Technical strategy for dealing with bleeding during thoracoscopic lung surgery

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Introduction

Uncontrollable bleeding caused by vascular injury is an important reason for conversion to thoracotomy during thoracoscopic lung surgery. Demmy *et al*. (1) summarized several effective methods for dealing with bleeding, such as the use of thrombostatic material, biological sealant, or discreet utilization of energy sources. However, managing more severe bleeding is quite challenging even for experienced thoracoscopic surgeons.

The most common solution for this situation is compression or tamponade of the injured site while converting to open thoracotomy (1,2). We have previously described a series of skills named the "suction-compressing angiorrhaphy technique (SCAT)" for dealing with severe bleeding due to vascular injury during thoracoscopic lung surgery (3). Bleeding control and angiorrhaphy were both achieved through thoracoscopy in most of the cases of vascular injury in our center. Here, we present our technical strategy for dealing with bleeding and vascular injury during thoracoscopic lung surgery with a video series.

Minor bleeding

Mild bleeding is usually not a troublesome problem and can typically be solved easily. Some biological materials can be used to stop bleeding as previously mentioned in the literature (1,2). However, we generally use the electrocoagulation hook or Harmonic scalpel to achieve exact hemostasis. Titanium or Hemlock clips may also be used to stop bleeding from some visible small blood vessels. The situation which needs to be highlighted is bleeding of the vascular stump after transecting the pulmonary vessels with an endostapler. We choose the electrocoagulation hook to stop bleeding in this situation. The hook is inserted at the bleeding point of the stump to perform a quick electrocoagulation. Special attention is needed to avoid melting the staple and causing additional injury to the vessels.

Major bleeding

The most common etiology of major bleeding is vascular injury, especially injury of major pulmonary artery branches. This is a more serious situation that usually leads to conversion. Dunning *et al*. (4) introduced their "swab-on-a-stick" method to control bleeding temporarily. The method generated a secure interval for emergent thoracotomy. We usually use a suction to control bleeding in these cases before further manipulation of the accident. The next step can be divided into several stages, including transecting the injured vessel after temporary control of bleeding, performing angiorrhaphy with suction-compressing bleeding control, performing angiorrhaphy after proximally clamping the injured vessel, and converting to open thoracotomy.

Transect the injured vessel after temporary control of bleeding

In the first part of *Video 1*, we performed a right lower lobectomy for a 35-year-old female patient with pulmonary sequestration. The anomalous artery of the sequestrated lung located in the inferior pulmonary ligament was mistaken for

dense adhesions and was injured by electrocoagulation hook when dissecting the inferior pulmonary ligament. We used two curved Kelly forceps to clamp the injured vessel to stop bleeding first. The distal Kelly forceps was then replaced by a Titanium clip to make sufficient room for the endostapler. Finally, the vascular bundle was directly transected using an endostapler.

The next section of *Video 1* shows an example of clamping the injured site before performing angiorrhaphy. An accidental injury to the truncus anterior occurred during thoracoscopic right upper lobectomy for a patient with adenocarcinoma. The operation was carried out with the single-direction technique as previously described (5). Hilar structures of the upper lobe were transected in the order of superior pulmonary vein, truncus anterior and the upper lobe bronchus. The truncus anterior was injured by the electrocoagulation hook during this procedure. We used the curved Kelly forceps to clamp the vascular laceration temporarily. The superior pulmonary vein was transected for better exposure of the injured artery. We then sutured the injured site with the SCAT method (situations 1 and 2), followed by transecting the truncus anterior using the endostapler.

In these two cases, both of the injured vessels were planned to be transected. However, a temporary bleeding control was still needed to ensure the safety of the operation and to reduce blood loss. For the first case, the injured vessel was relatively long enough to allow the use of an endostapler, even with a pair of Kelly forceps on the vessel. Thus, there was no need to suture the laceration. Angiorrhaphy was needed to control bleeding instead of the Kelly forceps because of limited room for the involvement of an endostapler. The decision whether to use a clip or perform a suture was made according to the convenience of the operation.

Perform angiorrhaphy with suction-compressing bleeding control

If the injured vessels are to be preserved, a more careful angiorrhaphy is needed. As for the situation of a relatively minor injury, side compression of the injured site with the suction tip is usually enough to control bleeding and offers a chance to perform angiorrhaphy directly. In some cases, if the laceration is larger, usually more than 5 mm but not exceeding one-third of the vascular circumference, or if additional preparation is needed before performing angiorrhaphy, we may use a pair of Allis forceps or curved Kelly forceps to clamp the vascular wound. Instances of performing angiorrhaphy directly, with the technique of side compression via suction for bleeding control (SCAT situation 1) are shown in the accompanying video.

In the first case, the patient had a lymph node adherent to the superior vena cava, and injury occurred to the wall of the superior vena cava from the scissors during sharp dissection. We used the suction tip to compress the injured site to avoid blood loss. Angiorrhaphy was then carried out directly. The lymph node was confirmed, by intraoperative frozen section, to be without metastasis and was partially left *in situ*.

The second example presents a case of injury to the azygos vein. The suction was used to compress the injured site immediately, followed by suturing the wound directly. In contrast to the previous case we used a "rotating-technique" when performing angiorrhaphy in this case. The first suture was done on one side of the wound after slightly rotating the suction tip to expose the injury. The second suture was then performed on the other side of the wound after rotating the suction towards the opposite direction.

Perform angiorrhaphy after proximally clamping the injured vessel

Occasionally, an unexpected major laceration of pulmonary artery which exceeds one third of the circumference of the vessel may occur during the operation. Furthermore, sometimes, it may be inconvenient or unsafe to perform suturing directly with a pair of curved Kelly forceps or Allis forceps clamping the vascular laceration. In these cases, we choose to dissect the proximal artery and clamp the vessel. Angiorrhaphy is completed with the method summarized as SCAT situation 3 (3). In this video, we were performing a thoracoscopic left upper lobectomy for a patient with proven adenocarcinoma using the Single-direction method (5). After transecting the superior pulmonary vein and left upper lobe bronchus, we found dense adhesions surrounding the pulmonary artery. The adventitia of the pulmonary artery was then carefully dissected first to get a better exposure of the lingular artery. When we tried to dissect the lingular artery bluntly, an accidental laceration emerged at the crux of lingular artery and the main pulmonary artery. The suction tip was immediately introduced to compress the wound site for bleeding control. A pair of Allis forceps was used to clamp the vascular wound for further manipulation, instead of using the suction for bleeding control. The left main pulmonary artery was then dissected and clamped

with endoscopic atraumatic vascular clamp. Angiorrhaphy was then carried out with continuous suture using 5-0 Prolene stitch. After the knot was made, we carefully removed the vascular clamp. The lingular artery was then carefully dissected and transected, followed by transecting the posterior ascending artery and the oblique fissure.

Convert to open thoracotomy

This is considered as the last line of defense to guarantee the safety of thoracoscopic lung surgery. Though most of the bleeding and vascular injury can be successfully managed with the above skills in our daily work, emergent conversion to open thoracotomy is still sometimes unavoidable, for example, when the vessel is unexpectedly transected or there is insufficient room to get a satisfactory proximal clamping of the injured vessel. If an emergent conversion is unavoidable, we often use the suction tip to compress the injured vessel to control bleeding during thoracotomy.

In short, patient safety should always be the top priority during thoracoscopic lung surgery. When it is technically difficult to control the bleeding according to the surgeon's own experience, a timely conversion should be adopted. The emergent conversion is not a label of unsuccessful operation. Instead, it is an important step of thoracoscopic lung surgery when needed.

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