American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Blunt Chest Trauma — Suspected Aortic Injury**

Radiologic Procedure	Rating	Comments	RRL*
CTA chest with IV contrast	9	This is the diagnostic test of choice for suspected blunt aortic injury.	☢☢☢
X-ray chest	9	Radiographs are complementary to more definitive studies.	☢
MRA chest without and with IV contrast	7	This procedure should be performed on patients with contraindication to CTA.	O
Aortography thoracic	6		☢☢☢
CT chest without IV contrast	5		☢☢☢
US echocardiography transesophageal	5		O
MRA chest without IV contrast	5		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

BLUNT CHEST TRAUMA — SUSPECTED AORTIC INJURY

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Summary of Literature Review

Introduction/Background

Trauma ranks fifth behind cardiovascular disease, cancer, chronic lower respiratory disease, and cerebrovascular disease as a cause of death in the United States [1]. Seventy-five percent of deaths from blunt trauma are due entirely or in part to chest injuries. Although reported incidence of aortic injury is approximately 5% [2], only 20% of patients with isolated aortic rupture will survive the initial injury [3]. Of those who survive the initial injury, approximately 30% will die within first 6 hours and 49% within 24 hours [4]. With advanced imaging technology leading to accurate diagnosis, coupled with innovative procedures such as endovascular graft repair, the mortality rate has decreased over time.

There are 4 theories of mechanism of aortic injury: 1) sudden increase in intravascular pressure, 2) shearing due to sudden deceleration, 3) sudden stretching of the isthmus, and 4) osseous pinch [3,5,6]. Baque et al [5] physically demonstrated properties of stretching of the isthmus and suggested that a better understanding of mechanism of injury may result in improvement in vehicle safety. Whatever the mechanism may be, isolated thoracic aortic injury tends to occur most commonly distal to the left subclavian artery (79%). Of these, 61% arise at the aortic isthmus and 21% at the ascending aorta or the aortic arch [3]. Preservation of the adventitia is crucial to maintain a barrier to exsanguination in survivors. Therefore, most demonstrate injury to the intima and media (60%) with intact adventitia [7]. Although survival has been reported in the past, complete laceration of the aorta more commonly results in death at the accident site and is seen at autopsy. Such rare cases of survival are often due to contained pseudoaneurysm by periaortic tissue. Chronic pseudoaneurysm may arise years after the traumatic event.

To add to difficulties of correctly identifying patients with aortic injury, there is great variability in presentation. Patients may present in full cardiovascular collapse or complain of chest pain, midscapular pain, abdominal pain, dyspnea, tachycardia, hemoptysis, and cyanosis. Even with clinical manifestations, most of these findings are a result of other related chest injuries. In patients with aortic rupture, 36% had minimal or no evidence of external injury [3]. Because of the variable presentation, a high index of suspicion for traumatic rupture of the aorta must be assumed for any patient who has sustained high-speed rapid deceleration.

Modern imaging technologies enable accurate diagnosis and treatment planning, including the identification of minimal aortic injury and small tears of the intima. The Vancouver simplified grading system demonstrated correlation with patient mortality: grade I (minimal aortic injury) and II (intimal flap larger than 1cm) injuries demonstrated 100% survival, grade III (traumatic pseudoaneurysm) demonstrated 90% survival, and grade IV (active contrast extravasation) demonstrated 33% survival, allowing early prognostication of patients [8].

Overview of Imaging Modalities

Chest Radiography

Chest radiography (CXR) is the standard first examination for evaluation of blunt aortic injury (BAI) and is often included in most trauma center protocols in the initial evaluation of patients with polytrauma [9]. Radiographs are complementary to more definitive studies such as computed tomography angiography (CTA) of the chest with contrast or magnetic resonance angiography (MRA) of the chest without and with contrast. Even though some studies suggest reserving further imaging with normal CXR for certain populations [10], if aortic injury is

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suspected, CXR should be followed with CTA, as approximately 7% of patients with BAI will have a normal CXR [11-13]. Alternatively as noted below, MRA of the chest without and with contrast can be used to confirm clinically suspected traumatic injury to the aorta.

Uncertainty of patient stability and injury can limit image acquisition in the trauma setting, sometimes limiting a study to supine portable anteroposterior (AP) radiographs that magnify the width of the superior mediastinum. Sitting the patient upright when feasible for an anteroposterior radiograph will mitigate this technical limitation [14]. A widened mediastinum suggests hematoma. However, hemorrhage in the mediastinum is most often commonly from rupture of small arteries and veins [7], and this finding is not specific for aortic injury. Although first and second rib fractures indicate a significant trauma, data suggest that these injuries are not associated with greater incidence of aortic injury [15]. Other findings include obscuration of aortic knob, AP window, and superior mediastinum, left paraspinous line displacement, deviation of the trachea, and enlargement of the aortic knob. Although all radiography findings can suggest of aortic injury, the sensitivity is also <100% [9]. In patients with an abnormal CXR, thoracic CT was more likely to alter management [16], and if aortic injury is suspected then concomitant CTA should be performed.

Computed Tomography Angiography
Advancement in technology and availability has increased the role of CT for assessment of patients with suspected aortic injury [17-19]. Multidetector CT protocols and image postprocessing allow reconstruction of angiographic images of the aorta and its branches in multiple planes. Electrocardiography (ECG) gating allows even better visualization of the aortic root by decreasing pulsation artifact [20,21], allowing radiologists to more confidently exclude aortic root injuries from artifacts without proceeding with more invasive studies. Studies have shown high sensitivity and negative predictive value in the evaluation of suspected traumatic aortic injury when there are no signs of direct aortic injury such as an intimal flap, change in aortic contour or caliber, intraluminal irregularity, pseudoaneurysm, or intramural hematoma. Some authors have found that even in the presence of mediastinal hematoma, aortic injury is unlikely without direct evidence of aortic injury on CTA [22]. Others have shown a high specificity for aortic injury when such direct signs are present [23,24]. False-positive scans may occur secondary to false identification of ductus arteriosus remnant or atherosclerotic plaque as aortic injury [18]. Many centers have abandoned aortography in the initial evaluation of patients at risk of aortic injury and instead use CTA [25]. With improved sensitivity, specificity, and negative predictive value approaching 100% [17,26], along with the ability to detect other occult thoracic findings such as pneumothorax, pulmonary contusions, and fractures, CTA has gained wide approval and acceptance as the diagnostic test of choice for evaluation of BAI.

Computed Tomography
It has been suggested that routine CT has relatively lower, though still substantial, added diagnostic value compared with selective CT of the chest in patients with severe blunt trauma [27]. In patients with absolute contraindication to intravenous iodinated contrast material, noncontrast CT of the chest may be a good alternative diagnostic test. Although intraluminal integrity of the aorta cannot be assessed, absence of mediastinal hematoma or the ability to exclude other causes of mediastinal widening such as mediastinal fat, anatomic variation, or artifact may be enough to exclude aortic injury in certain patients. Multiple studies have found, in absence of mediastinal hematoma, that the probability of significant aortic injury is very low [22,26,28]. Studies have confirmed that patients with a negative chest CT in this setting have favorable clinical outcomes [29].

Magnetic Resonance Angiography
Due to long acquisition time, clinical instability of the patient, restricted accessibility to patient, and patient motion secondary to loss of consciousness or ventilator dependence, MR does not play a significant role in the initial diagnostic evaluation of the critically ill, hemodynamically unstable patients. Despite such limitations, MRA has proven to be useful in evaluation of chronic traumatic aortic pseudoaneurysms [30]. The benefit of MRI/MRA is its ability to incorporate functional cardiac data much like transthoracic echocardiography (TTE)/transesophageal echocardiography (TEE) while providing excellent visualization of the vasculature [30]. Typically, MRA of the chest without and with contrast is performed in lieu of CTA for those patients with relative contraindication. Breath-hold ECG-gated contrast-enhanced MRA can provide diagnostic images of the thoracic aorta in cooperative, hemodynamically stable patients with blunt chest trauma [31], especially in patients with contraindication to iodinated contrast material.

Aortogram
Before technical advances in CT, thoracic aortography was widely accepted as the reference standard for evaluating patients with suspected aortic injury [2]. The aortogram establishes the diagnosis, defines the anatomy

of the lesion, and also identifies additional sites of injuries. Approximately 20% of patients have multiple tears [32]. The catheter-based aortogram has become a problem-solving tool in certain patients with indirect signs of aortic injury on CT [33]. Various film sequences have been used, including AP, lateral, and oblique projections. It should be emphasized that more than one projection should be used to detect an aortic injury, as aortic injuries may be missed on single-projection views. Because acutely injured patients are in a hyperdynamic state, high-contrast volumes of 60 to 70 mL must be rapidly injected. The development of intravascular ultrasound (IVUS) has offered an adjunct to standard transfemoral aortography. Although the routine use of IVUS is neither indicated nor practical, in a few cases it has been found to be useful in confirming or excluding thoracic aortic injury when angiographic findings are subtle or uncertain [34,35]. For example, a study by Malhotra et al [36] demonstrated a sensitivity of the initial aortogram for minimal aortic injury to be 37.5%; however, with IVUS, sensitivity, specificity, and negative predictive value were 100%, suggesting its utility in identifying subtle intramural abnormalities.

Transesophageal Echocardiography

Echocardiography has been used in the acute trauma setting to evaluate the heart for contusions and abnormalities in the thoracic aorta. Focused Cardiac Ultrasound (FoCUS) in the emergent setting is typically performed by emergency medicine physicians and has been recommended for clinically suspected cardiac injury, particularly with respect to volume resuscitation [37]. However, FoCUS has not been recommended for suspected injury to the aorta [38]. TTE is also of limited use [39] and, like FoCUS, will not be further evaluated. TEE has a higher sensitivity than TTE. Given that only 4% of patients with combined aortic rupture and cardiac injury survive the initial injury when compared to 20% of those with isolated aortic rupture [3], additional information obtained by TEE maybe helpful for prognosis. TEE is operator-dependent, requires sedation, and is more invasive than CT. In some patients, blind spots created by the tracheobronchial bifurcation may preclude adequate visualization of portions of the aortic arch. Other blind spots for TEE are the distal ascending aorta and the aortic arch vessels, sites of traumatic injury in up to 20% of patients with blunt chest trauma [40]. Thus, TEE is not recommended as a sole diagnostic study for patients with suspected aortic injury [40,41]. When CTA must be delayed for emergent abdominal exploration, intraoperative TEE may be a useful modality to evaluate for aortic injury [42]. Several studies have reported excellent diagnostic accuracy using TEE for recognizing aortic injury [34,41,43-47]. This experience, however, has not been uniformly positive.

Summary of Recommendations

- The literature supports chest radiography as the initial screening examination in the patient who has sustained blunt chest trauma.
- CTA is the most sensitive and specific examination for acute aortic injury and has replaced thoracic aortography as the primary imaging tool in many trauma centers.
- MRA is usually appropriate and is typically performed for patients with contraindication to CTA.
- With this expanding role for CTA, the use of IVUS and TEE is diminishing but may be useful in select cases.

Summary of Evidence

Of the 47 references cited in the *ACR Appropriateness Criteria® Blunt Chest Trauma-Suspected Aortic Injury* document, all of them are categorized as diagnostic references including 1 well-designed study, 7 good quality studies, and 12 quality studies that may have design limitations. There are 27 references that may not be useful as primary evidence.

The 47 references cited in the *ACR Appropriateness Criteria® Blunt Chest Trauma-Suspected Aortic Injury* document were published between 1958–2014.

While there are references that report on studies with design limitations, 8 well-designed or good quality studies provide good evidence.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document.

Relative Radiation Level Designations		
Relative Radiation Level*	**Adult Effective Dose Estimate Range**	**Pediatric Effective Dose Estimate Range**
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢ ☢	0.1-1 mSv	0.03-0.3 mSv
☢ ☢ ☢	1-10 mSv	0.3-3 mSv
☢ ☢ ☢ ☢	10-30 mSv	3-10 mSv
☢ ☢ ☢ ☢ ☢	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies".		

Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

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