Surgical Technique

Modular 3-cm uniportal video-assisted thoracoscopic left upper lobectomy with systemic lymphadenectomy

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Abstract: Uniportal video-assisted thoracoscopic lobectomy for non-small-cell lung cancer is accepted worldwide, with incisions ranging from 4 to 6 cm. We believed in less invasive and more precise that uniportal video-assisted thoracoscopic lobectomy could be. Therefore, we performed modular uniportal thoracoscopic lobectomy with systemic lymphadenectomy on left upper lobe using a 3-cm-diameter port. And the modular surgical route was arranged in seven modules. Anesthesia, patient positioning and instruments play an important role in the surgery. From October 2014 to June 2015, 96 patients underwent this modular surgery and all patient were discharged uneventfully with no postoperative deaths. Compared with multi-port VATS, the operation time were longer than multiport video-assisted thoracoscopic surgery (VATS) (164.70±12.50 *vs.* 160.70±11.60 min, P>0.05), and the mean lymphadenectomy station was 6.00±0.77, and the mean lymphadenectomy number was 17.58±5.33. There is no significant difference on lymphadenectomy. Thus, modular uniportal video-assisted thoracoscopic lobectomy with systemic lymphadenectomy on left upper lobe using a 3-cm-diameter port is a safe, feasible, and less painful technique for select patients with lung disease.

Keywords: Uniportal thoracoscopy; lobectomy; lung cancer surgery

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Introduction

Uniportal video-assisted thoracoscopic surgery (VATS) is now accepted and used in lung surgery worldwide. Gonzalez-Rivas and colleagues first introduced their experience using uniportal thoracoscopic lobectomy in 2011, and researchers in Taiwan were the first to report using uniportal VATS in Asia, followed by Hong Kong and South Korea. We began performing thoracoscopic lobectomy in 2010, and refined uniportal thoracoscopic lobectomy with systematic lymphadenectomy since 2013 based on our experience using multi-portal VATS. However, the diameter of incision was not defined clearly, ranging from 4 to 6 cm mostly. Postoperative incisional pain is a concern with VATS, which led us to question whether uniportal video-assisted thoracoscopic lobectomy could be less invasive. Therefore, we performed uniportal VATS with systemic lymphadenectomy on left upper lobe using a 3-cm-diameter port, although left upper lobectomy is difficult in vascular variation of pulmonary artery.

We describe our surgical method of modular uniportal VATS with systemic lymphadenectomy on left upper lobe using a 3-cm-diameter port, and we provide a video to present our modular surgical route.

Operative techniques

Anesthesia and patient positioning

Anesthesia included general anesthesia, double-cavity tracheal cannulas, and contralateral one-lung ventilation. Patients were placed in the full lateral position on the operating table, left side up, with both arms forward and fixed on a special support. Depending on the operating table,

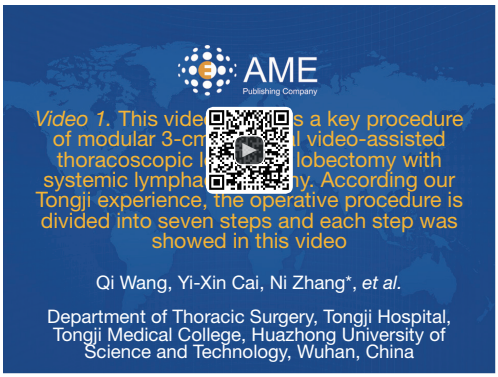

Figure 1 This video presents a key procedure of modular 3-cm uniportal video-assisted thoracoscopic left upper lobectomy with systemic lymphadenectomy. According our Tongji experience, the operative procedure is divided into seven steps and each step was showed in this video (1).
Available online: http://www.asvide.com/articles/1108

sandbags were used as needed to improve rib spreading. The operating table is changing in different module.

Operating instruments

The operating instruments included an Olympus high-definition (HD) thoracoscopic surgical system (Olympus Medical Systems Corp., Tokyo, Japan); 30°, 5/10-mm HD video camera; endoscopic linear cutter; flexible endoscopic stapler; and an Olympus ultrasonic scalpel (Olympus, Tokyo, Japan). Certain double-joint endoscopic instruments (dissecting forceps, grasping forceps, and others) and electric coagulation hook were custom-made. We also used 12 Fr catheter, Hem-o-lok® ligature clips (Weck Closure Systems, Research Tri-angle Park, NC, USA), a custom-made endo-pouch, soft suction catheter, and other standard laparoscopic instruments. Instruments for conventional open thoracotomy were prepared at the same time.

Incision

The surgical incision was located at the fifth intercostal space along the anterior axillary line and extended from the intersection of the anterior axillary line and the center line of the intercostal space to both sides for approximately 1.5 cm in each direction. Scalpel dissection along the center line of the intercostal muscles followed, and a wound edge laparotomy protector was placed at the intercostal muscles only in obese patients.

Operating procedure

Following our experience with uniportal thoracoscopic lobectomy with systemic lymphadenectomy using a 3-cm-diameter port, we designed a modular operating approach, which contains seven steps with each step comprising a 2-cm^2 operating area which is showed in the *Figure 1*.

Step 1: exploration

The surgeon stands facing the ventral side of the patient and the camera operator stands same side. The skin incision is made as described previously and a double-joint endoscopic grasping forceps expanded incision and insert the video camera. The modular surgical approach begins with an exploration of the pleural cavity, loosening adhesions, with the presence of dense pleural adhesions requiring additional ports or conversion to conventional thoracotomy. The presence of metastasis indicates a need for biopsy without proceeding further with the surgery.

Step 2: dissection of the inferior pulmonary ligaments and dissection of station 9 and 8 mediastinal lymph nodes

The posterior inferior mediastinum is assessed next. The left inferior lobe is clamped by endoscopic grasping forceps with the left hand and retracted towards the patient's head. Next, using a hook, dissect the inferior pulmonary ligaments until inferior pulmonary vein level. Station 9 and 8 lymph nodes are now visible. Grasp the lymph node capsule with lymph nodes forceps in the right hand and dissect the station 9 and 8 lymph nodes with an ultrasonic scalpel or hook.

In this step, the camera rests on the incision at the dorsal end directing towards posterior mediastinum. The endoscopic grasping forceps are behind the camera, the aspirator and hook share the remaining incisional space. An aspirator may be required for regional hemorrhage and tissue retraction.

Step 3: dissection of station 7 lymph nodes

The posterior mediastinum near the hilum is assessed next. The operating table is raised and tilted towards the surgeon to expose the posterior hilum. Clamp the left upper lobe by forceps and retracted toward the surgeon using appropriate force. The pleura is then incised along the inner side of the aortae and end at the arcus aortae with a hook and an aspirator, vagus must be protected there. Then the gap between the descending aortae and pericardium is then enlarged with an ultrasonic scalpel or hook, creating two

separate regions (aortae side and pericardial side). Next, separate the adhesions between the aortae and lymph nodes with a hook. Hold up the aortae with aspirator and grasp station 7 lymph nodes, then dissecting the entire station 7 lymph node from pericardial side.

In this step, the camera rests at the dorsal end of the incision pointing towards the posterior mediastinum near the hilar station and the forceps are located at the distal end of the incision. The aspirator, hook, and ultrasonic scalpel share the remaining incisional space. The stances of the surgeon and camera operator are as in step 2. An aspirator is used to depress the pericardium and provide regional hemostasis suction and tissue retraction.

Step 4: dissection of station 5 and 6 lymph nodes

Station 5 and 6 lymph nodes are next target. The operating table is raised to expose the superior mediastinum. Clamp the left upper lobe by endoscopic grasping forceps and retracted toward the patient's foot using appropriate force. Hook starts at knuckle level, the pleura is then incised along the inner side of the acrus aorta. Vagus must be identified and protected. Separate the area below aortic arch with hook or ultrasonic scalpel. Blunt separation may be proper for those areas. Meanwhile identify the recurrent laryngeal nerve and protect it when dissect the lymph nodes.

In this step, the camera rests at the cranial end of the incision directed towards the posterior hilum with the endoscopic grasping forceps located at the distal end of the incision. The aspirator, hook and ultrasonic scalpel share the remaining incisional space.

Step 5: dissection of station 10/11 lymph nodes and transection of the left superior pulmonary artery, vein, bronchus and the oblique fissure of the left lung

The anterior hilum is assessed at this stage. The operating bed is tilted forwards the surgeon. Holding the left upper lobe with the grasping forceps, separate the pleura along the phrenic nerves to reveal left pulmonary artery and vein with a hook. Dissect the station 10 and 11 lymph nodes around. Dissociate the left superior pulmonary vein fully and elevate it with a 12 Fr catheter. One side of the catheter is clamped by an assistant and the other side is connected to the flexible endoscopic stapler. The surgeon slowly places the stapler at the desired location using the catheter as a guide while the assistant simultaneously retracts the catheter, and the left superior pulmonary vein and its branch are dissociated clearly and transected followed by the left superior pulmonary artery. When difficulty in transection of the superior pulmonary artery, first branch of left superior pulmonary arteries are transected primarily and then transected the following branch until branchi. Finally dissociate the left superior bronchus clearly and transect it as left superior pulmonary vein. And at this moment, the oblique fissure of the left lung is identified and clamped by dissecting forceps, retracting cranially. And dissect the oblique fissure using the flexible endoscopic stapler.

In this step, the camera rests at the cranial end of the incision directed towards the anterior hilum and the endoscopic grasping forceps are located at the distal end of the incision. Aspirator, hook, ultrasonic scalpel, and the flexible endoscopic stapler share the remaining incisional space. The flexible endoscopic stapler transects the vessels at the proper angle.

Step 6: withdraw the specimen using the custom-made endo-pouch

Cutting a 15-cm length of endoscopic protective sleeve to make an endo-pouch and tying one end. Using a sterile clamp to hold the sleeve, place the endo-pouch into the thoracic cavity. Place the specimen into the endo-pouch and retract the endo-pouch approximately 5 cm out of the skin incision. Open the endo-pouch and use the sterile clamp or gauze to slowly and gradually remove the specimen, submitting the specimen for histopathology once it is completely removed.

Step 7: leak test, coagulant, insertion of the chest drainage tube, and incision closure

Before performing the leak test, the anesthetist aspirates any sputum. Approximately 500 mL of dilute polyninylpyrrolidone solution is then introduced into the thoracic cavity and ventilation of the terminal right lung is observed by camera for escaping air. If none is identified, coagulant is placed in several areas including anterior and posterior hilum. Two 16 Fr stomach tubes with an adequate number of side holes are placed to the limits of the thoracic cavity though the posterior and anterior mediastinum in a "U"-shape. Finally, the incision is closed routinely.

Comments

Since Gonzalez-Rivas colleagues first described their experience using uniportal thoracoscopic lobectomy in 2011 (2), uniportal video-assisted thoracoscopic surgery is now accepted and used in lung surgery gradually, especially non-small cell lung cancer (3,4). Uniportal VATS has

several advantages, including reduced trauma and pain, quicker recovery, safety, and reliability. With developments in minimally invasive surgery and endoscopic equipment, uniportal VATS improvements now aid in the diagnosis and treatment of thoracic diseases deeply, worldwide (3,5,6). However, the diameter of incision was not defined clearly, ranging 4 to 6 cm mostly (2,7).

We began performing VATS in 2010, and we refined uniportal thoracoscopic lobectomy with systematic lymphadenectomy in 2013 based on our experience using multi-port VATS. More than 200 cases of uniportal complete VATS (cVATS) procedures have been performed in our center since October 2014, with 96 cases undergoing uniportal thoracoscopic left upper lobectomy. Because of vascular variation, uniportal VAT left upper lobectomy with systemic lymphadenectomy is a challenge for most thoracic surgeons especially when using a 3-cm-diameter port. Our modular operating protocol can help novice surgeons learn this technique with a shorter learning curve for uniportal approaches.

The location of the incision in uniportal cVATS is important as it affects the complexity of the surgery (7,8). Our surgical incision was made at the fifth intercostal space on the midaxillary line, and was based on our previous experience. This location provides a proper angle for flexible endoscopic stapler. Our incision was made along the center line of the intercostal space. This incision may reduce damage to the intercostal nerves, intercostal rib membranes, and intercostal vessels, improving postoperative recovery. On the other hand, in pursuit of less invasive and more precise, we collect other centers' data and find the incision ranging 4 to 6 cm mostly (2,4,6,9), then we improved and calculated the total diameter of the endoscopic instruments (3.0 cm). We even tried incision of 2.5-cm diameter, however, with this size port, we found it difficult to perform lobectomy rather than pneumothorax operation. Therefore, a 3.0 cm port is minimal incision for lobectomy now. We expect that incisions will become smaller with improvements in camera systems, instrumentation, and stapler technology. Finally, lap protectors were not used commonly in our study because they restrict portal elasticity and worsen blood interference with camera visualization of the instruments.

An outstanding concern in uniportal cVATS is interference between the instruments, especially with a 3-cm port. To address this difficulty, we used the described instruments and adjusted their arrangement. A 30°, a 5-mm HD thoracoscope provides more space for endoscopic instruments and double-joint top-curved endoscopic instruments, creating a clear operating field and enhancing instrument use. A 30° HD thoracoscope also provides a flexible view and high-quality frames. However, because of our proficiency with this surgery, a 30°, 10-mm HD thoracoscope was used in this study when experienced. All endoscopic instruments were custom-made, and the stems of the instruments are thin and long, which economizes the port and reduces instrument inference outside the thoracic cavity. We used a soft suction catheter to aspirate "smoke" and blood rather than a laparoscopic aspirator in some cases. The arrangement of the instruments is also important. We preferred to rest the camera at the dorsal end of the incision directed towards the operating area and positioned instruments of low mobility at the distal end of the incision. The remaining larger incisional space allowed for easier operation and reduced interference. Finally, crossing of hands and instruments is inevitable, but grasping the instruments with thumb and forefinger helps solve this problem and allows for the dominant hand to be in the ideal position most of the time, which is more comfortable and provides better instrument handling.

Our modular operating protocol is central to successfully performing uniportal VAT left upper lobectomy with systemic lymphadenectomy using a 3-cm-diameter port. We proceed a unidirectional route starting with inferior pulmonary ligation, turn at the posterior hilum, and end at the anterior hilum, which is different from convenient uniportal VAST. We operate separately along the route and each step contains a 2-cm^2 operating area. We take advantage of freed tissue for retraction when dissecting lymph nodes. With this method, the camera is directed at the target tissue and moved along the modular operating route, maintaining the desired distance of 2–4 cm. Our method reduces the difficulty of uniportal VAT left upper lobectomy, but practice is necessary for novice surgeons and assistance is required during the learning curve for uniportal VAT lobectomy, especially with a 3.0-cm-diameter port.

Mediastinal lymph node dissection is also a central step in the surgical therapy of non-small cell lung cancer (10,11). We performed lymph node dissection rather than sampling. According to the National Comprehensive Cancer Network guidelines for non-small-cell lung cancer adequate mediastinal lymphadenectomy should include stations 5, 6, 7, 8, and 9 for the left side. Stations 10 and 11 were dissected in all cases. We dissected all lymph stations before lobe removal. Dissection of station 5, 6 and 7 lymph nodes is relatively difficult because of their location, with some skill required. The aspirator plays a vital role in avoiding

rupturing the lymph nodes. Anatomical dissection is also important to free tissue for retraction during dissection, creating a clearly visible space between the lymph nodes and the parenchyma, and avoiding excessive bleeding.

Prevention is the optimal strategy to address bleeding and the sharp angle limitation of the endoscopic stapler creates the most risk for bleeding. To solve this problem, we recommend isolating the vessel more fully than conventional thoracic surgery and advise against blunt dissection. Dissecting the vascular sheath with a hook can avoid rupturing the lymph nodes and bleeding from breaking down adhesions. More distal dissection of the vascular sheath to the heart is advantageous for the insertion of endoscopic staplers. We also guide the staplers with a 12 Fr catheter for better stapling success and reduced risk of vessel damage and for vessels that cause difficult stapler positioning, Hem-o-lok® clips and ligation may be better alternatives. When bleeding was severe, we performed hemostasis by compression first, and added an additional port or converted to conventional open thoracotomy, when necessary (12,13). Last but not least, a good command of anatomy do help to the prevention of bleeding.

Uniportal VAT left upper lobectomy with systemic lymphadenectomy is challenging, especially with a 3-cm-diameter port. Our unidirectional modular operating protocol can solve this problem safely and feasibly. We have applied uniportal thoracoscopic surgery with a 3-cm-diameter port in other surgeries and we will share our experiences in future reports.

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None.

Footnote

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

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