

4. THORACIC INJURY
F. Penetrating Thoracic Injury

OBJECTIVE:

To provide guidelines for the diagnosis and management of patients with penetrating thoracic injuries.

GUIDELINES:

1. Any penetrating injury to the chest must be assumed to have caused internal organ damage, which may involve the:
 - a) Lungs and/or tracheobronchial tree (65% - 90%)
 - b) Esophagus (rare)
 - c) Great vessels (4%)
 - d) Cardiac (50%)
 - e) Diaphragm (30%)
2. In all unstable patients, assess the [ABCs](#) and secure the airway as quickly as possible, if necessary, while you obtain vascular access above and below the diaphragm.
3. If the patient has sustained cardiac arrest and has had signs of life (e.g., pulse, EKG activity, cardiac activity on the FAST) at any time (< 15 minutes before arrival) or is *in extremis* with low blood pressure, proceed directly to a left antero-lateral resuscitative thoracotomy in the 5th ICS, just below the nipple in the male or below the mammary fold in women.
4. If hemodynamically unstable or in respiratory distress, insert a large bore chest tube on the side where breath sounds are absent. If there is no improvement, consider placing another chest tube on the opposite side. Hemodynamic instability can be due to massive HTX. Signs of tension PTX/HTX include:
 - a) Absent breath sounds
 - b) Distended neck veins.
 - c) Shift of the trachea.
 - d) Dullness to percussion on the affected side
5. Pericardial FAST exam and obtaining CXR should be the first studies of choice.
6. Indications for prompt transfer of the patient with HTX to the OR for thoracotomy include:
 - a) Initial drainage of $\geq 1,500$ mL of blood
 - b) Drainage $\geq 2-300$ mL/hr for ≥ 3 hours.
 - c) Massive air leak causing loss of $\geq 40\%$ of TV.
7. If the injury is in the “**cardiac box**,” between nipples, xiphoid, and sternal notch, you must rule out a cardiac injury. Look for signs of tamponade, namely, hypotension, distended neck veins, distant heart sounds, and pulsus paradoxus.
 - a) Unstable patient: OR for left anterolateral thoracotomy (preferred) or median sternotomy as dictated by suspected injury.

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- b) Stable patient: perform the subxiphoid portion of the FAST/ Ultrasound for the presence or absence of cardiac effusion, *remember, FAST cannot rule out cardiac injury when there is a hemothorax on CXR.*
- c) If positive pericardial FAST: take the patient to the OR for a subxiphoid pericardial window and/or median sternotomy.
- d) FAST negative for effusion with negative CXR (no hemothorax): admit for observation
- e) FAST negative and CXR with hemothorax: consider subxiphoid window.

Approach to specific injuries

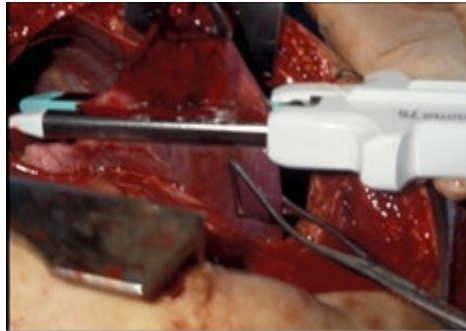
Tracheo-bronchial tree: regardless of the MOI (blunt or penetrating), the majority of injuries are within 2.5 cm of the carina with the following distribution: main stem 86%, distal bronchial 9.3%, and complex injuries 8%. Associated intrathoracic and mediastinal injuries are the rule. Cervical injuries may present with stridor, hemoptysis, cervical subcutaneous emphysema, hoarseness, or respiratory distress secondary to an obstructed airway. Thoracic injuries generally present with pneumothorax (PTX) and/or hemothorax (HTX). A PTX that persists after chest tube placement or has a continuous air leak indicates possible tracheobronchial damage. The “fallen lung sign” is a radiographic feature that is highly specific for tracheobronchial injury. On the CXR, the lung is falling away from rather than toward the hilum.

1. The diagnosis of tracheobronchial injury is made based on clinical and radiological findings and it is confirmed by bronchoscopy.
2. Most injuries should be approached through a right thoracotomy over the 5th rib since the majority of injuries are within 2.5 cm of the carina.
3. Left main stem bronchial injuries > 3 cm distal to the carina are best approached through a left posterolateral thoracotomy.
4. A dual-lumen endotracheal tube (Carlen or Robert Shaw) should be used for intubation.
5. The injury should be repaired with interrupted monofilament suture with extraluminal knots protected by buttressing with a muscle flap. Up to 2 cm of trachea can be resected with primary reconstruction.
6. The approach to the unstable patient with a massive air leak compromising oxygenation and ventilation, who cannot be brought to the OR because of hemodynamic instability, includes single lung ventilation. If necessary, extracorporeal veno-venous membrane oxygenation can be done.

Lung parenchyma⁶:

1. Superficial bleeding can be controlled with suture ligation with sutures.
2. Deep bleeding from penetrating injuries should be controlled with GIA stapler tractotomy to expose the bleeding vessels and subsequent suture ligation of the bleeding vessels with absorbable sutures.
3. Most lung injuries that require thoracotomy can be treated with tractotomy and non-anatomic lung resection. Shown below is a GSW to the lung treated with a GIA resection.

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4. Try to avoid clamping the hilum since the right ventricle cannot tolerate the increased afterload. If the bleeding cannot be controlled and you must clamp the pulmonary hilum and you do not have adequate exposure, you can control the bleeding by twisting the lung 180 degrees after taking down the inferior pulmonary ligament. Always attempt to control the bleeding first with pressure, including bimanual pressure, if necessary.
5. Trauma pneumonectomy has a very high mortality and should be avoided. If the patient is unstable at the end of your control of the bleeding, do not hesitate to complete your operation with the damage control approach to the chest. If performing trauma pneumonectomy, consider VV ECMO to offload the right heart.

Esophagus⁷:

Esophageal injuries are rare. They are usually caused by penetrating injuries. The cervical esophagus is the first 15cm from the incisors and is approximately 6cm long. The thoracic esophagus is the next 15cm (23cm from incisors). The intra-abdominal esophagus is 2-3cm long (38cm from incisors). The approach to the upper and middle thoracic esophagus is via a right postero-lateral thoracotomy in the 5th or 6th ICS. In contrast, the approach to the lower third is via a left postero-lateral thoracotomy in the 7th or 8th ICS. Caution to avoid injury to the Azygos vein on the right side (can be divided if necessary) or thoracic duct on the left side. Primary repair in two layers, with absorbable sutures for the mucosa and non-absorbable for the muscle layer. Buttress with pleural/pericardial flap or intercostal muscle flap should be done in all injuries < 24 hours. If necessary, you can use a diaphragmatic flap. Routine wide drainage should be performed.

Great vessels⁸:

1. The great vessels of the aorta include the left subclavian, the left common carotid, and the innominate arteries. Great vessel injuries are rarely encountered after penetrating chest trauma (4%) because victims typically exsanguinate into the chest or externally before arrival to the hospital. The presence of a wound at the base of the neck or a transmediastinal gunshot should alert you to the possibility of great vessel injury. The patient may be pulseless or moribund at presentation, and diagnosis is confirmed at the time of resuscitative thoracotomy.
2. In the stable patient or in the patient who is stable after resuscitation, the diagnosis can be confirmed with CTA. The incision of choice is a median sternotomy with a supraclavicular extension if necessary.

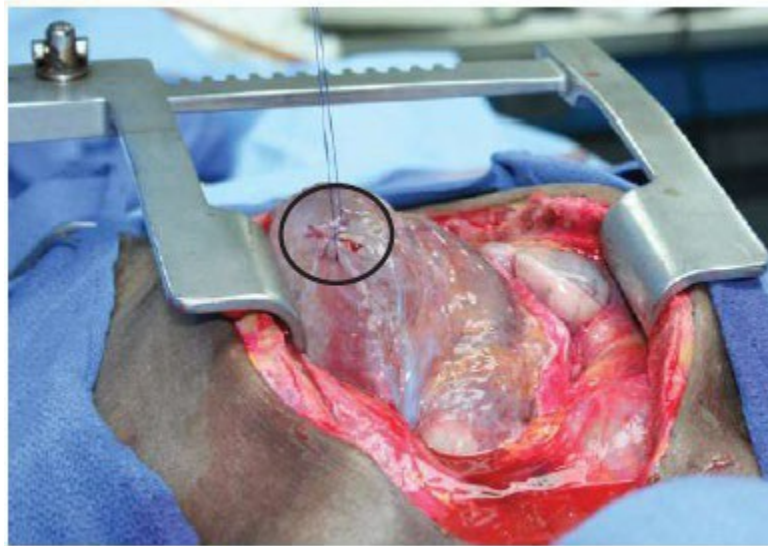
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In the case of isolated injury to the left subclavian (partial transection), temporary control can be achieved with a trans-brachial retrograde balloon approach and definitive control can be achieved with the deployment of a covered stent. Proximal control can also be obtained through a median sternotomy at the origin of the vessel.

Cardiac⁹:

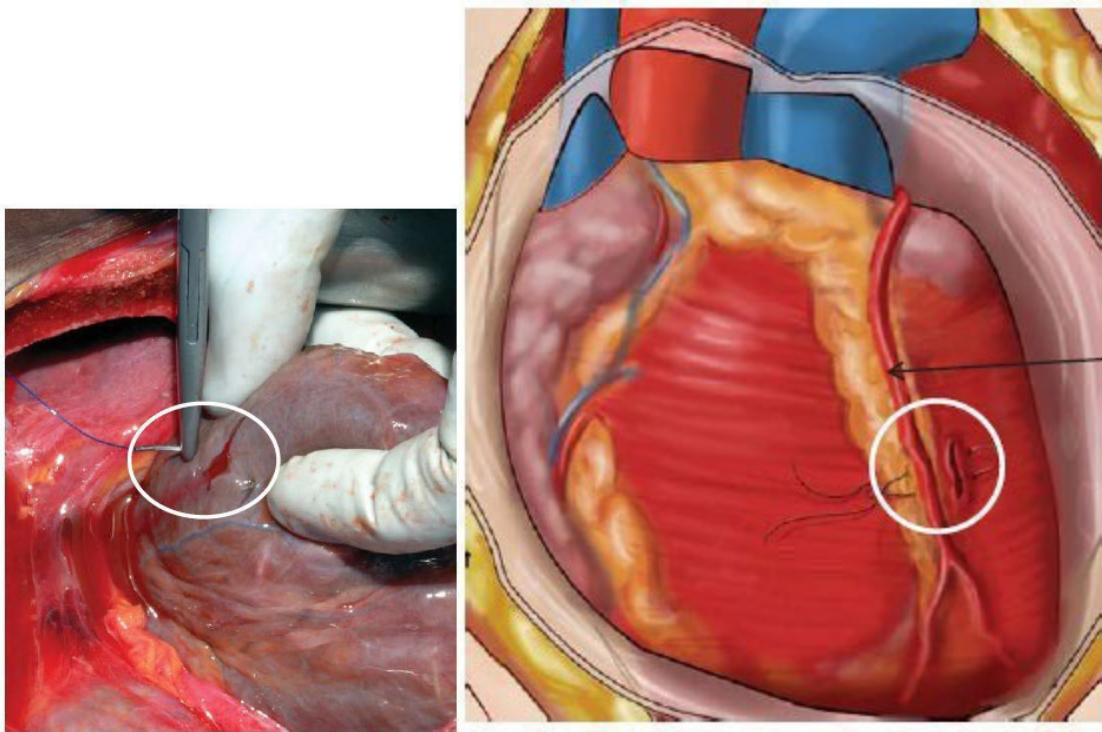
Distribution of injuries include the right ventricle 40%, left ventricle 40%, right atrium 24%, left atrium 3%, and coronary arteries 5%.

Atrial wounds can be controlled rapidly with a Satinsky clamp and then oversewn with a running 3-0 Prolene suture, as shown below.



Injuries to the free wall of the right and left ventricle that are remote from the coronary arteries are controlled with digital pressure and then repaired using horizontal mattress polypropylene sutures (3-0 or 4-0) with large needles and pledgets, if necessary. Injuries near the coronary arteries must be closed without encompassing the coronary artery. Horizontal mattress sutures are placed deep and lateral to the coronary artery across the injury and out the opposite side, as shown on the next page.

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An alternate temporary way to control bleeding involves placement of a Foley catheter in the injury site; while the method is described as simple, it is **not recommended** for ventricular injuries because it is associated with complications.

Once you have repaired the cardiac injury, you must exclude a coexistent intra-cardiac injury. If the patient is stable, consider an intra-operative TEE; otherwise delay the TEE to a later time since the intra-cardiac injury may be delayed.

Diaphragm:

The incidence of injuries is 1% in patients with blunt trauma and 8% in patients undergoing laparotomy for thoraco-abdominal trauma.

Penetrating injuries to the lower chest have a high incidence of diaphragmatic injuries: 32% with SWs and 59% with GSWs.

Patients with left lower chest injuries from SWs without evidence of peritonitis should undergo diagnostic laparoscopy during their hospitalization. Diaphragmatic injuries may be repaired laparoscopically or open. Those with peritonitis should undergo conventional laparotomy.

All patients with penetrating thoracoabdominal trauma should be considered for laparotomy or laparoscopy to rule out associated abdominal injuries, depending on the patient's hemodynamics and preoperative workup.

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References:

1. Miglietta MA et al: Current opinion regarding indications for emergency department thoracotomy. J Trauma 2001; 51(4):670–6.
2. Ivatury RR et al: Directed emergency room thoracotomy: a prognostic prerequisite for survival. J Trauma 1991; 31(8):1076–81.
3. Bleetman A et al: Review of emergency thoracotomy for chest injuries in patients attending a UK Accident and Emergency department. Injury 1996; 27(2):129–32.
4. Rhee PM et al: Survival after emergency department thoracotomy: review of published data from the past 25 years. J Am Coll Surg 2000; 190(3):288–98.
5. Branney SW et al: Critical analysis of two decades of experience with post-injury emergency department thoracotomy in a regional trauma center. J Trauma 1998; 45(1):87–94
6. Petrone P, Asensio JA. Surgical treatment of penetrating pulmonary injuries. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine 2009, 17:8
7. Asensio JA, Chahwan S, Forno W, et al. Penetrating esophageal injuries: multicenter Study of the American Association for the Surgery of Trauma. J Trauma 2001; 50(2):289–96.
8. Demetriades D. Penetrating injuries to the thoracic great vessels. J Card Surg 1997; 12 (2):173–9.
9. Asensio JA, Stewart BM, Murray J, et al. Penetrating cardiac injuries. Surg Clin North Am 1996; 76(4):685–724.
10. “Section 5: Chest.” *Atlas of Surgical Techniques in Trauma*, by Demetrios Demetriades et al., Cambridge University Press, 2020.

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