Chapter 38
Chest Trauma: Blunt Aortic and Cardiac Trauma

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Clinical Problem

A 25-year-old restrained driver of a motor vehicle involved in a head-on collision was admitted to the intensive care unit with multiple complex extremity fractures, sternal fracture, and scattered trunk abrasions and ecchymoses. A left-sided chest tube was placed in the trauma bay for pneumothorax. The patient continues to complain of chest pain. He has been hemodynamically stable after fluid resuscitation, except for mild persistent tachycardia.

Blunt chest trauma may result in serious and potentially life threatening injuries to the heart and great vessels. Greater than two-thirds of all thoracic aortic injuries are consequent to motor vehicle crashes (MVC). Aortic injury occurs in approximately 1.5–2 % of all MVC's, but accounts for up to 15 % of MVC-related deaths. The majority of such injuries are fatal at the scene of accident.

Cardiac contusion is exceedingly uncommon in the injured patient, but it is the most common cardiac injury associated with blunt trauma. Its mechanism usually requires extreme blunt force, often with a significant head-on component. While a

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variety of mechanisms have been described, the most common cause of myocardial contusion is deceleration in a motor vehicle crash, followed by falls, animal kicks, industrial crushing injuries and assaults.

Imaging Techniques

If the index of suspicion for a blunt chest trauma is high and the patient survives to a trauma center imaging is required very early on to rule out life-threatening injuries. Volumetric helical computed tomography angiography with appropriately timed intravenous contrast has become the gold standard for diagnosing and characterizing injuries to the aorta and other great vessels. Transesophageal echocardiography (TEE) may additionally be helpful in evaluating the thoracic aorta. While sensitivity and specificity have been reported as high as 100 %, these tend to be variable among reports and are notably operator dependent. A unique advantage of TEE in evaluating the aorta lies in its portability. TEE may be used intraoperatively during a trauma laparotomy or at the bedside in the ICU. If negative, CT angiography is still recommended once the patient is stable enough for the study in order not to miss more subtle injuries.

Blunt Aortic Injury

This is an imprecise term used to describe a range of injuries to the aorta. Patients who survive to hospital typically have a tear of the intima or of intima and media. The integrity of the aorta is, at least temporarily, maintained by the adventitia. The most widely accepted mechanisms for aortic injury are those of high-velocity abrupt deceleration or massive blow to the anterior chest. In the setting of rapid deceleration the most frequent location of an aortic tear occurs just distal to the takeoff of the left subclavian artery, at the level of the ligamentum arteriosum. The aorta just proximal to the ligamentum arteriosum is more mobile and can forcefully swing away from the fixed distal portion. The resulting shear stress causes aortic disruption.

Up to one-third of patients brought to hospitals with traumatic aortic injuries have minimal, if any, external evidence of injury to the chest. Clinical findings that should lead the practitioner to consider aortic injury include sternal instability, heart murmur between the scapulae, unequal extremity blood pressure readings and flail chest on the left. Hypotension is not usually caused by the aortic injury; patients with aortic injuries significant enough to cause hemorrhagic shock tend not to survive to hospital.

A number of features have been described on chest radiographs as being associated with blunt aortic injury (Fig. 38.1, Table 38.1). None of these findings are particularly sensitive or specific for aortic injury. While such findings may raise

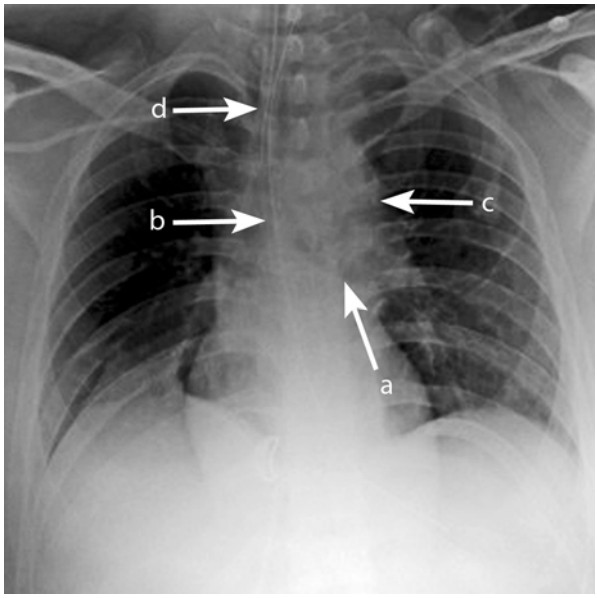

Fig. 38.1 Chest radiograph demonstrates typical findings associated with aortic injury: downward displacement of the left mainstem bronchus (*a*), right sided displacement of the esophagus with nasogastric tube shifted to the right of midline (*b*), widened superior mediastinum and ill-defined aortic knob (*c*), trachea and endotracheal tube shifted to the right of midline (*d*)

Table 38.1 Plain chest film features associated with aortic injury

Widened mediastinum
Prominent or obliterated aortic knob
Trachea deviated to the right
Esophagus deviated to the right
Left main bronchus depression
Hemothorax
Loss of aorto-pulmonary window
Left apical cap

one's index of suspicion, plain chest radiography cannot serve as a definitive diagnostic modality.

CT imaging is the reference standard for diagnosing aortic injury (Figs. 38.2 and 38.3). With modern scanners and higher resolution output, the sensitivity and negative predictive value of CT in evaluating the integrity of the thoracic aorta approaches 100 %. Further, the wide availability, speed, safety, and ease of interpretation make CT more attractive than formal angiography. The CT findings associated with aortic injury are summarized in Table 38.2. Despite the numerous strengths of the CT in evaluating aortic injuries, its sensitivity and specificity can vary among centers and radiologists. Potential pitfalls in imaging the thoracic aorta, including failure to distinguish true intimal injuries from anatomic variants—such as ductus diverticulum—and pulsation artifact, are minimized with experienced image interpretation.

Prior to recent improvements in CT imaging, catheter aortography was long held as the gold-standard test for aortic injury. Its role is now fairly limited, as it requires considerable investment of time and cost, and it is more invasive than CT

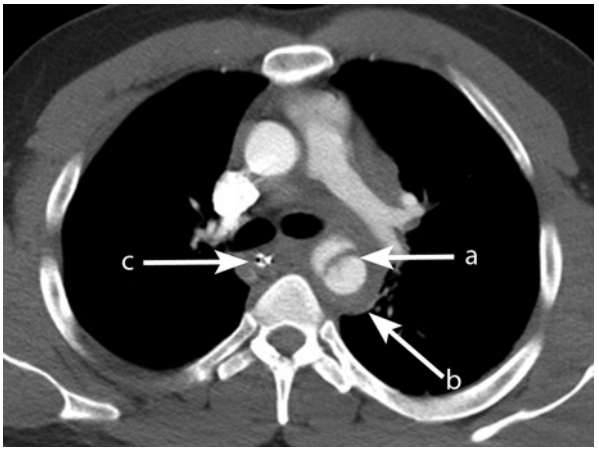

Fig. 38.2 Multi-detector computed tomography (CT) angiogram demonstrating: pseudoaneurysm distal to the aortic isthmus (*a*), surrounding mediastinal hemorrhage (*b*), rightward displacement of the esophagus (*c*)

Fig. 38.3 Sagittal Maximum Intensity Projection (MIP) image demonstrates pseudoaneurysm and intima injury, just distal to the aortic isthmus at the level of the ligamentum arteriosum (*a*)

evaluation. However, its utility should not be forgotten, along with its near 100 % sensitivity and specificity. While it is no longer considered the reference-standard examination, there may be circumstances in which catheter aortography can be

Table 38.2 CT features associated with aortic injury

Extravasation of contrast
Filling defects
Para-aortic hematoma
Mural thickening
Vascular intimal flaps
Mural thrombi
Pseudoaneurysm
Contained rupture
Abnormal aortic contour
Sudden change in aortic caliber

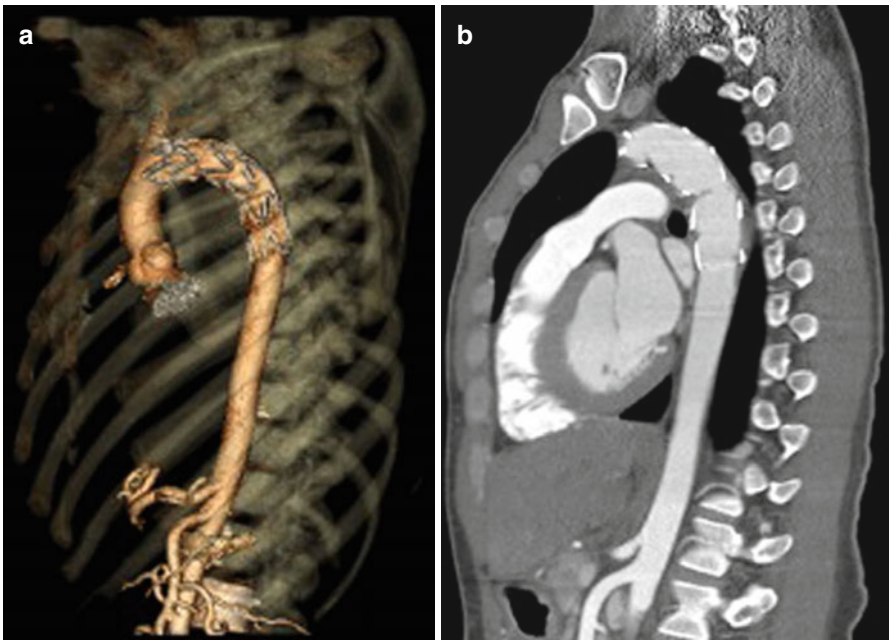

Fig. 38.4 Postoperative imaging of a successful endovascular stent graft bridging the site of aortic injury, including: (**a**) volume rendered image; (**b**) sagittal Multiplanar Reformatted (MPR) Image

useful. Aortography should be considered when a patient is already undergoing catheter-based angiography, such as pelvic angio-embolization. Angiographic, endovascular management of the aortic injury is now commonly employed (Fig. 38.4a, b).

Intravascular ultrasonography, performed by threading a high-frequency ultrasound transducer through a large arterial sheath, allows acquisition of real-time circumferential images of the aorta. While this technique requires further development and standardization, there are data to suggest that intravascular sonographic evaluation may be more specific than catheter-based contrast aortography among patients with equivocal CT findings. However, at present, this technique is limited due to its

cost, invasiveness, and paucity of data. As further developments proceed, this strategy may have a role in future approaches to evaluating patients with potential aortic injuries.

Minimal Aortic Injuries (MAI)

This term refers to a classification of small intimal tears and intramural hematomas, the discovery of which have led to recent controversy with regard to subsequent requisite management. These small, sub-centimeter intimal injuries have been identified with greater frequency as CT resolution has improved. MAI were probably under-recognized during the era of catheter angiography as the primary diagnostic modality.

MAIs tend to appear as small luminal defects, intimal flaps, or intramural collections, usually without any associated pseudoaneurysm or mediastinal hematoma. A range of treatment strategies have been suggested for patients with these small injuries, varying from imaging surveillance to endovascular therapy to more invasive operative intervention. While it appears safe to observe subcentimeter lesions, this remains an ongoing area of interest and investigation.

Blunt Cardiac Injury

High-pressure forces may be inciting factors for severe, immediately life-threatening injuries, including ruptures of the cardiac free wall or intraventricular septum, valvular cusps, or chordae tendinae. More often, and with less dramatic findings, these forces may result in myocardial contusion. The most common anatomic location injured is the right ventricle, due to its placement in the anterior mediastinum. The diagnosis of cardiac contusion requires the presence of:

- an appropriate mechanism
- chest wall tenderness or pain
- demonstration of early arrhythmia or signs of heart failure.

One should have a high index of suspicion based on the mechanism of injury. Additional clinical settings that may raise concern include the young trauma patient with unexpected arrhythmias and the older trauma patient with angina unresponsive to nitroglycerin.

The diagnosis of myocardial contusion can be difficult. Confirming the diagnosis in a stable patient may not be critical, as it does not change management. Electrocardiography tends to be nonspecific. A number of potential arrhythmias have been described, the most common of which is sinus tachycardia – which is a common finding in the trauma population at large. Cardiac enzymes may or may not be abnormal, and trending of CK and troponin levels is of unclear utility.

In patients with normal electrocardiogram and normal chest x-ray, no further cardiac imaging is generally recommended, as the combination of these two studies has adequate negative predictive value. If concerns about heart failure continue to exist echocardiography is the most useful imaging study, as it can demonstrate wall motion abnormalities and valvular injury. Evidence does not support the use of this tool for routine screening.

Teaching points

1. Findings on chest x-ray concerning for aortic injury include: widened mediastinum (>8 cm), prominent or obliterated aortic knob, tracheal deviation, depressed left mainstem bronchus, hemothorax, and loss of aortopulmonary window. Presence of these findings mandates CT for further characterization.
2. Contrast-enhanced spiral CT serves as the current standard for evaluating the thoracic aortic. One should look for evidence of extravasation of contrast, filling defects, associated para-aortic hematomas, mural thickening, vascular intimal flaps, mural thrombi, and pseudoaneurysms.
3. While the management of subcentimeter intimal lesions continues to evolve, such findings are increasing in frequency with improved CT resolution. Minimal aortic injuries should be noted, with consideration given to treatment or surveillance options.
4. Cardiac contusion can be difficult to diagnose with imaging modalities. Evaluation should be focused on physiologic parameters, with the use of echocardiography reserved for functional evaluation in the presence of clinical abnormalities.