Great Vessel Injury in Thoracic Surgery

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KEYWORDS

• Bleeding control • Minimally invasive thoracic surgery • Mediastinoscopy • Lung resection
• Thymectomy • Esophagectomy

KEY POINTS

- Prevention is the optimal method of dealing with intraoperative bleeding complications in thoracic surgery.
- Thorough preoperative workup, including review of relevant imaging, with a particular focus on normal and variant vascular anatomy, is important in detecting risk factors for bleeding.
- Preparedness for complications ensures an effective and expedited response when intraoperative bleeding presents, especially in settings with limited access to the injury.
- Once bleeding occurs, continuous communication with the surgical team and immediate availability of surgical instruments and blood products are fundamental for an effective and successful response to the event.

INTRAOPERATIVE BLEEDING IN GENERAL THORACIC SURGERY

Due to the nature of vascular structures within the chest, including complex anatomy and high rates of blood flow often involving a significant portion of the cardiac output, injury can result in significant and life-threatening blood loss within seconds of occurring. Effective and expedited treatment is key to preventing poor outcomes in these events.

Vascular injuries during open surgery are addressed through the same incision with few exceptions, such as transhiatal esophagectomy and mediastinoscopy. During minimally invasive procedures, decision factors regarding the best incision to perform include adequate access to the vascular injury, as well as the ability to complete the index procedure. **Tables 1** and **2** summarize procedure-specific vascular injury risks and injury-specific incisions for exposure.[1]

During an intraoperative bleeding event, basic principles include obtaining proximal and distal vascular control, assessment of injury, and repair. In general, injuries less than 30% of the vessel circumference can be repaired primarily; injuries between 30% and 50% of the vessel circumference may be patch repaired with elements such as vein, pericardium, or prosthetic materials; and injuries involving more than 50% of the circumference require either end-to-end anastomosis (if length is adequate), conduit interposition, or ligation.

Preoperative Imaging and Vascular Anatomic Variation

Preoperative imaging, especially computed tomography (CT), provides a valuable opportunity to identify vascular anatomic variations and understand tumor location with respect to major

The authors have nothing to disclose.
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Thorac Surg Clin 25 (2015) 261–278
http://dx.doi.org/10.1016/j.thorsurg.2015.04.001
1547-4127/15/$ – see front matter

Table 1
Procedure-related potential causes of bleeding

Procedure	Vascular Structure in Risk
Mediastinoscopy	Innominate artery SVC Azygous vein Main pulmonary artery Hilar pulmonary artery Ascending aorta
Lung resection	Pulmonary vessels Bronchial arteries Descending thoracic aorta Subclavian artery
Transhiatal esophagectomy	Inferior pulmonary vein Aortoesophageal branches Short gastric vessels
Transthoracic esophagectomy	Aortoesophageal branches Bronchial arteries Azygous vein
Thymectomy	Innominate vein SVC Internal thoracic vessels

Abbreviation: SVC, superior vena cava.

vascular structures. It is estimated that 95% to 98% of the vascular anatomy pertinent to the surgical procedure can be accurately determined preoperatively by CT.[2–5] The presence of calcification affecting lymph nodes has been associated with increased risk of vascular injury and a cause of conversion. Samson and colleagues[6] reported that patients with evidence of calcifications involving the hilum had a 37% risk of conversion, and a 25% risk of conversion with calcifications involving the bronchial tree.

Variations in the pulmonary arterial branching pattern are common and often may be the cause of bleeding complications when unrecognized, such as a posterior ascending artery originating from the superior segmental artery, and the wide variation in number of arterial branches to the left upper lobe. Although less common, venous abnormalities also have been recognized as a potential cause of vascular complications. The most common is locating a pulmonary segmental vein takeoff posterior to the bronchus intermedius, which is critical to recognize during subcarinal lymph node dissection.[7]

This finding was detected in 41 patients (5.7%) in a review of 725 CTs, and in 9 patients (3.9%) of 230 thoracotomy cases, with 55% draining to the upper pulmonary vein, 41% to the inferior pulmonary vein, and 4% to the superior segmental vein.[8] The number and distribution of the pulmonary venous drainage is also variable. In a review of 201 CT scans, Marom and colleagues[9] identified 2 primary right-sided pulmonary veins in 71% of patients, with the middle lobe vein joining the superior vein in 68%, and the inferior vein in 3%. In 28% of the patients there were between 3 and 5 pulmonary veins identified, and a single

Table 2
Recommended incisions to approach specific vascular injuries

Vascular Structure	Incision	Useful Measures
Innominate artery	Median sternotomy	Division of the innominate vein may offer better exposure
Innominate vein	Median sternotomy	Ligation for complex injuries is well tolerated
Superior vena cava	Median sternotomy	Fluid loading and vasoactive agents as required if cross clamping the SVC to be performed
Ascending aorta and aortic arch	Median sternotomy	—
Descending aorta	Left posterolateral thoracotomy	Left heart bypass may be required for complex injuries
Azygous vein	Right thoracotomy	—
Pulmonary vessels	Posterolateral thoracotomy	Intrapericardial vascular control sometimes may be required
Subclavian artery		
Left	Left anterolateral thoracotomy	Left posterolateral thoracotomy to be considered, may allow both repairing the injury and performing the index operation
Right	Median sternotomy	—

Adapted from Wall MJ Jr, Tsai P, Mattox KL. Heart and thoracic vascular injuries. In: Mattox KL, Moore EE, Feliciano DV, editors. Trauma. 7th edition. New York: McGraw Hill; 2013. p. 502.