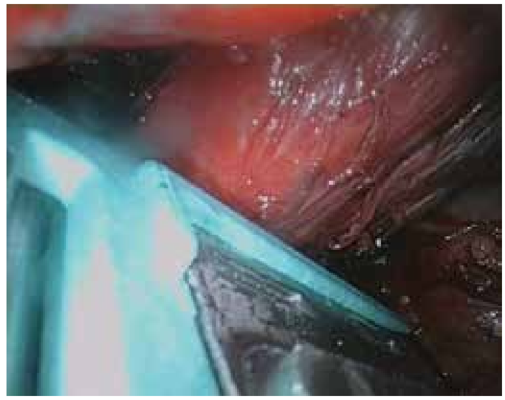

Figure 11 Use of TA 30 linear stapler to transect the left main bronchus.

vein first. This is done either by ligating or stapling the anterior branches of the pulmonary artery to the upper lobe first to improve access to the superior vein or by using a TA 30 vascular stapler (2 loads) to divide the vein to expose the main pulmonary artery.

Access to the inferior pulmonary vein is granted by taking down the pulmonary ligament. The inferior vein can then be easily divided with an endostapler after retracting the lung cranially (*Figure 10*). Subsequently, the lung is retracted anteriorly to perform a subcarinal lymph node dissection and to better expose the main bronchus. The lymph node dissection of level 5 mobilizes the superior aspect of the mainstem bronchus and level 7 lymphadenectomy mobilizes the posterior aspect of main bronchus.

When the angle for artery is not adequate for endostaplers we recommend to use a linear stapler for the main artery. We put the pin down and pull the lung through the stapler and we place an additional stapler, distally to the artery to avoid back bleeding when artery is cut with scissors or long knife.

The bronchus is dissected as proximal as possible after all the vascular elements have been divided (*Figure 11*). The bronchus is elevated by retracting the whole lung and we recomend to use a linear stapler used in open surgery, either a TA 30 (Covidien Inc, Mansfield, MA) or TX 30 (Ethicon Endosurgery, Cincinnati, OH). The pin is put down and we pull the lung through the stapler to achieve a short bronchial stump (*Figure 12*). Bronchial stump coverage with a vascularized flap is not usually performed. A single chest tube is placed in the posterior portion of the incision at the end of the surgery (*Figure 13*)

Intrapericardial pneumonectomy

The performance of intrapericardial pneumonectomy is more complex but the steps are similar to standard

Figure 12 Transection of lef main bronchus by using a TA 30 linear stapler (7). Available online: http://www.asvide.com/articles/54

Figure 13 Single chest tube placed in the posterior portion of the left incision.

Figure 14 Left intrapericardic pneumonectomy after induction treatment (8). Available online: http://www.asvide.com/articles/55

pneumonectomy (*Figure 14*). The pericardium is opened with scissors or cautery between the phrenic nerve at the anterior portion of the superior pulmonary vein. The incision is continued upward toward the pulmonary artery

Figure 15 Left pneumonectomy in two steps: lower and upper lobectomy (9). Available online: http://www.asvide.com/articles/56

and downward toward the inferior pulmonary vein. Extra care must be taken in case of adhesions or fibrotic tissue. The intrapericardial proximal division of vessels facilitates the insertion of staplers to divide the main artery as the first step.

The main pulmonary artery and both pulmonary veins are encircled. The aortopulmonary window is dissected taking care to identify and divide the ligamentum arteriosum and to identify and protect the left recurrent laryngeal nerve which lies in the operative field. The main artery is divided by using an endostapler after caudal retraction of lung. Once the artery is divided the upper vein is stapled holding the lung in the same position. To divide the inferior pulmonary vein the lung is retracted cranially. The use of TA linear stapler for vessels is not usually needed but is an option in case of no good angles for endostaplers. The bronchus is mobilized from the pericardium and a TA stapler is used to transect the bronchus as deep as posible, closest to the carina.

Completion pneumonectomy

The pneumonectomy can also be performed removing both lobes separately (lower and upper lobectomy). We have performed this procedure in case of N1 persistent interlobar lymph node affection discovered after lobe removal or positive margins (when sleeve reconstruction is not possible). It is an option to accomplish the pneumonectomy performing upper and lower lobectomy separately. If the lower lobectomy is performed first we need to assure that the main artery and bronchus is stapled as proximal as posible in order to minimize the risk of fistula (*Figure 15*).

Uniportal Re-VATS for completion pneumonectomy refers to surgery intended to remove remaining lobe not

Figure 16 Completion pneumonectomy: right lower lobectomy after induction chemotherapy (previous bilobectomy) (10). Available online: http://www.asvide.com/articles/57

Figure 17 Instrumentation for completion pneumonectomy.

resected during a previous operation. The procedure carries a higher risk of operative mortality and morbidity than does standard pneumonectomy, specially when chemo or radiotherapy has been previously administered (*Figure 16*).

The use of induction chemotherapy or radiotherapy may increase the fibrotic tissue surrounding the hilum. This makes thoracoscopic surgery harder but does not necessarily contraindicate the procedure. A careful vascular dissection is mandatory and a sponge stick should always be available for compression in case of major bleeding. An energy device facilitates the dissection of hilar structures (*Figure 17*). Intrapericardial resection is usually frequent for completion pneumonectomy cases, especially after induction treatment.

Discussion

Recent advances in surgical and video-assisted techniques have allowed minimally invasive pneumonectomy to be safely performed. VATS pneumonectomy is not a new procedure. In fact, it was initially reported 15 years ago and associated with less postoperative pain and a faster return to normal activities (11). Despite this, there have been only a few series published (2,12).

Most of the authors describe the VATS approach to pneumonectomy using 3 to 4 incisions (13). The surgery can also be performed with 2 incisions with similar outcomes (14) and even by a single-incision (15).

Single-incision pneumonectomy is a feasible and safe procedure from a center with consistent experience with VATS lobectomy (15). Since June 2010, we started performing VATS major pulmonary resections by a single-incision and non rib-spreading (16). Individual division of all hilar structures and mediastinal lymph node dissection was performed in all patients. To date, we have performed 10 uniportal VATS pneumonectomies (80% intrapericardic; 4 right, 6 left). The mean surgical time was 201±40 minutes (range, 130-250 minutes).The mean number of nodal stations explored was 5.4±1 (range, 4-7) with a mean of 17.1±7 (range, 9-29) lymph node resections. The mean tumor size was 4.8±2.1 cm (range, 3-12 cm).The median length of stay was 4 days (range, 3-12 days). One patient needed a reoperation by VATS due to bleeding on the fifth postoperative day.

The size of the utility incision is comparable to the ones commonly used for double or triple-port approach. The incision is made at the level of the 5th intercostal space in a more lateral position as usually reported with VATS. The proper placement of this incision and an adequate exposure of the lung is crucial in order to get good access to the hilar structures. The parallel instrumentation achieved during the single port approach mimics inside the maneuvers performed during open surgery. The direct view to the target tissue facilitates the hilar dissection and the bleeding control in case of vascular injury. In our experience, resulting from the evolution from multiple port to single port VATS, the bleeding can be better controlled through a single incision approach when performed by experienced uniportal VATS surgeons.

Sequential extraction of the upper and lower lobe in a protective bag facilitated the entire lung removal through the 4-5 cm utility incision. We recommend to open the external bag neck to allow for air release and subsequently pull and slide the lobes. Decompression of blood and air from the surrounding pulmonary parenchyma facilitates the entire lung extraction.

VATS pneumonectomy should be only performed in centers with experience in minimally invasive VATS lobectomy. We believe that the decision to proceed with an uniportal thoracoscopic pneumonectomy requires thoracoscopic assessment at the time of operation. We consider pneumonectomy in cases where it is not feasible to perform a sleeve resection. As has been shown in many minimally invasive procedures, there is a learning curve with thoracoscopic pneumonectomy as with the lobectomy (17). The completion of pneumonectomy is a difficult procedure but is feasible by VATS in experienced centers (18). There are several studies reporting that pneumonectomy performed either by means of thoracoscopy or thoracotomy resulted in equivalent survival rates. Further studies and follow-up are needed to verify the benefits of VATS pneumonectomy for lung cancer (19).

Acknowledgements

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Uniportal video-assisted thoracoscopic lobectomy with en bloc chest wall resection

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Background: Lobectomy with chest wall resection was traditionally performed by thoracotomy or by conventional video-assisted thoracoscopic surgery (VATS) during the last decade. However, this procedure can be performed by using only a single incision thoracoscopic approach.

Methods: The publications of uniportal VATS lobectomy requiring chest wall resection describes the use of one incision for the lobectomy (uniportal approach) and a posterior or lateral incision for the chest wall resection. This additional incision ensures a better control from outside and inside to achieve a costal resection with good oncologic margins.

Results: This video shows a total uniportal VATS lobectomy with en bloc chest wall resection through a single 5-cm incision with no rib spreading. The total surgical time was 150 minutes. The postoperative course of the patient was uneventful.

Conclusions: Uniportal VATS lobectomy with en-bloc chest wall resection is a feasible and safe technique. The full procedure can be performed by using only a single incision in selected cases.

Keywords: Chest wall resection; uniportal lobectomy; rib resection; video-assisted thoracoscopic surgery (VATS)

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Lobectomy requiring chest wall resection is usually performed by thoracotomy but thanks to the advances in the field of thoracoscopic surgery this procedure can be performed by video-assisted thoracoscopic surgery (VATS). Recent improvements in surgical devices and the experience gained in VATS enable this complex surgery for advanced stages to be undertaken safely. Most of the thoracoscopic lobectomies with rib resection are performed by using 3-4 incisions. However, the lobectomy and the chest wall resection can be performed by using only one incision. When a lung cancer with chest wall involvement is approached, we can perform the lobectomy first and tackle the chest wall once the lobe is freed. Alternatively, the rib resection can be done first and then finish the procedure with the lobectomy. This video shows a uniportal VATS lobectomy with en bloc chest wall resection through a 5-cm incision with no rib spreading (*Figure 1*). This

Figure 1 Uniportal video-assisted thoracoscopic lobectomy with en bloc chest wall resection (1). This video shows an uniportal VATS lobectomy with en bloc chest wall resection through a single 5-cm incision with no rib spreading. VATS, video-assisted thoracoscopic surgery. Available online: http://www.asvide.com/articles/602

surgery was done by first performing the lobectomy and once the lobe was free, the chest wall resection was completed with the help of a conventional and an adapted long thoracoscopic rib cutter instrument. The postoperative course of the patient was uneventful.

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Footnote

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Informed Consent: Written informed consent was obtained from the patient. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

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Uniportal video-assisted thoracoscopic right upper sleeve lobectomy

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Contributions: (I) Conception and design: D Gonzalez-Rivas, W Guido; (II) Administrative support: W Guido; (III) Provision of study materials or patients: Y Yang; (IV) Collection and assembly of data: G Jiang, L Duang, W Lee; (V) Data analysis and interpretation: Y Yang; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Background: The development of minimally invasive thoracic surgery in recent years is undeniable, VATS has evolved from the conventional three-port technique to an uniportal approach, without compromising the type of cases that can be operated successfully.

Methods: Thanks to the continuous progress of uniportal video-assisted thoracoscopic surgery (VATS) the complexity of cases performed by this approach has improved remarkably since the first procedures were made, recent advances in surgical thoracoscopic technology had made feasible to achieve vascular and bronchial sleeve lobectomies. Anatomic variants in patients can increase the technical difficulty of the procedure making the process more challenging.

Results: In this case the sleeve right upper lobectomy was performed by uniportal VATS despite the obstruction of the right pulmonary artery (PA) for the bronchial anastomosis.

Conclusions: In the hands of experienced surgeons in uniportal VATS with background in thoracoscopic suturing, sleeve lobectomies are feasible and safe to perform even when anatomic variants increase the complexity of the case.

Keywords: Sleeve lobectomy; bronchoplasty; uniportal video-assisted thoracoscopic surgery (VATS); bronchial resection; lobectomy

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Minimally invasive surgery for cancer patients has proven to offer many benefits over traditional surgery, including less pain, faster recovery and better cosmesis, without compromising oncologic results (1,2).

Video-assisted thoracoscopic surgery (VATS) is the representation of this concept in thoracic surgery and it has evolved from the conventional three port technique to the uniportal approach (2).

Uniportal VATS follows the same principles of coordination as in open surgery, since the camera is usually placed at the posterior part of the incision and the instruments performing the procedure are always bellow, mimicking the eye-hand position and coordination of open surgery (3).

This technique has improved substantially since the first reports of major lung resections were reported in 2011 (4,5) to advances cases (6) and more complex resections such a sleeve and double sleeve lobectomies in recent days (7,8). With the development of high definition cameras,

Figure 1 Uniportal video-assisted thoracoscopic right upper sleeve lobectomy (12). This video shows a complex case of a sleeve right upper lobectomy performed by uniportal VATS. VATS, video-assisted thoracoscopic surgery.
Available online: http://www.asvide.com/articles/618

energy devices, articulating instruments and the growing experience of surgeons performing this technique almost any major lung resection and reconstruction procedure can be done with this technique.

Sleeve lobectomies are among the most complex cases in thoracic surgery, even in open surgery these cases are usually challenging for thoracic surgeons (9,10).

Thanks to the rapid progress of uniportal VATS, complex procedures such as bronchial and vascular reconstruction can be perform safely in the hands of expert surgeons.

Although there are a several reports of thoracoscopic sleeve lobectomies, only a few of them are performed by using only one incision (11).

This video shows a complex case of a sleeve right upper lobectomy performed by uniportal VATS (*Figure 1*). This surgery was specially difficult because the right pulmonary artery (PA) was almost over the location in which the bronchial anastomosis was performed, making the procedure particularly challenging. The PA was initially retracted and taped, allowing a better visualization of the divided bronchus. The anastomosis was performed using a 3/0 polydioxanone suture (PDS), with continuous suture in the membranous portion and also for the cartilaginous part.

The direct view that uniportal VATS provides makes feasible and safe to perform complex maneuvers such as bronchial suturing even when there are anatomic conditions that blocks the working field, such as the PA in this case.

Only VATS surgeons with experience in thoracoscopic suturing should attempt this kind of cases in order to perform a safe anastomosis and minimize the risk of complications during surgery and in the postoperative setting.

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Footnote

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Informed Consent: Written informed consent was obtained from the patient. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

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Complex uniportal video-assisted thoracoscopic sleeve lobectomy during live surgery broadcasting

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Abstract: The uniportal approach for major pulmonary resections began in 2010 with the first case being performed by González-Rivas and colleagues in La Coruña. Since then a number of teams around the world had being performing hundreds of cases, applying it to more advance and complex cases recently. The technique has been reported to be feasible and reliable with similar results to that obtained in early stage lung cancer lobectomies. The case presented in this article is an example of an extreme condition: very obese patient, strong adhesions, fused lower lobe to the diaphragm and enlarged inflammatory adenopathies that made the procedure very technically challenging. In addition, the surgery was performed during a live surgery event and it was broadcasted to an auditorium. However, the case was successfully completed through a uniportal VATS approach with no complications.

Keywords: Sleeve lobectomy; uniportal VATS; bronchoplasty; difficult case; single port lobectomy; live surgery

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Introduction

The impact and evolution of minimally invasive thoracic surgery has been substantial during the last decade. The uniportal VATS technique has emerged as a revolutionary approach for early stage and advanced tumors (1). A lot of experience has been acquired in order to progress from the first thoracoscopic lung resections performed in the early 90s (2) to the complex vascular and bronchial reconstruction lobectomies performed by experience surgeons nowadays (3-5). Improvements in thoracoscopic instrumentation and technology such as high definition cameras and energy devices contributed considerably in this evolution (6).

Sleeve and double sleeve lobectomies are complex procedures even when they are performed in open surgery. These procedures are preferred instead of pneumonectomies for advance stage lung cancer because they preserve lung parenchyma and avoid the morbidity associated with pneumonectomies (7,8). Since the oncologic principles are not compromised the postoperative results in term of oncologic safety should be similar, but the patient obtains the advantage of a minimally invasive procedure such as less pain, faster recovery and less hospitalization time.

In the hands of expert VATS surgeons, bronchial and vascular reconstructions can also be done safely and many groups have published their results with multiport VATS and more recently with the uniportal approach (4-6,9,10).

The case reported in this article (*Figure 1*) shows that even extremely complex cases that require an sleeve resection can be safely performed through uniportal VATS by an expert surgeon (Dr. Gonzalez-Rivas) during a live surgery event.

Clinical summary

A 42-year-old morbidly obese female patient (BMI 40)

Figure 1 Left lower lobe sleeve resection and anastomosis (11). Available online: http://www.asvide.com/articles/983

Figure 2 Surgical photo showing the physical condition of the patient (BMI 40).

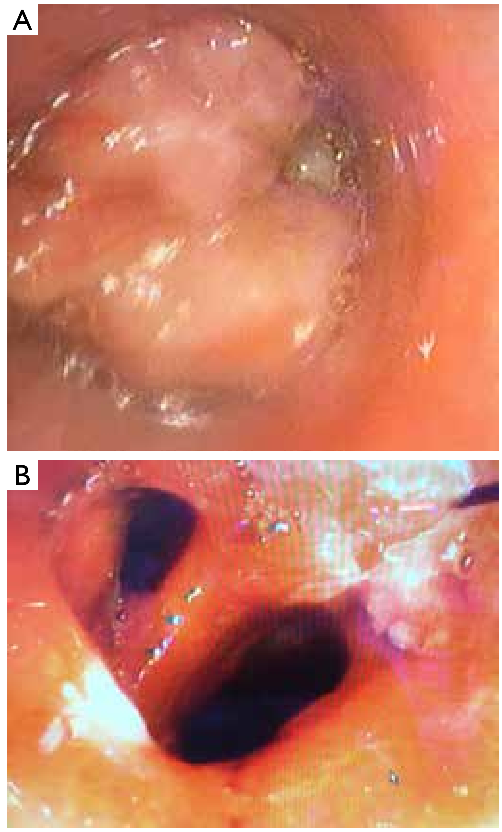

Figure 3 Bronchoscopy. (A) Before surgery showing endobronchial mass on the left main bronchus; and (B) after surgery showing good caliber of the anastomosis.

was diagnosed with a left upper lobe tumor (*Figure 2*). The patient suffered from recurrent pneumonias during the last year. The surgical case was selected for uniportal VATS live surgery during a workshop. The bronchoscopy showed an endobronchial mass in the left upper lobe bronchus involving the the main bronchus close to the carina (*Figure 3A*). The patient was placed in a right lateral decubitus position. A 4cm incision was made in the fifth intercostal space and dissection was performed until access to the thoracic cavity was obtained. No rib spreader was used during the surgery. The camera was placed in the posterior part of the incision and the instruments were introduced from below. Since the patient was obese, the diaphragm was highly located because of the pressure from abdominal cavity. Severe adhesions to the parietal pleura and mediastinum were found and detached. The left lower lobe was fused to the diaphragm and it was carefully detached with bimanual instrumentation and using an energy devices. After liberating the lower lobe, the fissure was handling. Identification of the interlobar plane was difficult because it was and incomplete fissure with a lot of adhesions between the lobes, so it was approach from anterior to posterior, with blunt dissection and remaining lung parenchyma in the fissure was stapled. The dissection continued with the pulmonary artery, which was technically challenging due to inflammatory changes of the tissues and also because of lymph nodes that obstruct the planes of dissection. Carefully identifying the adventitial plane of the pulmonary artery allows to safely dissecting it and dividing the first branches with a vascular endostapler. The left upper lobe vein was dissected and divided afterwards with the help of a tie to retract to avoid injury to the pulmonary artery when introducing the endostapler. Small branches of the pulmonary artery were ligated with a silk for the proximal end and divided with the energy device for the distal end. The interlobar artery was found dissecting above the junction of the inferior and superior pulmonary vein, completing the fissure stapling the lung tissue and identifying and dividing the lingular artery. Afterwards the interlobar artery was mobilized to facilitate exposure to the bronchus, which was carefully dissected. An incision was made in the base of the left upper bronchus and a circumferential cut was made with scissors to the main stem bronchus and the lower lobe bronchus. The left upper lobe was removed using an endobag. Further dissection was necessary to correctly expose the divided left main bronchus, since huge lymphadenopathies were obstructing it and will complicate the anastomosis procedure. Complete lymph node dissection was performed prior to initiating the anastomosis.

An end-to-end anastomosis was performed starting with a posterior stitch in the cartilaginous-membranous junction to help approximate the left lower and main stem bronchus. A continuous suture was initiated in the membranous portion from posterior to anterior, using a not pusher to tie the knot. Afterwards another continuous suture from posterior to anterior was done for the cartilaginous part and tie after completion with the running suture of the membranous wall. Air leak was ruled out with a water test upon insufflation. No tissue flap was used to protect the anastomosis and a single chest tube was placed through the incision. The postoperative bronchoscopy showed good caliber of the anastomosis (*Figure 3B*).

The postoperative course of the patient was uneventful and the patient was discharged home on the 7th postoperative day with excellent recovery. The pathological analysis showed a moderately-differentiated mucoepidermoid carcinoma with no lymph node involvement (11 adenopathies studied free of tumor).

Discussion

Indications and contraindications for VATS lobectomy have changed over time, due to increased experience in the technique. Initially VATS lobectomy was only consider for early stage lung cancer but thanks to the advances in thoracoscopic technology VATS has now a role in advance stage cases, even if they required bronchial or vascular reconstruction and it had been gaining acceptance in the thoracic community (3,9,12). The uniportal VATS technique, which is the latest step in VATS evolution, has also been used to safely perform this kind of complex cases (1,4-6).

As in any other surgical procedure, the uniportal sleeve technique has a learning curve, and it only should be attempted by expert surgeons with the uniportal VATS approach for lobectomy and the open sleeve procedures. Some authors suggest at least 200 VATS lobectomies and 20 open sleeve procedures before attempting a thoracoscopic sleeve resection (13).

Among the different sleeve lobectomies, the left side procedures are usually the more complicated ones, due to the presence of the aortic arch, the bigger size of the pulmonary artery and the absence of the intermediate bronchus (14).

Principles of single port VATS bronchoplasty are the same as in open surgery, the anastomosis has to be well vascularized, free of tension and in the left upper sleeve care must be taken to avoid injury to left recurrent laryngeal nerve during dissection and anastomosis. The preferred technique for anastomosis of the authors is a continuous suture with and absorbable 3–0 suture in two steps for the posterior and anterior wall of the bronchus, it is quicker and avoids tangling (6,14) .Usually there is no need of buttressing the anastomosis and anastomosis without coverage with tissue flap are safe (15). We only buttress the anastomosis after radiation or when there are signs of infection (14).

Currently, not many teams around the world are able to complete a uniportal VATS sleeve lobectomy, this slow adoption is because it requires advance training and experience and lacking of it rises concerns about technical issues like maintaining oncologic principles and the possibility of facing a major intraoperative bleeding (6,14).

There are very few published articles of bronchial or combined bronchovascular sleeve performed by VATS, and the vast majority are done through multiport VATS (16,17). Most of the articles published on uniportal VATS complex reconstruction belong to the team from La Coruña (4-6,14) and is that experience gained that has allowed to perform not only conventional sleeve procedures, which by themselves are challenging but to be able to successfully perform sleeve lobectomies even in extremely difficult scenarios like the case presented above. There were a number of conditions that made the surgery extremely difficult; the obesity, contributing also to a highly located diaphragm, the severely attached diaphragm to the lower lobe and the enlarged lymph nodes that were blocking the vascular structures and the bronchus (18).

Recently, tracheal and carinal uniportal VATS resections had been reported, emerging as an option to the conventional approach of a right thoracotomy or median sternotomy (14), although time will be need it before other groups obtain the necessary experience to be able to attempt such cases.

The case presented in this article shows that the limits are there to be surpassed and that the indications and capabilities of uniportal VATS continue to growth as it goes on erasing previous boundaries.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Uniportal video-assisted thoracoscopic right upper sleeve lobectomy and tracheoplasty in a 10-year-old patient

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Abstract: Tracheobronchial pediatric tumors are very rare and procedures like pneumonectomy are seldomly indicated due to the associated morbidity. If a surgical approach is considered, the ideal oncological technique would be the minimally invasive sleeve resection, allowing preservation of lung parenchyma (very important in pediatric patients). Here we present the first report of a thoracoscopic right upper tracheo-bronchial sleeve lobectomy in a pediatric patient. A 10-year-old female patient, who received multiple antibiotic treatments for recurrent pneumonia without improvement, was diagnosed with a right upper lobe (RUL) carcinoid tumor. The patient was proposed for uniportal thoracoscopic surgery. The patient was placed in a lateral decubitus position and a single 3 cm incision was performed at the anterior level of 4th intercostal space. A right upper lobectomy with a tracheo-bronchial sleeve resection using the uniportal technique was successfully performed. The postoperative course was uneventful and the patient was discharged home on the 7th postoperative day. The bronchoscopic control showed excellent caliber of the anastomosis with no complications. The uniportal video-assisted thoracoscopic surgery (VATS) approach is an excellent option for endobronchial tumor management in pediatric patients, offering a quick recovery and low morbidity. The performance of a thoracoscopic sleeve anastomosis in young patients is crucial and should only be performed by very experienced thoracoscopic surgeons.

Keywords: Carcinoid tumor; sleeve lobectomy; bronchoplasty; tracheal reconstruction; uniportal; single-port

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Introduction

Carcinoid tumors are neuroendocrine lung tumors that occur in 1–2% of all lung cancers, and is even less frequent in the pediatric population. This oncologic disease has a good prognosis when complete surgical excision of the tumor is performed (1).

Given its endoluminal location they are characterized by causing non-specific respiratory symptoms such as cough, hemoptysis and often generate or simulate recurrent respiratory infections with partial improvement delaying the oncological diagnosis (2,3).

Sir Clement Price Thomas proposed implementing bronchial resections since 1947 when he first performed a lobectomy with a bronchial sleeve to resect an adenoma of the right main bronchus. Later in 1955 the surgeons Paulson and Shaw, added the technique known as "bronchoplasty" in bronchial resections (4-7).

During the last decade, different techniques of minimally invasive surgery for bronchial resections have been introduced, among these, the single port (uniportal) video-assisted

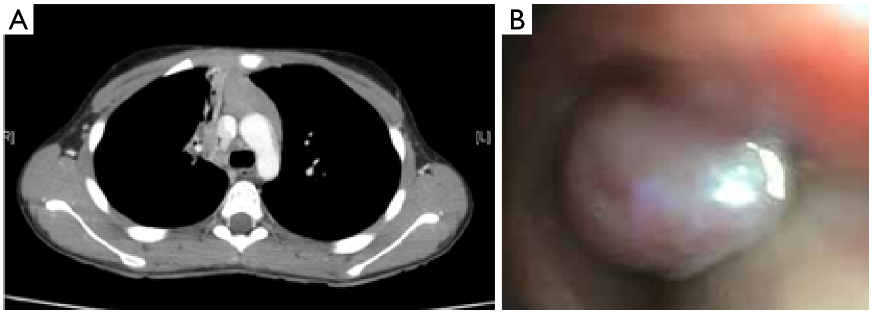

Figure 1 Preoperative studies. (A) Bronchoscopic aspect of the tumor; (B) CT showing tumor at the entrance of right upper lobe bronchus.

Figure 2 Uniportal VATS right upper sleeve tracheobronquial lobectomy (9). VATS, video-assisted thoracoscopic surgery. Available online: http://www.asvide.com/articles/1149

Figure 3 Surgical photo showing camera and instruments through the incision.

thoracoscopic surgery (VATS), this being the less morbid and less invasive technique with excellent results in expert hands (8).

In this article a successful sleeve lobectomy in a pediatric patient by uniportal VATS with excellent postoperative results is reported.

Case presentation

A 10-year-old female patient with a 1-year history of clinical symptoms characterized by episodic cough and mild fever was diagnosed of pneumonia so an empiric antibiotic treatment was initially prescribed. The patient showed partial improvement with persistence of cough with a later onset of hemoptysis, with serial smears reported as negative for bacilli identification.

According to the demographic and epidemiological profile of the patient, oral antibiotic management with anti-tuberculosis treatment was prescribed (isoniazid—pyrazinamide—ethambutol—Rifampicin) for 6 months without improvement. She underwent a diagnostic bronchoscopy with biopsy, where a polypoid tumor was seen blocking the entrance of the right upper bronchus (*Figure 1A*). The result of the biopsy reported a low-grade neuroendocrine carcinoid tumor.

A CT Scan confirmed the presence of endobronchial lesion and secondary atelectasis of the right upper lobe (RUL), without the presence of mediastinal enlarged lymph nodes (*Figure 1B*).

The patient was proposed for a uniportal VATS right upper sleeve lobectomy.

Surgical technique (*Figure 2*)

Under general anesthesia and double lumen intubation the patient was placed in a left lateral decubitus position with abduction and flexion of the right upper limb.

A uniportal VATS approach through a 3-cm incision was performed at the 4th intercostal space, anterior axillary line. A 30-degree high definition thoracoscope was inserted through the incision and a panoramic view of the right chest cavity was obtained showing a chronic atelectasis of RUL (*Figure 3*).

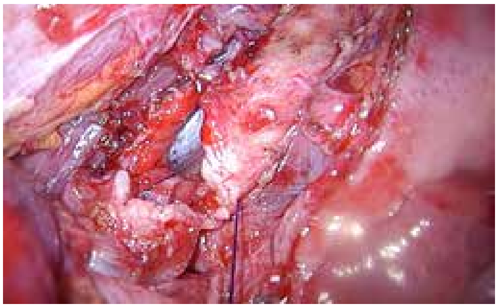

Figure 4 Surgical image of posterolateral wall of the anastomosis between bronchus intermedius and lateral part of the carina.

Figure 5 Postoperative X-chest ray.

A right upper sleeve lobectomy was performed leaving the bronchial division for the end. The main and intermediate bronchus was cut by means of a bronchoplastic resection. An intra-operative frozen section was positive for malignancy from the proximal segment so a wider proximal resection margin towards the carina and distal trachea was performed until a disease-free histopathology report was confirmed.

The dissection of the right lower lung ligament was carried out to allow the mobilization of the remaining lobes and to avoid tension on the anastomosis.

The mediastinal lymphadenectomy was performed prior doing the anastomosis, to release trachea and bronchus and avoid tension on the suture. The posterior part of the trachea was initially reconstructed by using single PDS 3/0 sutures. The anastomosis of the bronchus intermedius and the edge of the carina was performed in two steps: first a continuous PDS 3/0 suture from back to front for the posterolateral wall of carina and another continuous suture for the anterolateral wall (lateral side of trachea and bronchus intermedius), tying both sutures at the anterior corner of the anastomosis (*Figure 4*).

After the hemostasis was checked, a single chest tube (20F) was inserted and the wound was closed. The patient was successfully extubated and transferred to the intensive care unit.

Evolution

The patient was discharged from the intensive care unit to the ward 24 hours after the surgical procedure. She referred a 3/10 score on the visual analog pain scale without respiratory symptoms. A postoperative chest X-ray showed a normal expansion of the right middle and lower lobes.

The chest tube was removed on the fourth postoperative day and the patient was discharged home on the seventh postoperative day with excellent recovery (*Figure 5*). Before being discharged home, a bronchoscopy was performed confirming a perfect caliber of the anastomosis with no complications.

Discussion

The vast majority of bronchial sleeve resections are performed in patients diagnosed with tumor or polypoid bronchial disease, more frequently occurring in adult patients rather than in the pediatric population. In addition, reported cases refer to open surgical treatment instead of thoracoscopic surgery. To our knowledge and with a thorough review of PubMed, Science Direct, Cochrane and Ovid, there are no reports of uniportal VATS in pediatric patients.

Although technically more demanding, minimally invasive thoracoscopic surgery allows rapid recovery and generates less morbidity compared with open surgery (10). Technical advancements in surgical instruments designed for thoracoscopic surgery, allow surgeons to innovate and to make adaptations to techniques for the treatment of oncological diseases.

Uniportal VATS is an example of the continuing search for methods that aim to provide the patient a surgical cure of the disease with the lowest morbidity (11). In this particular case, the minimization of surgical invasiveness and preservation of the lung parenchyma is of great importance, as it offers better postoperative results and less rate of complications (12).

The application of uniportal VATS requires a highly trained surgical team in thoracoscopic surgery and when executed with dexterity, reduces morbidity and mortality. Despite current evidence being based on retrospective studies and case series, it is hereby shown that sleeve lobectomy by uniportal VATS is safe. It also offers great advantages such as reduction in postoperative complications and speeds up the period of patient recovery (12,13).

The sleeve bronchoplastic resection is usually the surgical method of choice in cases with proximal bronchial tumor obstruction. We must avoid thoracotomy and its associated morbidity and mortality, with particular emphasis on the pediatric population, so susceptible to alterations in their chest and lung development after surgical interventions.

In summary, we believe that the uniportal VATS technique for bronchoplastic procedures is an excellent option for the treatment of endobronchial tumors especially in the pediatric population

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Informed Consent: Written informed consent was obtained from the patient for publication of this manuscript and any accompanying images.

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Uniportal video-assisted thoracoscopic sleeve lobectomy and other complex resections

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Abstract: Thanks to the recent improvements in thoracoscopy, a great deal of complex lung resections can be performed without performing thoracotomies. During the last years, experience gained through video-assisted thoracoscopic techniques ,enhancement of the surgical instruments and improvement of high definition cameras have been the greatest advances. The huge number of surgical videos posting on specialized websites, live surgery events and experimental courses has contributed to the rapid learning of minimally invasive surgery during the last years. Nowadays, complex resections, such as post chemo-radiotherapy resections, lobectomies with chest wall resection, bronchial and vascular sleeves are being performed by thoracoscopic approach in experienced centers. Additionally, surgery has evolved regarding the thoracoscopic surgical approach, allowing us to perform these difficult procedures by means of a small single incision, with excellent postoperative results.

Keywords: Sleeve lobectomy; bronchoplasty; bronchial anastomosis; uniportal VATS; single-port lobectomy

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Although the first thoracoscopic lung resection was performed in 1991 (1), the development and expansion of video surgery has been greater in the last 10 years. Internet and specialized web pages have been critical in this expansion, for they have given access to a great number of videos showing surgical techniques. Nowadays, more complex resections, such as post chemo-radiotherapy resections, lobectomies with chest wall resection, bronchial sleeves or vascular reconstructions are being performed and published. The experience acquired in the last years, as well as the development of thoracoscopic equipment (especially the introduction of the high definition) and the improvements of the surgical instruments have contributed to this.

The bronchial or vascular reconstruction procedures are usually planned to preserve the lung parenchyma, avoiding pneumonectomies. Generally, these are complex procedures even with open surgery, but they can be performed thoracoscopically obtaining similar postoperative results in expert hands. During the last years, many groups have published their experience with sleeve procedures by conventional VATS (2,3). Most surgeons use a 3-4 incision VATS technique for sleeve anastomosis but the surgery can be performed by using only one incision (4,5). When performing bronchial suturing using single port VATS, it's very important to maintain the camera on the posterior part of the incision, operating with both hands below the camera. Here we apply the same principle as when performing an anterior thoracotomy in open surgery: to have a direct view with the surgeon's eyes above his/her hands. Using a plastic wound protector is helpful when dealing with obese patients because fatty tissue could interfere with the suture threads.

The use of material with proximal and distal articulation (Scanlan International Inc.) is crucial (*Figure 1*). The surgeon ties the knot outside of the chest with the right hand, holding both ends of the thread with the left hand's index and little fingers and pushing down the knots using a thoracoscopic knot pusher (*Figure 2*). We usually don't buttress the suture except in cases of preoperative

Figure 1 Surgical image of instrumentation during sleeve procedures.

Figure 2 Technique for knot pushing through a single port (6).
Available online: http://www.asvide.com/articles/352

Figure 3 Simple bronchoplasty (7).
Available online: http://www.asvide.com/articles/353

radiotherapy. In these cases we use an intercostal muscle flap or a pedicle pericardial or mediastinal fat pad.

The operating table's position makes the lung exposure easier to perform the anastomosis (the anterior rotation of the table 45° to the surgeon places the lung on an anterior position and makes easier the posterior bronchial suture, especially the membranous portion).

Suture may be performed with single stitches or

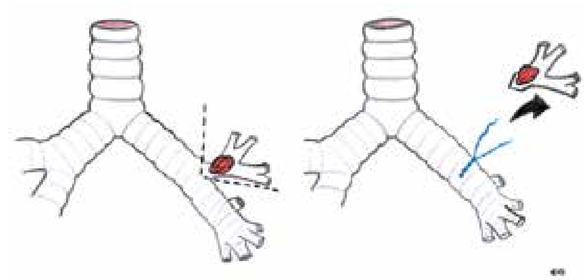

Figure 4 Drawing showing wedge bronchoplasty.

continuous suture. The usage of monofilament suture makes the thread movement easier, as well as the tying. The bronchial edge must be assessed during the operation, the suture is checked at the end of the surgery using insufflation under water and bronchoscopic control to check integrity and secretion aspiration.

We can classify three types of bronchoplastic procedures according to the resection type:

(I) Simple bronchoplasty. The bronchus is cut in its origin using a scalpel, when the tumor is located to the bronchial base (due to this the use of an endostapler is not possible). For the closure, we use single double PDS 3/0 stitches (flushed shape) (*Figure 3*). Flap protection is not usually needed. When doing a simple bronchoplasty on the inferior right lobe, the suture must be carefully handled to avoid stenosis of the middle lobe bronchus.

(II) Wedge bronchoplasty. In this case the bronchial cut is made deeper in wedge shape to the main bronchus (*Figure 4*). This kind of suture may call for a transverse closure, but if the wedge is large and doesn't allow the approximation, it may be reconstructed using a lateral closure (*Figure 5*). We recommend the subcarinal lymph node dissection (lymphadenectomy) before the bronchoplasty in order to free the main bronchus and avoid an excessive traction once the suture is done.

The suture is made without tension, with approximation to the mucosa using monofilament absorbable interrupted or continuous suture (PDS 3/0), with all knots preferably placed externally. The monofilament suture facilitates the movement through the bronchus and the tying of the knots.

(III) Sleeve bronchoplasty. The bronchial sleeve resections with end to end anastomosis are the most complex bronchoplastic procedures (*Figure 6*). The right upper lobe bronchoplasty is normally the less difficult procedure, due to the alignment of

Figure 5 Wedge bronchoplasty (8).
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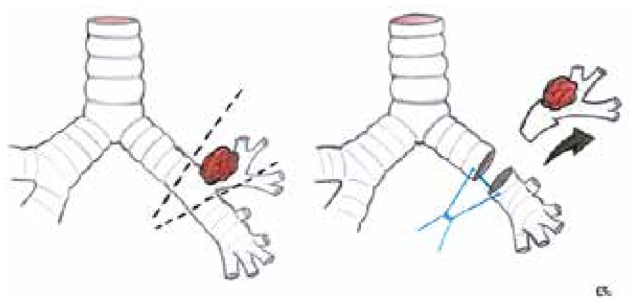

Figure 6 Drawing showing sleeve bronchoplasty.

Figure 7 Sleeve bronchoplasty (9).
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the main and the intermediate bronchi (4). This location makes operating with both hands easier. The liberation of the pulmonary ligament, as well as the subcarinal lymph node dissection facilitate the lung mobility and avoid tension during the anastomosis.

The bronchus may be cut initially using a long scalpel,

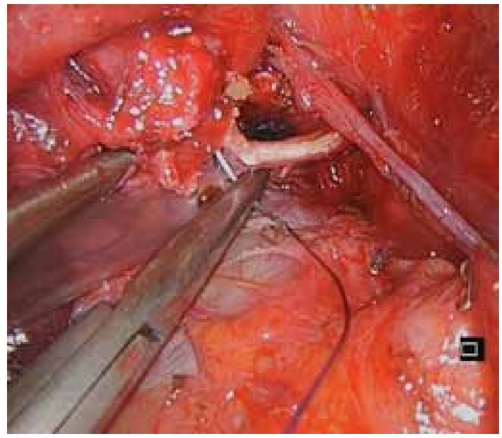

Figure 8 Surgical image of left lower sleeve anastomosis (main bronchus to left upper bronchus).

the bronchial circumference section may be completed using scissors.

We can use single stitches for the cartilage part and continuous suture for the membranous portion. It's best to tie the single suture one by one, to avoid that the threads touch each other, and it's preferable to tie the knot outwards (*Figure 7*). Another, more simple option (and with identical results) is to make the whole anastomosis using continuous PDS 3/0 suture. Usually, the posterior bronchus wall is stitched first and the anterior wall, from behind so that both edges are tied at the anterior level.

The most complex sleeve procedures are usually those of the left side, due to the presence of the aortic arch and the bigger size of the pulmonary artery (*Figure 8*) (5). For left-sided bronchial resections, it's best to use a right-sided double-lumen tube, in order to make suture easier and reduce the bronchus tension.

Segmental bronchial sleeve reconstruction (*Figure 9*)

In this particular case, In order to avoid a full sleeve, we perform a resection of the right main bronchus and right upper bronchus after a lower bilobectomy. The reconstruction is more complex in these cases, with anastomosis of the main bronchus to the right upper individual segmental bronchi. A careful reconstruction of the main bronchus' suture is especially important, in order to avoid that the small segmental bronchi be closed after the anastomosis. In this scenario is better to perform interrupted sutures to adjust the segmental bronchi

Figure 9 Sleeve segmental bronchoplasty (10).
Available online: http://www.asvide.com/articles/356

Figure 10 Surgical image of instrumentation during right vascular reconstruction.

Figure 11 Vascular reconstruction (12).
Available online: http://www.asvide.com/articles/357

Vascular resections

These procedures are complex and usually performed by open surgery or by conventional VATS by experienced and skilled thoracoscopic surgeons. However the same operation can be accomplished by using only a single incision VATS approach.

When the tumour invades the pulmonary artery, the artery as well as the basal trunk must first be controlled and dissected. Sometimes it's necessary to perform an intrapericardial control. Before the pulmonary artery clamping, 5,000 UI heparine iv must be administered to prevent thrombosis. We prefer the pulmonary artery clamping with a large thoracoscopic clamp (D'Amico Clamp, Scanlan International, Inc.), which is placed on the inferior part of the wound. For distal clamping it's better to use bulldog clamps on the most distal part of the basal trunk, or clamping the inferior pulmonary vein to interfere as less as possible with the instruments. Sometimes, a double vessel loop is enough for distal clamp, especially in the less complex reconstructions (*Figure 10*).

There are three types of vascular reconstructions:

Partial resection of the pulmonary artery

It's a less complicated vascular reconstruction and it's performed especially when the tumor invades the base of one of the mediastinal branches but without a large involvement into the main pulmonary artery (11).

After heparinization and clamping of the main artery and basal trunk we perform a tangential incision on the pulmonary artery and a direct closure by means of a running suture with prolene 5/0 or with several interrupted double sutures (*Figure 10*).

Once the suture is completed we release the most distal clamp to release any air thanks to the return flow and we tie once the artery is full. Then we do a progressive release of the proximal clamp. The clamp will not be entirely removed until we confirm that there is no bleeding (*Figure 11*).

Patch reconstruction

It's a complicated procedure with VATS. Bovine pericardium may be used as well as a patch from the patient's pericardium. The use of patches should be avoided as it could increase the risk of thrombosis. In the case of an extensive end-to-end resection, a tube may be created out of the pericardium in order to do an end-to-end anastomosis at each end of the resection. To our knowledge, these procedures have not been reported yet by VATS.

End-to-end anastomosis

Is probably the most complex procedure that can be done through VATS and it requires special skills and an extensive

Figure 12 Sleeve end to end vascular anastomosis (13). Available online: http://www.asvide.com/articles/358

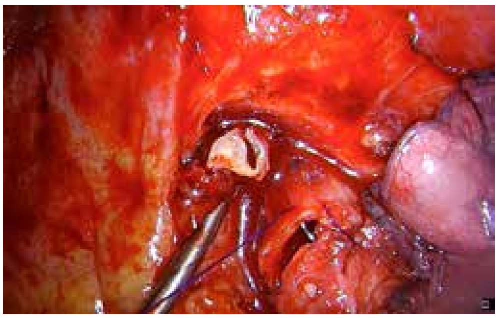

Figure 13 Surgical image of double bronchovascular procedure.

experience with video-assisted thoracoscopic surgery. In these cases of vascular reconstruction, it is advisable that this be the last step of the lobectomy (first divide the veins, bronchus and fissure) in order to have a larger surgical field and more control of the section of the pulmonary artery. Once the arterial trunk is clamped we cut the proximal and distal side using scissors and we position the lobe in the costodiaphragmatic angle, over the diaphragm in order to be extracted once the suturing is complete.

Vascular sleeve is more frequent on the left side, with tumors that invade the main pulmonary artery or the mediastinal branches that lead to the upper lobe.

For the end-to-end anastomosis it is important to free up the pulmonary ligament and sometimes open up the pericardium to free up tension. Due to the fragility of the pulmonary artery and in order to avoid ruptures during the anastomosis, special care must be given to the manipulation of sutures as well as a correct traction of the pulmonary artery.

It's very important to adjust the diameters of the main artery to the lobar branches during anastomosis, in order to avoid kinking or stenosis. We start anastomosis with an anterior and posterior traction suture to adjust the diameters by using prolene 4/0 or 5/0. For the posterior suture, both needles are kept and once the knot is tied one of them is kept separately in the interior of the chest cavity (it will be used for suturing the superior face). A running suture is done on the inferior side of the artery from a posterior to anterior direction and we tie it to the anterior traction end. Then we use the other needle from the posterior traction end to complete the suture of the superior side and it is then tied to the anterior suture. Before tying we must release air and check the flow after opening the distal clamp (*Figure 12*).

In case of the double sleeve, it is better to do the bronchial suturing first and after that the arterial reconstruction in order to avoid traction on the arterial suture (14) (*Figure 13*).

Other complex resections

The single port technique allows us to make other complex procedures, such as Pancoast tumors (hybrid approach is necessary), superior sulcus tumors, and tumors with chest wall invasion or contralateral nodule resections on patients with previous pneumonectomy.

Sulcus tumors

The approach for Pancoast tumors approach is hybrid. We make the incision at the fifth intercostal space for the lobectomy and a high posterior incision or anterior superior Dartevelle or Grünenwald incision for the resection at apical level and vascular control. We can perform the superior approach first in order to free the lobe to the superior level or we can begin with the lobectomy and then perform the superior approach for resection, once the lobe has been freed.

For sulcus tumors without bone or vascular involvement, sometimes it's enough to perform a deep extrapleural resection. We present the following case: a 50-year-old man with a sulcus tumor, treated with chemotherapy and concomitant radiotherapy, having good response. A right upper lobectomy was done, from anterior to posterior using the fissureless technique with the lung fixed to the apex. Once the lobectomy was done, a partial resection of the healthy lobe zone was performed in order to obtain more space to accomplish the resection of the tumor. It's important to use energy devices to perform a more secure apical and extrapleural liberation. Surprisingly, the final pathological examination of this case confirmed a complete tumoral Junker regression. After 3 years there hasn't been

Figure 14 Superior sulcus tumor (15).
Available online: http://www.asvide.com/articles/359

Figure 15 Lower lobectomy with chest wall resection (17).
Available online: http://www.asvide.com/articles/360

Figure 16 Nodule resection in a patient with contralateral pneumonectomy (18).
Available online: http://www.asvide.com/articles/361

any sign of the tumor growing again (*Figure 14*).

Tumors with chest wall involvement

When dealing with tumors that invade the chest wall we use a combined approach: single port for the lobectomy (fifth intercostal space) and a small lateral or posterior incision for the costal resection, according to the location of involvement (16). After evaluation of costal invasion and the tumor's size (better or worse lobe mobility), we will perform either the lobectomy or the costal resection first. On this video we performed the right inferior lobectomy first using single port, once the lobe was freed the chest wall was resected and a mesh was placed thanks to the thoracoscopic vision (*Figure 15*).

Tumors on patients with previous pneumonectomy

Surgery on these patients must be extremely careful. Therefore, the resection must be as limited as possible. It's important that the lobe to be operated is collapsed. A good option is the endotracheal intubation with a single tube and fogarty catheter directed with bronchoscopy to collapse the selected lobe. In this case we present a video of a patient with previous pneumonectomy (10 years before) and a new primary tumor. The patient presented costal fractures and hemothorax (which needed chest tube) in the past, as well as a previous intervention of pericardiectomy caused by a chronic constrictive pericarditis. These findings increased the difficulty and risk of the case. However the patient was proposed for a uniportal VATS resection. After a difficult extrapleural liberation of the lung (maintaining the superior lobe ventilation), we palpated the tumor into the left lower lobe and we resected it with endostaplers (*Figure 16*).

Discussion

Uniportal VATS is not only indicated to initial stages or easy cases. With gained experience the most complex cases can be performed in the same manner as with double or triple port approach (19,20). Previous experience in VATS is necessary to perform these advanced cases with success (21). We have performed lobectomies with strong adherences after TB, redo-VATS, tumors with chest wall involvement, cases after high doses of chemo-radiotherapy, anatomic complex segmentectomies, vascular reconstruction, sleeve lobectomies, double sleeve, pneumonectomies and huge tumors by single incision VATS.

Despite the multiple advantages of conventional or uniportal VATS compared with thoracotomy as decreased postoperative pain, decreased hospitalization, diminished inflammatory response or faster access to chemotherapy, the uniportal VATS approach for advanced stages of lung cancer is still infrequent. The concern about an intraoperative thoracoscopic major bleeding or the technical complication of performing a radical oncologic resection by single port VATS in advanced cases are the main reasons for the low adoption. We recently assessed and published the feasibility of uniportal VATS approach in the treatment of advanced NSCLC and compared the perioperative outcomes with early-stage tumors with excellent postoperative results (21).

Since we developed our uniportal technique for VATS lobectomies in 2010 we have increased the application of this technique to more than 90% of cases in our routine surgical practice. The experience we acquired with the uniportal technique during the last years, as well as technological improvements in high definition cameras, development of new instruments, vascular clips and more angulated staplers have made this approach safer, incrementing the indications for single-port thoracoscopic resections. We believe it is important to minimize the surgical aggressiveness especially in advanced stage lung cancer patients where the immune system is weakened by the disease or by induction treatments (22). The minimally invasive surgery represents the least aggressive form to operate lung cancer and the single-port or uniportal technique is the final evolution in these minimally invasive surgical techniques.

The most complex resections are the thoracoscopic sleeve procedures. There are few articles published in the literature describing bronchial sleeve, vascular sleeve or combined bronchovascular sleeve by VATS, and all of these resections are reported by using conventional thoracoscopic techniques (23,24). As our experience has grown with the single-port VATS approach (4,20) we have increased the rate of thoracoscopic sleeve procedures and decreased the incidence of pneumonectomy, and even we have performed bronchovascular sleeve procedures by uniportal VATS (14,25). We found several advantages of the single incision thoracoscopic technique especially for sleeve procedures. The geometrical explanation of the approach, the direct view and bimanual instrumentation could explain the excellent results we have obtained with this technique (26).

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Bronchovascular right upper lobe reconstruction by uniportal video-assisted thoracoscopic surgery

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Abstract: Lung cancer requiring double bronchial and vascular reconstruction of the pulmonary artery is a challenging procedure usually performed by thoracotomy. However, recent development of video-assisted thoracoscopic techniques allows experienced and skilled surgeons to perform these cases through a minimally invasive approach. Most of these complex thoracoscopic resections are performed by using 3 to 4 incisions. We present the first report of a right side combined vascular reconstruction and bronchoplasty performed through a single-incision video-assisted thoracoscopic surgery (VATS) technique.

Keywords: Thoracoscopy/video-assisted thoracoscopic surgery (VATS); minimally invasive surgery; pulmonary artery reconstruction; vasculoplasty; vascular reconstruction; bronchoplasty; surgery/incisions/technique

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Introduction

In the past two decades with increasing frequency video-assisted thoracoscopic surgery (VATS) has been performed for lung cancer treatment. However, complex cases are only performed in a few centers. Most surgeons use a 3-4 port VATS approach for difficult resections such as bronchial or vascular sleeves. This report describes the technique for a right upper lobectomy with bronchoplasty and vascular reconstruction by using a uniportal VATS technique.

Clinical summary

A 73-year-old male, smoker, with severe comorbidities (COPD, obesity, hypertension and cardiomiopathy) was diagnosed with a right upper lobe (RUL) tumor. The CT scan showed the tumor located on the posterior segment of the RUL with bronchial and vascular invasion by lymph nodes (*Figure 1*). The pulmonary function test was normal (FEV1 70%). The patient was proposed for single incision VATS approach.

Surgical technique

Under general anesthesia, a VATS approach using a 4 cm single-incision was made in the 5th intercostal space with no rib spreading (no soft tissue retractor and no direct vision).

A tumor was detected in the RUL and lymph nodes were involving the bronchus and apical-anterior branch of the pulmonary artery (PA) and interlobar artery. The incomplete fissure was divided from anterior to posterior from the hilum to expose and control the artery. The RUL bronchus was not possible to be dissected so it was transected by using a long knife. The main pulmonary artery and the basal trunk were dissected to have adequate proximal and distal vascular control. Before clamping the PA, 5,000 units of heparin were injected intravenously to prevent clotting. The interlobar artery was occluded by using a double vascular sling vessel loop and the main PA was closed using a thoracoscopic clamp (Scanlan International, Inc, Saint Paul, MN, USA). The clamp was placed towards the anterior portion of the incision and the vessel loop was placed in the posterior part. The camera was located in the posterior part of the incision, and the instrumentation was placed and used below the camera.

The PA was transected laterally and the specimen was temporarily placed in the costo-diaphragmatic space. The defects in the interlobar artery and base of apico-anterior branch were repaired by using interrupted double lateral

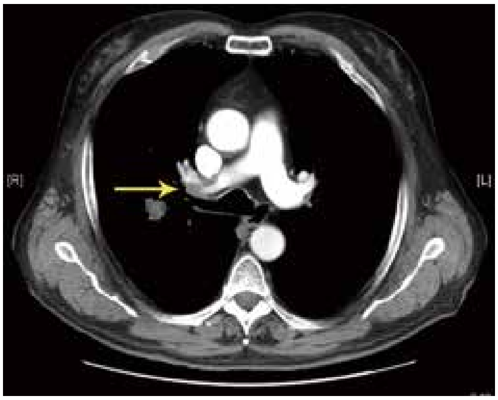

Figure 1 Computed tomography scan showing right upper lobe (RUL) bronchial and vascular lymph node invasion.

Figure 4 Postoperative result with chest tube placed in the posterior part of the incision.

Figure 2 Bronchovascular resection and reconstruction. Available online: http://www.asvide.com/articles/255

Figure 3 Surgical image of instrumentation during bronchoplasty.

4-0 monofilament non-absorbable sutures. The sutures were tied and the air was released through one of the posterior branches which was cut and then closed by using a vascular clip (Click aV, Grena^{R}) (*Figure 2*). The specimen was then removed in a protective bag (1).

The bronchus was reconstructed and closed by using interrupted double sutures of 3-0 PDS (*Figure 3*). The lung was inflated and no air leak was observed. Systematic lymph node dissection was then performed to complete the procedure and a single chest tube was placed (*Figure 4*). Total surgery time was 310 min and estimated blood loss was 180 cc. The chest tube was removed on the sixth postoperative day and the patient was discharged on the same day with no complications and excellent recovery.

Discussion

Bronchovascular reconstructive surgery is a technically feasible alternative to pneumonectomy and has the advantage of sparing the functioning of the lung parenchyma. These procedures are very complex and usually performed by open surgery (2). However, with the recent developments in VATS technology and acquired experience, this surgery can be performed thoracoscopically by experienced and skilled VATS surgeons. There are very few articles published in the literature describing a combined bronchial and vascular reconstruction by VATS, and these resections are reported on the left side by using conventional multiport thoracoscopic technique (3,4). We have recently published the first case of double sleeve VATS resection by a single incision approach (5).

As our experience has grown with the single-port VATS approach (6) we have increased the rate of thoracoscopic sleeve procedures and decreased the incidence of pneumonectomy and today our list of contraindications is very limited (7). Advanced uniportal thoracoscopic procedures as bronchial sleeve lobectomy (8), lobectomy with chest wall resection, vascular reconstruction (9) and double sleeve (5) have already been performed with good postoperative outcomes. To April 2014 we have performed 11 uniportal VATS lobectomies with reconstruction: wedge bronchoplasty (3 cases), bronchial sleeve (5 cases), pulmonary arterioplasty 3 (1 vascular reconstruction, 1 vascular reconstruction combined with bronchoplasty and one double bronchovascular sleeve). The postoperative course of these patients was uneventful. Mean operative time was 215±54 minutes (range, 120-310 minutes) and median hospital stay was 6 days (range, 2-21 days).

The success in performing complex lobectomies by uniportal approach is a result of skills and experience accumulated over time by performing many uniportal VATS surgeries (6). The advantage of uniportal VATS surgery is the vision is direct to the target tissue providing a similar angle of view as for open surgery. Conventional multi-port VATS triangulation creates a new optical plane with genesis of torsional angle that is not favorable with standard two-dimension monitors. Another advantage of the uniportal VATS technique is that instruments inserted parallel to the camera mimic inside the chest maneuvers performed during open surgery. This geometric uniportal VATS concept facilitates the bronchovascular reconstruction in complex resections such as the one described in this article (10).

Most of the published cases requiring sleeve or vascular reconstruction are located on the left side. Infiltration of the PA on the right side requiring arterial reconstruction is less frequent. Reconstruction of the PA enables complete cancer resection while preserving functioning pulmonary tissue, and has a definitive role in the surgical management of lung cancer. In this particular case there was a partial infiltration of the surface of the artery (base of apical-anterior and posterior branch) by lymph nodes needing tangential resection with direct repair, and a total sleeve was not necessary. In this case partial resection of the PA was performed in conjunction with bronchoplasty of the RUL. The use of thoracoscopic instruments with proximal and distal articulation (Scanlan International, Inc, Saint Paul, MN, USA) facilitate the instrumentation through a single-incision, especially for clamping the main pulmonary artery with no interference to the broncho-vascular reconstruction. For clamping the basal trunk we usually prefer to use a double vessel loop or a bulldog-clamp (placed inside the cavity) to facilitate the instrumentation.

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Footnote

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Uniportal video-assisted thoracoscopic sleeve resection

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With continually growing interest in video-assisted thoracoscopic surgery (VATS) sleeve procedures in the international community, mastery of uniportal VATS sleeve resections is still a complex issue for surgeons. Several articles published recently have shown that VATS sleeve procedures can be performed safely (1-3). In this article the technique of a complex uniportal VATS sleeve resection is presented.

Case 1

Clinical vignette

The patient is a 67 year-old woman with a left upper lobe squamous cell carcinoma (cT3N0M0) involving mediastinal pleura and the pulmonary artery. Her pulmonary function testing indicated 43% of her predicted forced expiratory volume in one second (FEV1). Uniportal VATS double sleeve left upper lobectomy was scheduled.

Surgical technique

The patient was set in the lateral position. After single-lung ventilation, a 5 cm long incision was made in the fifth intercostal space (*Video 1*). The first step was revision and dissection of the mediastinal pleura, division of the pulmonary ligament, dissection of lymph nodes from stations 5, 6, 8 and 9 and visualization of the lower lobe vein (*Video 2*). The extra-pericardial part of the upper lobe vein was involved in the tumor. Therefore the pericardium was opened and both the upper lobe vein and left pulmonary artery were dissected. The upper lobe vein was divided by an endostapler. Then, the left main bronchus and lower lobe bronchus were dissected and cleared. After that, the *ductus arteriosus* was dissected and divided. The fissure was completed by endostaplers. After dissection of the lower lobe artery and division of the lingular artery, the possibility of resection was confirmed. Before clamping the left pulmonary artery, 5,000 units of heparin were injected intravenously. The left pulmonary artery and lower lobe artery were occluded by placing an arterial clamp and bulldog-clamp respectively. The arterial clamp was placed in the anterior portion of the incision. After that, the upper sleeve lobectomy with sleeve pulmonary artery resection en-bloc was performed. The specimen was temporarily placed in the diaphragmatic sinus. Then, after lymph node dissection from station 7, we performed bronchial and arterial anastomoses. The bronchial anastomosis was performed with a continuous suture (V-loc 3-0). The water probe was negative. The arterial anastomosis was performed with a continuous suture (prolene 4-0) and covered by oxidized regenerated cellulose (Surgicel). The specimen was removed by endo-catch. Surgery time was 300 minutes. Blood loss was 200 mL.

Case 2

Clinical vignette

The patient is a 54 year-old man with a right upper lobe squamous cell carcinoma (cT4N0M0) involving the right main bronchus and superior vena cava. After three courses of neoadjuvant chemotherapy (gemcitabine and cisplatin), the tumor size was reduced to some extent. Pulmonary function testing showed 74% of his predicted FEV1. Uniportal VATS total sleeve carinal pneumonectomy with vena cava resection was scheduled.

Surgical technique

The patient was set in the lateral position. After single-lung ventilation, a 5 cm long incision was made in the fifth intercostal space. The first step was revision, dissection and partial resection of the superior vena cava by endostapler. The next step was dissection of lymph nodes from stations 2, 3 and 4 and visualization of the anterior walls of the trachea and carina. Then, the upper lobe vein was dissected. The posterior part of the azygos vein was dissected, clipped and divided. Following dissection of the posterior wall of the carina, the possibility of resection was confirmed. The next step was dissection and consistent division of the inferior pulmonary vein, superior pulmonary vein and pulmonary artery by endostaplers. After mobilization of the right lung and carina with lymph node dissection from station 7, total carinal resection was performed with a double lumen tube. Frozen section histological examination of the tracheal margin was positive therefore we resected one tracheal ring. When the specimen was removed and hemostasis was checked, we commenced high frequency ventilation. The trachea-bronchial anastomosis was performed with a continuous suture. We used the V-Loc 3-0 wound closure device, which facilitates secure anastomosis closure without knot-tying. The water probe was negative. To cover the anastomosis, we used a mediastinal pleural flap. The operation time was 280 minutes. Blood loss was 100 mL. Flexible bronchoscopy at the end of the procedure showed a normal endobronchial view of the anastomosis.

Comments

Clinical results

There were no postoperative complications. Final pathology revealed pT3N0M0 in case 1 and. pT4N0M0 in case 2.

Advantages

The uniportal approach for VATS sleeve procedures provides a perfect direct view, which is required to perform reliable bronchial and vascular anastomoses. In the case of conversion, the uniportal approach can be expanded to thoracotomy within 1 or 2 minutes. Another advantage is that the instruments are inserted parallel to the thoracoscopy. This makes the technique of performing arterial anastomosis similar to open surgery.

Caveats

Usually, the intrapericardial part of the upper lobe vein is involved in the tumor in double sleeve cases. It is impossible to execute the uniportal VATS principle of 'first artery then vein' in double sleeve cases. This is the serious obstacle to division of the upper lobe vein by endostaplers by the uniportal approach. To overcome this situation, we have to open the pericardium in order to lengthen the vessel. We can use a 30 mm vascular stapler for open surgery or ligature and clips to divide the vein safely. To evaluate tumor invasion in the lower lobe artery, the fissure should be divided. This is the main point to confirm the possibility of the double sleeve procedure. As a general rule, the left pulmonary artery is very short. Therefore the ductus arteriosus must be dissected and divided. It provides 1–1.5 cm of length to the vessel and this is very important for placing an arterial clamp safely. After lung mobilization, carinal resection by the uniportal approach must be performed with a double lumen tube to avoid any blood aspiration into the left main bronchus. After removing the specimen and ensuring hemostasis, it is necessary to start high frequency ventilation in order to perform the anastomosis more easily.

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None.

Footnote

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Double sleeve uniportal video-assisted thoracoscopic lobectomy for non-small cell lung cancer

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Double sleeve (vascular and bronchial) lobectomy is a reasonable alternative to pneumonectomy in patients with centrally located tumors involving the pulmonary artery and bronchus. However, it is a challenging and complex procedure even when performed through thoracotomy.

Despite the advances in thoracoscopic surgery, double sleeve lobectomy by conventional thoracotomy is still the preferred approach because of the technical difficulties of thoracoscopic surgery and the potentially increased operative risks even when performed by experienced video-assisted thoracoscopic surgery (VATS) surgeons. There are very few reported cases of double sleeve lobectomy by VATS using 3-4 incisions (1,2). We present the first report of double VATS sleeve resection by a single incision approach.

Clinical tummary

A 65 year-old male, smoker, was diagnosed with a 7.2 cm left upper lobe adenocarcinoma with vascular and bronchial involvement. The patient received neoadjuvant Platinum based chemotherapy (six sessions) with poor response. A chest computed tomography (CT) scan performed before surgery (*Figures 1* and *2*) showed progression of the tumor (9 cm mass with left upper lobe atelectasis) despite neoadjuvant chemotherapy. The patient was offered left upper lobe resection with uniportal VATS.

Surgical technique

Under general anesthesia, we performed flexible video bronchoscopy. The right-sided airways had normal anatomy with no endobronchial lesions and no significant amount of secretions or pus. In the left-sided airways, there was an obvious tumor mass that had completely occluded the entire orifice of the left upper lobe of the lung and was entering the distal left main bronchus.

The patient was positioned into right lateral decubitus position with the left side up, and a VATS approach using a 5 cm single-incision was made in the 5th intercostal space with no rib spreading (no soft tissue retractor and no direct vision).

The upper lobe was adherent to the chest wall, the mediastinum, and the aorta without signs of invasion, and was detached and freed of its adhesions using cautery. Digital palpation confirmed the presence of a 9 cm mass occupying most of the upper lobe and involving all arterial branches of the upper lobe. There was no other evidence of pleural disease in the chest.

The first step was to expose and control the main pulmonary artery (PA), which was dissected and encircled with a double vessel loop, while the superior pulmonary vein was also dissected free and transected using endostaplers. We then opened the fissure between the upper and lower lobe. The tumor did not involve the fissure or the lower lobe and the artery was dissected and mobilized.

The left main bronchus and the lower lobe bronchus were dissected and cleared, with dissection of the subcarinal lymph node and subsequently the interlobar and peribronchial lymph nodes up towards the specimen. The main bronchus and left lower lobe bronchus were transected with a long handle No. 10 blade (sleeve resection). The inferior pulmonary ligament was released to allow greater mobilization of the lower lobe. Before clamping of the PA, 5,000 units of heparin were given intravenously to prevent clotting. The main PA was occluded using a thoracoscopic D'Amico clamp (Scanlan International, MN, USA) and

Figure 1 Computed tomography scan after chemotherapy showing arterial involvement.

Figure 2 Computed tomography scan after chemotherapy showing bronchial involvement.

the interlobar artery was occluded with a bulldog clamp (Aesculap, Inc., Center Valley, PA, USA). The main PA and the basal artery were transected with scissors (vascular sleeve) to remove the left upper lobe en-block. The specimen was temporarily placed in the lower chest cavity above the diaphragm. We started the double sleeve reconstruction by the bronchial anastomosis using a running, non-absorbable suture (PDS 3/0) for cartilaginous and membranous portions. The posterior wall of the bronchus was sutured first, the anterior wall was sewn up last, and then both sutures were tied together. The lower lobe was inflated and no air leakage was detected underwater. The arterial sleeve anastomosis was performed thereafter by using a monofilament non-absorbable continuous suture (prolene 4/0) in two different rows, with a similar method as for the bronchus (the medial arterial wall was sutured first, followed by the lateral wall). Both suture lines were tied together at the anterior part of the anastomosis using a thoracoscopic knot pusher.

The edges of the anastomosis were everted to enhance arterial intimal interface and maximize the opening of the anastomosis. The bulldog clamp was opened for back bleed to remove the air, and the inflow and outflow were flushed and checked prior to the anastomosis. The clamp from the main PA was slowly opened and no bleeding from the vascular anastomosis was found.

The bronchial anastomosis was then wrapped with a piece of oxidized regenerated cellulose (Surgicel®), to be isolated from the vascular suture. The specimen was inserted into a protective plastic bag and removed by enlarging the incision. A single chest tube was placed at the end of the operation. Frozen section confirmed that all surgical margins were clear, including our bronchial and left main stem bronchus margin. The total surgical time was 260 min and estimated blood loss was 170 cc.

Patient recovery was satisfactory, and the chest tube was removed on the 5th postoperative day. Pathological examination revealed a 7.5 cm adenocarcinoma with bronchial and vascular involvement (free tumoral margins) and no lymph node malignancy (pT3N0M0).

Discussion

The thoracoscopic approach for major lung resection for advanced lung cancer is now gaining wide acceptance worldwide (3). However, lobectomies requiring double sleeve are challenging procedures, even when performed by thoracotomy. As such, it still remains a contraindication for VATS approach, even for experienced thoracoscopic surgeons, primarily due to concerns of vascular injury during thoracoscopy as well as the technical complexity of the procedure for an optimal bronchovascular reconstruction. There are few articles published in the literature describing a double bronchial and vascular sleeve reconstruction by VATS, and all of these cases are reported by using 3-4 incisions (2,3). VATS sleeve lobectomies are still being refined.

Through recent technical advances in VATS lobectomy (instruments and HD cameras) and the skills and experience gained from treating large numbers of patients, these complex procedures can be performed by using only a single incision approach. As a result, advanced procedures such as uniportal sleeve lobectomy (4,5) or uniportal vascular reconstruction (6) have already been published with good postoperative outcomes (7). The advantage of uniportal VATS surgery is that it allows the target tissue to be directly visualised at a similar angle of view as for open surgery (8). Conventional multi-port VATS triangulation creates a new optical plane for the genesis of a dihedral or torsion angle not favorable with 2D monitors. Another advantage of the uniportal VATS technique is that instruments are inserted parallel to the video-thoracoscope, therefore mimicking the maneuvers performed inside the chest during open surgery. This geometric uniportal VATS concept facilitates the double bronchial and vascular anastomosis in complex resections such as the one described in this article.

The use of thoracoscopic instruments with proximal and distal articulation is very useful for sleeve procedures through a single incision approach, especially for clamping the pulmonary artery and for suturing the artery and bronchus. The use of a bulldog clamp placed inside the chest cavity for clamping the basal artery allows surgeons to have more space for instrumentation through a single incision approach. The clamp for the main artery is placed in the anterior portion of the incision and the camera in the posterior portion, making the instrumentation similar as for an open approach for bronchial and vascular anastomosis.

With the single incision thoracoscopic view, the bronchus is located behind the artery, making it easier to perform bronchial anastomosis first, followed by arterial, in order to avoid excessive manipulation and traction to the arterial suture.

Several reports confirm the safety of bronchovascular reconstructions after chemotherapy (9). Video-assisted thoracoscopic sleeve procedures enable faster patient recovery and preserve pulmonary function (10,11). This is especially important in patients receiving induction treatment, as the implementation of a pneumonectomy would increase the rate of postoperative complications (12). In the current literature, there is also evidence supporting the use of neoadjuvant treatment and minimally invasive techniques.

In conclusion, single incision thoracoscopic bronchovascular double sleeve lobectomy is technically difficult, but feasible, when performed by skilled surgeons experienced with the uniportal approach.

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Uniportal video-assisted thoracoscopic bronchoplastic and carinal sleeve procedures

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Abstract: Despite of the recent advanced with the video-assisted thoracoscopic surgery (VATS), the most common approach for bronchial and carinal resection is still the open surgery. The technical difficulties, the steep learning curve and the concerns about performing an oncologic and safe reconstruction in advanced cases, are the main reasons for the low adoption of VATS for sleeve resections. Most of the authors use 3–4 incisions for thoracoscopic sleeve procedures. However these surgical techniques can be performed by a single incision approach by skilled uniportal VATS surgeons. The improvements of the surgical instruments, high definition cameras and recent 3D systems have greatly contributed to facilitate the adoption of uniportal VATS techniques for sleeve procedures. In this article we describe the technique of thoracoscopic bronchial sleeve, bronchovascular and carinal resections through a single incision approach.

Keywords: Sleeve lobectomy; bronchoplasty; vascular reconstruction; carinal resection; uniportal video-assisted thoracoscopic surgery (VATS); double sleeve

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The thoracoscopic approach for major pulmonary resection has numerous advantages compared to open techniques (1-4) without sacrificing the oncologic principles of thoracic surgery. In fact, there is evidence that video-assisted thoracoscopic surgery (VATS) lobectomy may even offer reduced rates of complications and even better survival rates for early stage tumors (5). Future studies will be needed as well to determine if there are advantages for thoracoscopic sleeve resections when comparing with open surgery.

The sleeve procedures offer benefits of parenchymal preservation and oncologic safety even for patients who can tolerate more extensive resections (6). However sleeve resections are technically more demanding than pneumonectomy and are more prone to particular complications (7).

Sleeve procedures are contraindicated when local extension of the tumor requires pneumonectomy as it occurs with involvement of interlobar fissure. The surgeon must identify and avoid reconstructive techniques with risk to develop a severe complication. If the bronchial reconstruction is likely to fail because of the excessive tension or poor anastomotic technique, the result should be carefully evaluated at the end of the procedure, leading to an extensive resection in case of doubt.

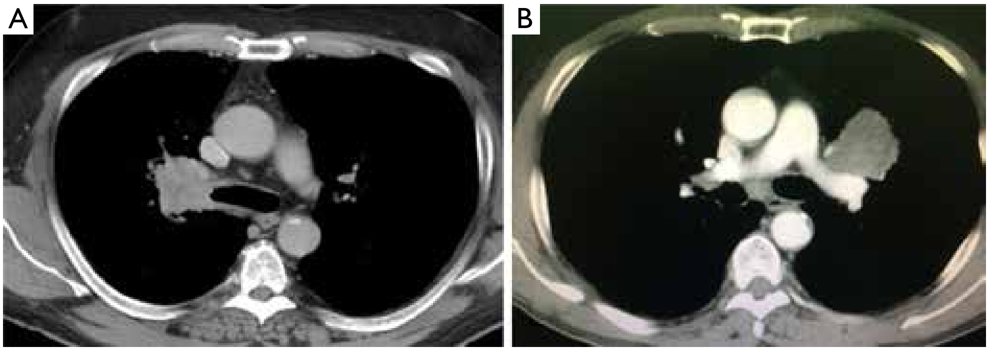

Figure 1 CT scan showing a tumor on the main RUL bronchus (A) and a tumor involving the left main pulmonary (B). CT, computed tomography; RUL, right upper lobe.

Thanks to the recent improvements in thoracoscopy, advanced cases and sleeve resections can be performed without performing thoracotomies (8). During the last years, experience gained through VATS techniques, design improvements of the surgical instruments and improvements of high definition cameras have greatly contributed to advances in VATS (9). Because its approach is less invasive, the uniportal approach for VATS has emerged as a novel technique, applicable to all large spectrum of pulmonary resections including sleeve reconstructions.

In this article we describe the technique of thoracoscopic sleeve procedures through a single incision approach for bronchial, bronchovascular and carinal resection.

Preoperative planning

The indication for a sleeve resection is usually made preoperatively based on computed tomography scan (CT), Positron emission tomography—computed tomography scan (PET-CT) and bronchoscopy (*Figure 1*). Mediastinoscopy or endobronchial ultrasound biopsy (EBUS) should be performed prior to the operation in the case of uptake on PET-CT. The extension of the tumor should be carefully ascertained and histology should be confirmed with biopsy. Preoperative bronchoscopy can identify the need for a sleeve lobectomy when the tumor is at the entrance of a lobar bronchus, or when there are exophytic tumors in a main-stem bronchus or when submucosal signs indicate cancer extension. This diagnostic information is helpful at the time of the surgery when the bronchus is incised and divided. Suitability for surgery should also be assessed, and a pulmonary function test and a perfusion scan performed to predict postoperative lung function are relevant when planning a sleeve.

Typical carcinoid tumors are the ideal cases for sleeve resections. They frequently have a limited base of invasion of the bronchus and the margins do not need to be too large.

During the postoperative management, the patients are usually given antibiotics, humidification or mucolytic and physiotherapy. A bronchoscopy should be performed to check the integrity of the suture and to clear secretions before patient is discharged home.

Surgical thoracoscopic technique

Most of the authors use 3 incisions for the VATS sleeve procedures but the surgery can be performed by using only one (10,11). The patient is positioned in a lateral decubitus position. We consider very important the proper placement of the incision, especially when it is performed by uniportal VATS. Performing the incision at the fourth or fifth intercostal space, more anterior (anterior axillary line), helps to use the needle holder parallel to the hilum, making suturing similar to an open anterior thoracotomy. Using a wound protector is helpful because fatty tissue could interfere with the suture threads (*Figure 2*).

The operating table's position makes the lung exposure easier to perform the anastomosis (the anterior rotation of the table 45° to the surgeon places the lung on an anterior position and makes easier the posterior bronchial suture, especially the membranous portion).

Our preferred method for suturing is to use a continuous absorbable suture (Polydioxanone, PDS 3/0) which makes the thread movement easier, as well as the tying or a novel absorbable barbed suture device, the V-Loc™ wound closure device (Covidien, USA), which avoids knot-tying and keeps strength and security (13). We always test the

Figure 2 Surgical technique for thoracoscopic suturing by uniportal VATS (tying the knots) (12). VATS, video-assisted thoracoscopic surgery.
Available online: http://www.asvide.com/articles/814

Figure 4 Simple bronchoplasty for a right upper lobe endobronchial tumor (15).
Available online: http://www.asvide.com/articles/815

Figure 3 Surgical photo showing instrumentation for bronchial sleeve anastomosis.

anastomosis under saline water and we only place one chest tube at the end of the operation.

When performing bronchial suturing using uniportal VATS, it's very important to maintain the camera on the posterior part of the incision, operating with both hands below the camera. Here we apply the same principle as when performing an anterior thoracotomy in open surgery. That is to have a direct view with the surgeon's eyes above his/her hands (*Figure 3*). The geometrical explanations of the approach (14) are important factors to facilitate the sleeve reconstructions through a single incision approach. As a result, the anastomosis can be accomplished from a straight perspective in our opinion (*Figure 2*).

We can classify 3 types of bronchoplastic procedures according to the resection type:

(I) Simple bronchoplasty. It is the easiest bronchoplastic procedure. When the tumor is located at the bronchial base, the bronchus is incised at its origin using a long scalpel. For the closure, we use a single PDS 3-0 suture (flushed shape) (*Figure 4*);

(II) Wedge bronchoplasty. In this case the bronchial incision is made deeper in a wedge shape to the main bronchus. This kind of incision may call for a transverse closure, but if the wedge is large and doesn't allow approximation, it may be reconstructed using a lateral closure. The closure stitches are made without tension, and with approximation to the mucosa using a monofilament absorbable interrupted or continuous suture. Recent studies have shown that wedge bronchoplasties, when possible, are a good oncological equivalent to sleeve bronchoplasties, enabling better preservation of the bronchial vascular supply. This is suitable for small tumors with limited invasion of the bronchus, and it allows surgeons with limited experience performing VATS bronchial sleeves to accomplish an oncologic and safe resection (16);

(III) Sleeve bronchoplasty. The bronchial sleeve resections with an end to end anastomosis are the most complex bronchoplastic procedures. The right upper lobe (RUL) bronchoplasty is normally the most frequently performed and less difficult procedure, due to the

Figure 5 Right upper sleeve resection (17).
Available online: http://www.asvide.com/articles/816

Figure 6 Left upper lobe sleeve resection (20).
Available online: http://www.asvide.com/articles/817

alignment of the main and the intermediate bronchi. However, the right bronchus is located at the rear side of the pulmonary artery, and occasionally it is too hidden by the pulmonary artery or the azygos vein which increases the difficulty of the anastomosis (*Figure 1*). The liberation of the pulmonary ligament facilitates lung mobility and reduces tension during and after the anastomosis. For RUL sleeves, the subcarinal lymph node dissection should be performed at the beginning of the procedure. However, the paratracheal lymphadenectomy is preferably done last, after the anastomosis, to prevent the proximal bronchi from retracting under the azygos vein into the paratracheal space, which makes subsequent suturing difficult and requires division of the azygos vein.

The bronchus may be incised initially using a long scalpel, and then the bronchial circumference section may be completed using scissors. Our preferred method is to perform the entire anastomosis using a running suture in two steps. Usually, the first step is to suture the posterior bronchus wall and then the second step is to suture the anterior wall from behind (inside out) so that both edges are tied at the front level. Another option is a combined technique: interrupted stitches for the cartilage portion of the anastomosis and a continuous suture for the membranous portion. It is best to tie each interrupted stitch before placing the next interrupted stitch to avoid having the free ends of the suture touch each other and get tangled. It is also preferable to tie the knot outwards.

The most complex sleeve procedures are usually those of the left side, due to the presence of the aortic arch and the larger size of the PA. For left-sided bronchial resections, it's best to use a right-sided double-lumen tube in order to make the suturing easier and reduce to the tension on the bronchus.

Right upper lobe (RUL) sleeve lobectomy (*Figure 5*)

Clinical case: 55-year-old male. Squamous cell carcinoma located on the main right bronchus. The patient received 3 cycles of chemotherapy with good response. The incision, 4–5 cm long, was performed on the 4th intercostal space (more convenient for anastomosis on the right side). After division of the vessels and opening the fissure, the right main bronchus, upper lobe bronchus and intermediate bronchus were dissected and sectioned using a long scalpel or scissors (18). The margins were inspected macroscopically and a frozen section was performed before starting the anastomosis. The azygos vein was transected with endostaplers. Sutures were placed on the edge of the main and intermedius bronchus and the bronchial anastomosis was initiated by using a continuous monofilament absorbable 3/0 suture (PDS or V-loc). To compensate the difference of caliber between both bronchi, the interval between the sutures of main bronchus was slightly larger than the intermedius and was adjusted during continuous suture (19).

Left upper lobe (LUL) sleeve resection (*Figure 6*)

The absence of intermediate bronchus, the interference with aortic arch and main PA and the short length of upper lobe bronchus, makes the anastomosis more difficult than on the right side. Care must be taken to avoid injury of the left laryngeal nerve when dissection and anastomosis involves the main bronchus or when complete lymph node dissection of station 5 is performed.

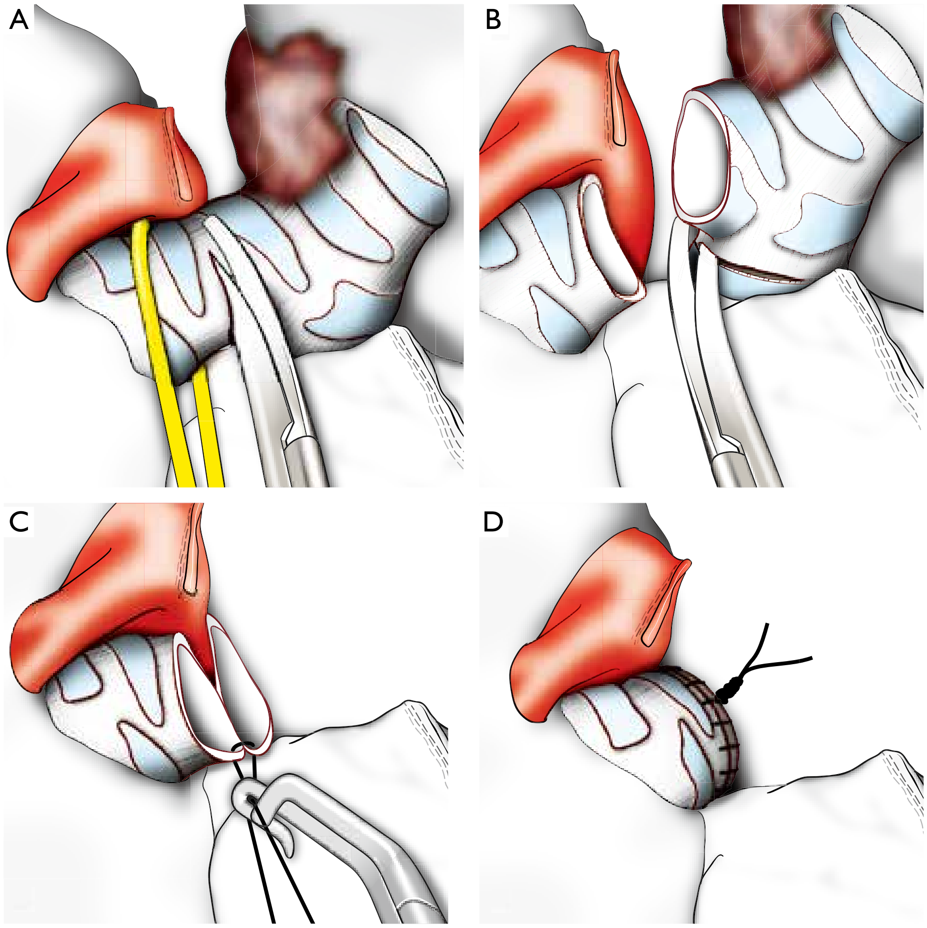

Figure 7 Drawing showing the sequence of lower lobe sleeve resection and anastomosis. (A) Exposure of left upper, lower and main bronchus and transection of LUL bronchus; (B) transection of the main bronchus using scissors; (C) a suture is placed at the angle of anterior portion of both ends of bronchi; (D) final result. LUL, left upper lobe.

Division of the bronchus occurs just proximal and distal to the base of the LUL. Division of the distal end is potentially hazardous because the base of the superior segmental bronchus is next to the LUL's base, and care must be taken not to injure this structure.

The subcarinal lymph node dissection should be performed before the bronchial division. The main bronchus and lower lobe bronchus are initially incised with a long scalpel and then with scissors. The anastomosis is performed as previously described. The running suture technique is performed in two steps: every 180 degree of the 360 degree of the bronchus circumference.

Left lower sleeve anastomosis

The left lower sleeve lobectomy is technically more complex because of the presence of the pulmonary artery (which should be retracted), the atrium and upper lobe vein. The orientation to perform the anastomosis is also more difficult because the upper lobe bronchus needs to be re-implanted on the main bronchus from an anterior view position, and once we incise the main bronchus is deeply located (10).

The left upper lobe (LUL) bronchus is dissected and exposed. The mainstem and the upper lobe bronchi are cut circumferentially with a knife on a long handle and scissors (*Figure 7*). We commence an end-to-end anastomosis with the first suture in the cartilaginous-membranous junction to help appose the upper lobe bronchi and mainstem bronchi, and then proceeded with a running suture in the posterior wall of airway (the most difficult part of anastomosis). Once the posterior wall of the anastomosis is completed, a running anterior suture is then performed and both sutures

Figure 8 Bronchus intermedius resection (sparing lung) (21). Available online: http://www.asvide.com/articles/818

are tied with the help of a thoracoscopic knot-pusher.

Bronchial sleeve resection (sparing lung) (*Figure 8*)

Bronchoplastic resections with preservation of parenchyma should be attempted whenever possible when treating distal tracheal or centrally located endobronchial tumors rather than performing a lobectomy, especially for young patients or with poor pulmonary function (22). Generally, the main indications for this surgical technique without lung resection include bronchial low malignant tumors and some benign diseases (23).

VATS lung sparing bronchial sleeve resection is a technically more complex procedure than a standard VATS sleeve lobectomy.

The bronchial anastomosis after a VATS sleeve lobectomy is less difficult to perform as exposure for suturing of the two bronchial ends is easier after removal the lobe (24). The overlying undivided lobar structures limit the exposure for mobilization and sewing during sparing lung sleeve procedures. Compared to the right bronchial sleeve resection, the thoracoscopic reconstruction of the second carina on the left side is usually more complex because the anastomosis of upper and lower lobe bronchus and the left main bronchus is often hidden in the rear of the left pulmonary artery (24).

Clinical case: a 34-year-old young women with an endobronchial carcinoid located on the intermedius bronchus. The main and the RUL bronchus were dissected and exposed. The subcarinal and peribronchial lymph nodes were removed to better expose the anatomy. Once the fissure was divided, the basal artery for lower lobe was taped and retracted. The bronchus intermedius was incised distally above the origin of the right middle bronchus and proximally just below the origin of the RUL bronchus (*Figure 9*). The anastomosis was commenced by suturing the posterior wall of the bronchus from anterior to posterior direction by using a 3/0 PDS suture. Another continuous suture was done to complete the anterior wall of the anastomosis and both sutures were tied together. The integrity of the anastomosis was tested under saline water. The postoperative recovery of the patient was uneventful and the patient was discharged home on the third postoperative day.

Bronchial sleeve and vascular reconstruction (*Figure 10*)

When the tumor invades the pulmonary artery sometimes it's necessary to resect part of the artery (26,27) or, occasionally a total sleeve (28). The dissection and control of the PA is recommended from the beginning (sometimes intrapericardial control is needed). Before the PA clamping, 5,000 UI intravenous heparin must be administered to prevent thrombosis. We can perform the proximal pulmonary artery clamping with a thoracoscopic clamp. For distal clamping it's better to use bulldog clamps on the artery or clamping the inferior pulmonary vein to interfere as less as possible with the instruments (28). Occasionally, a double vessel loop is enough to clamp the distal artery for partial resections.

When vascular reconstruction is necessary it is advisable that it is done during the last step of the lobectomy (first divide the veins, bronchus and fissure) in order to have a larger surgical field and more control of the section of the pulmonary artery.

The indications for sleeve resection of the pulmonary artery are mostly upper lobe tumors where the tumor or malignant lymph nodes affect the main PA or the upper lobe branches (*Figure 1B*).

A partial resection of the pulmonary artery can be performed especially when the tumor invades the base of one of the lobar branches but without a large involvement (less than 1/3 circumference) into the main PA. After heparinization and clamping of the main artery and distal trunk a tangential incision on the pulmonary artery is performed and a direct closure by means of a running suture with prolene 5/0 or with several interrupted sutures.

In case of vascular sleeve, the bronchial anastomosis should be performed first in order to avoid traction to the vascular suture (*Figure 11A*). The end-to-end vascular

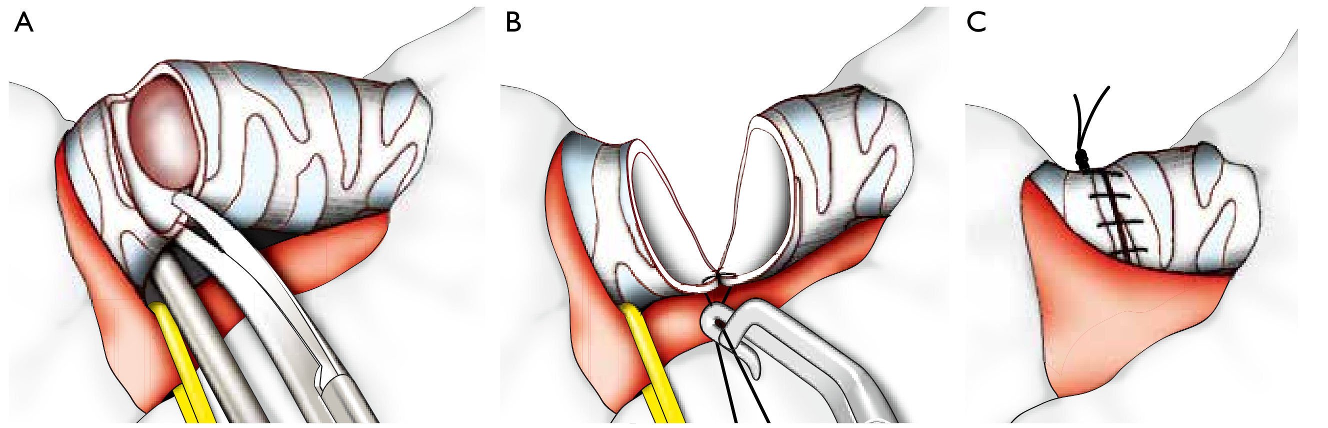

Figure 9 Drawing showing bronchus intermedius bronchial resection and anastomosis (carcinoid tumor). (A) Bronchial distal resection by using scissors (artery is retracted); (B) anterior suture used for apposition of distal and proximal bronchial end; (C) final result.

Figure 10 Left upper sleeve resection and vascular reconstruction (25). Available online: http://www.asvide.com/articles/819

anastomosis can be performed with a running monofilament suture (prolene 5/0) in two steps: the first suture line must be the posterior wall of the anastomosis from a back to front direction (*Figure 11B*). Another running suture is used to complete the anastomosis of the anterior wall and it is then tied to the first suture.

Once the vascular suture is completed the distal clamp is removed to release any air thanks to the return flow and tied once the artery is filled. Then a progressive release of the proximal clamp is done.

Carinal resection

Tumors invading the distal trachea or carina represent a challenge due to the complexity of airway reconstruction and management through a thoracoscopic approach (29). The surgical approach for distal trachea or carinal resections should by the right side (30). A total coordination with the anesthesiologist is paramount during airway resection and a plan in case of emergency should be carefully stablished preoperatively.

To perform this procedure through uniportal VATS, there are two options in order to maintain lung ventilation: the use of an intra-surgical field tracheal tube (31) or through high frequency jet ventilation (32). In the first option a sterile circuit is passed onto the field and prepared to directly ventilate a single lung. For high frequency ventilation jet, the catheter can be introduced through the endotracheal tube and thanks to the small diameter of the catheter for ventilation; it doesn't interfere with the anastomosis of the membranous portion (*Figure 12*). This way we do not need intra-field intubation. Both strategies require a perfect communication with the anesthetics team.

The mode of airway reconstruction depends greatly on the extent of resection. For limited resections of the carina, the right and left mainstem bronchi can be reapproximated to form a "neocarina," which is then attached to the distal trachea. When a right upper lobectomy is necessary with carinal resection, a careful reimplantation of the bronchus intermedius or right lower lobe bronchus to the trachea or left mainstem should be performed to avoid airway necrosis and narrowing. To avoid anastomotic angulation, devascularization, or excesive tension, it is recommended to perform maneuvers for hilar release before the anastomosis. The azygos vein can be transected by using vascular clips (click aV, Grena[R], UK) or endostaplers.

To avoid the aspiration of blood into the left main bronchus, carinal resection should be performed without removing the double-lumen tube. This maneuver allows a

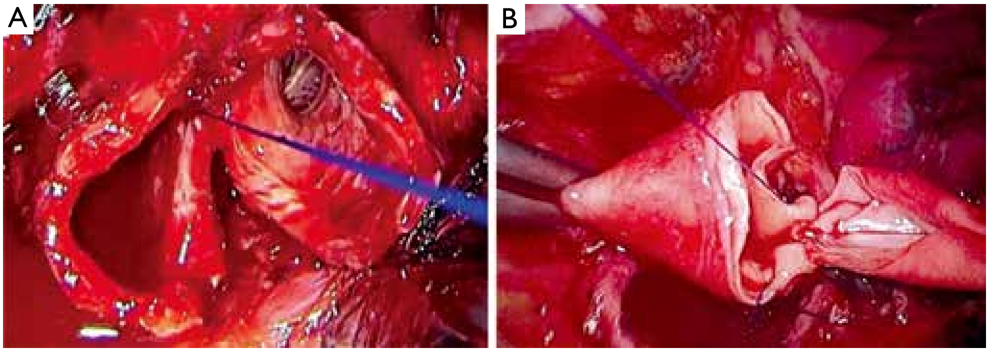

Figure 11 LUL double sleeve lobectomy. (A) Bronchial sleeve; (B) vascular sleeve. LUL, left upper lobe.

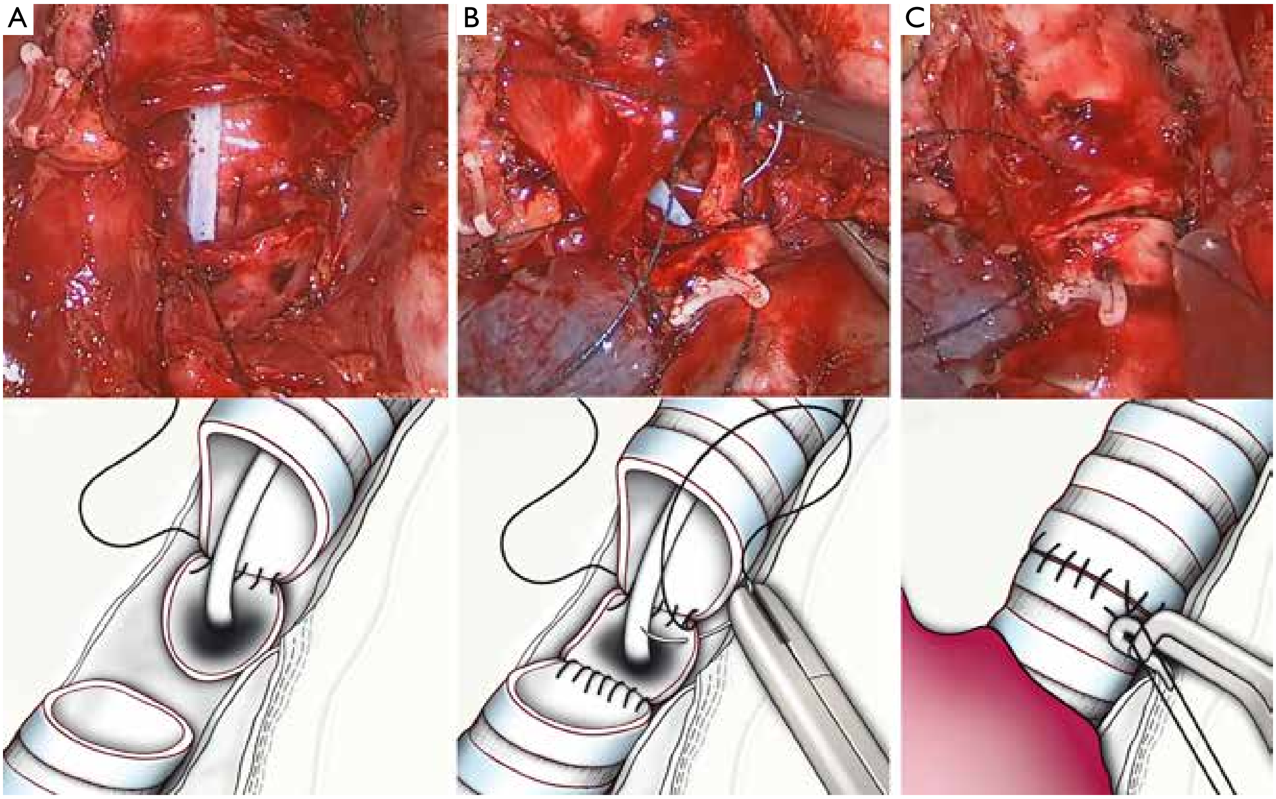

Figure 12 Combined drawings and surgical photos showing carinal reconstruction after right upper sleeve carinal resection. (A) Completed continuous suture of left side wall of the anastomosis between trachea and left main bronchus; (B) after creation of neocarina (left main to intermedius bronchus) the right side wall of the trachea, left main and bronchus intermedius is completed; (C) final result.

safe incision and resection of the distal trachea, right main and left main bronchus. The use of high-frequency jet ventilation of the left lung is useful to maintain oxygenation and facilitates the anastomosis of the left side wall of the main stem bronchus and distal trachea, avoiding the insertion of a tracheal tube through the incision (33).

The suture should be commenced first suturing the left side wall of the trachea and left main bronchus (*Figure 12A*). Then sutured membranous trachea and left main bronchus. Then neo-carina of left main bronchus and right main (in case of pure carinal resection) or intermediate bronchus (in case or RUL and carinal) (*Figure 12B*). Finally the right side wall of the trachea, left main bronchus and right bronchus should be anastomosed (33) (*Figure 12C*). It is

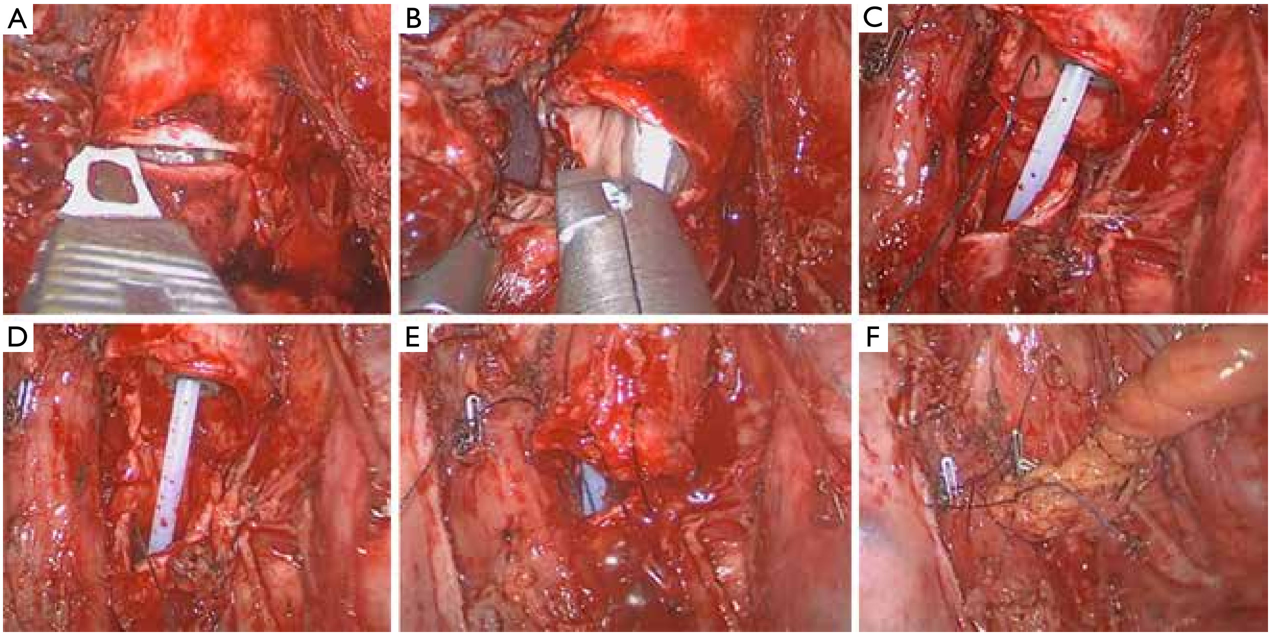

Figure 13 Surgical images of right carinal pneumonectomy. (A) The distal trachea is incised; (B) the circunferencial resection is completed by using scissors. (C) the running suture was started on the left wall of the trachea and left main bronchus; (D) the membranous portion was anastomosed after the left wall was completed; (E) the right side of the trachea and left main is performed; (F) a pericardial flap covered the anatomosis.

recommended to cover the suture with a pericardial flap.

Another option is the resection of the carina, followed by a total end-to-end anastomosis between the left main bronchus and the trachea with an anastomosis of the right main bronchus to the lateral, cartilaginous wall of the trachea (at least 2 cm above the first anastomosis).

When carinal reconstruction can not ensure a tension-free anastomosis, the safest option is to perform a carinal pneumonectomy (if patient tolerate the procedure) by doing an end-to-end anastomosis of the trachea to the remaining mainstem bronchus (*Figure 13*). The suture should be commenced first suturing the left side wall of the trachea to the left side wall of the left main bronchus, then membranous portion and finally right side of trachea and left main bronchus.

We have analyzed our experience with double sleeve and carinal resections in conjunction with the Tyumen Regional Oncological Center (Russian Federation). To date we have performed 10 cases (8 male, 2 female) with a mean age of 61±4.6 years (range, 48–68 years): 7 uniportal VATS double-sleeve resections (6 left upper lobectomy, 1 RUL) and 3 uniportal carinal resections (2 RUL and 1 sleeve pneumonectomy). Three cases of uniportal double-sleeve lobectomy and one case of uniportal carinal resection received neoadjuvant chemotherapy (gemcitabine + cisplatinum). The mean operative time was 260±20 min (range, 240–330 min) and the mean intraoperative blood loss of 235.5±55.6 mL (range, 50–460 mL). The mean number of lymph nodes resected was 13.12±5.13 (range, 12–20). The mean postoperative hospital stay was 10±1 days (range, 7–20 days). Two cases of double-sleeve lobectomy developed postoperative pneumonia but were succesfully treated with intravenous antibiotics. There was no postoperative 60-day mortality in this serie of patients.

Discussion and literature review

Minimally invasive surgery for cancer has proven to offer many benefits over traditional open surgery, including less pain and faster recovery without compromising oncologic results (1-5). VATS has evolved from the conventional three-port technique to the uniportal approach during the last decade (34).

Thanks to the increasing experience with thoracoscopic suturing, tying techniques and development of new instruments, the bronchoplastic procedures can be performed thoracoscopically by expert surgeons (33,35,36). There are many publications showing that an open sleeve lobectomy results in a better survival rate than pneumonectomy, a reduced loss in lung function, and an improved operative mortality (37,38). The first description of a VATS sleeve procedure was published 15 years ago by conventional VATS (39). The concerns about performing an oncologic resection and a safe anastomosis when bronchoplasty is needed are the main reasons for the slow adoption of the technique. This limits the number of surgeons that are able to master the sleeve technique by VATS. Some authors consider a minimum number of 25 cases for overcoming the learning curve and safely perform locally advanced cases by VATS (40).

Like all other procedures, VATS sleeve lobectomy has its natural learning curve. According to our own experience, at least more than 200 VATS lobectomies and at least 20 cases of open sleeve procedures should be done in order to lay the anatomical and operative technique foundation, before you can perform a thoracoscopic sleeve resection (41).

The principles of the VATS bronchoplasty are the same as for open surgery (37). The anastomosis must be performed free of tension for mucosa to mucosa approximation. We recommend using monofilament absorbable sutures for smooth placement and sliding of knots (non-absorbable sutures can irritate the airway and cause significant postoperative cough). A critical technical issue is the management of the sutures to avoid the tangling of the untied ends. The management of the instruments and sutures is more crucial in VATS than in an open thoracotomy. The tension of the suture can be carefully adjusted with a sliding knot-pushing instrument.

Some authors recommend interrupted sutures to allow better size matching, less anastomotic site ischemia and prevent the loosening and entanglement of the sutures (42).

Other authors improved the suturing technique by using both continuous and interrupted suturing, for the membranous and cartilaginous portions of the bronchus respectively (43). In our particular experience a continuous suture performed in two steps for the posterior and the anterior bronchial wall results in less suture tangling and is quicker (33,35). A novel absorbable barbed suture device, the V-Loc™ wound closure device can be used to avoid knot-tying (13).

We routinely do not buttress the suture unless the case was after radiation or presented with signs of infection (44). In these cases we can use an intercostal muscle flap, pedicle pericardial or mediastinal fat pad.

There are few articles published in the literature describing bronchial, vascular or combined bronchovascular sleeve by VATS, and most of these resections are reported by using conventional thoracoscopic techniques (45,46). As our experience has grown with the uniportal VATS approach we have increased the rate of these reconstruction techniques and decreased the incidence of pneumonectomy (27-29,33,34). In a recent publication, we assessed the feasibility of uniportal VATS approach in the treatment of advanced NSCLC and compared the perioperative outcomes with early-stage tumors with good postoperative results (47).

There are several case reports of NSCLC sleeve procedures of the RUL by using 4 ports (48), 3 ports (49,50) or 2 ports (51). Mahtabifard *et al.* reported a series of 13 sleeve resections. Median operative time was 167 min (range, 90–300 min) and chest tube duration was 3 days (range, 2–6 days). Morbidity was 31% (42).

Yu *et al.*, reported case series of 9 bronchial thoracoscopic sleeve lobectomies performed through four ports. The authors modified the technique from interrupted sutures in the first cases to a continuous suture combined with discontinuous anastomosis in the late surgeries. The mean surgical time was 203±20 min. Two 28F chest tubes were placed at the end of the operation. The total duration of hospitalization lasted, on average, 20.8 ± 2 days. No recurrences or severe complications were reported (52).

Agastian *et al.* reported 21 VATS bronchoplastic procedures (9.1% of all VATS in his serie) including wedge (9), sleeve bronchoplasty (8) and other extended bronchoplasties (4). The authors used an interrupted suture technique for anastomosis. Mean surgical time was 287 min (range, 135–540 min), mean hospital stay was 5.2 days. Most of the cases were NSCLC (24). All brochial margins were negative for malignancy. Only one patient developed broncho pleural fistula and in a follow up of 26 months there was no tumor recurrence (36).

Xu *et al.* reported 20 sleeve lobectomies (including a RUL sleeve resection combined with half-carinal reconstruction and right medial lung sleeve resection combined with lower right dorsal segment). The average time of surgery was 239±51 min (range, 142–330 min), and the average time of airway reconstruction was 44±17 min (range, 22–75 min). The median postoperative hospital stay was 10 days (range, 8–12 days). None of the patients developed anastomotic leak and perioperative mortality was not observed. The bronchial suture was initially performed with a modified interrupted suture and subsequently with a continuous suture during which the membranous posterior and the cartilage wall were anastomosed with single 3/0 polypropylene suture (53).

The serie of Li *et al*. included 15 VATS sleeve lobectomies with bronchoplasty for NSCLC (RUL 10, right middle and lower lobes 1, left lower lobe 2 and LUL 2) by using 3 ports. The authors describe the technique for anastomosis by using a simple continuous and simple interrupted suturing of the membranous and cartilaginous portions of the bronchus. All procedures were uneventful, (only 1 minor complication) with a median operative time of 165 min (median bronchial anastomosis time of 44 min). The median duration of chest tube drainage was 5.4 days, and the median length of hospital stay was 7 days. All patients were followed postoperatively for a range of 1–16 months without tumor recurrence (43).

When experience is acquired with VATS, more advanced procedures such as double sleeve, tracheal or carinal resection can be performed by using even only a single incision (33). A perfect planning of the operation and coordination with the anesthesiologist are mandatory when dealing with these cases. The use of uniportal VATS for reconstructive surgery represents a challenge for the thoracic surgeon because of the technical difficulties for anatomic reconstruction, vascular and airway management.

There are few publications of VATS double sleeve procedures reported in the literature (54,55). Our group published several case reports of bronchoplastic procedures including vascular reconstruction (27) and double bronchial and vascular sleeve procedures (28,33). Huang *et al.* showed a retrospective multi-center study with thirteen thoracoscopic double sleeve resections for NSCLC patients. There were no conversions to thoracotomy. The median operative time was 263 min and the median postoperative hospital stay was 10 days (55).

The thoracoscopic technique for other complex procedures such as tracheal or carinal sleeve resections has recently been described (33). The classic approach for carinal reconstruction is the right thoracotomy or median sternotomy (29) but these complex procedures can be also performed by uniportal VATS through the right side. After carinal or tracheal resection, ventilation can be maintained by using a high ventilation jet (32) or by using an intraoperative single lumen tube (through the uniportal incision or adding an additional 1 cm skin incision). For resection of the distal trachea or carina, the left and the right main bronchus can be re-approached to create a new carina and then re-anastomosed to the trachea (33).

Conclusions

Thanks to the acquired experience with minimimally invasive techniques such the uniportal VATS, the broncoplastic procedures and even the most complex reconstructions including VATS broncho-vacular sleeve and carinal resections can be performed safely. These procedures must be performed as an alternative to pneumonectomy ensuring a safe anastomosis and complete tumor resection. Further studies will be necessary to evaluate the long term results of a large serie of these complex resections operated by uniportal VATS.

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Thoracoscopic double sleeve lobectomy in 13 patients: a series report from multi-centers

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Background: This study aims to explore the feasibility and safety of video-assisted thoracic surgery (VATS) double sleeve lobectomy in patients with non-small cell lung cancer (NSCLC).

Methods: Between June 2012 and August 2014, 13 NSCLC patients underwent thoracoscopic double sleeve lobectomy and mediastinal lymphadenectomy at three institutions. A retrospective analysis of clinical characteristics, operative data, postoperative events and follow-up was performed.

Results: Thirteen NSCLC patients (median age, 60 years; range, 43-67 years) underwent thoracoscopic double sleeve lobectomy. There were no conversions to thoracotomy. Left upper lobectomy was most frequently performed (eleven patients). Median operative time was 263 minutes (range, 218-330 minutes), and median blood loss was 224 mL (range, 60-400 mL). The learning curve revealed reductions in both operative times and blood loss of ten cases from one center. Median data were duration of blocking pulmonary artery (PA) 72 minutes (range, 44-143 minutes), resected lymph nodes 24 (range, 10-46), stations of retrieved lymph nodes 6 (range, 5-9), thoracic drainage 1,042 mL (range, 500-1,700 mL), duration of thoracic drainage 5 days (range, 3-8 days), postoperative hospital stay 10 days (range, 7-20 days), and ICU stay 1 day (range, 1-2 days). One patient (1/13, 7.70%) suffered from pneumonia after surgery. There were no deaths at 30 days. Median duration of follow-up was 6 months (range, 1-26 months). And no local recurrences or distant metastasis were reported.

Conclusions: Thoracoscopic double sleeve lobectomy is a technically challenging, but feasible procedure for NSCLC patients and it should be restricted to skilled VATS surgeons.

Keywords: Non-small cell lung cancer (NSCLC); video-assisted thoracic surgery (VATS); sleeve lobectomy; learning curve

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Introduction

Cao and his colleagues (1) reported that video-assisted thoracic surgery (VATS) lobectomy for non-small cell lung cancer (NSCLC) can yield similar long-term survival outcomes with conventional open lobectomy. With the widely application of VATS technique, the indication of this procedure has been greatly broadened, and the technical barriers have been constantly broken (2,3). As an less invasive alternative procedure to total pneumonectomy in patients with locally advanced tumors involving the pulmonary artery (PA) and bronchus (4), sleeve lobectomy by conventional thoracotomy, especially double sleeve lobectomy (vascular and bronchial) is still the preferred approach due to high difficulty in operation and potentially undesirable complications, even when performed by skilled

VATS surgeons.

Since the first reported VATS bronchial sleeve lobectomy was published (5), more and more technical challenges have become reality, which would be VATS angioplasty (6-8), uniportal VATS bronchial sleeve lobectomy (9,10), and even thoracoscopic double sleeve lobectomy (11-13). However, all of these reports were single center experiences, and most series were less than five patients. Hence, the thoracic society urged for a multi-center data of thoracoscopic double sleeve lobectomy to addresses the feasibility and safety of this operation. In this study, we present the first multi-center experiences of thoracoscopic double sleeve lobectomy.

Patients and methods

The medical ethics board of all participating hospitals approved the study. Between June 2012 and August 2014, 13 patients underwent a thoracoscopic double sleeve lobectomy including mediastinal lymphadenectomy for primary NSCLC at the First Affiliated Hospital of Guangzhou Medical University (Guangzhou, China), Coruña University hospital (Coruña, Spain) and Tyumen Regional Cancer Center (Tyumen, Russia). Clinical records of the patients were retrospectively analyzed.

All patients were diagnosed with NSCLC by bronchoscopy. Preoperative staging was determined mainly by enhanced thoracic computerized tomography, brain magnetic resonance or computed tomography (CT), and bone scintigraphy, except that one patient received positron emission tomography/CT (PET-CT). Physical examination, standard laboratory tests, electrocardiograms, and lung function tests were performed in all patients.

There were two patients with clinic N2 disease, and both received induction chemotherapy. One patient with squamous cell carcinoma had four cycles of paclitaxel + cisplatin before surgery (case 6), the other patient with adenocarcinoma had six cycles of pemetrexed + cisplatin (case 11). Two patients rejected to receive adjuvant chemotherapy.

Surgical technique

All patients received a combination of epidural and general anesthesia before the operation. The patients were placed in a lateral decubitus position. All 13 procedures were performed via 3-4 ports, or uniportal. The detailed port design for different methods was described in *Table 1*.

Before dissection, the mediastinal pleura were inspected to assess the mobility of the tumor and its invasion into surrounding structures. Once radical surgery (*Figure 1*) was guaranteed, the superior or inferior pulmonary vein would be dissected and then transected with endostapler (Ethicon Endo-Surgery, Johnson & Johnson, Cincinnati, OH, USA). The main bronchus and distal bronchus were transected with a long handle blade and scissor (*Figure 1A*).

After the main PA was dissected, there were four methods with different port design to clamp the PA: (method A) two patients (case 1-2) underwent three ports thoracoscopic double sleeve lobectomy (*Table 1*). One pair of vascular blocking forceps was placed through the operative port (3.5 cm) on the proximal PA, and the other pair of forceps was placed through the left port (10 mm) on the distal PA (*Figure 2*); (method B) one patients (case 3) underwent three ports thoracoscopic double sleeve lobectomy (*Table 1*). One pair of vascular blocking forceps was placed through the operative port (3.5 cm) on the proximal PA. Different with method A, the other pair of forceps was placed through the camera port (10 mm) on the distal PA (*Figure 3*); (method C) seven patients (case 4-10) underwent four ports thoracoscopic double sleeve lobectomy (*Table 1*). One pair of vascular blocking forceps was placed through a 5-mm port located in anterior chest wall at the level of the proximal PA, and the other pair of forceps was placed through the posterior axillary line port (10 mm) on the distal PA (*Figure 4*); (method D) three patients (case 11-13) underwent uniportal thoracoscopic double sleeve lobectomy (*Table 1*). A bulldog clamp was used for the distal PA while the vascular blocking forceps were used to clamp the proximal PA (*Figure 5*). After the PA clamp was completed, the invasive part of main PA was resected (*Figure 1B*). The surgical technique for PA circumferential sleeve resection is similar to previous reports (11,14). The wedge anastomosis for uniportal approach would only be applied if the tumor invasion was less than 1/3 of the circumference and 2 cm width of the basilar part. After confirming the resected margin of PA, the PA was reconstructed with a primary closure using 4-0 Prolene (Ethicon, Somerville, NJ, USA) (*Figure 1C*). A standard needle holder and a pair of forceps were inserted to complete running suture through the 3.5-5 cm operative port (*Table 1*). After the bronchial margins were confirmed as negative by intraoperative frozen section, the bronchial sleeve reconstruction was performed by using a 3-0 Prolene (Ethicon, Somerville, NJ, USA) for cartilaginous and membranous portions (*Figure 1D,E*). The residual lobe was inflated and no air leakage was

Table 1 The ports design of thoracoscopic double sleeve lobectomy

Method	Case	Ports	Camera port	Operative port	VBF port 1	VBF port 2
A	Case 1-2	3	Midaxillary line/7^{th} ICS/10 mm	Preaxilary line/4^{th} ICS/3.5 cm	Postaxillary line/7^{th} ICS/10 mm	–
B	Case 3	3	Postaxillary line/7^{th} ICS/10 mm	Preaxilary line/4^{th} ICS/3.5 cm	Midaxillary line/7^{th} ICS/10 mm	–
C	Case 4-10	4	Midaxillary line/7^{th} ICS/10 mm	Preaxilary line/3^{th} ICS/3.5 cm	Postaxillary line/7^{th} ICS/10 mm	Anterior chest/PA level/5 mm
D	Case 11-13	1	Preaxilary line/4^{th} or 5^{th} ICS/4-5cm			

VBF, vascular blocking forcep; ICS, intercostal space; PA, pulmonary artery.

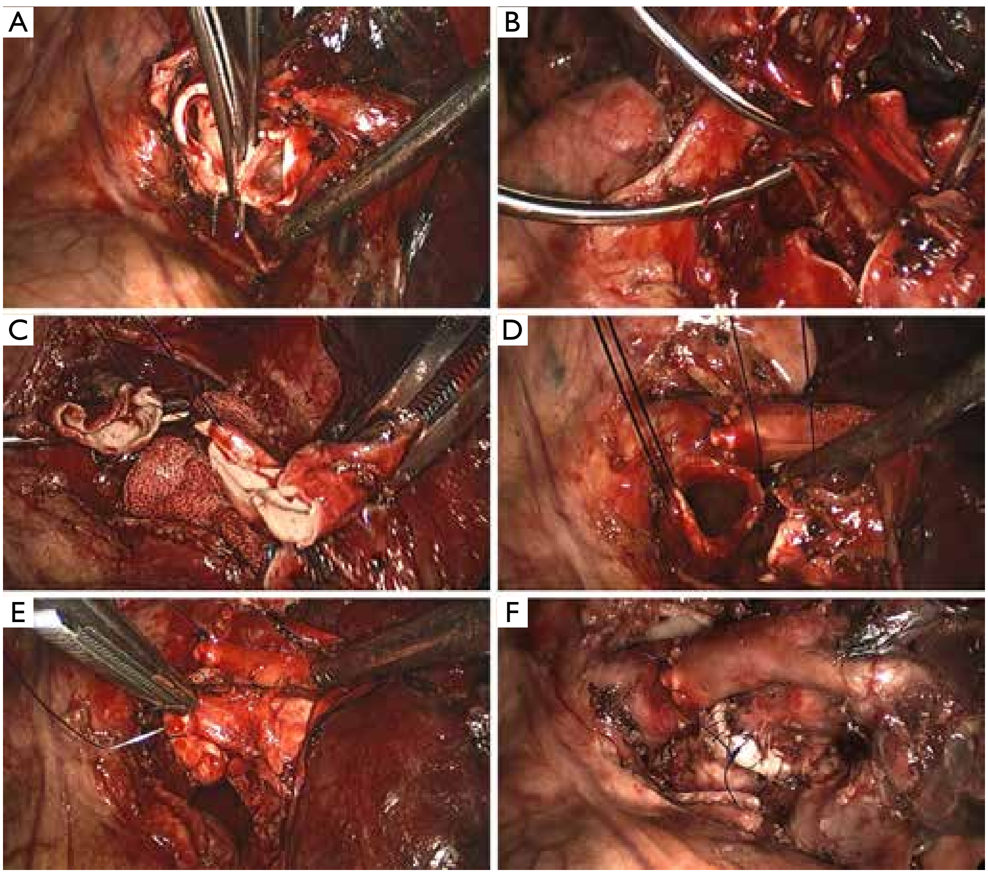

Figure 1 Surgical technique of thoracoscopic double sleeve lobectomy. (A) Transecting the main bronchus; (B) sleeve resecting the blocked PA; (C) sleeve reconstructing the blocked PA; (D) completed vascular reconstruction and starting sleeve bronchial reconstruction; (E) sleeve reconstructing the bronchus; (F) over view of double sleeve reconstruction. PA, pulmonary artery.

detected underwater. Then, the distal clamp was removed before tying the arterial sutures to remove the intravascular air. The proximal clamp was finally removed to ensure hemostasis of the sewn PA (*Figure 1F*).

During uniportal thoracoscopic double sleeve lobectomy, bronchial sleeve reconstruction was completed before angioplasty to avoid traction on the arterial suture. In three cases (case 1, case 3 and case 6), pericardium, pleura and other tissue were used to separate the PA and bronchus to prevent bronchial artery fistula.

Thoracic surgery was completed by placement of one or two intercostal drainage tubes and closure of the thoracic

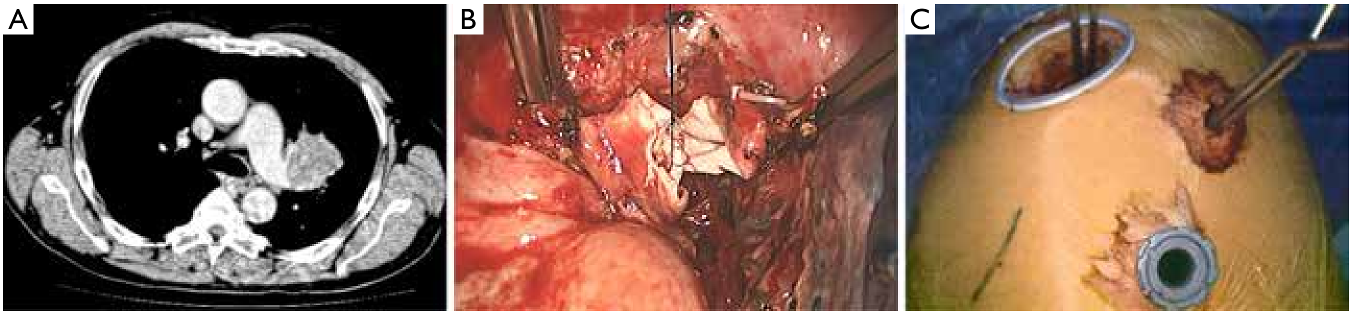

Figure 2 Method A: ports design of thoracoscopic double sleeve lobectomy.

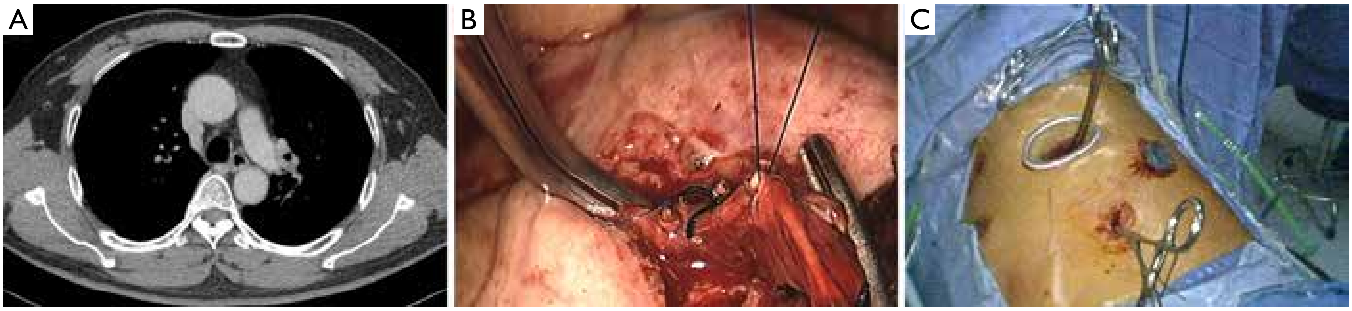

Figure 3 Method B: ports design of thoracoscopic double sleeve lobectomy.

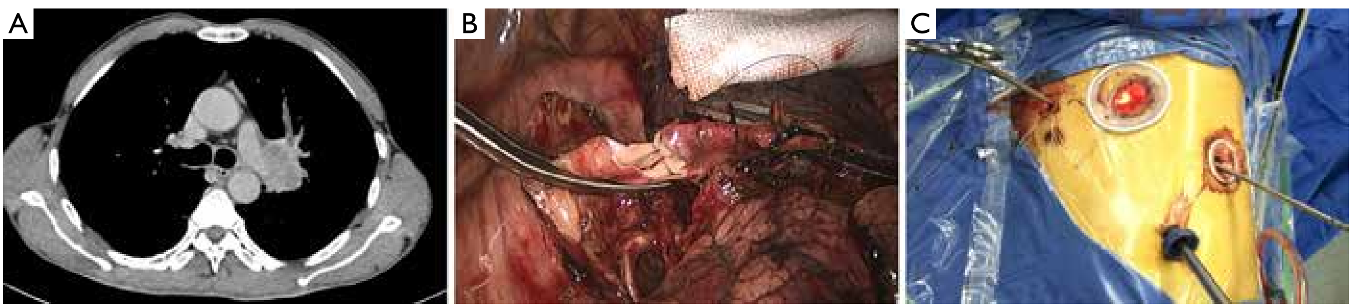

Figure 4 Method C: ports design of thoracoscopic double sleeve lobectomy.

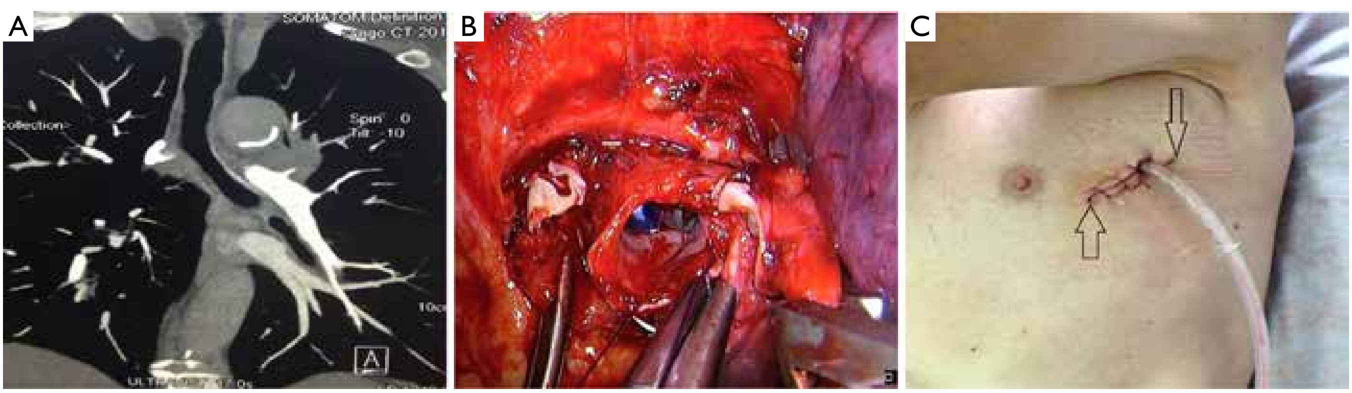

Figure 5 Method D: ports design of thoracoscopic double sleeve lobectomy.

incisions. Postoperative bronchoscopy is then performed to clear the airways of blood and secretions before extubation.

Statistical analysis

Clinical information was recorded in Microsoft EXCEL (Microsoft Corp, Redmond, WA, USA) for further processing. Enumeration data were presented with frequencies and percentages. Measurement data were presented with median and range.

Results

The clinical characteristics of all patients were summarized in *Table 2*. All thirteen patients were males. Median age was 60 years (range, 43-67years). Twelve patients (12/13, 92.3%) had a smoking history. Ten patients (10/13, 76.9%) were diagnosed as squamous carcinoma, while two patients (2/13, 15.4%) were adenocarcinoma, and one patient (1/13, 7.7%) was adenosquamous carcinoma. The location of the tumors was as follow: eleven left upper lobe (LUL) (11/13, 84.6%), one right upper lobe (RUL) (1/13, 7.7%), and one left lower lobe (LLL) (1/13, 7.7%). There were ten invasion of main PA (10/13, 76.9%), and two invasion of branch PA (2/13, 15.4%).

The operative data of all patients were shown in *Table 3*. There were no conversions to thoracotomy. The median operative time was 264 minutes (range, 218-330 minutes). The median blood loss was 224 mL (range, 60-400 mL). There were reductions in both operative times and blood loss of ten cases from one center, which were from 298.5 to 253 minutes, and 300 to 150 mL separately (*Figure 6*). The median duration of blocking PA was 72 minutes (range, 44-143 minutes); the median duration for PA anastomosis time was 45 minutes (range, 26-75 minutes); the median duration for bronchial anastomosis was 31 minutes (range, 15-50 minutes); the median length of resected PA was 2 cm (range, 1-3 cm); the median length of resected bronchus was 2 cm (range, 1.5-3 cm). The median numbers of resected lymph nodes were 24 (range, 10-46), and the median stations of retrieved lymph nodes were 6 (range, 5-9).

Postoperative events were summarized in *Table 4*. One patient suffered from pneumonia after surgery, and no patients died at 30 days. The median postoperative hospital stay was 10 days (range, 7-20 days). The median ICU stay was 1 day (range, 1-2 days). The median duration of thoracic drainage was 5 days (range, 3-8 days); the median thoracic drainage was 1,042 mL (range, 500-1,700 mL). The median duration of follow-up was 6 months (range, <1-26 months). Eight patients had completed four cycles platinum-based adjuvant chemotherapy, the chemotherapy treatment of the remaining three patients is still ongoing. Two patients received at least four cycles of neoadjuvant chemotherapy, and so, did not receive adjuvant chemotherapy. To date, no local recurrences or distant metastasis were reported.

Discussion

In this retrospective multi-center series report, thoracoscopic double sleeve lobectomy was successfully performed to thirteen NSCLC patients. There were no conversions to thoracotomy. The median operative time was 263 minutes. The median blood loss was 224 mL. The reductions in operative times and blood loss of ten cases from one center were promising. The median numbers of resected lymph nodes were 24. The median postoperative hospital stay was 10 days. The median duration of follow-up was 6 months. To date, no local recurrences or distant metastasis were reported.

Although VATS lobectomy has been widely applied (15), double sleeve lobectomy is still a contraindication to VATS in most medical centers (16). To offer potential benefits of VATS to more NSCLC patients, progressively technical innovations have been made, and several institutes have reported their initial experiences of thoracoscopic double sleeve lobectomy (11-13). However, all of these recent reports were same series, or even single patients from one medical center, and they mainly focused on technical feasibility instead of general safety.

Technically, though there were separate methods of clamping the PA for uniportal or multiport procedures, each method was equally effective in blocking PA. In the uniportal procedure, a bulldog clamp is placed inside the chest cavity to clamp the distal artery, which allowed surgeons more operative space. Additionally, once the proximal PA was cut, the exposure and reconstruction of the bronchus could be more convenient through the 4-5 cm operative port, based on the relative anatomical position of the PA and bronchus. For bronchial anastomosis eased subsequent PA reconstruction and reduced vascular tension at the same time. In multiport procedure, an additional 5 mm incision greatly eased the surgical performance, which has already been reported in major thoracic pulmonary resection (17) and minimally invasive cardiac surgery (18,19). Although the choice involving the numbers of port during the procedure is simply based on the surgeons' preference

Table 2 Patient characteristics

Character	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10	Case 11	Case 12	Case 13
Age (years)	60	67	58	57	54	63	62	67	60	43	65	66	52
Gender	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male	Male
Smoking history	40 y, 40/d	30 y, 20/d	35 y, 20/d	35 y, 60/d	25 y, 60/d	50 y, 60/d	40 y, 20/d	30 y, 20/d	40 y, 40/d	No	31 y, 40/d	40 y, 40/d	32 y, 40/d
Histology	Sqa	Ad-Sqa	Sqa	Sqa	Sqa	Sqa	Sqa	Sqa	Sqa	Ade	Ade	Sqa	Sqa
Tumor size	4.5×3.4	5.7×5.3	3.0×2.2	5.8×4.8	4.3×3.2	3.8×2.2	4.8×4.3	3.6×3.5	1.6×1.1	7.6×7.4	7.5×7.5	5	5
Pathological stage	T3N1M0	T3N1M0	T3N0M0	T3N0M0	T3N1M0	T3N1M0	T3N2M0	T3N0M0	T3N2M0	T3N1M0	T3N0M0	T3N1M0	T2aN0M0
Location	LUL	LUL	LUL	LUL	LUL	LUL	LLL	LUL	RUL	LUL	LUL	LUL	LUL
PA invasion	Main	Main	Branch	Main	Main	Main	Main	Main	Branch	Main	Main	Main	–
Pulmonary function													
FEV_1	2.71	2.58	2.67	2.98	2.73	1.79	2.48	2.32	1.86	3.35	NA	NA	NA
FEV_1%	93.33	87.61	88.73	89.17	74.00	63.15	87.52	92.97	69.58	92.53	109	NA	NA
MVV	120.6	88.86	78.43	109.4	100.7	80.9	102.58	96.3	99.51	125.9	NA	NA	NA

Sqa, squamous carcinoma; Ad-Sqa, adenosquamous carcinoma; Ade, adenocarcinoma; LUL, left upper lobe; LLL, left lower lobe; RUL, right upper lobe; PA, pulmonary artery; NA, no available; FEV_1, forced expiratory volume in first second; MVV, maximal ventilatory volume; y, years.

Table 3 The operative data

Character	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10	Case 11	Case 12	Case 13
Blood loss (mL)	200	400	400	60	70	400	200	300	100	200	80	300	200
Operative time (min)	274	323	253	218	222	274	230	256	230	276	260	330	280
Duration of blocking PA (min)	68	108	76	44	45	55	50	60	60	143	110	70	50
Duration of angioplasty (min)	44	60	30	26	35	40	45	41	35	75	60	60	40
Duration of bronchialplasty (min)	35	32	42	30	25	15	30	23	30	24	40	50	30
Length of resected PA (cm)	2	3	1	1	3	2	1	1	1	2	3	3	3
Length of resected bronchus (cm)	2	2	2	1.5	2	1.5	1.5	2	1.5	1.5	1.5	3	3
Numbers of resected LN	37	26	20	46	27	21	19	20	34	24	10	12	13
Stations of retrieved LN	7	7	6	7	9	5	6	7	6	6	5	5	5

PA, pulmonary artery; LN, lymph nodes.

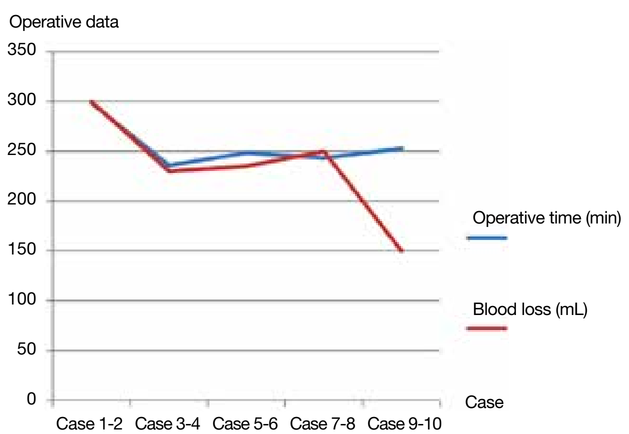

Figure 6 Promising reductions in operative times and blood loss of ten cases from one center.

and experience, it is not a key issue when it comes to the success of thoracoscopic double sleeve lobectomy.

As for surgical trauma, the median operative time and blood loss of this study were 264 minutes and 224 mL, which were consistent with previous reports of thoracoscopic double sleeve lobectomy (11,13,14). And the *Figure 6* also revealed promising reductions in both operative times and blood loss of ten cases from one center, which were from 298.5 to 253 minutes, and 300 to 150 mL separately. Hence, it indicated that thoracoscopic double sleeve lobectomy could be easily done by skilled VATS surgeons with progressive accumulation of surgical experience.

In this series, the median duration of blocking PA was 60 minutes (range, 44-110 minutes) and no complications associated with clamp of the PA occurred. The longest duration of blocking PA among these patients was 143 min, postoperative recovery was uneventful, and no reperfusion injury or thrombosis occurred. Jiang and his colleagues (20) reported a pulmonary vessel blocking model in rabbits that underwent a block of the PA and veins compared to block of the PA alone and found that it might be safe to block the pulmonary vessels up to one hour during pulmonary surgery. In our experience, with satisfactory blocking PA, the arterial reconstruction would be safer and easier during the operation. Since there were no surgical reports concerning this issue, we appeal for further research to determine the proper time for this procedure.

With regard to postoperative complications, only one significant complication was observed and was attributed to effects from the second line of treatment: pneumonia was diagnosed in a patient who received six cycles of neoadjuvant chemotherapy. This suggests that neoadjuvant

Table 4 Postoperative events

Character	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10	Case 11	Case 12	Case 13
Morbidity	–	–	–	–	–	–	–	–	–	–	Pneumonia	–	–
Postoperative hospital stay (d)	7	10	12	8	7	15	8	9	7	13	20	12	9
ICU stay (d)	1	1	1	1	1	1	1	1	1	1	1	2	1
Duration of thoracic drainage (d)	3	6	6	5	3	8	5	4	5	6	5	4	2
Thoracic drainage (mL)	700	1500	1,500	1,330	835	1,700	950	1,100	850	680	700	NA	NA
Adjuvant chemotherapy	TXT/TO	TXT/LOP	PAX/LOP	PAX/DDP	PAX/LOP	–	PAX/DDP	PAX/DDP	–	–	–	VP-16/DDP	–
Chemotherapy cycles	4	4	4	4	4	–	4	4	On	On	–	4	On
Follow-up duration (month)	26	15	9	7	4	3	3	3	2	<1	3	6	1
Status	Live	Live	Live	Live	Live	Live	Live	Live	Live	Live	Live	Live	Live

TXT, docetaxe; TO, oxaliplatin; LOP, lobaplatin; PAX, paclitaxel; DDP, cisplatin; VP-16, etoposide; NA, no available.

chemotherapy patients can successfully undergo the operation, but postoperative management needs more attention, especially in regards to anti infection, and nutrition. There were no significant complications observed in the remaining 12 patients. However, there are also several limitations to our study. First, there were only 13 patients in this series, and most tumors of these patients were located in LUL. This might contribute to the surgeons' preference and experience. Second, the median duration of follow-up was only 6 months, and there were still three patients on chemotherapy. The potential long-term benefit of this operation is still unclear. Hence, further experience of both short-term and long-term benefit of thoracoscopic double sleeve lobectomy is needed to be accumulated.

Conclusions

Thoracoscopic double sleeve lobectomy is safe and feasible when performed by a skilled VATS surgeon, although further investigations are needed to confirm this conclusion.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Double-sleeve and carinal resections using the uniportal VATS technique: a single centre experience

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Background: Video-assisted thoracic surgery (VATS) double-sleeve lobectomy and carinal resections are two of the most complex procedures in thoracic surgery. The uniportal approach provides an advantage for performing these procedures successfully; however, knowledge of the important technical details is required. This study describes the experience of implementing these procedures by Russian specialists.

Methods: Six patients (one woman; mean age, 57.3±3.6 years) who underwent a uniportal VATS double sleeve and carinal resections were consecutively included in this study. A 5- to 6-cm incision was made at the fifth intercostal space on the middle axillary line.

Results: Double sleeve left upper lobectomy was completed in four cases. One case of the right sleeve carinal pneumonectomy and one case of the right sleeve carinal upper lobectomy were completed. The mean operation time was 280±13 minutes. There was no conversion to thoracotomy. The mean postoperative hospital stay was 10.8±0.8 days. There was no postoperative mortality. In one case of double-sleeve lobectomy, postoperative pneumonia developed. The postoperative diagnoses of the four uniportal double-sleeve cases were as follows: T2aN2M0 in one case, T3N1M0 in two cases, and T2aN0M0 in one case. The postoperative diagnoses of the two uniportal totally carinal resections were as follows: T4N0M0 and T3N0M0.

Conclusions: This study results suggest that a uniportal VATS approach might be a feasible option for complex sleeve resections with acceptable postoperative outcomes in the advanced stages of lung cancer. To further evaluate the feasibility, safety, and efficacy of this technique, more experience would be required.

Keywords: Uniportal video-assisted thoracic surgery (uniportal VATS); single-port video-assisted thoracic surgery (single-port VATS); video-assisted thoracic surgery double-sleeve lobectomy (VATS double-sleeve lobectomy); video-assisted thoracic surgery sleeve pneumonectomy (VATS sleeve pneumonectomy)

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Introduction

With the constant improvement in thoracoscopic techniques, an increasing number of thoracic surgeons have performed single-port video-assisted thoracic surgery (VATS) lung resections. However, few reports are available on uniportal VATS lobectomies with bronchovascular and carinal reconstructions for lung cancer in recent years (1,2). In Russia, the number of sleeve lobectomies performed using VATS remains unknown. Uniportal VATS lobectomy has been adopted for patients with central localised tumours requiring bronchovascular and carinal sleeve resections.

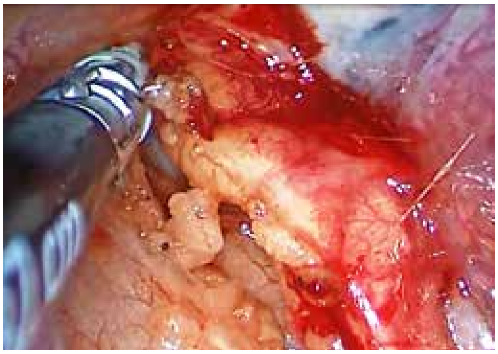

Figure 1 Mediastinal pleura and diaphragmatic nerve resection.

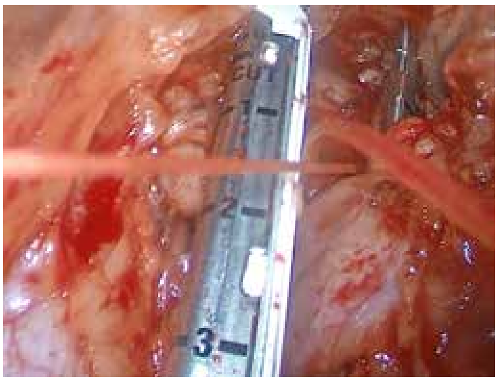

Figure 2 Dividing of the left upper lobe vein by endostapler.

Figure 3 Dividing of the left upper lobe vein by stapler for open surgery.

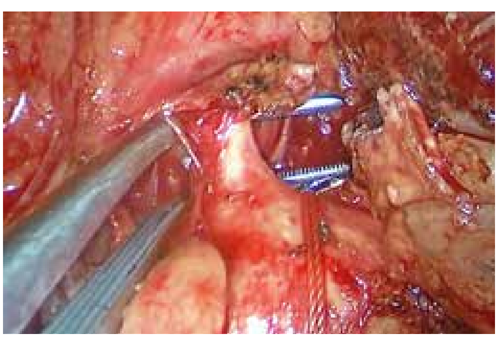

Figure 4 Dividing of the ligamentum botalli.

This study describes the experience of implementing the VATS double-sleeve lobectomy and carinal resections in these patients.

Methods

Case series

Between December 2013 and September 2015, four patients received uniportal, double-sleeve left upper lobectomy, and two patients received uniportal total carinal resections. All of the operations were conducted by the same surgical team. The mean age was 57.3±3.6 years (range, 48–68 years). In two cases of uniportal double-sleeve lobectomy and one case of uniportal total carinal resection, neoadjuvant chemotherapy (gemcitabine + cisplatinum) was administered.

Operative technique

The patients were positioned in a typical lateral decubitus position, and one-lung ventilation general anaesthesia was administered. A 5- to 6-cm incision was made in the fifth intercostal space. A wound protector was placed to provide optimal exposure.

Double-sleeve resections

The operation started with dissection of the mediastinal pleura above the root of the lung. If the tumour affected the mediastinal pleura and phrenic nerve, a resection of those structures was performed (*Figure 1*). Next, dissection and revision of the blood vessels at the root of the lung were conducted. Once the procedure was indicated, the upper pulmonary vein would be dissected and then transected with an endostapler or an open surgical stapler (*Figures 2,3*). The left pulmonary artery was then dissected, and the ligamentum botalli was transected (*Figure 4*). The left main lower lobe and upper lobe bronchi were dissected thereafter. The arterial forceps were used to clamp the central part of the artery; a bulldog clamp was placed on the lower lobe artery. Next, 5,000 IU of heparin was administered prior to transecting the arteries. In each case, en bloc resection was completed (*Figure 5*). Urgent histological examination of the resection margins was carried out in each case. Once a positive margin was confirmed, a re-resection of the margin would be completed. The specimen was placed temporarily into the diaphragmatic sinus. At the beginning of the

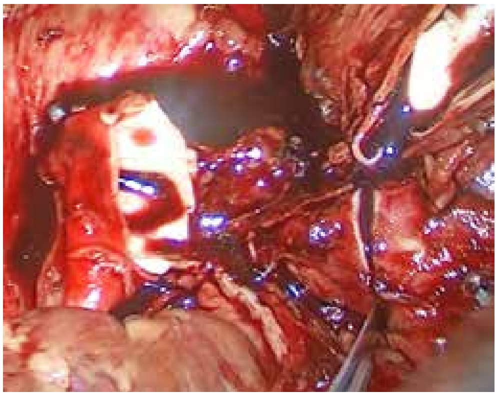

Figure 5 En-block resection.

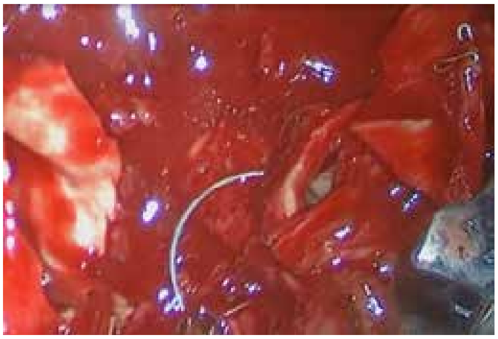

Figure 6 Performing the anterior wall of bronchial anastomosis.

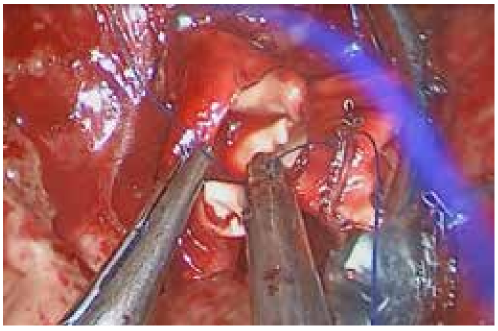

Figure 7 Performing the posterior wall of arterial anastomosis.

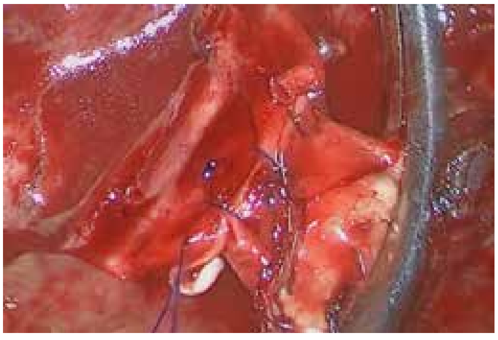

Figure 8 Performing the anterior wall of arterial anastomosis.

Figure 9 Initial view of the vena cava superior lesion.

reconstruction phase, bronchial anastomosis was performed using complete continuous suture. The procedure started with the lateral wall, and then continued with the medial wall. The anterior wall of the anastomosis was the last to be reconstructed (*Figure 6*). Once the sutures were tied, a water probe was used. The last suture was closed with a Hem-o-lock or titanium vascular clips. The artery was reconstructed with complete continuous monofilament suture in two lines: the first suture line was placed in the lateral wall of the anastomosis, and then the posterior and partly inner walls were formed (*Figure 7*). Next, the anterior wall of the anastomosis was constructed using the second suture line (*Figure 8*). De-aeration of the anastomosis was performed before the suture was tied. Oxidised regenerated cellulose was used to cover the anastomosis. The specimen was removed in endo-catch. Systematic lymph node dissection was performed in all of the cases.

Carinal resections

Before dissection, the mediastinal pleura were inspected to assess the mobility of the tumour and its invasion into surrounding structures. In one case, the vena cava superior was affected by the tumour, and it was subjected to partial resection (*Figures 9,10*). Next, mediastinal lymph node dissection and dissection of the pulmonary vessels, right main bronchus, and carina were carried out. Once radical surgery was guaranteed, the pulmonary vessels of the lobe or lung being removed were transected with endostaplers. Carinal division was performed using a double-lumen tube (*Figure 11*). Urgent histological examination of the resection margins was carried out in each case. Once a positive margin was confirmed, a re-resection of the margin would be completed. After removal of the specimen and checking for

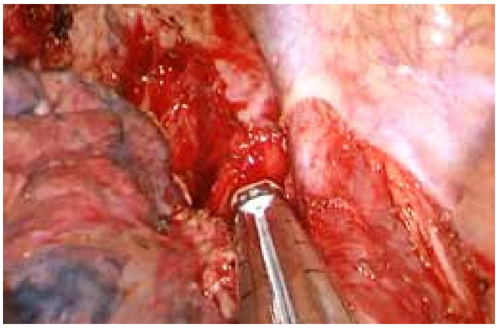

Figure 10 Partial resection of the vena cava superior by endostapler.

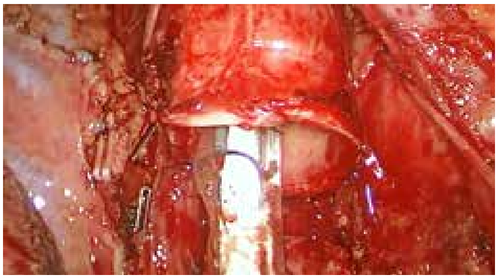

Figure 11 Sleeve carinal resection on a double-lumen tube.

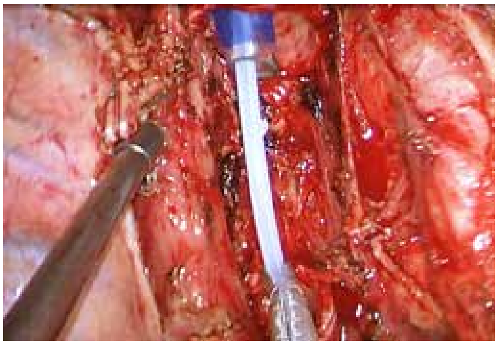

Figure 12 Switch to high-frequency ventilation.

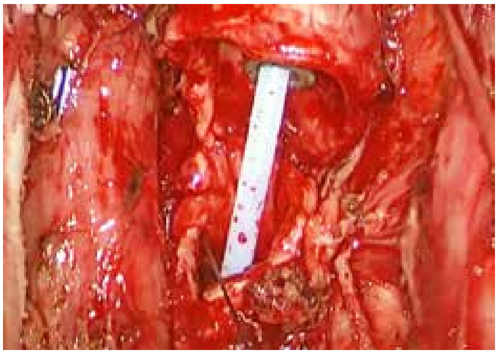

Figure 13 Performing the left wall of the trachea-bronchial anastomosis.

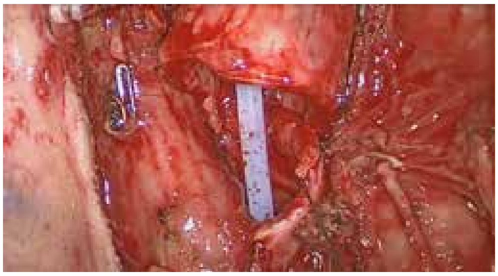

Figure 14 Performing the anterior wall of the trachea-bronchial anastomosis.

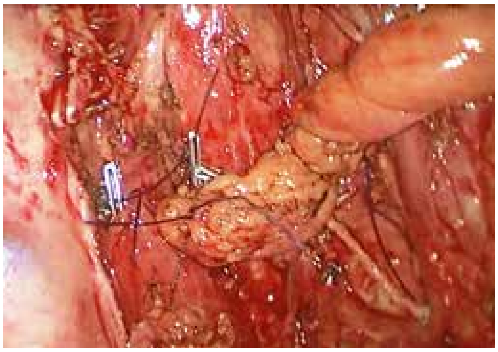

Figure 15 Trachea-bronchial anastomosis covered by the mediastinal pleura flap.

haemostasis, the patients were switched to high-frequency ventilation to facilitate the performance of tracheobronchial anastomosis (*Figure 12*). The anastomosis was performed using complete continuous suture in two lines. The first suture line was placed on the left wall of the trachea and left main bronchus, and then on its membranous part and partially on the right wall of the trachea (*Figure 13*). The second suture line was placed on the anterior and right walls of the anastomosis (*Figure 14*). Once the sutures were tied, they were tested with water and were closed with vascular clips. The anastomosis was then covered with the pleural flap from the anterior mediastinum (*Figure 15*). Systematic lymph node dissection was performed in all of the cases.

Results

The mean operative time was 280±13 minutes (range, 250–330 minutes). The mean intraoperative blood loss was 225±59 mL (range, 100–450 mL). There was no conversion to thoracotomy. The mean postoperative hospital stay was 10.8±0.8 days (range, 9–14 days). There was no postoperative mortality. In one case of double-sleeve lobectomy, postoperative pneumonia developed. The postoperative diagnoses of the four uniportal double-sleeve cases were as follows: T2aN2M0 in one case, T3N1M0 in two cases, and T2aN0M0 in one case. The postoperative diagnoses of the two uniportal totally carinal resections were as follows: T4N0M0 and T3N0M0 (*Table 1*).

Discussion

A standard, single-port approach, thoroughly described by Diego Gonzalez-Rivas, was used in this study (3-5). Using a plastic wound protector is very helpful when performing bronchial and arterial anastomoses.

When performing VATS double-sleeve lobectomy and carinal resections, a surgeon has to face the same challenges as those that occur during open surgery. These are generally related to large-sized tumours accompanied by inflammatory changes in the pleural cavity and hilum, and strong adhesions after neoadjuvant chemo radiotherapy. To perform such complicated procedures, one has to be skilled in using a single-port approach for standard lobectomies. In our opinion, 100 cases and more are required to achieve efficiency, and to begin perform double sleeve and carinal resections. The perfect collaboration and coordination with the anaesthesiologist is mandatory when performing these complex reconstructive procedures.

The uniportal approach provides a direct view when performing anastomoses, bringing the technique closer to open surgery. All types of anastomoses were performed using complete continuous suture. V-Loc thread was used to perform bronchial and tracheobronchial anastomoses. The V-Loc wound closure device (Covidien, USA) is a novel, absorbable barbed suture device that facilitates secure wound closure without knot tying. The 4-0 and 5-0 Prolene sutures are used for vascular anastomoses. The use of special VATS instruments (Scanlan) is preferable when performing the procedures.

For double-sleeve procedures, it is very important to understand and visualise the extent of tumour invasion into the artery of the lower lobe in order to define the fundamental ability to perform this procedure. Usually, double-sleeve cases involve large tumours, in which portions of the tumour blood vessels free from very short. Thus, in all double-sleeve cases, pericardiotomy and intrapericardial upper pulmonary vein isolation should be performed. It is also important, upon the decision to mobilise the pulmonary artery, to consider the transection of the ductus arteriosus, which extends 1–1.5 cm and allows for safer placing of the arterial clamp. Shallow mobility of the hilar vessels in some patients limits the use of standard endoscopic staplers. The 45% maximum articulation of these devices is not always possible during single-port procedures to divide the upper pulmonary vein. To overcome this situation, we use a 30-mm vascular stapler for open surgery or ligature to divide the vein safely.

The arterial clamp should be placed in the anterior portion of the incision. Clamping the distal end of the vessel using a bulldog clamp is considered the most appropriate choice. The clamp is placed completely in the pleural cavity, allowing more space in the single port. The arterial clamp is placed in the anterior portion of the incision, and the thoracoscope is placed in the posterior portion, making the process of manipulating the instruments more comfortable while performing bronchial and arterial anastomoses.

Carinal resections and reconstructions, with or without lung resection, are challenging operations that may be indicated in less than 1% of operable patients with non-small-cell lung carcinoma or benign lesions involving the carina (6).

These are complex procedures, even for open surgery. To confirm the possibility of performing carinal resection, it should be possible to mobilise the trachea, carina, and vessels of the lungs. In all cases of carinal resections, the azygos vein was ligated and crossed. To prevent the aspiration of blood into the left main bronchus, carinal resection was performed on the double-lumen tube. This allowed safe transection of the trachea and left main bronchus, and the performance of haemostasis. Next, we switched to high-frequency ventilation. Regarding the tracheobronchial anastomosis, we always tried to invaginate the bronchus into the trachea. In our opinion, telescopic anastomosis is more secure. For tracheobronchial anastomosis, we always tried to cover the pleural flap.

Our recent experience demonstrated that the uniportal approach is a feasible and safe procedure for performing double-sleeve and carinal resections. These complex resections should only be performed by expert uniportal VATS surgeons.

Our clinical outcomes are limited to a small number of patients with a relatively short follow-up time. To further evaluate the feasibility, safety, and efficacy of this technique, more experience would be required.

Table 1 Perioperative characteristics

Character	Case 1 double-sleeve	Case 2 double-sleeve	Case 3 double-sleeve	Case 4 double-sleeve	Case 5 carinal sleeve	Case 6 carinal sleeve
Age	66	52	68	48	56	54
Gender	Male	Male	Female	Male	Male	Male
Smoking history (years)	40	32	40	45	35	40
Tumour situation						
Pathological type	Squamous-cell carcinoma	Squamous-cell carcinoma	Squamous-cell carcinoma	Squamous-cell carcinoma	Squamous-cell carcinoma	Squamous-cell carcinoma
Stage	T3N1M0	T2aN0M0	T3N1M0	T2aN2M0	T3N0M0	T4N0M0
Location	LUL bronchus	LUL bronchus	LUL bronchus	LUL bronchus	RUL bronchus	RUL bronchus/ carina
PA invasived	Yes	No	Yes	Yes	No	No
Lung function						
FEV_1	1.2 L (2.78 L due)	2.08 L (3.36 L due)	1.2 L (2.67 L due)	1.5 (2.5 L due)	3.2 (4.0 L due)	3.08 (4.4 L due)
Operation situation						
Total time (min)	330	280	270	250	300	250
Length of PA resected (cm)	3	3	3.5	2	–	–
Duration of PA clamped	70	50	70	60	–	–
Duration of angioplasty	60	40	40	45	–	–
Length of bronchus resected (cm)	3	3	2	2	–	–
Duration of bronchoplasty	50	30	25	20	–	60
Number of lymph nodes resected	12	13	14	12	–	14
How many stations of LN resected	No.5.6.7.8.9	No.5.6.7.8.9	No.5.6.7.8.9	No.5.6.7.8.9	No.2.3.4.7.8.9	No.2.3.4.7.8.9
Peri-operative bleeding (mL)	300	200	200	450	100	100
Duration of ICU stay	2	1	1	1	1	1
Drainage days of postoperative	4	2	3	3	5	1
Drain-volume of postoperative (mL)	1,150	500	850	600	1,300	–
Postoperative hospitalization	12	9	10	14	10	10
Complications	No	No	No	Pneumonia	–	–
Adjuvant chemotherapy	Yes	No	No	Yes	No	No
Chemotherapy fulfilled	Four courses of chemotherapy (etoposide + cisplatinum)	No	No	Four courses of chemotherapy (etoposide + cisplatinum)	–	–
Follow-up						
Follow-up time (months)	25	19	10	7	N/A	6
Status	ECOG 0	ECOG 0	1	1	N/A	1

FEV_1, the forced expiratory volume in one second; MVV, maximal voluntary ventilation; PA, pancreatic adenocarcinoma.

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Uniportal video-assisted thoracic surgery—the experiences of Shanghai Pulmonary Hospital

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Abstract: Uniportal video-assisted thoracic surgery (VATS) is getting recognized in thoracic surgery, especially in China. Although surgeons from some part of the world are still skeptic, those in China have witnessed its breathtaking growth, along with the development of the specialty of thoracic surgery. By introducing the history and experiences of one specialty hospital—Shanghai Pulmonary Hospital (SPH), we show the feasibility and safety of uniportal VATS, and illustrate the technical details of this procedure with the example of right middle lobectomy (RML).

Keywords: Uniportal VATS; right middle lobectomy (RML); lung resection

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Introduction

The concept of uniportal video-assisted thoracic surgery (VATS) is relatively new to thoracic surgeons (1). But ever since its birth over a decade ago, this surgical procedure has experienced rapid development. Now, the indications for uniportal VATS are already similar to those for three-port VATS (2-4). All over the world, more and more surgeons are changing their minds and beginning to accept this technique. This trend is more obvious in China.

Shanghai Pulmonary Hospital (SPH) was established in 1933, during the time when modern medicine was first introduced into China. She was a TB sanitarium in the beginning. But, later, as TB is getting controlled in Shanghai, and the incidence of lung cancer is growing rapidly, she has become one focusing on various diseases of the lung and mediastinum. The Department of Thoracic Surgery in SPH has been going through an unprecedented growth in recent years. Since the beginning of the 21 century, the annual number of surgeries has been growing at an astonishing speed, with less than 3,000 major surgeries in 2010, but almost 7,000 in 2014 and over 8,000 last year. VATS is prevalent in SPH, and almost half of all the surgeries are VATS lobectomies, now.

In retrospection of history, the development of VATS operation in SPH dated back to early 1990s. The first VATS operation in SPH was performed in 1994 for pneumothorax. The first VATS lobectomy in SPH was performed in 1999. In Europe, Rocco was one of the pioneers in uniportal VATS (1). In 2013, he published his 10-year experiences on over 600 cases of various surgeries performed by uniportal VATS (5). But Gonzalez was the first to accomplish an anatomical lobectomy by uniportal VATS (6). In 2012, we performed our first uniportal VATS operation in SPH. Now the uniportal technique has become mature and widely accepted in China.

In order to prove the safety and efficacy of this procedure, we carried a retrospective study of all the operations performed by uniportal VATS in SPH from May 2012 to May 2014 (7). The total number was 1,063, including 27 simultaneous bilateral operations. Lobectomy was performed in 569 patients, segmentectomy in 162, wedge resection in 264, mediastinal tumor resection in 54, and other types of operation were rare. The total conversion rate was 4.6%. The average operation time was 135±31 minutes, and the average blood loss was 117±47 mL. There were fifteen intraoperative vascular injuries. There was no operative death, and operative complications occurred in

59 patients (5.6%). The 1-year overall survival and 1-year disease free survival for the primary lung cancer group were 98% and 96%, respectively.

Our experiences proved that uniportal VATS was a safe and efficient procedure, just as the traditional three-port VATS. To illustrate how the procedure was performed, we hereby take right middle lobectomy (RML) as an example. Due to the characteristics of uniportal VATS, RML has its unique difficulties. The distance from incision to hilum is so short that the manipulation of stapler is restricted. The algorithm for the management of the main structures needs to be adjusted accordingly.

Patient selection and workup

Patients with solitary pulmonary nodules were included. These were either diagnosed with lung cancer by needle biopsy before surgery or highly suspected of having lung cancer based on computed tomography (CT) scan.

Pre-operative preparation

Thorough preoperative examination was performed in each patient. Distant metastasis or mediastinal lymph node involvement were excluded by CT scan, bone single photon emission computed tomography (SPECT), endobronchial sonography (E-BUS), or positron emission tomography (PET)-CT. Cardiopulmonary function of all the patients were within normal range. Comorbidities that would incur considerable dangers were not found.

Equipment preference card

(I) Video system: IMAGE1 HD system (Karl Storz, Inc., Germany);
(II) Ultrasonic scalpel: Harmonic (Ethicon Endo-Surgery, LLC, Puerto Rico, USA);
(III) Stapler: Endo GIA Ultra Universal Stapler (Covidien, LLC., MA, USA).

Procedure

General anesthesia with double lumen endobronchial intubation was routinely adopted for each patient. The patient was laid in a left-sided lateral position, with the right hemithorax slightly over extended, so that the intercostal spaces could be expanded to facilitate the operation.

A single incision of about 4 cm long was made along the fifth intercostal space just anterior to the mid-axillary line. A wound protector instead of rib spreader was used to keep the small incision open. Extra-long instruments specially designed for uniportal VATS by SHP were used in each operation.

After exploration and identification of the lesion in the right middle lobe, the dissection began from the venous branches from the middle lobe. Depending on the completeness of the major and minor fissures, the order of the management of the main structures should be adjusted accordingly.

The conventional order of performing a middle lobectomy starts from the vein or artery and ends with the bronchus. This can be achieved under uniportal VATS when both fissures are complete. But unfortunately, this is seldom the case.

When only the major fissure was complete, it was easier to dissect the arterial branches within. Then the inferior border of the vein was automatically exposed, making the management of the vein an easy job. The vein could be passed by the stapler either antero-superiorly or postero-inferiorly, depending on the relative position and direction of the vessel to the incision. The arterial branch in the major fissure could be divided by stapler, electric hook or ultrasound knife, depending on its size and direction. There were not many differences whether to divide the vein or the artery in the major fissure first. After the vein was severed, the middle lobe bronchus, which lied posteriorly was exposed. The parabronchial lymph nodes were removed to allow encirclement of the bronchus with a right angle clamp. After stapling the bronchus, there was, beneath the horizontal fissure, almost always one or two arterial branches which could be divided in the same fashion as the one in the major fissure. The horizontal fissure, which was rarely complete, was then cut open with ease (*Figure 1*).

When neither fissure was complete, we started from the middle lobe vein. There was usually no problem dissecting the vein, but passing a stapler through could be challenging, for the vein was usually too close to the incision for the stapler to have a satisfactory angulation. To overcome this inconvenience, the anterior end of the major fissure needed to be opened by a stapler, electric hook or ultrasound knife. The inferior border of the middle lobe vein was thus completely exposed. In most cases, the stapler could be passed through the vein without too much difficulty in this way. For the same reason, the anterior

Figure 1 RML with a relatively complete major fissure, when the artery within was divided first, and the one under the minor fissure was divided by Harmonic (8). RML, right middle lobectomy.
Available online: http://www.asvide.com/articles/864

Figure 2 RML with incomplete major fissure, and the artery was divided after the vein and bronchus (9). RML, right middle lobectomy.
Available online: http://www.asvide.com/articles/865

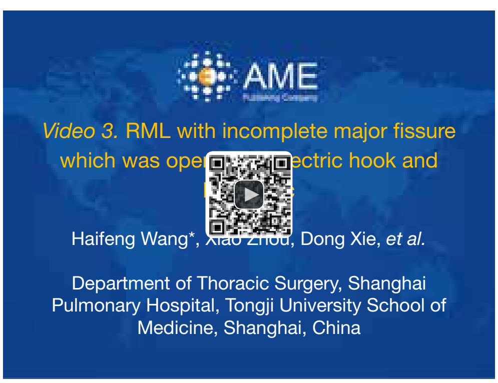

Figure 3 RML with incomplete major fissure which was opened by electric hook and Harmonic (10). RML, right middle lobectomy.
Available online: http://www.asvide.com/articles/866

part of the major fissure should be dissected to the degree so that it did not stand in the way while passing a stapler through the bronchus. After the bronchus was divided, the arterial branches to the middle lobe were easily exposed and divided. The remaining steps were the same as illustrated in the previous paragraph (*Figures 2,3*).

Post-operative management

One chest tube of 28 F was placed to the apex of the thorax. Another 18 F soft tube was left to the most dependent part of the thorax for drainage. No extra incision was made for drainage. Both chest tubes were connected to a water-seal drainage system without suction. The 28 F tube was removed 48 hours after surgery when there was no air-leak and the lung expanded well. The 18 F tube was kept until discharge when the drainage was less than 200 mL/d.

Tips, tricks and pitfalls

An incision at the 5^{th} intercostal space is preferred so that the incision was not to close to the vein to increase difficulty in passing a stapler through and the operation could be performed in one direction. We would avoid making the incision too anteriorly, either, otherwise the stapler could be thwarted, while passing through the vein, by the bronchus posteriorly and the subcarinal lymph nodes would be more difficult to expose.

We would leave the minor fissure to the last, after exposing and dividing the artery beneath it. In this fashion, not only the difficulties of operation but also airleak afterwards could be decreased.

When passing the stapler through the vein, we stopped pulling the lung so that the stapler could push the relaxed middle lobe vein anteriorly and pass in front of the branches from the upper lobe.

Dissection of hilar lymph nodes would help identify the main structures and accelerate the operation.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Uniportal VATS: the first German experience

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Background: The acceptance of uniportal video-assisted thoracic surgery (VATS) for minor and major thoracic procedures is growing in Europe. This study presents the first experience with uniportal VATS in Germany.

Methods: In a retrospective study of prospectively collected data, 56 uniportal VATS were analyzed between 06/2012 and 06/2014. The technique was used for diagnostic aims, pleurectomies, wedge resections, segmentectomies and major resections. All procedures were performed without rib spreading. Patients' demographic data, preoperative and postoperative management as well as results were analyzed.

Results: A total of 42 patients (75%) were males. The mean age was 59.2±15 years. The uniportal VATS procedures included one or multiple wedge resections in 30 cases (53.6%), major resections in 9 cases (16.1%), anatomical segment resections in 6 cases (10.7%) and other indications in 11 cases (19.6%). The median operation time was 252, 114, 88 and 73 minutes for major resections, anatomical segment resections, wedge resections and other indications, respectively. There were three conversions in two cases of major resections and in one anatomical segmentectomy. The mean chest tube duration was 3.4±2.1 days. The mean hospital stay was 8.3±5.3 days for the whole group.

Conclusions: Uniportal VATS is a feasible and safe technique for various indications in thoracic surgery. The perioperative results are promising. It can be performed by thoracic surgeons experienced in the postero-lateral thoracotomy approach.

Keywords: Video-assisted thoracic surgery (VATS); uniportal VATS; single-port thoracic surgery; minimally invasive thoracic surgery

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Introduction

The development of video-assisted thoracic surgery (VATS) over the past two decades has led to a significant shift in the management of an increasing number of thoracic pathologies. The procedure gained acceptance due to its clinical benefits in comparison to the conventional thoracic procedures, this is true too for the economic context (1-6). VATS is associated with less pain, decreased general complications and shorter hospital stay (7,8). VATS reduces surgical trauma and maintains the oncological principles of traditional open procedures (9). VATS leads to a fast postoperative recovery which allows the earlier administration of adjuvant therapy when necessary (10-13). A further development of the 2-3 trocar VATS with a utility incision for major lung resections is the uniportal VATS. The first description of this technique took place in 1998 and concerned a series of six patients, five wedge resections and one foreign bodies removal (14). This paved the way for the development of more complex uniportal procedures for a range of thoracic and mediastinal pathologies. This first progress of uniportal VATS was mainly pioneered by

Table 1 Demographic date of the patients

Variable	No. of patients (%)
Age (years)	59.2±15
Sex	
Male	42 (75.0)
Female	14 (25.0)
Comorbidity	
Diabetes mellitus	5 (8.9)
COPD	12 (21.4)
TBC/aspergilloma	4 (7.1)
Lung fibrosis	3 (5.3)
Pulmonary hypertension	6 (10.7)
Cardiac disease	26 (46.4)
Renal dysfunction	11 (19.6)
Liver cirrhosis	3 (5.3)
Other cancer	37 (66.1)
Previous chemotherapy/radiotherapy	15 (26.8)

Prof. Gaetano Rocco from the National Cancer Institute, Naples, Italy. Between 2003 and 2006, uniportal VATS was performed for pleural effusion, pleurodesis, pleural and mediastinal biopsies, lung wedge resections, and mediastinal pathologies (15-17) A milestone was the first report on a major lung resection with radical lymphadenectomy for non-small cell lung cancer (NSCLC), by Dr. Gonzalez-Rivas from Coruña University Hospital in Spain (18), followed by complex uniportal VATS lung resections including pneumonectomy, segmentectomy, bronchoplastic procedures and chest wall resection (18-21). The latest development was a lobectomy in a non-intubated patient by uniportal VATS (22). The implementation of uniportal technique into the clinical practice is spreading globally. Especially, a strong trend in research and practice of uniportal VATS is ongoing in Asia (23). The initial clinical outcomes and short-term results are encouraging, and more long term data is awaited (23,24).

The purpose of this study was to critically analyze the first preliminary experience on uniportal VATS in Germany, in order to contextualize it internationally and understand its benefits and disadvantages.

Patients and methods

Between June 2012 and June 2014, a retrospective study from prospectively collected data was performed for patients undergoing a uniportal VATS procedure. 56 Patients were included in this study. The demographic data of the patients are present in *Table 1*. The first operations were performed together with Dr. Gonzalez-Rivas. This study was approved by the review board at the Charité - Universitätsmedizin Berlin and Charité Kompetenzzentrum für Thoraxchirurgie, and all patients provided written informed consent before operation. The main endpoint of this study was the feasibility of this technique for thoracic surgeons mainly performing a postero-lateral thoracotomy approach for major lung resections but experienced in minor VATS procedures. The outcome of uniportal VATS in terms of morbidity, 30 days mortality, conversion rate, operative time and hospital stay was studied.

Surgical technique

The patients were placed in a right or left sided position as for the postero-lateral thoracotomy but with modification of the arms' position (*Figure 1A*). All procedures were performed under general anesthesia with single lung ventilation. The 3-5 cm single incision was placed in the 5th intercostal space. There was no rib spreading used. The 5 mm or 10 mm 30° scope camera was introduced in the upper part of the incision (*Figure 1B*). Nodule identification was performed through digital palpation under camera view in all cases where it was necessary. The incision allowed the introduction of more than two instruments beside the scope simultaneously. No additional skin incisions were made for any purpose such as placement of thoracoscope, graspers, or drains. A complete radical lymphadenectomy was performed in all patients with NSCLC. The surgeon and his assistant stand both in front of the patient. All tumor specimens were removed with an Endobag. At the end of the operation, one 24 or 20 Fr chest tube was inserted in the posterior part of the incision and was sutured to the anterior and posterior margins of the uniportal skin incision (*Figure 1C*). No additional incisions were made for the chest tube placement.

Postoperative management

The postoperative management applied an established Fast-Track concept of the thoracic surgery department. Most of the patients were admitted to an intermediate care unit and later on the same day to the normal ward. The mobilization and physiotherapy of the patients began on the operation day. Some of the patients received an epidural catheter while

Figure 1 The uniportal VATS technique: (A) patient positioning; (B) the incision placed in the 5th intercostal space, and the scope in the upper part of the incision; (C) chest tube inserted in the same incision at the posterior part.

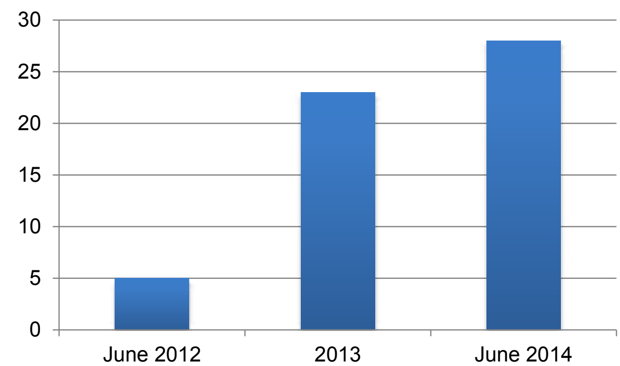

Figure 2 Development of the uniportal VATS at the Charité - Universitätsmedizin Berlin.

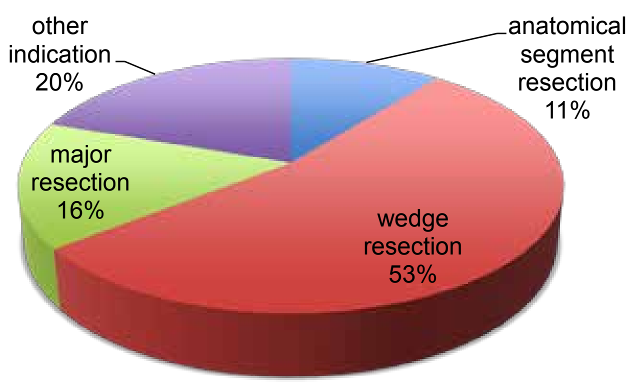

Figure 3 Spectrum of the uniportal VATS.

the others received an opiate pain medication. Thoracic X-ray was performed on the operation day and on the first postoperative day. The thoracic drainage was removed without clamping with normal X-ray findings, nor air leak and secretion below 200 mL within 24 hours. No patient was discharged with a chest tube *in situ*.

Statistical analysis

Parametric data are presented as mean values. SPSS v19 (SPSS Inc, Chicago, IL, USA) software was used and the significance level for all analyses was set at a P value of less than 0.05.

Results

Spectrum of the uniportal VATS

The uniportal VATS was introduced in the Charité department of thoracic surgery in June 2012 together with Dr. Gonzalez-Rivas. Until June 2014, there were 56 uniportal VAT procedures performed for different indications (*Figure 2*). There were 42 (75%) males and the mean age was 59.2±15 years. The 1 (41.1%), 2 (7.1%) and 3 (5.4%) wedge resections were the main procedures, being performed in 30 patients (53.6%). The 9 (16.1%) major lung resections included, 1 lower bilobectomy, 3 right upper, 4 right lower and 1 middle lobectomy. There were 6 (10.7%) anatomical one or more segment resections. The 11 (19.6%) other procedures included mainly pleurectomies, biopsies and lymphadenectomies (*Figure 3*). There were two conversions, in two cases of major resections. In one case the patient had a history of tuberculosis and there was a complete thoracic and mediastinal adhesion. In the other case, the lung resection was performed in a uniportal VATS technique but the lymphadenectomy was performed through a thoracotomy. In one anatomical segmentectomy the incision was enlarged, and a 12-cm thoracotomy with rib spreading was performed.

Operation time

The operation time was calculated from skin incision until wound closure. The operation time included also the time which was necessary for the frozen sections for histological

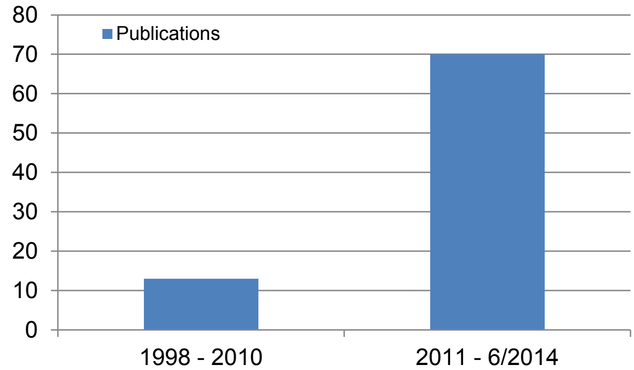

Figure 4 Literature growth of the uniportal VATS.

examination. The median operation time for major lung resections, anatomical segment resections, wedge resections and others was 252, 114, 88 and 73 minutes, respectively.

Histology

In 14 (25%) of the patients, the histological finding was NSCLC. The other histological findings included different lung metastases, aspergillum, or no malignancy in 19 (33.9%), 2 (3.6%) and 21 (37.5%) of the patients, respectively. All tumors were completely resected (R0).

Perioperative morbidity and mortality

There were three revisions due to postoperative hemothorax. In two of these patients, a wedge resection was performed after adhesiolysis, and one of them was suffering from Child B liver cirrhosis while the other had previous heart transplantation and was under anti-coagulation due to lung artery embolism. The third patient had a severe pulmonary hypertonia and underwent a pleurectomy with adhesiolysis. In two patients, a postoperative pneumonia was noticed and successfully treated. One patient developed a pneumothorax after removal of the chest tube. In this patient, placement of a new thoracic drainage was necessary. Non-surgery related mortality was recorded on the 18th postoperative day by a patient who suffered from severe cardiac disease with preoperative ejection fraction of 10-15%.

Postoperative management

The thoracic drainage was removed with a secretion volume below 200 mL. The chest tube was removed after a mean of 3.4±2.1 days. Two postoperative lung fistulas were successfully treated conservatively. The mean hospital stay was 8.3±5.3 days.

Discussion

Uniportal VATS is becoming accepted worldwide for minor and major procedures to treat thoracic and mediastinal pathologies (23,24). The initial results are promising and the technical feasibility has been shown (24) To date, there are no results of randomized controlled trials to compare the role of minimally invasive techniques and open procedures. However, the non-randomized evidence has shown that minimally invasive techniques in thoracic surgery are feasible and associated with less postoperative morbidity and fast recovery allowing the begin of adjuvant therapy when necessary without delay (13,25,26). The 1 and 3 years survival of patients after VATS is at least equivalent to open procedures, with a trend towards better survival at 5 years with a VATS approach (7,8). Despite the 16 years experience with this technique, there were only 13 published cases with uniportal VATS until 2010. From 2011 till June 2014, there were 70 publications after the first report on Uniportal lobectomy (10) (*Figure 4*).

The uniportal VATS program was started at our institution in June 2012. The 3-port VATS was the standard procedure for minor procedures whereas the postero-lateral thoracotomy was the standard approach for major resections. The operations were performed according to the availability of the instruments and experience of the thoracic surgeon with a learning curve. Patient selection was not limited to low risk individuals. There were 1, 12, 38 and 5 patients with “The American Society of Anesthesiologists score” I, II, III and IV, respectively. Most of the patients had four or more comorbidities. This is reflected in the prolonged hospital stay despite the removal of the chest tube. A limiting factor was the unavailability of the special instruments for the technique with proximal and distal articulation as reported in other centers (20). Only four major lung resections were performed with these instruments while the other operations were performed with various endoscopic and conventional instruments. This resulted in a prolonged operation time. Certainly, the use of such instruments for retraction and dissection during uniportal VATS major lung resection is possible but far from optimal (23,27). Specifically designed uniportal VATS instruments are available with slight curvature and narrower shaft to allow for a smaller incision and reduced instrument fencing (19). All procedures were performed as pure uniportal VATS approach without the use muscle spreading. Only in one patient there was a use of an extra 5-mm port for the camera. Our report represents the first German experience with uniportal VATS in a heterogeneous group demonstrating feasibility with low conversion rate and morbidity.

Various technical aspects are of importance for the uniportal VATS. The procedure can be optimally learned under the supervision of a team experienced with it. The development of a uniportal VATS program requires special instrumentations and previous general experience in VATS and could be even performed by thoracic surgeons experienced in postero-lateral thoracotomy approach. Furthermore, randomized controlled studies are necessary to compare the uniportal VATS with other techniques in terms of lymph node dissection as well as mid and long term results, which will influence the future of uniportal VATS in Germany.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Nonintubated uniportal video-assisted thoracic surgery course—live surgery

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Abstract: "Uniportal video-assisted thoracic surgery (VATS) course—live surgery" was held on 23rd of November 2015 in Lithuania, The Hospital of Lithuanian University of Health Sciences Kaunas Clinics. This international event has attracted many thoracic surgeons, doctors anesthesiologists-reanimatologists, operative theatre nurses and other medical specialists from Lithuania, Latvia, Estonia and Poland. The special guests of the conference were thoracic surgeon Dr. Diego Gonzalez-Rivas and doctor anesthesiologist Dr. Humberto Aymerich Cano. Since the first uniportal VATS lobectomy was performed on 29th of July, 2010, this innovative minimally invasive surgical technique has been adopted in many countries of the world. The first nonintubated VATS for lobectomy was initially described in 2007, although general anesthesia with intubation and one lung ventilation was traditionally considered to be necessary for major thoracoscopic pulmonary resections. During this course, right upper and left upper uniportal VATS lobectomies were performed for nonintubated patients, diagnosed with non-small cell lung cancer. These successful examples demonstrate a minimally invasive surgical technique—uniportal VATS lobectomy for a nonintubated patient.

Keywords: Uniportal video-assisted thoracic surgery (VATS) lobectomy; nonintubated thoracic surgery; lung cancer

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"Uniportal video-assisted thoracic surgery (VATS) course—live surgery" was held on 23rd of November 2015 in Lithuania, The Hospital of Lithuanian University of Health Sciences Kaunas Clinics. It was organised by the Department of Cardiothoracic and Vascular Surgery together with The Lithuanian Society of Cardiothoracic Surgeons. This international event has attracted many thoracic surgeons, doctors anesthesiologists-reanimatologists, operative theatre nurses and other medical specialists from Lithuania, Latvia, Estonia and Poland. The special guests of the conference were worldwide famous Spanish thoracic surgeon Dr. Diego Gonzalez-Rivas and his colleague doctor anesthesiologist Dr. Humberto Aymerich Cano.

Dr. Diego Gonzalez-Rivas is a highly skilled thoracic surgeon and world leading expert in uniportal VATS. He has performed the first uniportal VATS lobectomy on 29th of July, 2010. Since then, this innovative technique has been adopted in many countries of Europe, Asia, North and South America. Although general anesthesia with intubation and one lung ventilation was traditionally considered to be necessary for major thoracoscopic pulmonary resections, the first nonintubated VATS for lobectomy was initially described in 2007. Avoidance of general anesthesia results in a faster recovery, immediate return to daily life activities and minimizes the adverse effects of tracheal intubation and general anesthesia.

Dr. Diego Gonzalez-Rivas has presented some reports concerning the recent advances in the uniportal VATS and the thoracoscopic surgery technique performed for a nonintubated patient. The anesthetic protocol for a non-intubated VATS was also presented by doctor anesthesiologist Dr. Humberto Aymerich Cano. The attendees of the conference had a unique possibility not only to know about this minimally invasive surgery technique, but also to see the surgeries performed live.

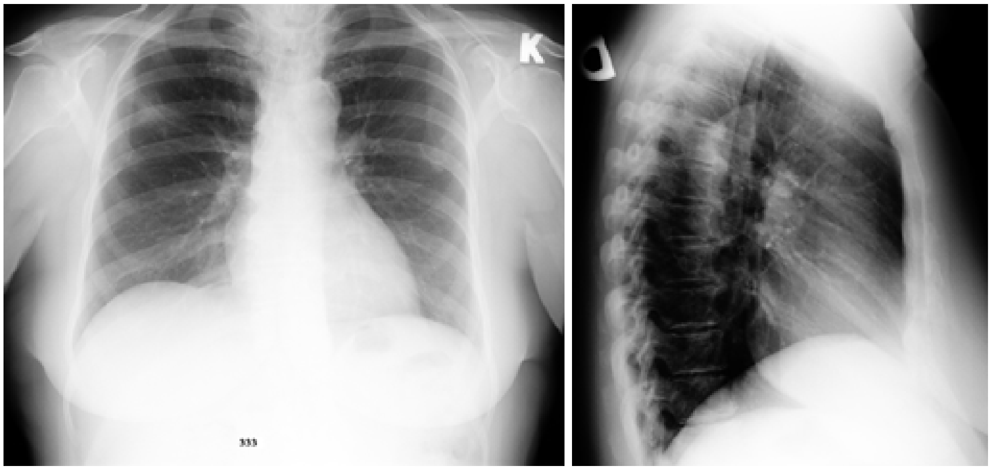

Figure 1 Chest X-ray shows a shadow in right lung S2 area.

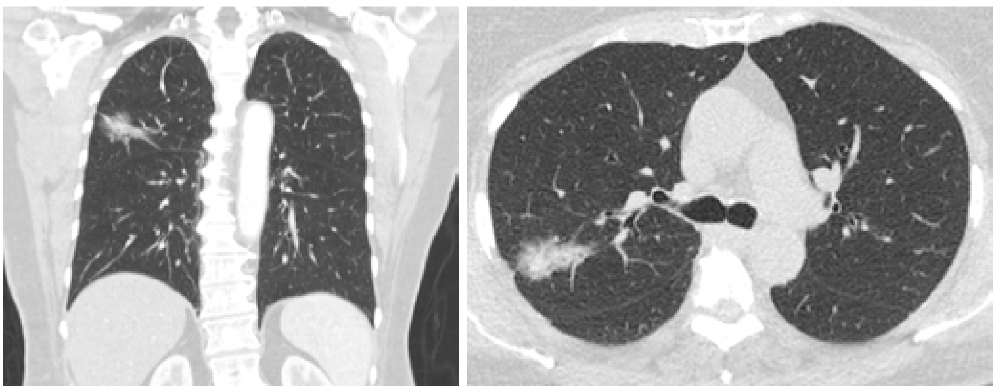

Figure 2 Chest CT scan confirmed ~1.6 cm × 2.8 cm tumor in the right lung S2 zone.

Cases

We have performed two uniportal VATS lobectomies for a nonintubated patient. This kind of surgical procedures in our institution were performed for a first time.

The first case was a 70 year old female, who was diagnosed with non-small cell lung cancer in the right upper lobe. She has complained of a dry cough for about 3 weeks. Chest X-ray showed a shadow in the right lung S2 area (*Figure 1*). Chest CT (*Figures 2,3*) and PET-CT scan has confirmed ~1.6 cm × 2.8 cm tumor in the right lung S2 zone, mediastinal lymph nodes: right paratracheal ~0.6 cm, right bronchopulmonary calcified up to 1.0 cm; FDG negative. Fibrobronchoscopy showed no endobronchial changes and transbronchial biopsy (TBB) has confirmed lepidic adenocarcinoma diagnosis. This patient is non-smoker, had no oncological anamnesis and has some comorbidities: arterial hypertension, type 2 diabetes, obesity [body mass index (BMI) 31.2 kg/m^2] and benign non-toxic multinodular thyroid enlargement deviating trachea to the left. Nonintubated uniportal VATS right upper lobectomy and mediastinal lymphadenectomy was performed (*Figure 4*).

The second case was a 68-year-old male. He was diagnosed with non-small cell lung cancer in the left upper lobe. The patient is a smoker for about 45 years, he smokes 10–20 cigarettes per day, has arterial hypertension, BMI is normal (24.5 kg/m^2). More than a year before he was diagnosed with colon cancer, right hemicolectomy was performed and histopathology confirmed adenocarcinoma, stage IIIB, he got adjuvant treatment. The patient has complained of a fatigue and dry cough. The chest X-ray showed ~4 cm × 3 cm tumor in the left lung S1-2 area (*Figure 5*). Chest CT (*Figures 6,7*) and PET-CT scan showed ~4.1 cm × 2.6 cm × 2.4 cm FDG positive tumour in the left lung S1-2 zone

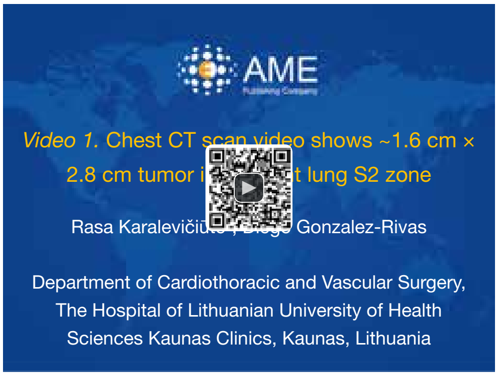

Figure 3 Chest CT scan video shows ~1.6 cm × 2.8 cm tumor in the right lung S2 zone (1).
Available online: http://www.asvide.com/articles/769

Figure 4 Nonintubated uniportal VATS right upper lobectomy and mediastinal lymphadenectomy was performed (2). VATS, video-assisted thoracic surgery.
Available online: http://www.asvide.com/articles/770

Figure 5 Chest X-ray shows ~4 cm × 3 cm tumor in the left lung S1-2 area.

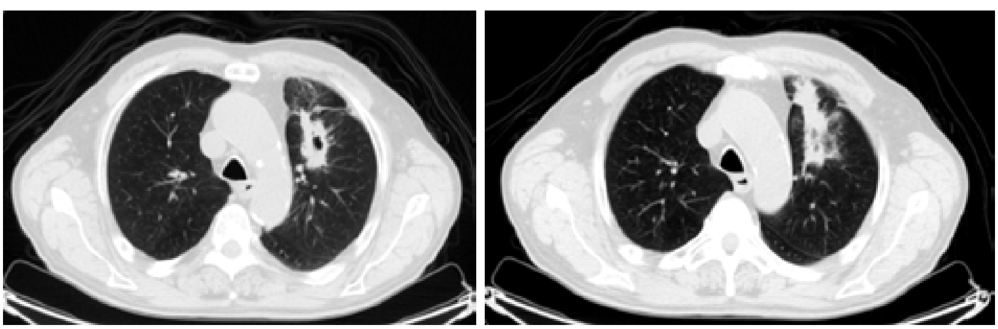

Figure 6 Chest CT scan shows ~4.1 cm × 2.6 cm × 2.4 cm tumor in the left lung S1-2 zone and tumorous infiltration extending to the front till the parietal pleura.

Figure 7 Chest CT scan video shows ~4.1 cm × 2.6 cm × 2.4 cm tumor in the left lung S1-2 zone and tumorous infiltration extending to the front till the parietal pleura (3).
Available online: http://www.asvide.com/articles/771

Figure 8 Nonintubated VATS left upper lobectomy and mediastinal lymphadenectomy was performed (4). VATS, video-assisted thoracic surgery.
Available online: http://www.asvide.com/articles/772

and tumorous infiltration extending to the front till the parietal pleura; small mediastinal lymph nodes with minimal FDG consumption. TBB has confirmed infiltrative squamous cell carcinoma diagnosis. This patient had nonintubated VATS left upper lobectomy and mediastinal lymphadenectomy (*Figure 8*).

Surgical technique

The patient was positioned in the lateral decubitus position. The oxygen was administered via face mask. Intravenous sedation was achieved by using propofol and remifentanil. The skin and intercostal space were infiltrated with levobupivacaine. A single 3 cm skin incision was made in the 5th intercostal space. The surgeon and assistant were positioned in the front of the patient. The 30° high definition thoracoscope, specially designed curved thoracoscopic instruments, endostaplers and vascular clips were used. The camera was placed in the posterior part of the incision and the instruments were placed below the camera. Vagus nerve blockade with local anesthetic was used to reduce cough reflex. The patient was breathing spontaneously, but the collapse of the ipsilateral lung was really good and the movements of the diaphragm were minimal. Lobectomy and mediastinal lymphadenectomy was performed. The lung was extracted in a protective bag. A single chest tube was inserted through the same incision and placed posteriorly at the end of the procedure.

Results

The vital signs of the patients were stable during the surgery. After returning to supine position the patients were already awake and were transferred to the intensive care unit for a full recovery. The patients were allowed to drink and eat after 2 hours and were sent back to the thoracic surgery department ward. Both patients have recovered after the surgery fast and easy. Postoperative pain was minimal. Chest tube was removed after 2 days and the patients were discharged to a rehabilitation centre.

Conclusions

These successful examples demonstrate a minimally invasive surgical technique—uniportal VATS lobectomy for a nonintubated patient. It is important to mention that the procedures were performed by a team of experienced anesthesiologist and a highly skilled single port VATS surgeon.

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None.

Footnote

Conflicts of Interest: The author has no conflicts of interest to declare.

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Teaching uniportal VATS in Coruña

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Abstract: Uniportal VATS is the newest development in thoracic surgery. Many thoracic surgeons are interested in learning this technique but are unsure as to how to best learn the uniportal approach. Wet lab courses in Coruña, Spain offer an excellent chance for surgeons to learn about and perform their initial attempts at this approach under the supervision of the inventor of this technique. This course offers a balanced framework consisting of didactic content, observation and a skills lab.

Keywords: Uniportal VATS; Coruña; wet-lab; Diego Gonzalez-Rivas

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Introduction

The uniportal surgical approach, utilizing one small incision for video-assisted thoracoscopic surgery has been the greatest advancement in minimally invasive thoracic surgery since the development of the original VATS technique 25 years ago. This technique has been critical in advancing the use of all minimally invasive techniques for the treatment of increasingly complex conditions. It offers visibility akin to open surgery without the pain and morbidity associated with standard thoracotomy incisions. Unlike traditional VATS, there is no reliance on geometric angles or awkward body positioning needed for lengthy cases.

The biggest challenge with this technique has been the dissemination of education aimed at surgeons wishing to adopt this approach. Currently this education is available in a multi-tiered approach that includes case observation, didactic coursework, discussions and the highest level of training, the wet-lab experience. The combined course at La Coruna is the best example of the highest level of training.

Here surgeons spend several days learning about the technique before spending a day in the lab, trying this technique under the close mentoring of the technique's inventor, Dr. Diego Gonzalez-Rivas and several of his Spanish colleagues. This chance to learn at the elbow of the master is invaluable. It also offers a chance to level the playing field in the world of surgical practice, where some hospitals have million dollar robots and others are just beginning their ingress into video-assisted technology. Any surgeon, from any background can come here, and many do. General surgeons from England rub shoulders with thoracic surgeons from Asia, while surgeons from Africa drop by to ask questions. Surgeons with 20 years of experience share frustrations with junior colleagues who have just begun practicing. This global sharing is unlike any previous phenomena, and adds to the learning experience (*Figure 1*).

Course framework

The beginning portion of the course is dedicated to didactic coursework which includes the indications and contraindications to using this approach. The didactic content is practical and avoids the application of theoretical models. The technical aspects of the approach are discussed in detail using audio-video materials for illustration. Identifying anatomical landmarks, choosing the site of incision based on pathology and how to position the surgical team are quickly covered in the introduction (*Figure 2*).

Separate lectures cover diverse topics such as maintaining oncological principles, advanced lymph node dissection for accurate staging, advanced complex resections and managing bleeding complications. Lectures are punctuated with videos demonstrating the techniques (*Figure 3*). During the lectures on bleeding and other adverse surgical events,

Figure 1 Participants from around the globe at the course in Coruña.

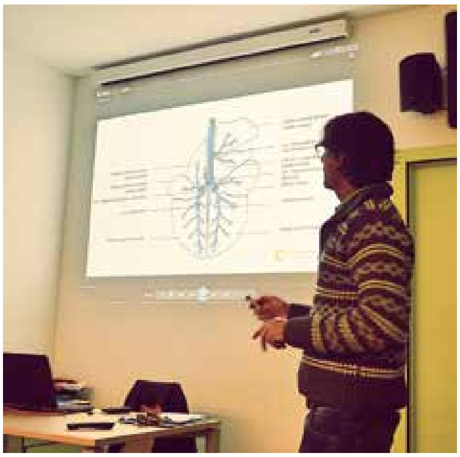

Figure 2 Classroom review of anatomy during lecture by Dr. Diego Gonzalez-Rivas.

Figure 3 Teaching uniportal VATS in Coruña (1).
Available online: http://www.asvide.com/articles/831

Figure 4 Students encounter serious complications in a safe setting of the animal lab.

Figure 5 Dr. Diego assists students during animal lab.

videos showing these seeming catastrophic complications buttress frank discussions of how to prepare for and prevent these accidents.

The remainder of the course consists of live surgery observation and a full day in an animal lab where surgeons can practice their newly taught skills. The wet lab also serves as a dramatic remainder of the fundamentals of the class, as several students, including some very experienced ones, quickly encountered difficulties such as accidental perforation of the pulmonary artery, massive hemorrhage or critical oxygen desaturation (*Figure 4*).

This animal lab also allows students to be guided by more experienced uniportal surgeons in a 'real-world' environment of living patients (*Figures 5,6*). It also reminds surgeons that their outside and previous experience may be

Figure 6 Italian surgeons receive assistance and supervision from Dr. Maria Delgado, an expert in uniportal surgery and one of Dr. Diego Gonzalez-Rivas' partners.

of only limited value when learning a new technique. This potentially humbling experience is an important one as it serves to remind surgeons to learn and to practice the basic principles taught during the didactic content. For surgeons at facilities that do not currently have surgeons using this technique, this experience is invaluable and irreplaceable.

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Uniportal lobectomy in Africa: a beginning

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Abstract: Report of the first uniportal wet lab run in South Africa. This included four university centers involving live surgery. Lobectomies as well as other video assisted procedures were performed. The results are the introduction of thorascopic programs in all four centers. The next stage in this program is to extend the outreach to the other centers in the country as well as in the neighboring countries. During 2016 a beginning will be made in Namibia as well as in Botswana.

Keywords: Uniportal video assisted thoracic surgery (uniportal VATS)

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Introduction

Thorascopic lobectomies have been performed in Southern Africa since the early 1990's (1). This is an ongoing area of surgery that although being available for at least 20 years worldwide has not become the universal approach. Most lobectomies are still performed with a full thoracotomy. The reasons are surgeon's preference, large tumors presenting later than stage 1, their training, the limited experience with thorascopic techniques and inability to visualize in a 2-D environment. These factors all influence surgeon's preference. Uniportal lobectomy is an attempt to combine the advantage of video assisted thoracic surgery (VATS) and open surgery.

Patient selection and workup

During August 2015 an animal wet-lab was arranged to demonstrate the techniques in South Africa. The visiting expert was Prof. Gonzalez-Rivas from Coruna Spain. Following the wet-lab Prof. Gonzalez-Rivas visited four of the South African medical schools demonstrating his techniques. The cases chosen were stage 1 tumors, benign conditions as well as mediastinal masses in which a similar approach to a lobectomy could be demonstrated. The work also emphasized the importance of screening for lung cancer in a group of patients with a high incidence of lung cancer. The patients were chosen by the academic centers but Prof. Gonzalez-Rivas confirmed the suitability for surgery before the procedures were performed. The indications for surgery were the standard as for any thoracotomy. The work-up was no different. We did request stage 1 cancers if possible.

Equipment

Each center had different thorascopic camera systems. The only additional equipment was thorascopic instruments supplied by Scanlan, vascular clips supplied by Grena and Endo-Gia staplers supplied by Covidien (Medtronic).

Procedure

The patients (*Figure 1*) were placed in a full lateral position with a support under the patient. The surgeon and assistant operated from the front of the patient allowing access to the vascular structures first. A 30-degree scope was utilized.

The standard indications are as for any thoracic procedure. VATS is performed for diagnostic as well as therapeutic procedures. In my practice it has replaced an anterior mediastinotomy (Chamberlain procedure) as a far less invasive but also superior procedure that allows far greater visualization of the pleural cavity, the entire mediastinum allowing the surgeon to perform biopsies safely with greater accuracy than the standard operation.

Figure 1 Roadshow in South Africa (2).
Available online: http://www.asvide.com/articles/861

Figure 2 Cape Town Stellenbosch University Wetlab.

Figure 3 Tygerberg Hospital live uniportal VATS surgery. VATS, video assisted thoracic surgery.

Post-operative management

Patients were mobilized as soon as they were awake from the anesthetic. Patient kept as pain free as possible. During the tour the individual hospitals did the post-operative

Figure 4 Steve Biko Hospital live non-intubated uniportal VATS resection. VATS, video assisted thoracic surgery.

care and discharge of the patients. No complications were experienced.

Discussion

South Africa is an emerging economy with a constant emphasis on saving money. At the same time we pride ourselves on the standard of our healthcare facilities. We have centers of excellence that match the standard of the best in the world. At the same time however our training in modern techniques has suffered due to the lack of modern equipment. This program of uniportal VATS with the wet lab (*Figure 2*) as well as the visits to four medical schools was an attempt to introduce VATS as the standard of care in a modern tertiary care hospital.

The program started with a wet lab utilizing pigs in which 27 young surgeons were exposed to VATS techniques. This was followed by visits to four medical schools. Starting at Tygerberg Hospital (*Figure 3*), we travelled to Durban (Albert Luthuli Hospital, University of KwaZuluNatal), University of Pretoria and finally the Sefako Makgatho University.

A uniportal VATS lobectomy was performed at each of the universities plus a variety of other VATS procedures. A VATS posterior mass was resected, a massive bullous was removed with preservation of the collapsed lung (*Figure 4*).

A striking feature of all four visits was the hunger to learn by the entire departments but in particular the young registrars and newly qualified surgeons.

VATS lobectomies can be performed as a uni-portal approach, a two-port, three-port and also in some centers a multiport approach. The very important point is that there is no spreading of ribs. The uni-portal approach is a combination of the open operation and a VATS approach. While the surgeons are learning the procedure the incision starts as a longer incision gradually becoming smaller and smaller until it is not more than 3 cm in length. It allows the surgeon to have the confidence to do the procedure knowing he can always open the chest. It is also a more intuitive approach, as the vision is more like what they are used to. Very important no spreading of the ribs is required even with removal of fairly large masses. It is my own experience not only in my patients but also in watching other surgeons that VATS surgeons are more careful in their dissection of the hilum as well as in the lymph node dissection including the sub-carinal space. Vision is magnified with a far better view of the structures. With the 30% thoracoscope the entire pleural cavity can be visualized. Thoracoscopy has stimulated the development of new instruments making the operations safer and much easier. This includes numerous instruments, staplers and clips. During the tour we utilized Scanlan instruments, Covidien and Ethicon staplers and Grena clips. The Scanlan instruments and Grena clips were designed by Prof. Gonzalez-Rivas and simplify the procedures.

Modern thoracoscopic surgery began in 1991. Lobectomies were performed in the early 1990's through multiple ports. Uniportal VATS has developed over the last about 10 years (3).

The standard thoracic operating theatre in my opinion should always have thoracoscopic instruments available. Although we still need the ability to perform open surgery the standard should be VATS. Just as other branches of surgery have evolved, so has cardiothoracic surgery. The speciality is totally different to what it was 30 years ago and will continue to change (4-6).

Africa is going through a development that is faster than most of the rest of the world. The training of medicine and particularly surgery needs to mirror this development (7,8).

Results

Since Prof. Gonzalez-Rivas's visit VATS programs have commenced at all four universities. Stellenbosch University will be performing their first VATS lobectomy in January 2016. As in all programs the programs have commenced with simple procedures such as lung biopsies, early pleural toilet and decortications before proceeding to the more advanced operations.

During 2016 thoracoscopic surgery will be introduced to Namibia and Botswana as well as a further tour of South Africa to visit the other medical schools and to encourage our local surgeons.

The opinion in this report is mine and is an appeal to African medical schools to maintain the very high standards that, in my case South Africa, has been justly proud of.

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Footnote

Conflicts of Interest: The author has no conflicts of interest to declare.

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Dr. Diego Gonzalez Rivas' trip to the Philippines in November 2015

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Abstract: Video-assisted thoracoscopic surgery (VATS) was introduced in the Philippines in 1992. Initially, multiport VATS was utilized for lung resections in 2012. In 2015, after attending a couple of Asian uniportal VATS workshops, where one of the lecturers/surgeons was Dr. Diego Gonzalez-Rivas, Filipino surgeons were able to do uniportal VATS for a lobectomy in 2015. In November 2015, Dr. Rivas went to the Philippines to give lectures and conduct a VATS pre-congress workshop during the 25th Clinical Congress of the Association of Thoracic and Cardiovascular Surgeons of Asia (ATCSA). He then went to the Lung Center of the Philippines (LCP) where he delivered a lecture and performed a uniportal VATS lobectomy on a 64-year-old male patient who had Adenocarcinoma of the left lower lobe. Anesthetic and surgical techniques are described. Uniportal VATS is a safe procedure and oncologic results are comparable with resections done using open thoracotomy. The patients' quality of life is better because of significantly less pain after the procedure.

Keywords: Thoracoscopy; video-assisted thoracoscopic surgery (VATS); lobectomy; lung cancer surgery; single port vats

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Video-assisted thoracoscopic surgery (VATS) was introduced in the Philippines in 1992 when Drs. Robert McKenna and William Laundrenau conducted the first Asian VATS Workshop at the Lung Center of the Philippines (LCP). In attendance were many Asian surgeons like Dr. Anthony Yim. The technique then was multiport VATS and anatomic lung resections were performed by the two American surgeons as part of the workshop.

VATS was confined to diseases of the pleura until the 2012 when several Filipino surgeons started performing multiport VATS lung resections. After attending the First Asian Uniportal VATS Workshop in 2013 at The Chinese University in Hong Kong, the technique was adopted in the Philippines. Dr. Diego Gonzales Rivas was a member of the faculty in that activity. The first anatomic lung resection using uniportal VATS was eventually performed in the Philippines in July 2015.

Dr. Diego Gonzalez Rivas was a speaker at the 25th Annual Congress of the ATCSA which was held at the Shangri-la Hotel in Cebu, Philippines from 12 to 15 November 2015.

He spoke on the following topics both at the pre-congress workshop and at the congress proper:

- Uniportal VATS intrapericardial pneumonectomy;
- Setting up a VATS training program in your institution: training the practicing thoracic surgeon;
- Uniportal VATS for complex intrathoracic procedures;
- VATS lobectomy: surgical evolution from conventional VATS to uniportal approach.

Dr. Diego Gonzalez Rivas then travelled to Manila where he performed uniportal VATS left lower lobectomy with mediastinal lymph node dissection on a 64-year-old male who has adenocarcinoma of the left lower lobe of the lung. The procedure was done at the LCP.

The surgical team also included:

- Dr. Edmund Villaroman;
- Dr. Edgardo Fullante;
- Dr. Aurelio Fajardo.

with Dr. Stephanie Balaoing as the primary anesthesiologist.

The case

A 64-year-old male diagnosed to have adenocarcinoma at

Figure 1 Adenocarcinoma at the left lower lobe.

Figure 2 Single port video-assisted thoracoscopic surgery left lower lobectomy (1).
Available online: http://www.asvide.com/articles/946

the left lower lobe underwent uniportal VATS. CT scan with contrast is shown (*Figure 1*).

Technique

General anesthesia was started using double lumen endotracheal tube. Patient was positioned, prepped and draped. A 3 centimeter port was made at the 5th intercostal space mid axillary line. The hilum was dissected using Harmonic Scalpel (R). Pulmonary artery to the lower lobe was isolated and transected using an endostapler. Pulmonary vein from the lower lobe was dissected and transected using an endostapler. The fissure was developed using Harmonic Scalpel (R). The bronchus to the left lower lobe was isolated and transected using an endostapler. Mediastinal lymph node dissection was carried out using the Harmonic Scalpel (R). A Fr 24 chest tube was inserted and the skin incision was closed (*Figure 2*).

Histopathologic result of specimens submitted

Left lower lobe adenocarcinoma, papillary predominant 4.0 cm largest tumor dimension, with invasion of visceral pleura, negative for tumor bronchial resection margin and all lymph nodes submitted negative for malignancy.

Drain was removed after several days and patient was discharged.

Dr. Rivas also delivered a lecture on advanced uniportal VATS techniques to the members of the medical staff of the LCP.

The LCP is a 250-bed government health facility. It is the only one of its kind in the country. Most of VATS procedures done in the Philippines are performed at the LCP.

Dr. Diego Gonzalez Rivas' visit to the Philippines last November 2015 was very beneficial to the country's thoracic specialists and operating room staff because of the first hand interaction with the master of uniportal VATS technique.

Conclusions

The successful anatomic resection of the patient's left lower lobe malignant tumor is an affirmation of the role of uniportal VATS in the management of pulmonary malignancies.

The issue of safety for uniportal VATS has been thoroughly discussed and found to be comparable with the standard thoracic surgical resective methods (2).

The other important aspects of surgical treatment would be the oncologic control and the quality of life of the patients. The disease free survival for medium term follow up of patients who underwent uniportal VATS showed comparable results with conventional VATS (3). The better quality of life in terms of significantly less post-operative pain is one distinct advantage of uniportal VATS (4).

The education of thoracic surgeons regarding uniportal VATS can be hastened with the sharing of knowledge by the acknowledged masters of the technique.

Acknowledgements

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Footnote

Conflicts of Interest: The author has no conflicts of interest to declare.

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Management of bleeding from an abnormally located S6 arterial branch in a common origin with S2 branch during live surgery

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Abstract: In 24th/03/2016 we organized the first uniportal video-assisted thoracic surgery (VATS) live surgery workshop in Jerusalem at our institution with our special guest Dr. Diego Gonzalez-Rivas, more than 30 participants attended this workshop from Israeli and the Palestinian territories (cardiothoracic and vascular surgeons, general surgeons, anesthesiologists and nurses). During the workshop Dr. Gonzalez operated two complex cases while the first case was an anatomical S1 segmentectomy, the second case (the one which we are reporting in this paper) was bilobectomy of right middle and lower lobes , during this case a profuse bleeding appeared while introducing the stapler in the interlobar fissure, the source of this bleeding was an abnormally located arterial branch, however the bleeding managed perfectly by Dr. Gonzalez-Rivas, although this surgery kept all of us in a state, all the attendees were happy to see the way how this bleeding managed and everybody was satisfied with the final result.

Keywords: Uniportal VATS bilobectomy; thoracoscopic bleeding management; abnormally located superior segmental branch of right lower lobe (s6); lung cancer; carcinoid tumor

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Text

Uniportal video-assisted thoracic surgery (VATS) is a relatively new surgical technique that was introduced at the beginning of the new millennium (1-3).

This technique was further developed and extended to major lung resections by Dr. Gonzalez-Rivas and his group in a Coruña, Spain and performed the first uniportal lobectomy in 2011 (4). Since that landmark report, he has expanded his technique to complex lung resection such as, Anatomical segmentectomies and sleeve lobectomies (5,6).

Uniportal VATS surgery has since gained popularity around the world with more and more Thoracic Surgery centers adopting this technique over the standard multi-port VATS approach.

The reason for adopting this technique throughout the world has not been because of its more appealing cosmetic result, but rather most probably because of its minimal invasiveness, surgical safety, reduced post-operative pain and shorter length of stay. These quality measures are indicators of greater efficacy compared with the standard approach.

Teaching VATS to Surgeons is a most challenging task as we are lacking effective simulators for this type of surgery. In standard VATS, the presence of the camera in a separate hole facilities the work and teaching through the working port. In uniportal VATS, the presence of camera and instruments in the same port make surgery more challenging not to mention teaching this technique.

Our group has adopted uniportal VATS as our surgical approach of choice since 2013, having transferred from standard thoracotomy directly to uniportal VATS. We use this technique exclusively in our thoracoscopic procedure. The transition learning curve through persistence, perseverance and especially the guidance of experts such as Dr. Gonzalez have allowed us to master the technique and apply it to a wide variety of procedures.

The story of adopting this technique in our institution

Figure 1 The first visit to a Coruña (August 2013).

Figure 2 Dr. Gonzalez performing uniportal VATS lobectomy in Jerusalem (Nov 2013). VATS, video-assisted thoracic surgery.

Figure 3 Part of the participants during the first uniportal VATS workshop in Jerusalem. VATS, video-assisted thoracic surgery.

was started after visiting Dr. Gonzalez in a Coruña (August 2013) (*Figure 1*) then we started immediately to perform minor cases like pneumothorax and wedge resections, then in (November 2013), Dr. Gonzalez was invited to our institution and he performed five successful cases of lobectomy during 2 days (*Figure 2*).

To refine our experience with this new technique we had to attend multiple important courses and meetings that were focusing on uniportal VATS in Spain, China, and Germany and this helped us to feel more comfortable to apply this technique.

In 24/03/2016 we organized the first uniportal VATS live surgery workshop in Jerusalem at our institution, more than 30 participants attended this workshop from Israeli and the Palestinian territory (cardiothoracic and vascular surgeons, general surgeons, anesthesiologists and nurses) (*Figures 3,4*).

During the workshop Dr. Gonzalez operated two complex cases while the first case was an anatomical S1 segmentectomy, the second case (the one we reports in this paper) (*Figure 5*).

Case

We report a case of a 60 years old female with an endobronchial lesion that was found on a CT scan done due to dyspnea and cough. The CT revealed a tumor at the orifice of the right middle lobe bronchus that caused total collapse of the right middle lobe and invasion to the bronchus intermedius, transbronchial biopsy revealed a diagnosis of a typical carcinoid tumor. Ga 68-DOTATATE

Figure 4 Dr. Gonzalez during the workshop.

Figure 5 Dr. Gonzalez operating during the workshop.

scan revealed an avid "2.7 cm" nodule (43 SUV) in addition to a sub carinal avid lymph node (3.7 SUV). The patient had normal lung function test (FEV1 =90%). The patient was non-smoker, had no oncological anamnesis and has some comorbidity: arterial hypertension, no-insulin dependent diabetes mellitus, hyperlipidemia and obesity (BMI >35) a decision to perform bilobectomy was taken (*Figure 6*).

Surgical technique

After insertion of venous cannula and arterial line, Intubation with double lumen tube was done and the patient was positioned in the lateral decubitus position. A single 4 cm skin incision was made the 5th intercostal space.

Figure 6 A video of uniportal VATS lower bilobectomy with management of bleeding from an abnormally located S6 arterial branch in a common origin with S2 branch (7). VATS, video-assisted thoracic surgery.

Available online: http://www.asvide.com/articles/959

The surgeon and assistant were positioned in the front of the patient. The 30° high definition thoracoscope, specially designed curved thoracoscopic instruments, and vascular polymer clips were used. During the surgery the camera was placed in the posterior part of the incision and the instruments were placed below the camera. Upon entering the cavity it became apparent that: (I) the diaphragm was very high; (II) dense adhesions of the lung to the chest wall and mediastinum; (III) small thoracic cavity.

All these findings presented extreme technical difficulties with visualization, instrumentation and dissection. Isolation and separation of vascular structure and bronchus was a most daunting and difficult task, while developing the minor fissure by advancing the stapler above the main arterial trunk a profuse bleeding appeared from an abnormally located S6 (branch to the superior segment of the right lower lobe) which had arisen in a common trunk with S2 arterial branch (posterior ascending artery) (*Figures 7,8*), bleeding control was achieved avoiding a thoracotomy (*Figures 9,10*).

Lower and middle lobectomy with mediastinal lymphadenectomy was performed. The lung was extracted in a protective bag. A single chest tube was inserted through the same incision and placed posteriorly at the end of the procedure. The patient was extubated at the conclusion of surgery and transferred to the recovery ward.

The recovery of the patient was uneventful, she consumed small amounts of analgesics during her stay, mobilization started at the same day of the surgery,

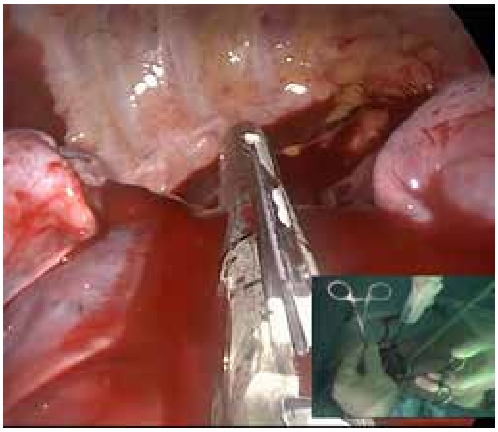

Figure 7 Profuse bleeding after advancing the stapler through the fissure.

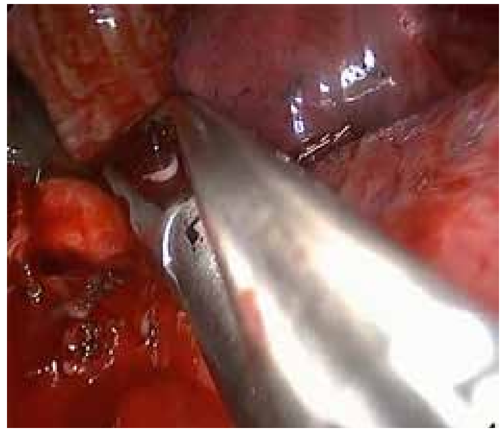

Figure 9 Controlling the bleeding with vascular clip.

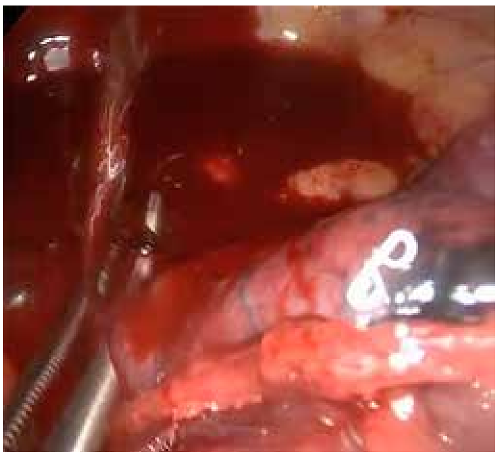

Figure 8 A bleeding jet from abnormally located S6 artery.

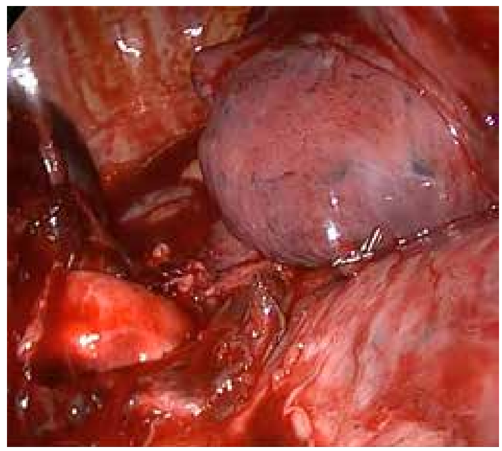

Figure 10 After the management of the bleeding.

removal of the chest tube was done in POD #4 and she was discharged the following day.

Discussion

Coordination of all the surgical team is essential when confronting an emergency such as a major bleeding. In the event of a bleeding, it is crucial to keep calm, don't panic and use compression and suction and the first step. Direct compression is the first measure to be taken when a bleeding occurs. The immediate manual control by means of our hands during open surgery is substituted by compression instruments in a thoracoscopic approach. At the same time it is to suck up the blood around (with long curved suction) in order to have a good the bleeding point as well as leaving a prepared field in case of the need for a later repair (8).

The suction can imitate the function of a finger compressing to stop the bleeding and allows to keep the bleeding point clear from blood. This enables a better assessment of the defect to be repaired. In addition, the curve of the suction doesn't interfere with the suturing maneuver and the thoracoscopic view through a single-port.

The use of polymer (Click a-V, Grena®) clips can be very useful for the control of small vessel bleeding (8). When we try to place a clip over a bleeding zone we must be sure that there is sufficient surface to secure the clip at the base of the vessel. We should be extremely cautious when a clip is being applied to control bleeding because misplacement could cause irreversible damage to the pulmonary artery.

Conclusions

Control of major bleeding with uniportal VATS is feasible, effective and safe in experts' hands. Once the experience is gained with the uniportal VATS approach the majority of the intraoperative bleedings can be controlled thoracoscopically without the need for conversion to thoracotomy. However, the conversion to open surgery should never be considered as a failure of VATS but rather as a form of guaranteeing the safety of the patient and avoid an unexpected resection.

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None.

Footnote

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Right pneumonectomy for carcinoid tumor extending through the intermediate bronchus and the interlobar artery

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Abstract: Uniportal video-assisted thoracic surgery (VATS) is the emerging technique in the modern thoracic surgery practice in Assiut University Hospitals in Egypt we try to keep up with the cutting edge of knowledge to deliver the best available service to our patient. So we invite Dr. Diego Gonzalez-Rivas the world pioneer surgeon in uniportal VATS approach to initiate a uniportal VATS program starting with a workshop with live surgery. The workshop was attended by 84 thoracic surgeons from all across Egypt with a high motivation for adopting the technique in the everyday practice. We believe that uniportal will be the first choice approach for thoracic surgeon in Egypt in the upcoming year.

Keywords: Uniportal; video-assisted thoracic surgery (VATS); pneumonectomy; minimal invasive; thoracic surgery

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Introduction

Minimal invasive techniques are on an increasing demand nowadays all over the world. Obviously thoracoscopic surgery were following the steps of laparoscopic surgery in the early years of its lunch with nearly the same instruments and techniques until thoracic surgeon start to get more familiar with the scopes and start to develop their own path for learning and using minimal invasive approaches. Uniportal video-assisted thoracic surgery (VATS) is the emerging technique in the modern thoracic surgery practice.

In Egypt, thoracoscopic surgery was performed for minor procedures with limited numbers of trials to initiate VATS lobectomy program. Assiut University in one of the leading universities in Egypt which harboring compound University Hospitals 4,200 beds capacity. Assiut University cardiothoracic surgery department initiate a VATS program in 2012 and a VATS lobectomy program in 2015 with four cases of lobectomies done through two ports approach in the first year.in February 2016, we organize the 2nd Assiut VATS workshop in collaboration with Prof. Diego Gonzalez during which we perform the first case of uniportal VATS right pneumonectomy in Egypt. Dr. Diego Gonzalez-Rivas is a world pioneer thoracic surgeon and expert in uniportal VATS. He has performed the first uniportal VATS lobectomy on 29th of July, 2010. Since then, this innovative technique has been adopted in many countries across the world (1).

Patient selection and workup

Twenty-three years old female patient complain of hemoptysis of 8 months' duration. She was diagnosed as having tuberculosis on a clinical suspension in another hospital and received anti tuberculous treatment for 6 months with no improvement then referred to our hospital where she underwent fiberoptic bronchoscopy that revealed endobronchial tumor at the right intermediate bronchus, biopsy was taken and pathologist report a benign endobronchial tumor. CT scan chest showed a mass 5 cm in maximum diameter extend from the right intermediate bronchus to the surrounding lung tissue with areas of

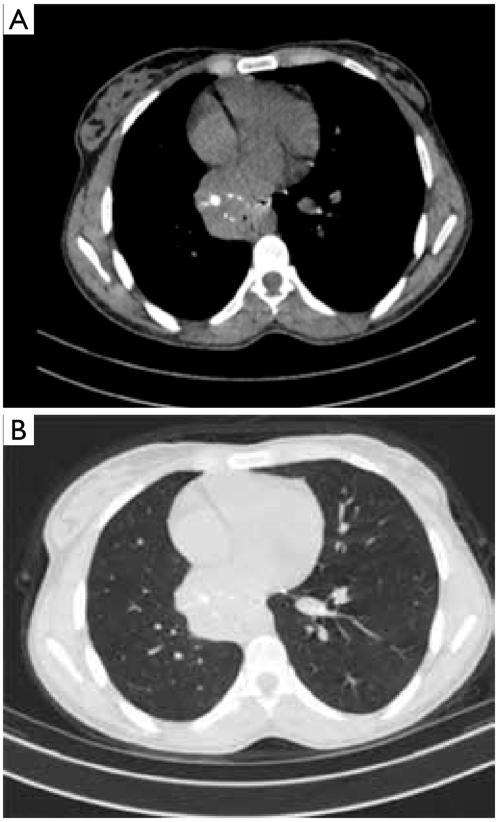

Figure 1 CT scan chest showing mass extending from the right intermediate bronchus.

calcifications (*Figure 1*). Lab investigation were normal, pulmonary function showed normal spirometer.

Pre-operative preparation

Surgery was planned as uniportal VATS right middle and lower lobectomy. Induction of anesthesia with single lumen tube though which surgeon perform a fiberoptic bronchoscopy to confirm tumor location then a double lumen endotracheal tube was inserted. Patient positioned in lateral decubitus position and a 3 cm port was opened in the 5th intercostal space just lateral to the anterior axillary line.

Equipment preference card

A 30° thoracoscope attached to a high definition camera (Image-1 system, Karl Storz Inc., Tuttlingen, Germany), specially designed curved thoracoscopic instruments, endostaplers, energy sealing device and vascular clips were used (*Figure 2*).

Figure 2 Surgeon and assistant stand in front of the patient.

Figure 3 Demonstrate the position of the surgeon, assistants and scrub nurse site of port placement, lysis of adhesions and skin suture to retract the soft tissue (2).
Available online: http://www.asvide.com/articles/962

Procedure

The camera was placed in the most superior part of the incision and the instruments were placed below the camera. Inspection of the chest cavity revealed extensive adhesions between the lung and chest wall (*Figure 3*) lysis of adhesions using Harmonic sealing device (Harmonic energy device, Ethicon Co., USA). The lung was retracted cranially and the inferior pulmonary ligament was divided using Harmonic to expose the inferior pulmonary vein which was divided using articulating vascular stapler. Trial to expose the interlobar artery inside the fissure revealed that the artery was incased by the tumor with no sparing to the upper and middle lobe branches so the decision was to go for right pneumonectomy. Division of the main bronchus followed by the superior vein

Figure 4 Demonstrate surgical steps; division of the inferior pulmonary vein, superior pulmonary vein, bronchus and pulmonary artery then retrieval of the specimen (3).
Available online: http://www.asvide.com/articles/963

Figure 5 A chest tube through the same incision.

Figure 6 Postoperative chest X-ray.

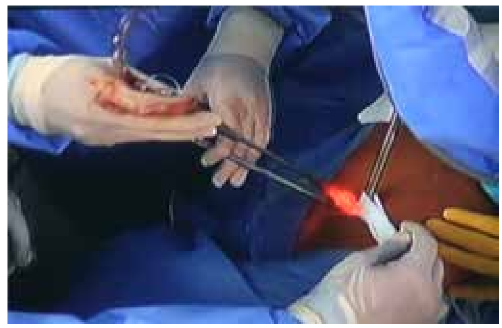

Figure 7 Gauze wrapped around the scope to fix it in its superior position.

then the main right pulmonary artery was done. Extraction of the specimen through an endo-bag (*Figure 4*). A single chest tube was inserted through the same incision and placed posteriorly at the end of the procedure (*Figure 5*).

Post-operative management

The vital signs of the patients were stable during the surgery with estimated blood loss of about 800 cc. After returning to supine position the patients were extubated and were transferred to the critical care unit. The patients were allowed to drink and eat after 2 hours and were sent back to the thoracic surgery department ward next morning. Recovery after the surgery was fast and easy. Postoperative pain was minimal; chest X-ray was excellent (*Figure 6*). Chest tube was removed after 2 days and the patient was discharged to home on 3rd day postoperative. Final pathology report was typical carcinoid tumor that 1 cm away from the bronchial and vascular surgical margin.

Tips, tricks and pitfalls

- The camera was placed in the most superior part of the incision and the instruments were placed below the camera;
- A long gauze wrapped around the scope can be used by the assistant to fix the camera at the superior part of the incision at all the time (*Figure 7*);
- A silk suture can be taken on the skin edge of the incision to retract the soft tissue away instead of use of soft tissue retractor.

Comments

In spite of the limited budget of health system in the developing countries, we committed to provide our patients with the best available health care. We started our VATS program in Assiut University in 2012, more cases were done every year with publication of our initial experience (4). The direction towards uniportal VATS was a dream taking to catch up with the cutting edge of knowledge in thoracic surgery and the workshop with live case transmission was the initial step. The workshop was attended by 84 thoracic surgeons from all across Egypt with a high motivation for adopting the technique in the everyday practice. We believe that uniportal will be the first choice approach for thoracic surgeon in Egypt in the upcoming year.

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Footnote

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The evolution of uniportal video assisted thoracic surgery in Costa Rica

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Abstract: Video-assisted thoracic surgery (VATS) has become one of the most important advances in thoracic surgery in this generation. It has evolved continuously into a less invasive approach, being uniportal VATS the last step in this evolution. Since the first uniportal VATS lobectomy was performed in La Coruña in 2010, the procedure has suffered and exponential growth that has allowed it to widespread around the world, expanding the indications from initially early stage lung cancer cases to complex advance cases nowadays. In Costa Rica, uniportal VATS started to be use for major pulmonary resection in June 2014, thanks to the tutoring from Dr. Gonzalez-Rivas. In our center, uniportal VATS is the standard approach for minimally invasive procedures, and major pulmonary resections had only been done through the single port approach. In order to evolve and progress in the experience of the procedure, and to expand the indications in which it was being performed, a "uniportal VATS master class" was held in Rafael Angel Calderón Guardia Hospital in San José, Costa Rica, from September 16 to September 18 2015. The master class was led by Dr. Diego Gonzalez-Rivas and it counted with the contribution of Dr. Li Wentao and Dr. Yang Yang, from Shanghai Pulmonary Hospital. The course attracted almost every thoracic surgeon in our country and participants also included anesthesiologists, pulmonologists, nurses and medical students. Three uniportal VATS were performed during the course, a left lower and a right upper lobectomy and a wedge resection that was the first non-intubated VATS procedure ever performed in our country.

Keywords: Uniportal VATS; lobectomy; single port; minimally invasive; non-intubated thoracic surgery; Costa Rica

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One of the most important advances in thoracic surgery of our generation has been video-assisted thoracic surgery (VATS) (1), it has evolved from the initial multiport approach to a less invasive approach using only a single incision or uniportal VATS.

As in multiport VATS, the first cases reported using the single port approach were procedures such as biopsies, wedge resections and pneumothorax surgery by the team lead by Gaetano Rocco (2). It was until 2010, that major pulmonary resections were completed successfully by uniportal VATS in La Coruña (3), starting and exponential growth that has allowed to perform even complex oncological cases through this approach (4).

Since Gonzalez-Rivas *et al.* performed the first uniportal VATS lobectomy, the approach has proven to be safe, feasible and reproducible, leading to a widespread of the procedure around multiple centers in the world. The growth of the technique cannot only be explained by its own advantages, a big part is due to the great effort by Dr. Diego Gonzalez-Rivas to teach it to any surgical team interested in learning it. It was in this process where he made another major contribution, he decided to travel around the world and teach the technique to thoracic surgeons in their hospitals, letting all the surgical team (nurses, assistants,

Figure 1 The master class was held with the collaboration of Dr. Diego Gonzalez-Rivas, Dr. Wentao Li and Dr. Yang Yang.

Figure 2 Live surgery performed by Dr. Gonzalez-Rivas in Rafael Angel Calderón Guardia Hospital.

anesthesiologist) to familiarize with the procedure, showing them that it could be done in their center and making the technique available to any thoracic surgical unit with a VATS program around the world.

In Costa Rica, VATS surgery started since the late 90s and uniportal VATS was used seldom for diagnostic procedures.

In May 2013, after attending a lecture from Dr. Gonzalez-Rivas in the ESTS conference in Birmingham, about his experience in major pulmonary resections, that included even sleeve resections, the author was convinced this was the present and future of thoracic surgery.

Our group started to use only the single port approach for every VATS surgery, including pleural biopsies, effusion drainage, wedges resections, drainage and decortication for empyemas and resection of mediastinal tumors. This was a step-by-step process, in which we gained confidence and skills with each procedure before progressing to another. Before we started using this approach for empyemas, many coagulated hemothorax were completed successfully. A lot of the skills of dissection in a uniportal approach were acquired during the decortication of phase 2 and 3 empyemas. Being able to completely decorticate this difficult cases gave us a push in our learning curve that prepare us for more difficult surgeries. Complex VATS surgery started in June 2014 with the first lobectomy being performed successfully. This process was only possible through the tutoring of Dr. Gonzalez-Rivas. The first case perform was a left lower lobectomy in a male patient with bronchiectasis.

After attending a uniportal VATS course in Shanghai Pulmonary Hospital directed by Dr. Gonzalez-Rivas, from October to November 2014 we started to carry out upper lobectomies also.

Thanks to the experience gained and in order to maximized our learning curve and teach the approach to other thoracic surgeons in our country, we decided to hold a course in our hospital with the help of Dr. Gonzalez-Rivas.

The course was divided into three days, the first day took place in the Medical and Surgeons College of Costa Rica (*Figure 1*), consisted in a lecture by Dr. Gonzalez-Rivas, directed to the medical community in general, this taught numerous general practitioners, pulmonologists and medical students the benefits and applications of uniportal VATS surgery. The second day consisted in a theory course directed to thoracic surgeons and the third day was reserved for three uniportal VATS surgeries performed by Dr. Gonzalez-Rivas, two lobectomies and one non-intubated wedge resection.

The first part of the course consisted in multiple lectures that explained the process and evolution of uniportal VATS, the steps to perform major lung resections and how to deal with complications that may arrive during surgery.

The second part consisted in live surgery (*Figure 2*), with three cases performed by Dr. Gonzalez-Rivas. All patients were placed in a lateral decubitus position, the incision was made in the fifth intercostal space, and no wound retractor was placed. All of the operations were completed without any complications.

The first case consisted in a 77-year-old woman with a 1.5 cm spiculated nodule located centrally in the left lower lobe (*Figure 3*). A left lower lobectomy with a radical lymph node dissection was performed (*Figure 4*). The pathological staging and diagnosis was stage IA adenocarcinoma (T1aN0M0).

Secondly a right upper lobectomy was performed in

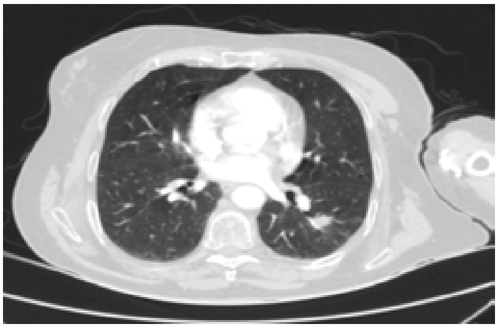

Figure 3 Chest CT shows a 1.5 cm central spiculated nodule in the left lower lobe.

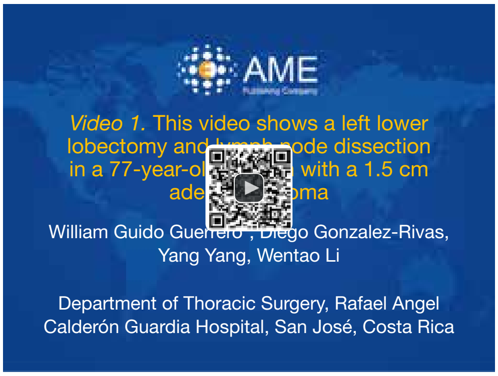

Figure 4 This video shows a left lower lobectomy and lymph node dissection in a 77-year-old women with a 1.5 cm adenocarcinoma (5). Available online: http://www.asvide.com/articles/964

Figure 5 Chest CT shows a 4 cm mass with cavitation, located in the right upper lobe.

a 76-year-old male with a 4 cm mass in the right upper lobe (*Figure 5*). Complete lymph node dissection was also performed (*Figure 5*) and the definitive pathological diagnosis was stage IB adenocarcinoma (T2aN0M0).

Figure 6 This video shows a right upper lobectomy with an incomplete fissure in a 76-year-old male with a 4 cm adenocarcinoma (6). Available online: http://www.asvide.com/articles/965

The last patient of the course had a previous history of right breast cancer, and had a 1.4 cm nodule located in the right upper lobe (*Figure 6*). This case was performed without intubation (the first case performed like this in our country), vagus blockage with lidocaine was done in order to avoid coughing and the patient was sedated through the procedure. After location of the lesion a wedge resection was carried out and the procedure was completed successfully. The frozen section was not able to differentiate between a primary and a metastatic lesion. The definitive diagnosis was atipic carcinoid tumor with vascular and lymphatic invasion. A reVATS right upper lobectomy was performed two weeks later, also by uniportal approach, without complications.

Comments

VATS lobectomies are now the standard approach for early stage lung cancer and uniportal VATS has proven to be safe and feasible not only for early stage lung cancer but for advance cases also (3,7). The team from La Coruña has the biggest series of lobectomies perform by a single port approach and their experience includes already complex bronchial and vascular reconstructions (7-9). Other thoracic units, especially in Asia had also reported their experience with the approach (10), were a lot of centers had adopted the technique and even started training programs.

In our hospital, uniportal VATS is now the standard approach in minimally invasive surgery, and the majority of our procedures are carried out this way. Currently more than 170 cases, 15 of the major lung resections had been

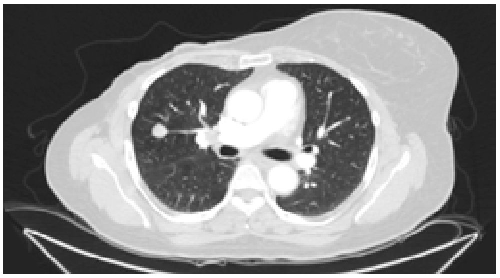

Figure 7 Chest CT shows a 1.4 cm nodule located in the right upper lobe. This patient had a prior right mastectomy.

achieve successfully with a uniportal approach. The success of the program is in a big way thanks to the guidance and continuous cooperation of Dr. Diego Gonzalez-Rivas. Being able to learn from his experience and incredible surgical technique has allowed our team to grow as surgeons and improve our results.

Uniportal VATS is a very innovating procedure in our country, and we are one of the few centers that are doing it as a standard approach for all the VATS cases. Because of this, a lot of press and media coverage was done to the visit of the pioneer of the approach and the master class taking place in our hospital. Most of the national newspapers and television news reported on the event (*Figure 7*).

After the course we have been able to emulate his surgical process and follow his recommendations, which has facilitated the procedure considerably and also improve our surgical time. We gained confidence and experience, letting us progress to more difficult cases including advance stage lung cancer.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Uniportal lobectomy in Jordan—the journey continues

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Abstract: Report of the first uniportal video-assisted thoracic surgery (VATS) lobectomy live surgeries course in Jordan. Live surgeries were performed in collaboration between Dr. Diego Gonzalez-Rivas and our Thoracic/Pulmonary Team at Istishari Hospital in Jordan. Such experience will pave the way for more thoracic surgeons to embrace the newest of the less-invasive thoracic surgical techniques in Jordan.

Keywords: Video-assisted thoracic surgery (VATS); uniportal; lobectomy; lymphadenectomy

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Introduction

The specialty of thoracic surgery has witnessed; in the past few years, an increasing number of innovations and extensive use of less invasive surgical techniques (1,2). The use of video-assisted thoracic surgery (VATS) is becoming the standard surgical method when managing pulmonary pathologies in many medical centers around the world (3-5). The continuous pursuit of less-invasive surgical procedures led to the development and advancement of uniportal VATS, which was pioneered by Diego Gonzalez-Rivas, MD from Spain. Uniportal VATS is currently being used to surgically treat much thoracic pathologies, notably the oncologic resections (lobectomies, pneumonectomies, sleeve resections, and lymphadenectomies) (6). Dr. Gonzalez has been visiting various hospitals and healthcare systems around the world showcasing and teaching his technique of uniportal VATS lobectomy.

In February 2016, Dr. Gonzalez collaborated with the multi-disciplinary thoracic-pulmonary team from Istishari Hospital in Jordan during the Jordanian Uniportal VATS live surgeries course (*Figure 1*).

Our specialized team currently utilizes VATS technique in 95% of all thoracic surgical cases, and we have the largest cohort and expertise in the world in using VATS for treating thoracic trauma patients and removing metallic foreign bodies and shrapnels form the chest cavity. Our team began performing uniportal VATS early 2015 after attending the Shanghai Uniportal Course in Shanghai, one of the biggest courses in the world in this field, where we were exposed to various uniportal VATS live surgeries and slide presentations.

Patient selection and workup

Case 1, was a 39-year-old male patient who had a 3.5 cm right upper lobe lesion (adenocarcinoma). The patient underwent neoadjuvant chemotherapy and was sent for surgical intervention. PET/CT scan showed ipsilateral PET avid mediastinal lymph nodes, which proved to be adenocarcinoma by mediastinoscopy lymphadenectomy. No other PET avid lesions were present (*Figure 2*).

Case 2, was a 19-year-old male patient with a 3-cm right lower lobe lesion (neuroendocrine tumor—typical type). The patient was referred for surgery (*Figures 3,4*).

Both patients had routine preoperative workup, which included complete blood count, kidney function test, liver function test, prothrombin time, chest X-ray, chest CT scan/PET, and a pulmonary function test.

Figure 1 The uniportal VATS in Jordan Team (from left to right: Dr. Baha Shihadeh: assistant surgeon; Dr. Hamdi Abu Ali: thoracic surgeon; Dr. Diego Gonzalez-Rivas: thoracic surgeon; Dr. Nada Abdulbaqi: assistant surgeon; Rama Swiss: thoracic surgery clinic coordinator).

Figure 2 During a uniportal right upper lobectomy.

Figure 3 The team during a uniportal right lower lobectomy.

Figure 4 Uniportal VATS right lower lobectomy for a typical neuroendocrine tumor (7). VATS, video-assisted thoracic surgery. Available online: http://www.asvide.com/articles/972

Equipment

The setup we used at our hospital includes a state of the art dual monitor thoracoscopic system with a 10 mm 30 degrees HD camera (Stryker®). We used double articulating long-shafted thoracoscopic instruments (Scanlan®). We utilized powered Vascular Staplers (PVS), powered tissue stapler, GST stapling loads, and Harmonic energy source (Ethicon®).

Procedure

The following procedural steps were used for each patient:

- All the necessary preoperative monitoring lines were inserted. A double lumen endotracheal tube was used with general anesthesia. The right lung was deflated. The patient was put in left lateral decubitus position with the right side up. Axillary roll was put underneath the left axilla. An underlying loin support was utilized to further spread the rib cages apart. A pillow was inserted between both legs;
- A multilevel intercostal nerve block was done;
- A 2-inch single (uniport) incision was created over the fourth intercostal space along the anterior axillary line;
- A uniportal VATS lobectomy and lymphadenectomy was done for each patient;
- A single chest tube (size 28f) was introduced into the pleural cavity via the uniport incision.

Postoperative management

Patients were extubated in the operative room and transferred to a step down unit. Chest tube was removed on postoperative day number two. Neither patient required any blood transfusion. Both patients had very good pain control using oral simple analgesia.

Role of team members

- Dr. Diego Gonzalez-Rivas: surgeon;
- Dr. Hamdi Abu Ali: surgeon;
- Dr. Khaled Al-Asad: pulmonologist;
- Dr. Osama Al-Bdour: pulmonologist;
- Dr. Sakher Alkhaderi: radiologist;
- Dr. Baha Shihadeh: assistant surgeon;
- Dr. Nada AbdulBaqi: assistant surgeon.

Discussion

Uniportal VATS technique is considered by many (including our team) to be the next level in performing less-invasive thoracic surgery procedures. Istishari Hospital in Jordan is an ultra-modern private hospital with excellent minimally invasive surgical setup for thoracic, bariatric, hepatobiliary and colorectal surgeries. Our multidisciplinary Thoracic/ Pulmonary Team consists of a pulmonologist, a thoracic surgeon, a thoracic surgery super fellow, an ENT surgeon, a conventional radiologist, an interventional radiologist, a pathologist, and an oncologist. Our team receives referrals for complex thoracic surgeries from the Middle East and North Africa region. Ninety-five percent of all our surgical procedures are done via minimally invasive VATS techniques. In addition, our team recently presented the largest series in the world using VATS to retrieve metallic foreign bodies and shrapnels from the chest cavity secondary to war injuries (mention the meeting's name). Our team members were introduced to Dr. Diego Gonzalez-Rivas during various international courses in addition to participating in the Shanghai Uniportal VATSs course in Shanghai, which was directed by Dr. Gonzalez.

Less-invasive surgeries in general and uniportal VATS thoracic surgeries represent the latest advancement in the field of thoracic surgery, and there are several emerging reports that highlight the benefits of uniportal surgery when compared to even the typical multiport VATS surgery. Less morbidity, less pain and less duration of stay are the expected outcomes with VATS surgeries compared to open procedures, and these favorable outcomes are even more noticeable using the uniportal method.

Tips and tricks

Over the course of the past year, we relied on several tricks and tips that enabled us to embrace the uniportal VATS technique and establish a successful minimally invasive thoracic surgery service. Here we discuss a few of them.

A multidisciplinary team is a cornerstone for success. The presence of a dedicated minimally invasive operating suite with modern equipment typically includes 30 degree HD cameras, double articulating surgical instruments, advanced stapling technologies including powered devices, and an advanced energy source for tissue dissection and sealing. In addition, a formal uniportal VATS training can be carried out in step-wise fashion. Our team started the uniportal service after attending international wet-labs with Dr. Diego Gonzalez-Rivas, followed by a mini-fellowship in Shanghai Pulmonary Hospital, which is the largest pulmonary hospital in terms of volume with an average operating load of 40 major thoracic cases per day. Then we started performing the more straightforward cases via uniportal method (wedge resections, lung biopsies, pleurectomies, lymph node dissections, decortications). Lastly, we had an official live surgery uniportal VATS in our hospital with live cases to demonstrate the practicality and applicability of uniportal VATS.

Acknowledgements

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Footnote

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Uniportal video-assisted thoracic surgery course in Mexico—first experience

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Abstract: "The First Minimally Invasive Thoracic Surgery Uniportal Course" in Mexico was held from July 13th to 15th in Mexico City, at the National Institute of Respiratory Diseases (INER). Thoracic surgeons from around Mexico assisted the course. The special guests were the Spanish doctor Diego González-Rivas and the Brasilian doctor Joao Carlos das Neves-Pereira. The course included live surgery and wet lab. Demonstration of the uniportal video-assisted thoracic surgery (VATS) technique was done. The course was a success and Mexican thoracic surgeons were ready to adopt this technique.

Keywords: Video-assisted thoracic surgery (VATS); uniportal VATS; endobronchial hemangioma; uniportal right lower lobectomy

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In recent years, uniportal video-assisted thoracic surgery (VATS) has become widely accepted as the technique of choice for many thoracic surgeons around the world. The reasons are many, but the principal, in my opinion, is the direct view of the instruments and the surgical target. It seems that with uniportal we can get better results in terms of length of hospital stay, overall rate of complications, postoperative pain, paresthesia and duration of postoperative drainage, compared to multiportal VATS (1,2). Uniportal VATS allows to perform basic minimally invasive thoracic surgery and also complex resections (bronchial and arterial sleeve) (3,4). At this time, even the surgery could be performed with a non-intubated anesthesia approach (5).

"The First Minimally Invasive Thoracic Surgery Uniportal Course" in Mexico was held from July 13th to 15th in Mexico City, at the National Institute of Respiratory Diseases (INER). Thoracic surgeons from around Mexico assisted the event. The special guests were Spanish doctor Diego González-Rivas and Brasilian doctor Joao Carlos das Neves-Pereira. The course was coordinated by Dr. Erick Céspedes-Meneses from the General Hospital "October the 1st", Institute of Security and Social Services for State Workers (ISSSTE) and Dr. Enrique Guzmán-de Alba, from the INER.

The course was divided in three parts: (I) Masterclass in Uniportal Video-Assisted Thoracic Surgery (VATS), (II) Live Surgery; and (III) Wet-lab.

The course started with the presentation of the conference "fast track rehabilitation in Thoracic Surgery" by Dr. Joao Carlos das Neves-Pereira. After the conference, Mexican thoracic surgeons reported the experience teaching VATS at their Institutions. Experience in uniportal VATS was reported only by one institution: Dr. Erick Céspedes-Meneses at the General Hospital "October the 1st", ISSSTE in Mexico City. Then, Dr. Diego González-Rivas started the masterclass.

The masterclass is a superb opportunity to learn

Figure 1 Pulmonary hemangiomas, bronchoscopy and chest CT scan. (A) Bronchoscopic image of bronchial hemangiomas; (B) chest CT scan showing right lower lobe bronchial stenosis; (C) chest CT scan showing complete atelectasis of right lower lobe.

Figure 2 Dr. Diego González-Rivas performing uniportal video-assisted thoracic surgery (VATS) right lower lobectomy.

Figure 3 Right lower lobectomy was performed by uniportal video-assisted thoracic surgery (VATS) (6).
Available online: http://www.asvide.com/articles/1101

uniportal VATS as Diego explains all the pearls of this technique. The class includes uniportal technique from its beginnings to the most complex resections. Here, you can learn from the position of the incision, to the placement of the instruments through it. It is an interactive class, with no wrong questions, where all participants can discuss the technique and interrupt the speaker at any time.

The second day, we could observe live surgery performed by Dr. Diego González-Rivas.

Case

The case operated was a 31 years old Mexican man, with history of being a worker in the United States. Last year was admitted to a hospital in the United States with moderate hemoptysis and pleural effusion. He was treated with a chest tube and bronchoscopy. Diagnosis was made of intrabronchial capillary hemangioma.

In Mexico, by the time of admission, the patient was complaining of productive cough and hemoptysis. Bronchoscopy showed intrabronchial hemangiomas (*Figure 1A*). Chest CT scan showed bronchial stenosis and atelectasis of the right lower lobe (*Figure 1B,C*).

Surgical technique

Under general anesthesia and left selective bronchial intubation, the patient was positioned in the left lateral decubitus. A single 3 cm incision was made in the 5th intercostal space. The surgeon and assistant were located in the front of the patient (*Figure 2*). As usual in uniportal VATS, the camera was placed in the posterior part of the incision and the instruments were introduced below the camera. A 30º

Figure 4 Mexican thoracic surgeons, Dr. Diego González-Rivas and Dr. Joao Carlos das Neves-Pereira prior to start the wet-lab.

Figure 5 Wet lab. Dr. Diego González Rivas explaining the uniportal video-assisted thoracic surgery (VATS) technique.

high definition camera, endostaplers, and VATS instruments were used. Right lower lobectomy was performed (*Figure 3*). The lung was extracted in a glove. A single 19 Fr chest tube was introduced through the same incision and placed inferiorly at the end of the procedure.

The postoperative course was uneventful. Postoperative pain was minimal. Chest tube drainage was removed at 24 hrs and the patient was discharged home at 48 hrs.

The last day was held the wet lab at the National Institute of Medical Sciences and Nutrition in Mexico City (*Figure 4*). Thoracic surgeons could practice the uniportal VATS technique with Diego González-Rivas in an animal model (*Figure 5*). This was also very useful because they could experiment with uniportal VATS technique which was new to the vast majority of participants. In addition to Dr. Diego, four skilled Mexican thoracic surgeons, led the participants: Dr. Erick Céspedes-Meneses, Dr. Enrique Guzmánde-de Alba, Dr. Francisco Lorente-Ludlow and Dr. José Ruiz-Flores.

Results

At the end of the course, all participants showed their interest to start their practice in the technique of uniportal VATS. Because of with uniportal VATS we have a direct view of the objective to operate, it is easier to adopt than the technique of three or more ports. This direct view is the same as with open surgery.

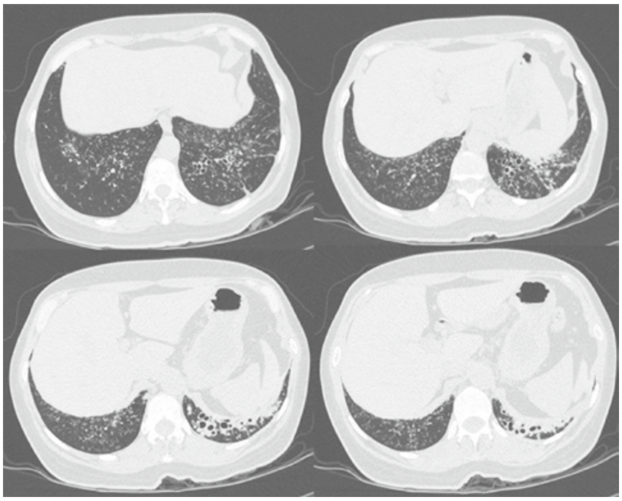

Figure 6 Chest CT scan showing bronchiectasis at left lower lobe.

Figure 7 First uniportal video-assisted thoracic surgery (VATS) lobectomy in Mexico (7).
Available online: http://www.asvide.com/articles/1102

Commentary

At this time, only one Mexican center is performing uniportal VATS major procedures (General Hospital “October the 1st”, ISSSTE). Dr. Erick Céspedes-Meneses had the opportunity to attend the International Uniportal VATS Training Program at the Shanghai Pulmonary Hospital in Shanghai, China last year. The experience is extremely rewarding and all thoracic surgeons are encouraged to attend at least once. Previously, Dr. Céspedes-Meneses was performing VATS by the biportal approach. From November 2015 to June 30th 2016, Dr. Céspedes-Meneses has performed 39 procedures, including the first uniportal lobectomy in Mexico on January 12 this year. The case was a 43 years old Mexican female with localized bronchiectasis at the left lower lobe (*Figure 6*). A left lower lobectomy was performed without complications. Postoperative course was uneventful and the patient was discharged home by postoperative day 4 (*Figure 7*).

The rest of the results are summarized on *Table 1*.

Conclusions

Uniportal VATS technique is very intuitive so, in my opinion, it will be the gold standard for minimally invasive thoracic surgery. Because of with uniportal VATS we have a direct view of the objective to operate, it is easier to adopt than the multiportal technique.

Acknowledgements

We would like to thank the companies that supported the

Table 1 Uniportal VATS procedures at General Hospital “October the 1st”, ISSSTE

Procedure	Cases	Conversion	Type of conversion
Decortication (empyema)	12	3	1 case: open procedure 2 cases: biportal procedure
Anatomic lung resections 8 lobectomies 2 segmentectomies: 1 lingulectomy, 1 right apical	10	3	2 lobectomy cases: open procedure (major bleeding); 1 lobectomy case: open procedure (aspiration)
Pulmonary wedge resections	9	0	
Pleural biopsy/pleurodesis	8	0	
Total	39	6	

ISSSTE, Institute of Security and Social Services for State Workers; VATS, video-assisted thoracic surgery.

event: Ethicon, Roche, Medicamex, Vanguardia Médica, B Braun and Fr Medical.

Footnote

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First non-intubated uniportal video-assisted pulmonary lobectomy in America

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Abstract: The first video-assisted thoracic lobectomy in non-intubated patient in America was performed on 27th of September 2014 in Bogotá Colombia, The National Cancer Institute in Bogotá received Dr. Diego González-Rivas to make possible this kind of procedure in a 53-year-old man, with a history of papillary thyroid cancer treated with surgery and Iodine therapy, in whom two pulmonary nodules were found in the monitoring tomography. We resected the nodule located at the right upper lobe previously marked by scintigraphy, the other one required a lobectomy because it was a deep nodule with malignant radiologic appearance inside of the middle lobe. The procedure discoursed in a non-intubated patient without technical difficulties or complications, very short recovery time, minimum pain and a quiet and usual postoperative evolution. This procedure, the first reported in America was replicated after others with similar results in several countries thanks to the collaboration between surgeons, anesthesiologists, radiologists, nurses and therapists, because especially in such interventions teamwork is essential. We believe that given the benefits in terms of recovery for the patient and anesthetic time, we could go on replicating the experience in selected patients.

Keywords: Uniportal video-assisted thoracic surgery (VATS); lobectomy; non-intubated thoracic surgery; single port; gamma probe-guided biopsy; awake surgery

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Introduction

The first video-assisted thoracic lobectomy in non-intubated patient in America was performed on 27th of September 2014 in Colombia, The National Cancer Institute in Bogotá received Dr. Diego González-Rivas visit to make it possible. In our country video-assisted thoracic surgery (VATS) surgery for lung resection has evolved so far in the last 16 years approximately, Initially using three or four ports, but in 2011 with the influence of Thomas D'Amico from Duke University (1) we were interested in switch to use just two ports, at that time the main cities around the country had successfully implemented the minimally invasive Thoracic surgery. With a unique training program, the transition from two ports to uniportal VATS was accelerated to the point that today thoracic surgeons trained in the past 2 years have taken on a daily basis this technique, some of them directly from open surgery (2). The way to single port was driven by the rapid educational work and publications around the world of Dr. Diego González-Rivas with a large number of procedures replicated in many countries with diverse health systems, populations and medical teams (3).

We present a case of uniportal VATS surgery in our institution with the cooperation of an anesthesiologist willing to do it, radiologists and nuclear physicians responsible for the radio guided location of the nodules (because its location seemed difficult by palpation), and

Figure 1 Right upper lobe nodule.

Figure 2 Middle lobe nodule.

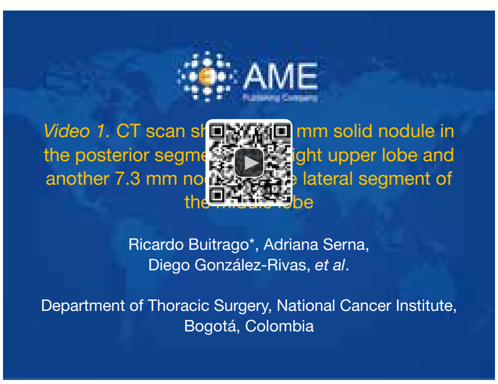

Figure 3 CT scan shows a 9.5 mm solid nodule in the posterior segment of the right upper lobe and another 7.3 mm nodule on the lateral segment of the middle lobe (6).
Available online: http://www.asvide.com/articles/1114

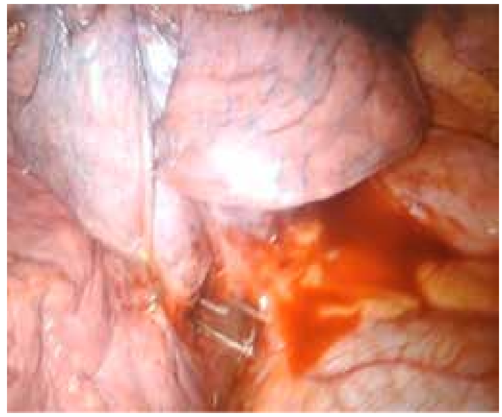

Figure 4 Pulmonary collapse made with iatrogenic pneumothorax.

surgeons in the company of Dr. González-Rivas. We describe the first lobectomy in non-intubated patient reported in America in a single port approach, with the same technical challenges than intubated patients but with less anesthetic time and a faster postoperative recovery (4,5).

Clinical case

This patient is a 53-year-old man, with a history of papillary thyroid carcinoma classic pattern and follicular variant, initially staged T3N1BM0; surgically treated with total thyroidectomy with central lymph node dissection and left radical modified neck dissection, besides iodine therapy. In this patient follow-up 5 months later the tomography shows a 9.5 mm solid nodule in the posterior segment of the right upper lobe and another one 7.3 mm on the lateral segment of the middle lobe (*Figures 1-3*).

Non-intubated uniportal VATS middle lobectomy and wedge resection in the upper lobe, guided by scintigraphy to improve the location of the lesion were performed (7).

There was no problem with the lung collapse in the absence of double-lumen tube for anesthesia, because pneumothorax generated with the chest incision is sufficient to operate comfortably (*Figure 4*).

Surgical procedure

The patient is positioned in left lateral decubitus; the anesthesiologist provides oxygen by facemask to the patient and introduces an intranasal multi-perforated catheter in order to increase the O_2 arterial pressure and to prevent upper airway obstruction (8,9). Intravenous anesthesia is administered and the surgeon makes a blockage in the fifth

Figure 5 The camera is located at the rear end of the incision, the remaining instruments are inserted below.

Figure 6 Wedge resection on the right upper lobe and middle lobectomy, with patient breathing spontaneously (10).
Available online: http://www.asvide.com/articles/1115

Figure 7 Actual X-ray.

intercostal space with Bupivacaine.

A single incision in the 5th intercostal space was made, in few seconds pneumothorax occurs and then a 30 degree lens is inserted into the posterior end of the wound, below the thoracoscope we introduce the instruments for dissection and the staplers corresponding to each step of the procedure (*Figure 5*). Meanwhile the patient is breathing spontaneously without pain and the surgeon accompanies the subtle movements of the diaphragm.

In this case we performed at first the wedge resection of the upper lobe, verifying that the nodule is in the resected tissue by using the gamma probe which marked 1,500 accounts. After this step, we took the decision to make middle lobectomy because of the profound location of the second nodule and its radiological suspicion of malignancy.

With ultrasonic scalpel we dissected the middle lobe vein which is after divided with stapler, very calcified lymph nodes were resected enabling the corresponding artery dissection to be further divided with stapler too, the same procedure was made with the middle lobe bronchus; finally we completed de division of the cisure.

The lobe resected is extracted in a protective bag and at the end a chest tube is inserted and fixed in the posterior end of the incision (*Figure 6*).

Results

Even though the patient was overweight with slightly elevated diaphragm, we could make a safe procedure without bleeding or other intraoperative complications and also comfortable for the surgeon. From the viewpoint of anesthesia the patient went after surgery to a recovery unit, ten minutes later he was talking with us, in minimum pain; and from there he went to a room in our department ward, without intensive care unit necessity.

His radiological evolution went as usual and he was discharged on the third postoperative day after the chest tube removal. Chest X-ray and CT scan today show no new lesions (*Figure 7*).

Conclusions

Uniportal VATS is a surgical approach that we have adopted in our institution whenever is possible, and therefore we are open to the possibility of new developments in the art, that's why it has been of great academic and practical interest to have made a middle lobectomy to a patient without endotracheal intubation, taught by the pioneer of the art and under strict security conditions in anesthesia.

This procedure the first reported in America, was replicated from others with similar results in several countries even in children (11); thanks to the collaboration between surgeons, anesthesiologists, radiologists, nurses and therapists and could be feasible in the future for our fragile oncologic population, with the advantage of the multidisciplinary approach that we can provide in our institution.

We believe that given the benefits in terms of spontaneous ventilation, fast recovery for the patient and the less anesthetic time, we could go on replicating the experience in selected patients.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Single port training in Latin-America—first uniportal video-assisted thoracoscopic surgery masterclass in Santiago, Chile

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Abstract: Video-assisted thoracoscopic surgery (VATS) surgery has become the standard technique in Thoracic Surgery since its introduction 20 years ago. Single port VATS appeared as the next step in its evolution, with rapid development since the first uniportal video-assisted thoracoscopic surgery lobectomy (VATS lobectomy) by Dr. Diego Gonzalez-Rivas. During the last 5 years, the approach has been simplified, standardized and taught in many countries, courses, live surgery and dedicated programs, with reproducible results. Hands-on courses represent the best way to learn a new surgical technique, as it shortens learning curves and decreases complications. We present the first training course in single port VATS in our country, which became the first hands course in Thoracic Surgery in Chile.

Keywords: Video-assisted thoracoscopic surgery lobectomy (VATS lobectomy); uniportal VATS; VATS training; VATS animal model

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Introduction

Since the first descriptions of video-assisted thoracoscopic surgery lobectomy (VATS lobectomy) in the early nineties, a rapid widespread of the technique occurred over the past two decades. Its clear advantages over open surgery, including among others, reduced post-operative pain, lower complication rates, lower LOS and faster recovery, made video-assisted thoracoscopic surgery (VATS) become the standard approach in the majority of thoracic surgical procedures (1).

Two ports VATS technique and single port approach appeared as the next step in reducing tissue trauma and pain (1,2).

Dr. Gaetano Rocco made the first descriptions of single port VATS surgery for wedge resections and pneumothorax (3,4), performed the first awake single port VATS for pneumothorax (5), and described the advantageous spatial features of uniportal VATS (6).

Dr. Diego Gonzalez-Rivas refined the technique and described the first single port VATS lobectomy in 2010 (7), rapidly expanded the indications of the single port VATS to more complex procedures (8,9), and used the awake technique for single port VATS lobectomy (10).

Since its first description, the single port approach has been safely used in almost every possible scenario and has proven to be comparable to multi-port VATS in expert hands (11). Its advantages related to traditional VATS are yet to be proven, but appear to be the expected ones due to lesser surgical trauma: less post-operative pain, and lower LOS, with similar oncologic outcomes compared with traditional VATS, and open surgery (12).

A remaining issue with single port VATS was the teaching and reproducibility of the technique. Dr. Gonzalez-Rivas has dictated many courses around the world and created a Single Port VATS Program in Spain and China for this purpose. The technique has been learned by surgeons around the globe, who have started single port VATS programs in different countries with similar results (13,14).

First uniportal masterclass in Chile

The President of the Department of Thoracic Surgery of ALAT (Thoracic Latin-American Society), Dr. Sara

Figure 1 Hands-on session.

Figure 2 Wet-lab.

Salvatierra proposed a Pre-Congress Single Port VATS Course, under the 10th Congress of ALAT to be hosted in 2016 in Santiago, Chile.

Along with the participation of Dr. Diego Gonzalez-Rivas, renowned Latin-American surgeons would participate. As hosts of the Congress, we enthusiastically agreed to coordinate the Course. These were days of intense preparation for the Pre-Congress Course, which would become the first practical theoretical course of Thoracic Surgery held in our country, and the first uniport masterclass in Chile.

ALAT Congress Single Port VATS Course "Curso pre Congreso de ALAT: lobectomía VATS Unipuerto" was held on July 6, 2016, at the Clinical Simulation Center of the Catholic University of Chile. It consisted of morning theoretical activities, practice in a perfused lung model and finally single port VATS practice in a swine model. A review of the course can also be found on the ALAT website (www.alatorax.org/cirugia-toracica/boletin-noticias-cirugia-toracica/resena-del-curso-pre-congreso-lobectomia-vats-unipuerto).

Dr. Diego Gonzalez-Rivas was the main guest speaker. Leading Latin-American surgeons with extensive experience in minimally invasive thoracic surgery and single port VATS also participated as speakers and instructors: Drs. David Smith from Argentina, Ricardo Terra and Fernando Vanucci from Brazil, and Cristián González from Chile.

During the morning theoretical lectures, the evolution of VATS to the single port approach, the requirements of the technique, its use in different surgeries, and the management of intraoperative complications were presented.

A detailed description of technical aspects of single port VATS, OR distribution, instruments, and required equipment was made by Dr. Smith. Single port VATS use in sublobar resections was presented by Dr. Vanucci, while single port lymphadenectomy was presented by Dr. Terra.

Finally, Dr. Gonzalez-Rivas shared with us his extensive experience in single port lobectomy, pneumonectomy, and management of complications, with detail in technical aspects, critical points, and resolution of challenges and complications.

During the afternoon we had the hands-on course, starting on a dry-lab with a perfused pig heart-lung *ex vivo* model, allowing greater surgical practice during the course. The model was designed by investigators of the Clinical Simulation Center of the Catholic University of Chile, and was evaluated as a good experimental model for VATS and single port surgery. The characteristics of this model are described in another issue of the Journal.

The final and most important part of the course was the hands-on session in the wet-lab, using a standard vivo swine model (15). Anesthesia and monitoring of the animals were carried out by Veterinary Doctors of the Simulation Center throughout all the procedures. After the preparation of the animals according to the protocol of care and use of animals for investigation of the Clinical Simulation Center, complying with international standard (16), swine were anaesthetized, and a tracheostomy was performed for single lumen intubation. The animals were placed in lateral decubitus and the skin prepared.

Participants were divided in groups and had the opportunity to perform right and left single port lobectomies under direct supervision of the instructors. All aspects of the single port approach discussed during the morning session were addressed at this stage.

The assistants had the opportunity to use dedicated instruments for single port VATS, different staplers, energy devices, and sealing materials. Instructors helped with their experience allowing a wide practice by all the attendees (*Figures 1,2*).

Dr. Gonzalez-Rivas rotated with all groups, showing tips and details of the technique, and answering the most

Figure 3 Dr. Gonzalez-Rivas during the hands-on session.

Figure 4 Participants of the course.

Figure 5 Drs. Jose M. Clavero and Diego Gonzalez-Rivas during the uniportal video-assisted thoracoscopic surgery (VATS) masterclass in Santiago, Chile.

frequent questions regarding the single port approach (*Figure 3*).

Like any first course, there were some shortcomings and mistakes that can be improved, but it was an overall very helpful course. We had excellent evaluations from all attendees, Latin-American surgeons, as well as lecturers and instructors. This first uniport masterclass fulfilled all the expectations of the participants. In their evaluation they were enthusiastic in starting using this technique in their practice (*Figure 4*).

Final reflections

After all the rush of the course, the ALAT meeting and a Single Port Surgery with Drs. Cristián Gonzalez and Diego Gonzales-Rivas, I have to say that this was an eye opening experience.

I must confess that despite performing the vast majority of my cases by VATS, and having taught minimally invasive thoracic surgery to my residents for more than 10 years, I long considered the single port approach as a difficult technique, hard to learn and difficult to reproduce.

I changed my point of view after this course. Dr. Gonzalez-Rivas has managed to standardize the technique. It is possible to learn how to do a standard case and how to overcome the difficulties of more complicate ones. With the normal learning curve of any surgical technique, this approach can be adopted for a wide variety of thoracic pathologies by trained thoracic surgeons.

I would like to emphasize the importance of this first hands-on course in Chile. In a time with increasing administrative restrictions and legal limitations, simulating models and wet-lab courses have helped to shorten learning curves and decrease complication rates in surgical procedures. This type of training constitutes the best way to learn a new surgical technique, like uniportal VATS. I would like to thank Drs. Salvatierra, Smith, Terra, Vanucci and González for their generous participation in the course, and of course my most sincere reconnaissance to Dr. Diego Gonzalez-Rivas for his incessant willingness to share his experience around the globe (*Figure 5*).

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Footnote

Conflicts of Interest: JM Clavero has been Speaker in courses sponsored by Ethicon since 2015.

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The adoption of uniportal approach in Chile: the experience of a single surgical team from Valparaíso, Chile

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Abstract: Uniportal VATS lobectomy in Chile began in 2013, in an old and small provincial hospital in Valparaíso, the main port of Chile, a few months after two thoracic surgeons had a short stay in Hospital La Coruña with the inventor of the most revolutionary technique in thoracic surgery of the last time. Four years after the first visit of Dr. González Rivas to Chile to sharing his initial experience, and after the explosive development of this technique especially in Asia, ALAT organization invited him again to our country as a main speaker in its International Congress, focused largely in uniportal lobectomy. As expected, these thoracic surgeons could operate with their teacher, and make true the dream of any thoracic surgeon who began with a new kind of surgery: perform it in their hospital with its inventor and also their friend.

Keywords: Uniportal VATS lobectomy; Chile; Valparaíso

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Introduction

As in the vast majority of surgical centers around the world since Dr. Gonzalez Rivas published his first experience in uniportal VATS lobectomy in 2011 (1), in Chile began an increasing interest among the different surgical groups to adopt this novel and promissory technique. In those days there were few communications of VATS lobectomy in our country, even with the three or four ports approach. The first report of VATS lobectomy in Chile was performed by Rodríguez and his group in Santiago, in 2012, with the classic multiport VATS approach (2), and that same year Velásquez from Colombia was publishing his experience in VATS lobectomy, using the new uniportal approach, but included only two cases of cancer (3), which was indeed a step forward of the Caribbean surgery compared with our experience in the south cone of America.

Our hospital is located at the shore of Chile, in the main port of our country, Valparaíso (*Figure 1*). This city has a population over 300,000 people, and our hospital is one of the oldest but still in service mayor public health center in Chile. It was born as a small TBC sanatorium with 200 beds in the middles of 1940, and now is advocated mainly to thoracic surgery and internal medicine. Nevertheless despite our vast historical background in the old classic (and extinct) anti TBC surgery performed during the previous century, we had not made the transition yet to the modern thoracic video surgery except for some minor resections and pleural procedures, and even much less through uniportal approach. We had made some advances with minimally invasive technique using three or four ports, but the uniportal VATS lobectomy seemed to be too struggled and operator dependent to us. Other thoracic units in Chile were performing their firsts VATS lobectomies in 2012, but all of them using three or four ports, and all of them in private centers in the capitol city, Santiago, with over 7 million people. There was not any public institution performing VATS lobectomies in Chile in 2012.

We were one of the most enthusiastic assistants enrolled in the symposium organized by the Thoracic Surgery Unit from Clínica Alemana in Santiago Chile, in October 2012, which was focused in minimally invasive thoracic approach including uniportal VATS and robotic surgery, which was indeed the first visit to Chile of Dr. González Rivas (*Figure 2*). We dreamed immediately that we could get the

Figure 1 Valparaíso, Chile.

Figure 2 From right to left, Dr. González Rivas, Dr. Raul Berrios (Chile), Dr. Ricardo sales do Santos (Brazil) and Dr. Raimundo Santolaya (Chile) in Clínica Alemana, Santiago Chile, October 2012.

Figure 3 From right to left, Dr. González Collao (author), Dr. González Rivas, and Dr. Jorge Avila (Chile), in Hospital La Coruña, April 2013.

Figure 4 Dr. González Rivas and the author in O.R, in Coruña, April 2013.

less invasive technique for our patients in the public health system, and that we didn't need to give the steps of four to three to two ports previous to single port approach adoption.

Soon after we met Dr. González Rivas in his brief stay in Chile, I dared to mail him with the purpose to better know the technique, and learn all the possible aspects that could help me to apply the same procedure in my old hospital. I have never expected that Dr. González Rivas answered me that very same day inviting us to me and my colleague Dr. Jorge Avila to visit him in La Coruña. There were ten intense days since the beginning (*Figures 3*,*4*), and it was enough to make us completely fall in love with the uniportal approach. We came back to Chile with great hope and the best experience with a tremendous human group from La Coruña Thoracic Surgery Unit. We felt like at home with them, and we still remember those days like the more pleasant learning opportunity in our careers.

The technique was quickly adopted by us in a short

Figure 5 Dr. Gaetano Rocco and Dr. González Collao in La Coruña, February 2014.

Figure 6 A 22 years old girl with CCAMF, first Uniportal Pneumonectomy.

Figure 7 Uniportal pneumonectomy in congenital cystic adenomatoid malformation (4).
Available online: http://www.asvide.com/articles/1118

time period, maybe due to our efforts to recover the lost time in minimally invasive mayor resections, so we began with uniportal approach for lung biopsies, pneumothorax, metastasectomies, thoracic duct ligation, and other minor procedures, until that 5 months later, in September 2013, we could perform our first uniportal VATS lobectomy, in a 70 years old patient with an adenocarcinoma, which was also the first lobectomy in Chile with this approach. We could soon persuade different private institutions in the city to acquire the specially designed instrumental for uniportal surgery, and polymer hemostatic clips, and we could also use a wide variety of energy devices and staplers, so we could rapidly begin to perform this surgery also in the clinics of the region. But nevertheless, mainly due to economic aspects we don't have yet Scanlan instruments in our public institution, so we still perform uniportal vats lobectomies in the hospital with classic instrumental of open surgery, which has no prevented us from accumulating the bigger experience in Chile with uniportal approach.

Next year, in February 2014, we decided to schedule to the International Symposium in uniportal VATS-Wet-lab and Live Surgery in La Coruña, and we could enjoy again with our friends, while we were getting a more formal instruction in uniportal focus, despite our initial and successful experience after our first internship. In that occasion we could meet and share great moments with others renowned professors like Dr. Gaetano Rocco, Dr. Alan Sihoe, and Dr. Anthony D'amico, among others, and we started to feel that we belong to a new kind of surgeons, inheritors of this treasure (*Figure 5*).

In March 2014, just a few weeks after the symposium, we were able to perform the first uniportal pneumonectomy in Chile, in a 22 years old girl with a congenital cystic adenomatoid malformation, and functional exclusion of the right lung. Her length of stay was only 3 days (*Figures 6,7*).

Since September 2013 our team is the only one who perform regular uniportal VATS lobectomies in Chile; nevertheless exists an increasing interest to adopt this approach among chilean thoracic surgeons, especially the new generations, and even some of them has made rotations in La Coruña like us, and others has participated in symposia, and wet-labs in Europe.

Since our first achievements in uniportal lobectomies we had established an reciprocal communication channel with our mentor, Dr. González Rivas, so each time we performed some interesting advance and achievement, like our first lobectomy post neoadjuvant therapy, or our first thymectomy, we received his congratulations and warm encouraging words.

From September 2013 we had performed 78 lobectomies, 2 pneunectomies, 5 bilobectomies, 2 non-intubated metastasectomies, and others mayor and minor procedures using exclusively uniportal approach, including the practice in our public institution and private clinics in this area in

Figure 8 “Hammock” stitches with 2.0 silk in the upper edge of the uniportal incision.

Figure 9 Dr. Diego González Rivas, Dr. Jorge Avila, Dr. José Clavero and Dr. González Collao in Valparaíso, July 2016.

Chile. We are always ready to stimulate others thoracic units in our country to adopt this approach, and we are often invited to share our experience with our colleagues since then. We did not change any aspect from the original technique, but we regularly use the soft tissue expander and we added a “hammock” stitch for the camera in the upper edge of the incision for comfort and avoid fatigue. We use a 2.0 silk in a U shape stitch for this purpose (*Figure 8*).

I felt very honored when ALAT organization and Dr. José Clavero from Chile invited me to participate in the First Uniportal Master Class in our country, in July 2016, a pre-congress course in Santiago. It was the opportunity to share experiences again with Dr. González Rivas and invite him to our old hospital in Valparaíso, distant 120 km from Santiago. We performed a middle lobectomy in a 64 years old woman, with Dr. José Clavero as third surgeon (*Figure 9*).

My final thoughts are full of gratitude to all the people involved in this incredible journey: to Dr. González Rivas and his group in first place because of his constant efforts to share his knowledge and experience through publications, videos, symposium, wet-labs and different courses around the globe; to my partners in Valparaíso Hospital, specially my colleague Dr. Jorge Avila, who has become my mainstay in each surgery with his enthusiasm and desire to learn. And finally to all those patients who trusted us and put their life in our hands.

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Footnote

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Prof. Diego Gonzalez-Rivas & Prof. Alan Sihoe: what do we need to think about uniportal video-assisted thoracoscopic surgery?

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Uniportal video-assisted thoracic surgery (VATS) is being more and more popular as a procedure of thoracic surgery. On March 16–18, 2016, the 3rd international uniportal VATS course—Live Surgery & Wetlab was held in Berlin.

It was a 3-day-masterclass symposium jointly organized by the University Hospital Charité in Berlin, Germany, the University Hospital in Coruña, Spain and the Shanghai Pulmonary Hospital, Tongji University Shanghai, China.

This symposium addressed the technique and advances of uniportal VATS by lectures, discussions and video sessions on the first day and Live Surgery and Live Broadcasting from Shanghai Pulmonary Hospital of major pulmonary resections via uniportal VATS on day 2. The third day of this symposium is a Hands-on class (Wetlab) (*Figure 1*).

During the course, we are honored to interview Dr. Diego Gonzalez-Rivas & Dr. Alan Sihoe, who shared about their reflection on uniportal VATS.

Like any other walks of life, in the thoracic surgeons' community, blossoms of friendship were witnessed for their commonly shared passion and outlook. Diego and Alan are such very good friends to each other well known in the thoracic surgery arena. They banteringly called themselves as "uniportal guy" as pioneer and successor of uniportal technique in thoracic surgery. Based on their communication and experience in Europe and China even Asia, Diego and Alan can take a look at the development of uniportal VATS in these two continents.

Interview questions (*Figure 2*)

- What do you love about uniportal VATS surgery?
- How popular is uniportal VATS in Europe and Asia?
- When did you first perform uniportal VATS?
- Is experience with conventional VATS needed before performing uniportal VATS?
- What is the challenge in promoting uniportal VATS further?
- What do you think is the future development of uniportal VATS? What about uniportal non-intubated surgery?
- What would be your suggestions for the young thoracic surgeons?

Introduction of the experts

Dr. Diego Gonzalez-Rivas is a graduate of Santiago de Compostela University and the College of Physicians & Surgeons of Coruña University (MD) (*Figure 3*). He received training in General Surgery, Thoracic Surgery, and lung transplantation at Coruña University Hospital. After completing a year working in Santiago University Hospital joined the faculty at Coruña Hospital and is currently Thoracic Surgeon in Coruña University center and an active member of lung transplantation program (40 cases per year). He is the creator of Minimally Invasive Thoracic Surgery Unit (UCTMI) working at Quiron Hospital, San Rafael and Modelo medical center. Actually he works in these four medical hospitals at Coruña city and in Shanghai Pulmonary hospital, in Shanghai, China. He is the director of the uniportal VATS training program at Shanghai Pulmonary Hospital (biggest thoracic center in the world).

Dr. Gonzalez Rivas serves on several editorial boards. He is the Associate Editor of *Journal of Visualized Surgery* (*JOVS*) and is reviewer of many scientific journals. He is the organizer of the annual meeting of Spanish Society of Thoracic Surgery (SECT) from 2014–2017. He also collaborates with educational activities of European Society of Thoracic Surgeons (ESTS) and International Society of Minimally Invasive Cardiothoracic Surgery (ISMICS). He is a board European certificated surgeon since 2010 (FECTS). He started to perform VATS lobectomies in 2007 after learning the technique at Cedars Sinai. After 100 major resections performed he visited Duke medical center to learn the double port technique with Dr. Thomas D'Amico. Once experience was gained with this technique he evolved to single-port approach.

He was pioneer surgeon in the world performing uniportal VATS lobectomies (first case in June 2010) and

Figure 1 Dr. Gonzalez-Rivas & Dr. Sihoe were signing on their book "*Uniportal Video-Assisted Thoracic Surgery*" for the best trainee in the course. For more information about the book, please go to: http://www.amazon.com/dp/9881402735

Figure 2 Prof. Diego Gonzalez-Rivas & Prof. Alan Sihoe: what do we need to think about uniportal video-assisted thoracoscopic surgery (1)? Available online: http://www.asvide.com/articles/1046

Figure 3 Snapshot of Dr. Diego Gonzalez-Rivas, Department of Thoracic Surgery, Coruña University Hospital, Coruña, Spain.

Figure 4 Snapshot of Dr. Alan Sihoe, Department of Surgery, The University of Hong Kong, Queen Mary Hospital, Hong Kong, China.

non-intubated uniportal major pulmonary resections (first case in April 2014). He has published several papers describing these procedures and the results in the most important medical journals and textbooks of thoracic surgery. More information about the technique in www.videothoracoscopy.com.

Dr. Alan Sihoe is currently a Clinical Associate Professor of the Departments of Surgery at the University of Hong Kong, and the Chief of Thoracic Surgery at the University of Hong Kong Shenzhen Hospital in Shenzhen, China (*Figure 4*). He is also an Honorary Consultant in Cardiothoracic Surgery at the Queen Mary Hospital in Hong Kong.

Dr. Sihoe received his medical training at the University of Cambridge in the United Kingdom, where he was awarded multiple prizes and where he received an Honors degree and a Master's degree for research in Pathology. After working in Scotland and England, he completed his training in Cardiothoracic Surgery in Hong Kong under the mentorship of Prof. Anthony Yim.

Dr. Sihoe is a recognized expert and advocate of 'next generation' minimally invasive thoracic surgery techniques—especially uniportal and needlescopic chest surgery. He is a frequent Invited Lecturer and Faculty member at conferences and surgical education events throughout Asia, Europe and North America, sharing his experiences in these advanced thoracic surgical techniques. His many research interests include pain reduction and air leak management strategies following pulmonary operations. Dr. Sihoe has published extensively, and has won or been short-listed for multiple awards in thoracic surgery and clinical research.

Dr. Sihoe is the co-Editor-in-Chief of *JOVS*, an Associate Editor of the *Interactive Cardiovascular and Thoracic Surgery* journal, and an Editorial Board member of multiple international journals in Surgery and Respiratory Medicine. He is the only Asian member of the Scientific Program Committee of the ESTS, and the Asia Team Captain for the ESTS Postgraduate Course. He is also a Committee Member of the Asian Thoracoscopic Surgery Education Program and of the Society for Minimally Invasive Thoracic Surgery. He is an examiner for the College of Surgeons of Hong Kong, a member of the Institutional Review Board of the University of Hong Kong, and a former member of the Cardiothoracic Surgery Board of Hong Kong.

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Footnote

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(Science Editor: Grace S. Li, JOVS, jovs@amegroups.com)

Meet the Professor

Dr. Diego Gonzalez-Rivas: uniportal video-assisted thoracic surgery has become increasingly important

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The 1st International Course on Tubeless and Advanced VATS Lobectomy Techniques was held successfully in the First Affiliated Hospital of Guangzhou Medical University from December 7–11, 2015. The course was chaired by Dr. Jianxing He from First Affiliated Hospital of Guangzhou Medical University, China and Dr. Diego Gonzalez-Rivas (*Figure 1*) from Coruña University Hospital, Spain. One hundred international experts from 16 different countries were invited to train the tubeless VATS lobectomy techniques. At the first day the course, I was honored to have an interview with Dr. Diego Gonzalez-Rivas after his speech on "Non-intubated VATS lobectomy surgery: CORUÑA experience".

Figure 1 Dr. Diego Gonzalez-Rivas.

In the interview, Dr. Gonzalez-Rivas briefly introduced the advances of VATS lobectomy over the past 8 years. He performed the first uniportal VATS lobectomy in June 2010 and performed the first non-intubated uniportal VATS lobectomy in the world in April 2014. Uniportal VATS for major resections has become a revolution in the treatment of lung pathologies since 2010, because the outcome of uniportal approach is good and it pushes the boundaries on the minimal thoracic invasive surgery.

When talked about the future development of uniportal VATS lobectomies, Dr. Gonzalez-Rivas expected that further development of new technologies like sealing devices for all vessels and fissure, robotic arms that open inside the thorax, and wireless cameras, which will probably allow the uniportal approach to become the standard surgical procedure for major pulmonary resections in most thoracic departments.

For more detail of this interview, readers can refer to the following video (*Figure 2*).

Figure 2 Dr. Diego Gonzalez-Rivas: uniportal VATS has become increasingly important (1).
Available online: http://www.asvide.com/articles/1014

Introduction

Dr. Diego Gonzalez-Rivas is a graduate of Santiago de Compostela University and the College of Physicians & Surgeons of Coruña University (MD). He received training in General Surgery, Thoracic Surgery, and lung transplantation at Coruña University Hospital. After completing a year working in Santiago University Hospital joined the faculty at Coruña Hospital and is currently Thoracic Surgeon in Coruña University center an active member of lung transplantation program (40–45 cases per year). He is the creator of Minimally Invasive Thoracic Surgery Unit (UCTMI) working at Quiron Hospital, San Rafael and Modelo medical center. Actually he works in these four medical hospitals at Coruña city and in Shanghai

Pulmonary hospital, Shanghai, China. He is the director of the uniportal VATS training program at Shanghai Pulmonary Hospital (biggest thoracic center in the world).

Dr. Gonzalez-Rivas serves on several editorial boards and is reviewer of many scientific journals. He is the Associate Editor of *Journal of Visualized Surgery* (*JOVS*), initiating the featured column "Teaching Uniportal VATS worldwide". He is also the Editor of the book *Uniportal Video-Assisted Thoracic Surgery and Video-Assisted Thoracic Surgery* and Associate Editor of Tubeless Video-Assisted Thoracic Surgery.

He is the organizer of the annual meeting of Spanish Society Of Thoracic Surgery (SECT) from 2014–2017. He also collaborates with Educational Activities of European Society of thoracic surgeons (ESTS), International Society of Minimally Invasive Cardiothoracic Surgery (ISMICS) and European Association of Cardiothoracic Surgery (EACTS). He was recently elected member of the American Association of Thoracic Surgery (AATS) He is a board European certificated surgeon since 2010 (FECTS). He started to perform VATS lobectomies in 2007 after learning the technique at Cedars Sinai. After 100 major resections performed he visited Duke medical center to learn the double port technique with Dr. Thomas D'Amico. Once experience was gained with this technique he evolved to single-port approach.

He was pioneer surgeon in the world performing uniportal VATS lobectomies (first case in June 2010) and non-intubated uniportal major pulmonary resections (first case in April 2014). He has published several papers describing these procedures and the results in the most important medical journals and textbooks of thoracic surgery.

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Footnote

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Uniportal VATS live surgery around the world

Editorial Office

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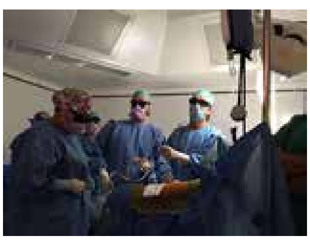
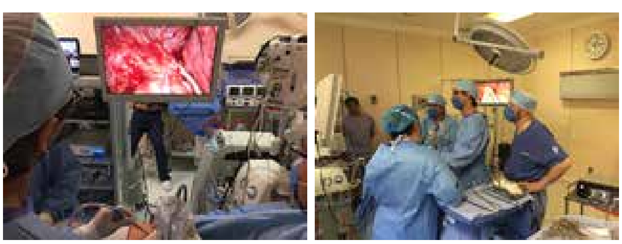
Prof. Diego Gonzalez-Rivas is launching a uniportal 'transformation' worldwide. So far, he has been invited to a huge number of countries and cities for live surgery demonstration, bringing the technique to a fast increasing number of thoracic surgeons. Dr. Gonzalez Rivas is probably the surgeon in the history of surgery, not just thoracic surgery, who has operated patients in more number of hospitals and countries around the world. With its wider application, uniportal VATS will benefit more and more patients. This effort of constant travelling, performing masterclasses and live surgery onsite, from the east to the west of the world, represents a new revolutionary way of learning. Teaching and sharing experiences in every country allows the increase and quicker worldwide adoption of the technique during the last years.

22 July 2016, Lisbon, Portugal



Live surgery from Santa Maria Hospital, Lisbon, Portugal (Non-intubated Uniportal VATS right upper lobectomy and left lower lobectomy).

13–15 July 2016, Mexico City, Mexico

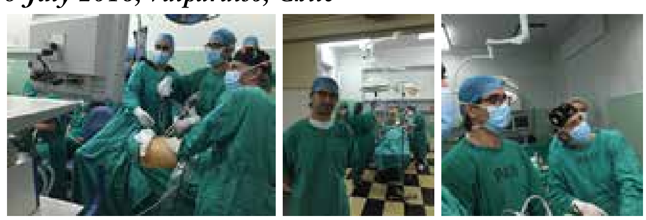


Live surgery from Mexico: Uniportal VATS right lower lobectomy
National Institute of Respiratory Diseases (INER), Mexico City, Mexico

11–12 July 2016, Sao Paolo, Brazil

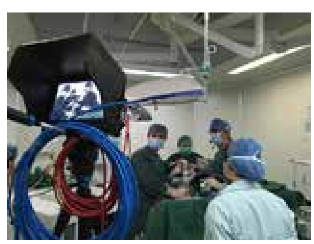
Live surgery from Sao Paolo (2 Uniportal VATS lobectomies)
Hospital Alemao Oswaldo Cruz, Sao Paolo, Brazil.

8 July 2016, Valparaiso, Chile



Surgery from Valparaiso, Chile: Uniportal VATS middle lobectomy
Doctor Eduardo Pereira Hospital, Valparaiso, Chile.

25 June 2016, Taizhou, China



Live surgery from Taizhou: Uniportal VATS anatomic

segmentectomy
Enze Medical Center, Taizhou, China.

19 June 2016, Huai'an, China

Live surgery from Huai'an: Uniportal VATS lobectomy for aspergilloma and Uniportal left upper for lung cancer
Huai'an First Peoples Hospital, Huai'an, China.

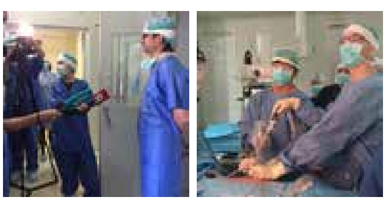
18 June 2016, Hefei, China

Live surgery from Anhui Chest Hospital, Hefei (China): 3 complex Uniportal VATS major resections

15 June 2016, Shanghai, China

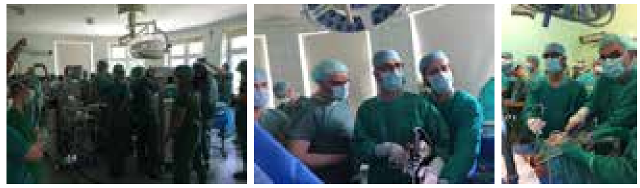
Live surgery from Shanghai to 16th ISMICS annual meeting (Montreal): Uniportal VATS right upper lobectomy
Shanghai Pulmonary Hospital, Tongji University, China.

9 June 2016, St Petersburg, Russia



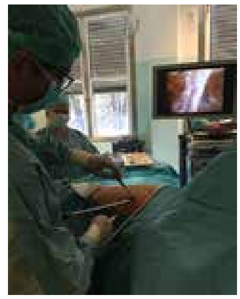
Live surgery from St Petersburg: complex Uniportal VATS anatomic segmentectomy S1+S2 for tuberculosis disease
Institute of Ptysiopulmonology in St Petersburg, Russia.

6–7 June 2016, Zakopane, Poland



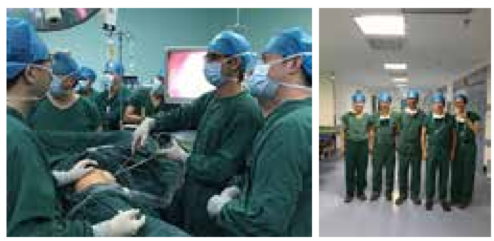
Live surgery from Poland: Uniportal VATS transcervical lobectomy and non-intubated Uniportal VATS lobectomy
Pulmonary Hospital, Zakopane, Poland.

8–9 May 2016, Oslo, Norway (1)



Live surgery from Oslo-first Uniportal VATS lobectomy in Norway (right upper and left lower lobe)
Oslo Universitetssykehus Hospital, Oslo, Norway.

28 April 2016, Zhoushan, China

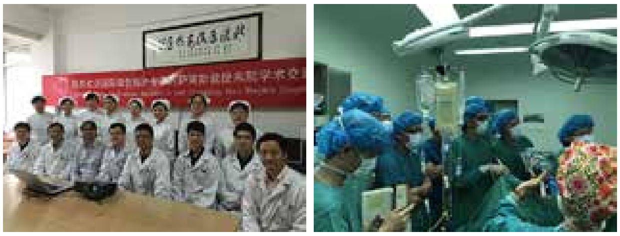


Live surgery from Zhoushan (Uniportal anatomic segmentectomy S8)
Zhoushan Hospital, Zhejiang, China.

24 April 2016, Weihai, China

Live surgery from Weihai (3 Uniportal VATS major resections and 1 Uniportal LUL sleeve procedure)
Weihai Hospital, Shandong, China.

23 April 2016, Changzhou, China



Live surgery from Changzhou (Uniportal right upper lobectomy)
Changzhou No.2 People's Hospital, Jiangsu, China.

10 April 2016, Taipei, Taiwan

Live surgery from Taipei: non-intubated Uniportal VATS anatomic segmentectomy
National Taiwan University Hospital, during the 4th Asian Single Port VATS Symposium, Taipei, Taiwan

7 April 2016, Split, Croatia

Live surgery from Split: Uniportal VATS right upper lobectomy
University Hospital of Split, Croatia.

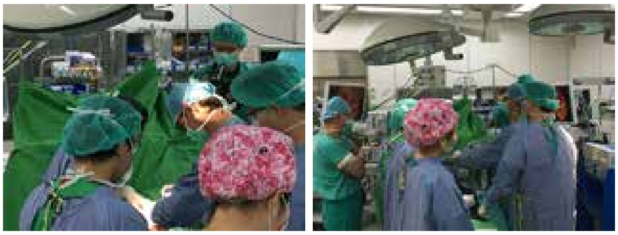
22–24 March 2016, Haifa, Beer Sheva and Jerusalem, Israel

Live surgery from ISRAEL Rambam Hospital, Haifa (22h March), (RUL and LUL), Soroka Medical Center, Beer Sheva (23rd March) (LLL and ML) and Shaare Zedek Medical Center, Jerusalem (24th March 2016) (segmentectomy S1 and Bilobectomy)

17 March 2016, Berlin, Germany

Live surgery from Charité hospital during the 3rd International Uniportal VATS Course and wetlab: from basics to advanced surgery
Charité University Hospital, Berlin, Germany

14 March 2016, Taipei, Taiwan



Live surgery from Triservice General Hospital (2 Uniportal lobectomies), Taipei, Taiwan

29th February 2016. Lisbon, Portugal

Live surgery from Lisbon (Non-intubated VATS left upper lobectomy).
Hospital Santa Maria, Lisbon, Portugal.

25 February 2016, Assiut, Egypt (2)

Live surgery from Egypt during the 1st Uniportal VATS course (First Uniportal VATS major resection in the country)
Assiut Heart University Hospital, Assiut, Egypt.

22 February 2016, Amman, Jordan (3)

First Uniportal VATS lobectomy in Jordan
Istishari Medical Hospital, Amman, Jordan.

21 February 2016, Riyadh, Saudi Arabia

Live surgery from Riyadh (Uniportal VATS right upper lobectomy)
King Khaled Medical Hospital, Riyadh, Saudi Arabia.

9–10 February 2016, La Habana, Cuba

Live surgery from La Habana during the first Uniportal VATS meeting in Cuba
Center of Medical and Surgical Investigations (CIMEQ), La Habana, Cuba.

4–5 February 2016, Amsterdam, Holland

Live surgery from Amsterdam during the 1st Uniportal VATS course in Holland (first non-intubated Uniportal VATS lobectomy in the country)
St Jansdal Hospital Harderwijk, Amsterdam, Holland.

15 January 2016, Nanjing, China

Live surgery from Nanjing Chest Hospital: Uniportal VATS left upper lobectomy, Nanjing, Jiangsu, China.

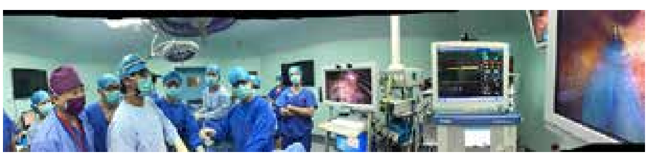
10 January 2016, Taizhou, China

Live surgery from Taizhou City Hospital: 5 Uniportal VATS major resections, Taizhou, Zhejiang, China.

18–19 December 2015, Jeddah, KSA

Live surgery during the 1st Uniportal VATS course in Saudi Arabia (Uniportal VATS complex sleeve lobectomy)
King Abdulaziz University, Jeddah, KSA.

10 December 2015, Guangzhou, China

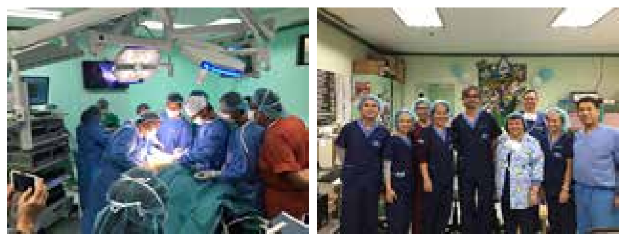


Live surgery from Guangzhou: first case in the world of non-intubated Uniportal VATS segmentectomy with 3D naked eye (No glasses)
The 1st International course on tubeless and advanced VATS lobectomy techniques, 1st Affiliated Hospital of Guangzhou Medical University, Guangzhou, China.

23 November 2015, Kaunas, Lithuania (4)

Live surgery from Kaunas (Lithuania): non-intubated Uniportal VATS lobectomy
Hospital of Lithuanian University of Health Sciences, Kaunas Clinics, Lithuania.

16 November 2015, Manila, Philippines



Live surgery from Manila (Philippines): Uniportal VATS left lower lobectomy
Lung Center of the Philippines, Manila, Philippines.

7 November 2015, Weihai, China

Live surgery from Weihai City, Shandong province (1 Uniportal VATS lobectomy and 2 segmentectomies)
Shandong Minimally Invasive Thoracic Symposium, Weihai City Hospital, Shandong, China.

31 October 2015, Nantong, China

Live surgery and conference from Nantong (China) Conference on Minimally Invasive Surgery, Affiliated Hospital of Nantong University, Nantong, China.

26 October 2015, Xiamen, China

戴上3D眼镜 看肺癌手术如观大片

Live surgery in 3D from Xiamen Hospital: Uniportal VATS lobectomy, Xiamen, Fujian, China.

25 October 2015, Urumqi, China

Live surgery from Urumqi (China): Uniportal VATS Right upper lobectomy

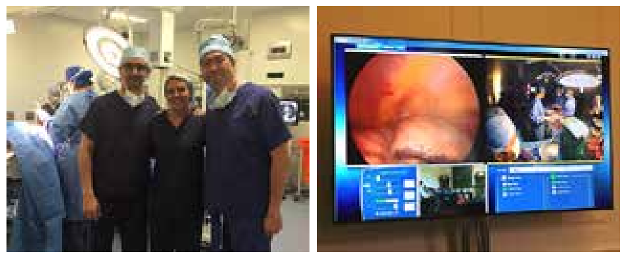
2015 Xiang Forum on Minimally Invasive Thoracic Surgery, Urumqi, Xinjiang, China.

24 October 2015, Shanghai, China

Live surgery from Shanghai: Uniportal VATS right middle lobectomy

Shanghai Pulmonary Hospital, Shanghai, China.

17 October 2015, Cambridge, UK



Live surgery from Cambridge: Non-intubated Uniportal VATS left upper lobectomy

Papworth Hospital, Cambridge, UK.

13 October 2015, Riyadh, Saudi Arabia

Live Surgery from Riyadh (first Uniportal VATS major and minor procedures in Saudi Arabia). King Saud Medical City, Shemaisi (KSMC) on 11th October and National Guard Hospital Riyadh, Saudi Arabia.

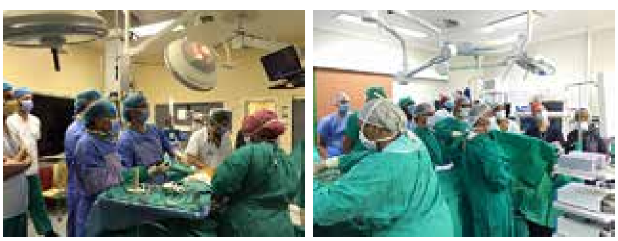
21–22 September 2015, Tacna, Peru

First course on Uniportal VATS in Peru (lectures, live surgery and wetlab)
Daniel Aleides Carrion III and Private University of Tacna, Tacna, Peru.

18 September 2015, San José, Costa Rica (5)

Live surgery from Costa Rica (3 Uniportal surgeries): First non-intubated major pulmonary resection in Central America.
Rafael Angel Calderon Guardia Hospital, San Jose, Costa Rica.

11–13 August 2015, Cape Town, Durban and Pretoria, South Africa (6)



Live surgery from Cape Town, Durban and Pretoria (first Uniportal VATS lobectomies performed in African continent)
Tygerberg hospital (Cape Town), Albert Luthuli Hospital (Durban), Steve Biko hospital (Pretoria) and George Mukhari Hospital (Pretoria), South Africa.

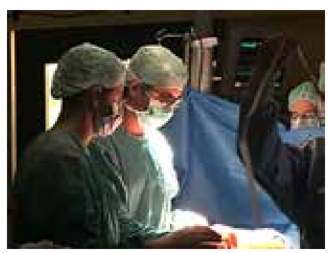
25 June 2015, St Petersburg, Russia

First non-intubated VATS lobectomy performed in St Petersburg (live surgery)
Institute on Phthisiopneumology, St Petersburg, Russia.

20 June 2015, Beijing, China

Live surgery from Beijing: Uniportal VATS lobectomy
Beijing Chaoyang Hospital, Beijing, China.

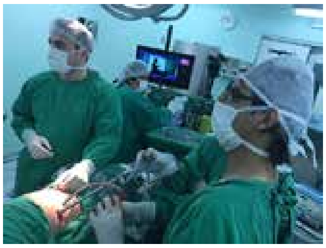
3 June 2015, Berlin, Germany



Live surgery from Berlin (first time in ISMICS): Uniportal VATS right upper and left upper lobectomy
XV annual meeting of International Society of Minimally

Invasive Cardiothoracic Surgery. Charite hospital, Berlin, Germany.

27 May 2015, Fortaleza, Brazil

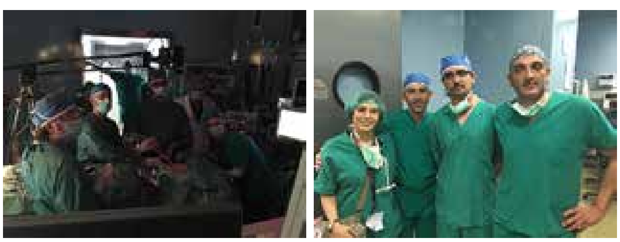


Live surgery from Fortaleza: First non-intubated VATS major pulmonary resection performed in Brazil
Precongress course during National Brazilian meeting on thoracic surgery. Messejana Hospital, Fortaleza, Brazil.

1 May 2015, Lisbon, Portugal

Live surgery from Lisbon: First Non-intubated VATS lobectomy in Portugal
Hospital Santa Maria, Lisbon, Portugal.

24 April 2015, Naples, Italy



Live surgery from Naples: Uniportal VATS left upper lobectomy
Monaldi Hospital, Naples, Italy.
CORSO DI CHIRURGIA TORACICA VIDEOASSISTITA E ROBOTICA

30 March 2015, Budapest, Hungary

First Uniportal VATS lobectomy performed in Hungary (live surgery)
National Institute of Oncology, Budapest, Hungary.

26 March 2015, Hong Kong

First non-intubated VATS lobectomy in Hong Kong
Prince of Wales Hospital, Hong Kong.

25 March 2015, Zhengzhou, China

Live surgery from the First Hospital, Zhengzhou University, Zhengzhou, Henan, China.

24 March 2015, Qingdao, China

Live surgery from The Affiliated Hospital of Qingdao University, Qingdao, Shandong, China.

23 March 2015, Fuzhou, China

Liver surgery from Union Hospital, Fujian Medical University, Fuzhou, Fujian, China.

21 March 2015, Harbin, China

Live surgery from the Second Hospital, Harbin Medical University, Harbin Hospital, Harbin, Heilongjiang, China.

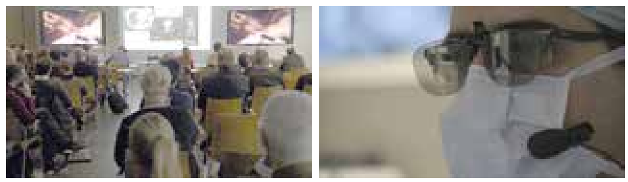
14 March 2015, Wenzhou, China

Live surgery from the First Hospital, Wenzhou Medical University, Zhejiang, China.

25-26 February 2015, Leeds, UK

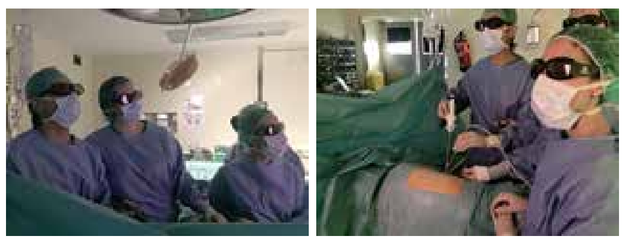
Live surgery and invited speaker at 7th advanced VATS course St James University Hospital, Leeds (UK).

19–21 February 2015, Berlin, Germany



Live surgery at 2nd International Symposium on Uniportal VATS-wetlab Live surgery
Charité Hospital, Berlin, Germany.

17–19 December 2014, La Coruña, Spain



Live surgery during International course advanced Uniportal VATS live surgery
Coruña Hospital and Technological Center, La Coruña, Spain.

10–11 December 2014, Kazan, Russia

VATS Masterclass in Kazan: first non-intubated VATS lobectomy in Russia (2 cases)
Advanced Medical Technology Education Center, Kazan, Russia.

28 November 2014, Shenzhen, China

Live surgery during the first Chinese International Single Port Symposium (Uniportal VATS bilobectomy and Uniportal VATS segmentectomy)
The Shenzhen Baoan affiliated Hospital of Southern Medical University, Shenzhen, China.

26 November 2014, Warsaw, Poland

Live surgery from Poland (Masterclass in Non-intubated Uniportal VATS): first non-intubated VATS lobectomy in East Europe
Warsaw University Hospital, Warsaw, Poland.

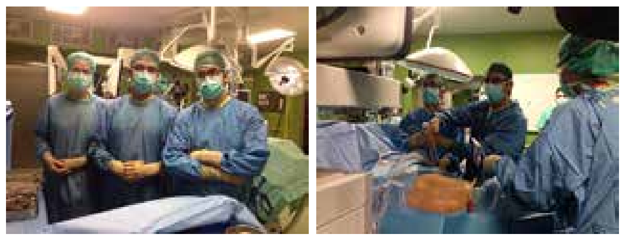
24–25 November 2014, Lodz, Poland

Live surgery from Poland. 3 Uniportal VATS lobectomies
Kopernicus Hospital, Lodz, Poland.

22 November 2014, Cambridge, UK

Live surgery from Papworth Hospital: Non-intubated Uniportal VATS RUL (first case in UK)
Cambridge International VATS Symposium, Cambridge University, Cambridge, UK.

20 November 2014, Udine, Italy



Live surgery from Udine (Italy): single port VATS right lower lobectomy
Convegno La Chirurgia mininvasiva nelle resezione polmonari maggiori, Udine, Italy.

13 November 2014, Abu Dhabi, Emirates

Live surgery from Abu Dhabi: first Uniportal VATS in Emirates
Tawan Hospital, Abu Dhabi, Emirates.

8 October to 12 November 2014, Shanghai, China

Live surgery during Uniportal VATS training program at Shanghai Pulmonary Hospital
Shanghai Pulmonary Hospital, Shanghai, China.

28 October 2014, Plovdiv, Bulgaria

Live surgery from Plovdiv (Bulgaria)
Saint George University Hospital, Plovdiv, Bulgaria.

27 October 2014, Sofia, Bulgaria

Live surgery from Sofia (Bulgaria)
Saint Sofia Pulmonary Hospital, Sofia, Bulgaria.

26th September 2014, Bogotá, Colombia

Live surgery from Bogotá, Colombia: First non-intubated thoracoscopic lobectomy performed in America
National Cancer Institute, Bogotá, Colombia.

15–16 September 2014, Klaipeda, Lithuania

Masterclass on Uniportal VATS and live surgery (2 Uniportal thoracoscopic anatomic segmentectomies)
Klaipeda University Hospital, Klaipeda, Lithuania.

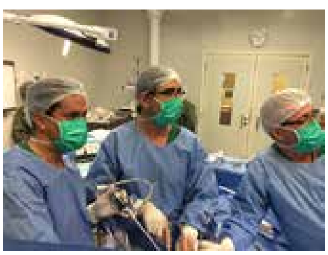
8–9 September 2014, Cardiff, UK

Live surgery during VATS Uniportal Lobectomy Cadaveric Workshop
Wales Institute of Minimal Access Therapy (WIMAT), Cardiff, UK.

4 September 2014, Jena, Germany

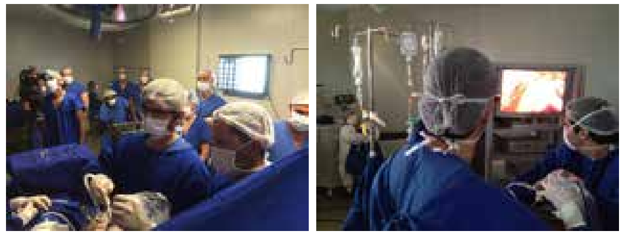
Masterclass on Uniportal VATS and live surgery (3 major pulmonary resections)
Klinik für Herz und Thoraxchirurgie_Universitätsklinikum Jena, Germany.

21–23 August 2014, Rio de Janeiro, Brazil



Single port VATS live surgery demonstration in 3 hospitals in Rio de Janeiro
Instituto Nacional de Câncer (INCA), Unimed Hospital and St. Lucia Hospital, Rio de Janeiro, Brazil.

16 August 2014, Belem, Brazil



Non-intubated live surgery demonstration from Belem, Brazil. Hospital Porto Dias, Belem, Brazil.

26 June 2014, St Petersburg, Russia

Live surgery demonstration from St Petersburg (Uniportal VATS left upper lobectomy)
Russian Institute of Phtysiopulmunology of St Petersburg, Russia.

24th May 2014, Zunyi, China

Live surgery during 6th West China international forum on minimally invasive surgery, Zunyi Hospital, Guizhou, China.

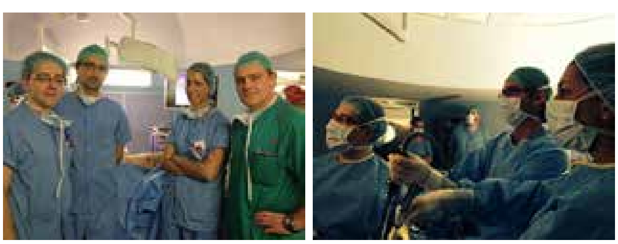
21-22 March 2014, Porto Alegre, Brazil

Live surgery from Porto Alegre (Brazil): left upper lobectomy and left lower lobectomy
VATS symposium at Pavilhao Pereira Filho. House of Mercy Hospital, Porto Alegre, Brazil.

13 February 2014, Taipei, Taiwan

Masterclass on Uniportal VATS in Taiwan: live surgery from hospital and theorical sessions at medical university
Triservice General Hospital and National Defense Medical Center, Taipei, Taiwan.

17 January 2014, Madrid, Spain

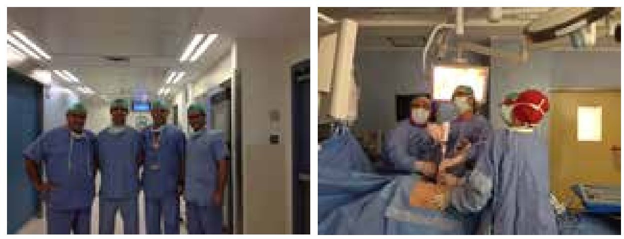


Live surgery and mentorship (Uniportal VATS left upper and middle lobectomy) at San Carlos University Hospital
The first Uniportal VATS meeting. Madrid, Spain.

28 November 2013, Salvador, Brazil

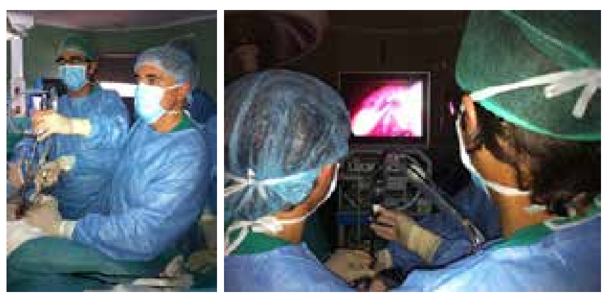
Live surgery (Uniportal VATS left lower lobectomy and middle lobectomy) from Salvador, Brazil
VI International Symposium of Minimally Invasive Thoracic Surgery, Savador, Brazil.

17–18 November 2013, Jerusalem, Israel (7)



Live surgery from Jerusalem: First Uniportal VATS lobectomies in Israel (5 lobectomies)
Shaare Zedek Medical Center, Jerusalem, Israel.

14 November 2013, Madrid, Spain



Live surgery at hospital 12 de Octubre de Madrid (mentorship): single port left upper lobectomy and single port left upper trisegmentectomy
Hospital 12 Octubre, Madrid, Spain.

8 November, 2013, Izmir, Turkey

Live surgery from Turkey: First Uniportal VATS right upper and left lower lobectomies performed in Izmir Dr Suat Seren Gogus Hastaliklari Hospital, Izmir, Turkey.

19 October 2013, Shanghai, China

Live surgery from Shanghai (Shanghai Pulmonary Hospital): Uniportal VATS left upper lobectomy Shanghai Pulmonary Hospital, Shanghai, China.

2 October 2013, Bucharest, Romania

Live surgery from Romania: First Uniportal VATS right upper and left upper lobectomies performed in Bucharest Marius Nasta institutul de pneumoftiziologie, Bucharest, Romania.

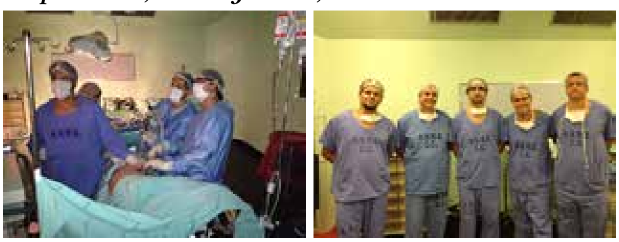
23 August 2013, Bogotá, Colombia

First Uniportal thoracoscopic surgery performed in Bogotá National Cancer Institute, Bogotá, Colombia.

26 June 2013, St Petersburg, Russia

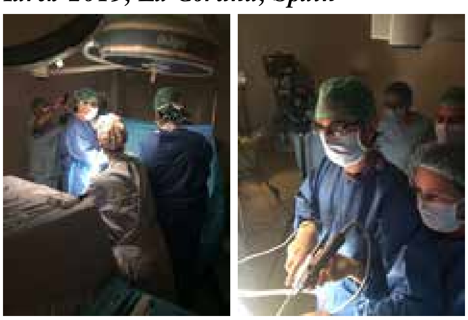
Single port VATS right upper lobectomy at Second Masterclass and live surgery (Uniportal VATS lobectomy) in Russia
St Petersburg Federal Hospital, St Petersburg, Russia.

20 April 2013, Rio de Janeiro, Brazil



First single-port VATS lobectomy performed in Brazil (live surgery)
Hospital da Marinha, Rio de Janeiro, Brazil.

20–22 March 2013, La Coruña, Spain



Live surgery (2 Uniportal VATS lobectomies) during II international Uniportal workshop, San Rafael Hospital, Coruña, Spain.

7–8 March 2013, Hong Kong

Live single port right upper lobectomy at 1st Asian Single Port VATS Symposium & live Surgery
Prince of Wales Hospital, Hong Kong.

12-14 December 2012, La Coruña, Spain

Live surgery on Workshop on Uniportal VATS-wetlab
Coruña Hospital and Technological Center, La Coruña, Spain.

28 June 2012, Berlin, Germany

Live surgery from Berlin (3 major pulmonary resections): first Uniportal VATS lobectomy and segmentectomy in

Germany
Charite University Hospital, Berlin, Germany.

23 May 2012, St. Petersburg, Russia

Live surgery from Russia: first single port right upper lobectomy in Russia
Hospital Federal de St. Petersburg, Russia.

2 March 2012, Oviedo, Spain

Live Uniportal VATS lobectomy from Oviedo during I workshop on Uniportal VATS
Hospital Central de Asturias, Oviedo, Spain.

January 2012, Craiova, Romania

Cuvântul Libertății

Operație efectuată în premieră națională la Craiova

Live surgery from Craiova (Romania): 3 cases
The first Uniportal VATS lobectomy in Romania, Craiova, Romania.

11 December 2011, Lisbon, Portugal

Live surgery from Lisbon: Single port VATS left upper lobectomy. Live surgery from Lisbon during the first workshop on Uniportal VATS: single port left upper lobectomy
Santa Marta Hospital, Lisbon, Portugal.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

References

1. Aamodt H. Transition from thoracotomy to uniportal video-assisted thoracic surgery in non-small cell lung cancer—the Oslo experience. J Vis Surg 2016;2:111.
2. Elkhayat H, Gonzalez-Rivas D. Right pneumonectomy for carcinoid tumor extending through the intermediate bronchus and the interlobar artery. J Vis Surg 2016;2:89.
3. Abu Ali H, Al-Asad K, Shihadeh B, et al. Uniportal lobectomy in Jordan—the journey continues. J Vis Surg 2016;2:93.
4. Karalevičiūtė R, Gonzalez-Rivas D. Nonintubated uniportal video-assisted thoracic surgery course—live surgery. J Vis Surg 2016;2:15.
5. Guerrero WG, Gonzalez-Rivas D, Yang Y, et al. The evolution of uniportal video assisted thoracic surgery in Costa Rica. J Vis Surg 2016;2:91.
6. Schewitz I. Uniportal lobectomy in Africa: a beginning. J Vis Surg 2016;2:54.
7. Abu Akar F, Gonzalez-Rivas D, Fink D. Management of bleeding from an abnormally located S6 arterial branch in a common origin with S2 branch during live surgery. J Vis Surg 2016;2:87.

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Editors：Diego Gonzalez-Rivas　Gening Jiang　Yuming Zhu

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