Troubleshooting complicated hilar anatomy via prophylactically clamping the pulmonary artery: three videos demonstrating three techniques

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Abstract: Complicated hilar anatomy (i.e., tumor invasion, lymphadenopathy, calcification, carbonization, and dense inflammatory adhesions) is technically challenging and often leads to catastrophic intraoperative complications and conversion to open thoracotomy during video-assisted thoracic surgery (VATS) lobectomy. The technique of prophylactically clamping the pulmonary artery (PA) has been reported to be effective in troubleshooting complicated hilar anatomy. However, there are no records on details regarding techniques to treat different hilar complication situations. In this paper, we will introduce three techniques, namely suture ligation, endo-stapler angioplasty, and suture angioplasty, for dealing with different kinds of complicated hili during VATS lobectomy through three video demonstrations.

Keywords: Video-assisted thoracic surgery (VATS); lobectomy; pulmonary artery (PA); complicated hilum; troubleshooting

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Introduction

Complicated hilar anatomy (i.e., tumor invasion, lymphadenopathy, calcification, carbonization, and dense inflammatory adhesions) is technically challenging and may lead to catastrophic intraoperative complications such as heavy bleeding and conversion to thoracotomy during video-assisted thoracic surgery (VATS) lobectomy (1-4). When encountering complicated hilar anatomy, cross-clamping the main pulmonary artery (PA) before starting vascular dissection can be used to prevent catastrophic vascular injury and bleeding. Sporadic literatures reported techniques of prophylactically clamping the PA during VATS lobectomy using silk sutures or vascular clamps (5-8). However, these experiences are limited to case reports and there are no detailed records regarding the techniques to treat different hilar complication situations. We also performed prophylactic clamping of the PA during VATS lobectomy with a different technique using detachable endoscopic bulldog clamps (9). We gradually developed a series of techniques aiming to troubleshoot complicated hilar anatomy and raised the indication for each technique according to different situations. There were four situations and relevant techniques after clamping the PA: (I) direct ligation (9), (II) suture ligation, (III) endo-stapler angioplasty, and (IV) suture angioplasty. We share three video demonstrations (two cases of left upper lobectomy and one case of right upper lobectomy) to show three techniques for dealing with complicated hili during VATS lobectomy.

Operative techniques

Anesthesia and position

General anesthesia was administered to each patient through double-lumen endotracheal intubation. Each patient is placed in lateral decubitus position with his/her

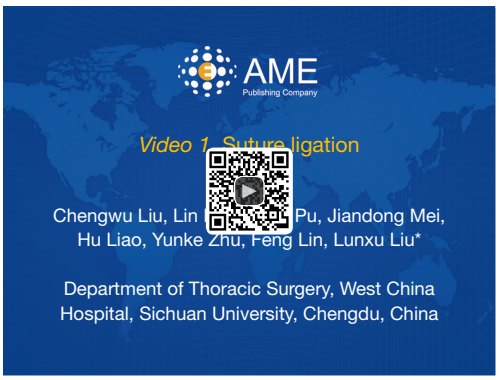

Figure 1 Suture ligation. The video depicts a three-portal thoracoscopic right upper lobectomy. There were dense inflammatory adhesions and severe lymphadenopathy between the bronchus and the pulmonary artery. The arterial branches were sutured and divided after prophylactically clamping the pulmonary artery (10).
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Figure 2 Endo-stapler angioplasty. The video depicts a three-portal thoracoscopic left upper lobectomy. There were dense adhesions and severe lymphadenopathy around the first arterial branch. Angioplasty was performed using endo-stapler after prophylactically clamping the pulmonary artery (12).
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body folding over.

Incision placement

The principles of incision placement are the same for both sides.

Observation port: made in the seventh intercostal space at the midaxillary line (1 cm).

Main utility incision: made in the third intercostal space at the anterior axillary line (3 cm).

Assistant utility incision: made in the ninth intercostal space between the posterior axillary line and subscapular line (2 cm).

Technique 1: suture ligation after clamping the PA (Figure 1) (a right upper lobectomy)

The pleural adhesions were first dissociated. The mediastinal pleura was opened just posterior to the phrenic nerve. The pulmonary vein of the right upper lobe was dissected and divided. Dense inflammatory adhesions and severe carbonized lymphadenopathy were found posterior to the PA. The first arterial branch could not be totally dissected even with sharp dissection using scissors. It was divided by scissors after having been sutured with 4-0 Prolene stiches. Carbonized lymph nodes between the PA and upper lobe bronchus made it hard to dissect between the artery and bronchus. Therefore, the proximal trunk of the PA was dissected and clamped using detachable bull dog clamps. The second feeding artery was then managed via suturing with 4-0 Prolene stiches. Then scissors were used to dissect those carbonized lymph nodes. The posterior ascending artery was dissected and divided using silk suture after ligation. At last, the upper lobe bronchus was transected by endo-stapler followed by completion of the fissures. The specimen was retrieved using a bag made from a surgical glove. The bull dog clamps were removed slowly. At last, systemic mediastinal lymph node dissection including stations 3, 4, 7, 9 was performed using the method of "non-grasping en-bloc mediastinal lymphadenectomy" (11).

Technique 2: endo-stapler angioplasty after clamping the PA (Figure 2) (a left upper lobectomy)

The mediastinal pleura were opened just posterior to the phrenic nerve and the superior pulmonary vein was dissected and divided after the inferior pulmonary vein been identified previously. Proceeding in single-direction, the upper lobe bronchus was then dissected and divided by endo-stapler. After that, the anterior part of the fissure was completed by ultrasonic scalpel. The feeding artery of the lingular segment was dissected and divided by ultrasonic scalpel after ligation using silk sutures. As dense adhesions and severe lymphadenopathy around the first arterial branch and the main PA trunk were identified, the risk of vascular injury would be high if the first arterial branch

Figure 3 Suture angioplasty. The video depicts a three-portal thoracoscopic left upper lobectomy. The left pulmonary artery trunk was partially involved by the lesion. Angioplasty with partial removal of the pulmonary artery using continuous suture was performed after clamping both of the proximal and distal trunks of the pulmonary artery (13).
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is dissected directly. Therefore, the proximal trunk of the PA was dissected and clamped using detachable bull dog clamps. A small posterior arterial branch was dissected and ligated followed by completion of the posterior part of the fissures using endo-stapler. When we tried to dissect another small artery, which entered into the tumor directly, the artery lacerated and bleeding occured. However, there is no need to worry about the bleeding because the trunk had been clamped proximally. The interlobar PA was then clamped using detachable bull dog clamps. At last, the first arterial branch was divided by endo-stapler directly and angioplasty was performed simultaneously with partial removal of the PA trunk. There was no obvious stenosis after angioplasty. The bull dog clamps were removed one by one. The specimen was retrieved using a bag made from a surgical glove. At last, systemic mediastinal lymph node dissection including stations 4, 5, 6, 7, 9 was performed using the method of "non-grasping en-bloc mediastinal lymphadenectomy" (11).

Technique 3: suture angioplasty after clamping the PA (Figure 3) (a left upper lobectomy)

The mediastinal pleura were opened just posterior to the phrenic nerve and the superior pulmonary vein was dissected and divided using endo-stapler. The next step was to dissect the upper lobe bronchus. The station 11 lymph nodes were found to be densely adhered to the upper lobe bronchus, and was dissected by sharp dissection using scissors. Dense adhesions were also identified between the PA and upper lobe bronchus. As direct dissection prose high risk, precontrol of the PA trunk was planned. The stations 5 and 6 lymph nodes were dissected to facilitate exposing the proximal trunk of the PA, which was then dissected and clamped using detachable bull dog clamps. After appropriate control of the PA, it became safer to pass through the space between the bronchus and PA using right angle forceps. The upper lobe bronchus was divided by endo-stapler. The lingular artery was dissected and divided by ultrasonic scalpel after ligation using silk sutures. Further exploration revealed that the PA trunk was partially involved by the lesions. Therefore, the distal trunk of the PA needed to be clamped for further angioplasty. With both of the proximal and distal parts of the PA trunk clamped, the involved part of the PA was removed using scissors. The endangium was washed with dilute heparin (25 U/mL). Then the PA was repaired via running suture using 5-0 Prolene stiches. Before tying the knot, the distal clamps were removed first to vent gas. At last, the proximal clamps were removed slowly. The specimen was taken out using a bag made from a surgical glove after completion of the fissures using endo-stapler. Further systemic mediastinal lymph node dissection including stations 4, 7, 9 was performed using the method of "non-grasping en-bloc mediastinal lymphadenectomy" (11).

Comments

Controlling the main PA can prevent catastrophic bleeding resulting from injuring of the vessels during dissection. In most cases, the arterial branches could be dissected successfully if we dissected it more boldly after the arterial trunk had been controlled. And then the branches could be managed through routine methods such as ligation using sutures or hem-o-lock, and firing using endo-stapler (9). However, complicated hilar anatomy differed among patients. Sometimes we could not separate the hili from surrounding tissues even with sharp dissection. In that case, more aggressive techniques should be applied.

It is important to choose an appropriate technique when complicated hilum is encountered. As manifested in the three video demonstrations, there are special indications for each technique. If the artery branch could only be partially dissected or there is not enough space for direct ligation, we could choose technique 1 (dividing it after suturing). If the artery branch could not be dissected out and the PA trunk is not involved, technique 2 would be appropriate (performing

angioplasty using the endo-stapler directly). If both the PA branch and part of the trunk are involved, technique 3 should be the choice (performing angioplasty by suturing after partial removal of the PA trunk).

Although we have demonstrated the detailed procedures in the video demonstrations, several technical details should be noted:

(I) Be careful when dissecting the PA trunks. On the right side, stations 10 and 4 lymph nodes could be first dissected to facilitate exposing the right PA trunk. On the left side, station 5 lymph nodes could be first dissected to facilitate exposing the left PA trunk.

(II) Branches of PA without adhesions or tumor invasion can be ligated or stapled first.

(III) Suturing the branches just closely to the posterior wall of the branch, or the artery may be easily lacerated when tying the knot.

(IV) Before performing angioplasty using endo-stapler, it must be sure that the PA trunk is not involved or there would be no stenosis after angioplasty by endo-stapler. In addition, the involved branches should be dissected as much as possible. It is best to isolate the involved part as an "island".

(V) If angioplasty is planned, the removed vascular wall must be less than a quarter or stenosis would occur after angioplasty and sleeve reconstruction should be considered.

(VI) If the pulmonary artery is cut open, the endangium should be washed repeatedly using dilute heparin.

(VII) Avoid transfixing suture of the PA when performing angioplasty.

These techniques are aggressive but effective for dealing with different situations of complicated hili. However, these techniques are technically demanding and the definition of "a complicated hilum" might vary among surgeons. Therefore, careful exploration and assessment should be performed before choosing a suitable technique. In addition, each surgeon should perform operations within his/her own ability.

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Footnote

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

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