American College of Radiology
ACR Appropriateness Criteria®
Penetrating Torso Trauma

Variant 1: **Adult. Penetrating torso trauma, hypotensive. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography trauma series	Usually Appropriate	☢☢☢
CT chest abdomen pelvis with IV contrast	Usually Appropriate	☢☢☢☢
CTA chest abdomen pelvis with IV contrast	Usually Appropriate	☢☢☢☢☢
MRI chest abdomen pelvis without and with IV contrast	Usually Not Appropriate	O
MRI chest abdomen pelvis without IV contrast	Usually Not Appropriate	O
CT chest abdomen pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CT chest abdomen pelvis without IV contrast	Usually Not Appropriate	☢☢☢☢

Variant 2: **Adult. Ballistic penetrating torso trauma, unknown trajectory, normotensive. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography trauma series	Usually Appropriate	☢☢☢
CT chest abdomen pelvis with IV contrast	Usually Appropriate	☢☢☢☢
CTA chest abdomen pelvis with IV contrast	Usually Appropriate	☢☢☢☢☢
CT chest abdomen pelvis without and with IV contrast	May Be Appropriate	☢☢☢☢
MRI chest abdomen pelvis without and with IV contrast	Usually Not Appropriate	O
MRI chest abdomen pelvis without IV contrast	Usually Not Appropriate	O
CT chest abdomen pelvis without IV contrast	Usually Not Appropriate	☢☢☢☢

Variant 3: **Adult. Ballistic penetrating torso trauma, limited to chest, normotensive. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography trauma series	Usually Appropriate	☢☢☢
CT chest with IV contrast	Usually Appropriate	☢☢☢
CTA chest with IV contrast	Usually Appropriate	☢☢☢
CT abdomen and pelvis with IV contrast	May Be Appropriate (Disagreement)	☢☢☢
CT chest without IV contrast	May Be Appropriate	☢☢☢
CTA abdomen and pelvis with IV contrast	May Be Appropriate (Disagreement)	☢☢☢☢
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☢☢☢
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢

Variant 4: **Adult. Ballistic penetrating torso trauma, limited to abdomen and pelvis, normotensive. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography trauma series	Usually Appropriate	☢☢☢
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
CTA abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢☢
CT chest with IV contrast	May Be Appropriate (Disagreement)	☢☢☢
CTA chest with IV contrast	May Be Appropriate (Disagreement)	☢☢☢
CT abdomen and pelvis without and with IV contrast	May Be Appropriate	☢☢☢☢
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☢☢☢
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢
CT chest without IV contrast	Usually Not Appropriate	☢☢☢

Variant 5: **Adult. Nonballistic penetrating torso trauma, unknown trajectory, normotensive. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography trauma series	Usually Appropriate	☢☢☢
CT chest abdomen pelvis with IV contrast	Usually Appropriate	☢☢☢☢
CTA chest abdomen pelvis with IV contrast	Usually Appropriate	☢☢☢☢☢
MRI chest abdomen pelvis without and with IV contrast	Usually Not Appropriate	O
MRI chest abdomen pelvis without IV contrast	Usually Not Appropriate	O
CT chest abdomen pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CT chest abdomen pelvis without IV contrast	Usually Not Appropriate	☢☢☢☢

Variant 6: **Adult. Nonballistic penetrating torso trauma, limited to chest, normotensive. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography trauma series	Usually Appropriate	☢☢☢
CT chest with IV contrast	Usually Appropriate	☢☢☢
CTA chest with IV contrast	Usually Appropriate	☢☢☢
CT abdomen and pelvis with IV contrast	May Be Appropriate (Disagreement)	☢☢☢
CT chest without IV contrast	May Be Appropriate	☢☢☢
CTA abdomen and pelvis with IV contrast	May Be Appropriate	☢☢☢☢
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☢☢☢
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢

Variant 7: **Adult. Nonballistic penetrating torso trauma, limited to abdomen and pelvis, normotensive. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography trauma series	Usually Appropriate	☢☢☢
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
CT chest with IV contrast	May Be Appropriate	☢☢☢
CTA chest with IV contrast	May Be Appropriate (Disagreement)	☢☢☢
CTA abdomen and pelvis with IV contrast	May Be Appropriate	☢☢☢☢
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢
CT chest without IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢

PENETRATING TORSO TRAUMA

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Summary of Literature Review

Introduction/Background

Penetrating torso trauma occurs when a foreign body disrupts the skin and enters the patient. The anatomical boundaries of the torso begin cranially at the thoracic inlet and caudally at the inferior margins of the greater trochanters, excluding the appendicular skeletal structures. Penetrating trauma most commonly occurs from gunshots and stabbings, although any object can impale the patient. High rates of mortality and morbidity are associated with gunshot wounds, with approximately 42,222 deaths in 2020 or 13.7 deaths per 100,000 people [1]. Stab wounds are much more common, estimated at 434,259 injuries annually; however, these wounds rarely result in death. According to the Centers for Disease Control and Prevention, between 2003 and 2019, a total number of 6,015 deaths were reported in the United States from stab injuries [1].

In penetrating trauma, the type and location of injury (or injuries), along with the patient's clinical status, guide immediate management, including what area of the torso that may require advanced imaging. The presumed trajectory of the foreign body at both clinical and radiologic examination often guides detection and treatment of injuries [2]. Furthermore, the type of penetrating trauma also plays an important role in the treatment decision algorithm of penetrating trauma. Most ballistic traumas are high-energy injuries and carry the risk of additional radial injury along the missile track due to the transfer of kinetic energy [3]. Knife injuries, on the other hand, are typically low-energy injuries with only tissue along the tract of the wound at risk and do not always require advanced imaging for evaluation depending on the depth of the penetrating wound [4].

This document only reviews penetrating torso trauma in adults. Specific recommendations on imaging suspected bladder and urethral injury to the ACR Appropriateness Criteria® topic on "Penetrating Trauma—Lower Abdomen and Pelvis" [5].

Special Imaging Considerations

Imaging, in particular multidetector CT, plays a central role in guiding management in patients with penetrating trauma. Contrast-enhanced CT with multiplanar reformations is the standard imaging tool in the evaluation of patients with penetrating trauma due to its fast acquisition and excellent resolution [2,3]. Single versus multiphasic protocols vary depending upon both institutional protocols and clinical presentation. Multiphasic protocols that include an arterial phase may improve the identification and characterization of vascular injuries, whereas the assessment of solid organs in the abdomen and pelvis is best performed during the portal venous phase [6]. Furthermore, the American Association for the Surgery of Trauma recommends dual-phase CT (arterial and venous phases) for accurate diagnosis of vascular injuries of the solid organs including the spleen, liver, or kidney [7]. Throughout this manuscript, CT angiography (CTA) will presuppose at least 2 postcontrast phases of imaging in addition to the angiography phase. When there is suspicion or knowledge of renal injury, delayed excretory phase imaging should be acquired [8]. In addition to intravenous (IV) administration of contrast, some institutions advocate the administration of oral and rectal contrast when there is concern for bowel injury in the setting of

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penetrating trauma [9,10]. Radiography and focused assessment with ultrasonography for trauma (FAST) play an important role in triage, often directing next step management [11-17].

The role of FAST (or extended-FAST or chest abdominal-FAST in evaluating chest injury) is primarily one of triage; a positive FAST and signs of hemodynamic instability may lead to immediate surgical intervention rather than CT [18,19]. Ultrasound (US) may be able to diagnose certain thoracic and abdominal injuries, but it is an insufficient test to fully exclude injuries to these areas because it has a relatively lower specificity compared with CT [20].

Initial Imaging Definition

Initial imaging is defined as imaging at the beginning of the care episode for the medical condition defined by the variant. More than one procedure can be considered usually appropriate in the initial imaging evaluation when:

- There are procedures that are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care)

OR

- There are complementary procedures (ie, more than one procedure is ordered as a set or simultaneously where each procedure provides unique clinical information to effectively manage the patient's care).

Discussion of Procedures by Variant

Variant 1: Adult. Penetrating torso trauma, hypotensive. Initial imaging.

It is important to assess for hemodynamic stability clinically before performing any imaging. Hemodynamic stability is defined as systolic blood pressure ≥90 mm Hg and a heart rate of 50 to 110 beats per minute [21]. Portable chest and pelvic radiographs and a focused abdominal US for trauma are valuable means in identifying such injuries. The initial focus in management of patients with penetrating hemodynamically unstable trauma should be early and aggressive hemostatic resuscitation, prompt diagnosis of all life-threatening injuries, and early control of ongoing bleeding [22,23].

FAST can help triage patients and direct initial bedside and surgical procedures. Hemopericardium, pneumothorax, and free intraperitoneal fluid discovered at FAST have significant implications on next steps in management of the patient. Some trauma systems also use prehospital FAST to expedite management upon arrival to the hospital [14,16].

CT Chest, Abdomen, and Pelvis With IV Contrast

Traditionally and in most practices, patients with penetrating trauma demonstrating signs of hemodynamic instability would be operatively managed without CT imaging [24]. However, recently, some authors recommend whole-body CT while continuing resuscitation regardless of hemodynamic status [25,26]. Proponents of this approach suggest the information gathered during CT helps determine the optimal surgical approach and prevents delay of definitive management. The degree of hemodynamic instability and distance to the CT scanner should be accounted for when deciding upon use of CT in this clinical scenario.

CT Chest, Abdomen, and Pelvis Without and With IV Contrast

There is no relevant literature regarding the use of CT chest, abdomen, and pelvis without and with IV contrast for initial evaluation of patients with penetrating torso trauma with hypotension. If CT imaging is performed in this patient population, the imaging time should be minimized as much as possible, and therefore without IV contrast imaging is not routinely recommended.

CT Chest, Abdomen, and Pelvis Without IV Contrast

There is no relevant literature regarding the use of CT chest, abdomen, and pelvis without IV contrast for initial evaluation of patients with penetrating torso trauma with hypotension. If CT imaging is performed in this patient population, IV contrast should be administered.

CTA Chest, Abdomen, and Pelvis IV Contrast

Most literature supporting the use of multiphase CTA imaging in the torso is derived from the blunt trauma patient population [27]. Literature suggests the detection of vascular injury is similar between routine contrast-enhanced CT of the chest and CTA of the chest; however, the justification for performing routine contrast-enhanced CT of the chest and CTA imaging was to reduce the need for two separate contrast injections [28]. Most modern-day CT

scanners and protocols enable imaging of the entire body in multiple phases with one IV contrast bolus [29]. If imaging is pursued in this imaging population, single-phase imaging to include the portal venous phase may provide the most relevant information for next step imaging.

MRI Chest, Abdomen, and Pelvis Without and With IV Contrast
There is no relevant literature regarding the use of MRI chest, abdomen, and pelvis without and with IV contrast for initial evaluation of patients with penetrating torso trauma with hypotension.

MRI Chest, Abdomen, and Pelvis Without IV Contrast
There is no relevant literature regarding the use of MRI chest, abdomen, and pelvis without IV contrast for initial evaluation of patients with penetrating torso trauma with hypotension.

Radiography Trauma Series
Chest radiographs can recognize contusions, pneumothorax, hemothorax, rib fractures, foreign bodies and/or ballistic fragments, and mediastinal injuries, which could be treated immediately. Radiographic evaluation can also help identify retained foreign bodies and suggest trajectory, which may direct initial surgical exploration.

Variant 2: Adult. Ballistic penetrating torso trauma, unknown trajectory, normotensive. Initial imaging.

FAST can help triage patients and direct initial bedside and surgical procedures. Hemopericardium, pneumothorax, and free intraperitoneal fluid discovered at FAST have significant implications on next steps in management of the patient. Some trauma systems also use prehospital FAST to expedite management upon arrival to the hospital [14,16].

CT Chest, Abdomen, and Pelvis With IV Contrast
In hemodynamically stable patients who have ballistic trauma of uncertain trajectory, CT of the chest, abdomen, and pelvis with IV contrast plays a vital role in management. Typically, CT is performed after initial triage imaging (radiography trauma series and FAST). However, Kondo et al [15] demonstrated that in-hospital mortality was not significantly different when FAST was bypassed in this patient population. To aid in detection of internal injuries, many trauma teams place radiodense markers or indicators at suspected entry and/or exit wounds to aid in determining trajectory [3]. CT is optimal for identifying the trajectory of the ballistic injury and predicting the organs and torso compartments that may be involved, and a recent international survey suggested that most radiologist use “cognitive” tractography rather than commercial software [30]. Single-acquisition whole-torso imaging is preferred over segmental imaging so that the tract of the bullet can be followed [2,3].

CT Chest, Abdomen, and Pelvis Without and With IV Contrast
There is no relevant literature regarding the use of CT chest, abdomen, and pelvis without and with IV contrast for initial evaluation of penetrating torso trauma. The addition of a noncontrast phase may delay definitive diagnosis and typically does not provide additional information pertinent to penetrating trauma [31].

CT Chest, Abdomen, and Pelvis Without IV Contrast
There is no relevant literature regarding the use of CT chest, abdomen, and pelvis without IV contrast for initial evaluation of penetrating torso trauma. Although noncontrast CT may be helpful in determining trajectory, demonstration of internal injuries, specifically solid organs, is much more apparent with IV contrast. During the global shortage of contrast in 2022, unenhanced CT scans were used for acute and posttraumatic patients in emergency departments at some institutions [32].

CTA Chest, Abdomen, and Pelvis IV Contrast
In the hemodynamically stable patient population, multiphasic imaging can provide additional useful information regarding the source of active bleeding. Additionally, it is important to remember that imaging can be performed after damage control surgery to identify injuries that may need definitive treatment [29,33]. In their retrospective study, Nummela et al [29] found that arterial and venous phases of the chest, abdomen, and pelvis CT facilitated recognition of active bleeding in patients with penetrating thoracic trauma. Differentiating between arterial and venous hemorrhage may have treatment implications. For example, a hemodynamically stable patient with active arterial bleeding may be treated with an angioembolization procedure, whereas bleeding from a venous structure may result in supportive care [29,33].

MRI Chest, Abdomen, and Pelvis Without And With IV Contrast
There is no relevant literature regarding the use of MRI chest, abdomen, and pelvis without and with IV contrast for initial evaluation of patients with penetrating torso trauma.

MRI Chest, Abdomen, and Pelvis Without IV Contrast
There is no relevant literature regarding the use of MRI chest, abdomen, and pelvis without IV contrast for initial evaluation of patients with penetrating torso trauma with hypotension.

Radiography Trauma Series
Chest radiographs can recognize contusions, pneumothorax, hemothorax, rib fractures, foreign bodies and/or ballistic fragments, and mediastinal injuries, which should be treated immediately. Radiographic evaluation can also help identify retained foreign bodies and suggest trajectory which may direct initial surgical exploration.

Variant 3: Adult. Ballistic penetrating torso trauma, limited to chest, normotensive. Initial imaging.

FAST can help triage patients and direct initial bedside and surgical procedures. Hemopericardium, pneumothorax, and free intraperitoneal fluid discovered at FAST have significant implications on next steps in management of the patient. Some trauma systems also use prehospital FAST to expedite management upon arrival to the hospital [14,16]. FAST is particularly important in patients with penetrating trauma to the "cardiac box" [34,35].

CT Abdomen and Pelvis With IV Contrast
CT could be performed if there is suspected suspicion for intraperitoneal violation. Overall, liberal use of imaging in ballistic trauma is recommend because the trajectory can be unpredictable. Diaphragmatic excursion may be high at time of injury, making intra-abdominal injuries difficult to exclude.

CT Abdomen and Pelvis Without and With IV Contrast
There is no relevant literature regarding the use of adding a noncontrast phase to a contrast-enhanced CT abdomen and pelvis for initial evaluation of penetrating torso trauma limited to the chest.

CT Abdomen and Pelvis Without IV Contrast
There is no relevant literature regarding the use of CT abdomen and pelvis without IV contrast for initial evaluation of penetrating torso trauma. During the global shortage of contrast in 2022, unenhanced CT scans were used for acute and posttraumatic patients in emergency departments at some institutions [36].

CT Chest With IV Contrast
CT of the chest has been established as the imaging modality of choice for characterizing penetrating thoracic injuries, including soft tissues and vascular structures, heart and pericardium and bony thorax, mediastinum, diaphragm, and lungs [37]. It offers a high negative predictive value up to 99% in triaging hemodynamically stable patients with penetrating chest trauma. Screening thoracic CT successfully excludes surgery in patients with nonsignificant radiologic findings [37]. CT with IV contrast also adequately identifies vascular injuries such as pseudoaneurysms, intimal flaps, filling defects, or contrast extravasation [28]. In their prospective study, Gunn et al [38] found that CT chest with IV contrast offered a fast, noninvasive means to assess missile trajectories and allows precise assessment of potential mediastinal injury and decreases the need for routine angiographic and esophageal studies in patients with mediastinal gunshot wounds. Special attention should be made to injuries in the "cardiac box" anatomically defined by the sternal notch superiorly, the xiphoid process inferiorly, and the nipples laterally [39]. Patients with injuries in this region can rapidly decompensate; however, selective CT imaging can help identify findings suggestive of cardiac injury, such as hemopericardium and pneumopericardium [40].

CT Chest Without And With IV Contrast
There is no relevant literature regarding the usefulness of adding a noncontrast phase to a contrast-enhanced CT chest for initial evaluation of penetrating torso trauma limited to the chest

CT Chest Without IV Contrast
During the global shortage of contrast in 2022, unenhanced CT scans were used for acute and posttraumatic patients in emergency departments at some institutions [36]. Noncontrast imaging of the chest is inadequate to definitively evaluate the chest for vascular injuries in the setting of ballistic trauma isolated to the chest.

CTA Abdomen and Pelvis With IV Contrast
Nummela et al [29] concluded that CTA of the whole body is recommended because multiple injuries and active bleeding are common in penetrating thoracic trauma. CTA of the abdomen and pelvis should be used liberally because the terminal ballistics of bullets and other fragments may have an unpredictable trajectory.

CTA Chest With IV Contrast
CTA of the chest is a valuable modality in assessment of penetrating transmediastinal injury in hemodynamically stable patients. It can guide immediate surgical intervention versus expectant management in conjunction with

transesophageal echocardiogram [38]. CTA may better demonstrate pseudoaneurysm, vascular occlusion, active contrast extravasation, intimal tear, and early venous filling in arteriovenous fistulas.

MRI Abdomen and Pelvis Without And With IV Contrast
There is no relevant literature regarding the use of MRI abdomen and pelvis without and with IV contrast for initial evaluation of patients with penetrating torso trauma.

MRI Abdomen and Pelvis Without IV Contrast
There is no relevant literature regarding the use of MRI abdomen and pelvis without IV contrast for initial evaluation of patients with penetrating torso trauma.

MRI Chest Without And With IV Contrast
There is no relevant literature regarding the use of MRI chest without and with IV contrast for initial evaluation of patients with penetrating torso trauma.

MRI Chest Without IV Contrast
There is no relevant literature regarding the use of MRI chest without IV contrast for initial evaluation of patients with penetrating torso trauma.

Radiography Trauma Series
Chest radiographs can recognize contusions, pneumothorax, hemothorax, rib fractures, foreign bodies and/or ballistic fragments, and mediastinal injuries, which could be treated immediately. Radiographic evaluation can also help identify retained foreign bodies and suggest trajectory, which may direct initial surgical exploration. Some authors suggest that a chest radiograph may be adequate in this patient population, and CT identifies additional findings that do not require surgical intervention [41]. Other authors, however, point out the limitations of chest radiography [42]. Berg et al [43] found that patients with penetrating thoracic trauma or asymptomatic patients with unremarkable initial chest radiographs can be safely discharged by short-term repeat chest radiographs.

Variant 4: Adult. Ballistic penetrating torso trauma, limited to abdomen and pelvis, normotensive. Initial imaging.

FAST can help triage patients and direct initial bedside and surgical procedures. Hemopericardium, pneumothorax, and free intraperitoneal fluid discovered at FAST have significant implications on next steps in management of the patient. FAST is particularly good at "ruling in" free intraperitoneal fluid but has not been shown to effectively exclude intraperitoneal injury in the setting of ballistic trauma [13].

CT Abdomen and Pelvis With IV Contrast
CT abdomen and pelvis with IV contrast is instrumental in decision making in this patient population. Traditionally, ballistic trauma to the abdomen and pelvis required laparotomy or, at the very least, diagnostic laparoscopy. However, recent literature suggests that "selective conservatism" can be accomplished with a combination negative CT imaging and clinical examination [44,45]. Literature supports the use of both "triple-contrast" (oral, IV, and rectal) and single-contrast (IV contrast) techniques [9,10,46]. Munera et al [47] prospectively evaluated the role of CT with triple-contrast material in evaluation of stable patients with abdominal gunshot wounds and found that triple-contrast CT can reduce the number of cases of unnecessary laparotomy and can identify patients with injuries that may be safely treated nonsurgically [10].

CT Abdomen and Pelvis Without And With IV Contrast
There is no relevant literature regarding the use of CT abdomen and pelvis without and with IV contrast for initial evaluation of penetrating torso trauma. The addition of a noncontrast phase does not provide additional information pertinent to penetrating trauma [31].

CT Abdomen and Pelvis Without IV Contrast
There is no relevant literature regarding the use of CT abdomen and pelvis without IV contrast for initial evaluation of penetrating torso trauma. During the global shortage of contrast in 2022, unenhanced CT scans were used for acute and posttraumatic patients in emergency departments at some institutions [36].

CT Chest With IV Contrast
Given the unpredictable trajectory of ballistic trauma, liberal use of CT imaging of the chest is typically performed when there is presumed isolated abdominal and pelvic trauma [2].

CT Chest Without and With IV Contrast
There is no relevant literature regarding the use of CT chest without and with IV contrast for initial evaluation of penetrating torso trauma. The addition of a noncontrast phase does not provide additional information pertinent to penetrating trauma [31].

CT Chest Without IV Contrast
There is no relevant literature regarding the use of CT chest without IV contrast for initial evaluation of penetrating torso trauma. During the global shortage of contrast in 2022, unenhanced CT scans were used for acute and posttraumatic patients in emergency departments at some institutions [36].

CTA Abdomen and Pelvis With IV Contrast
In the hemodynamically stable patient population, multiphasic imaging can provide additional useful information regarding the source of active bleeding. Additionally, it is important to remember that imaging can be performed after damage control surgery to identify injuries that may need definitive treatment [29,33]. In their retrospective study, Nummela et al [29] found that arterial and venous phases of the chest, abdomen, and pelvis CT facilitated recognition of active bleeding in patients with penetrating thoracic trauma. Differentiating between arterial and venous hemorrhage may have treatment implications. For example, a hemodynamically stable patient with active arterial bleeding may be treated with an angioembolization procedure, whereas bleeding from a venous structure may result in supportive care [29,33].

CTA Chest With IV Contrast
CTA of the chest is now routinely used for both blunt and penetrating trauma at many level 1 trauma centers. CTA may better demonstrate pseudoaneurysm, vascular occlusion, active contrast extravasation, intimal tear, and early venous filling in arteriovenous fistulas [29,48].

MRI Abdomen and Pelvis Without and With IV Contrast
There is no relevant literature regarding the use of MRI abdomen and pelvis without and with IV contrast for initial evaluation of patients with penetrating torso trauma.

MRI Abdomen and Pelvis Without IV Contrast
There is no relevant literature regarding the use of MRI abdomen and pelvis without IV contrast for initial evaluation of patients with penetrating torso trauma.

MRI Chest Without and With IV Contrast
There is no relevant literature regarding the use of MRI chest without and with IV contrast for initial evaluation of patients with penetrating torso trauma.

MRI Chest Without IV Contrast
There is no relevant literature regarding the use of MRI chest without IV contrast for initial evaluation of patients with penetrating torso trauma.

Radiography Trauma Series
It is common practice at many trauma centers to mark presumed penetrating wounds with radiodense markers. Radiographic evaluation can help identify retained foreign bodies and suggest trajectory, which may direct additional imaging or mandate surgical exploration.

Variant 5: Adult. Nonballistic penetrating torso trauma, unknown trajectory, normotensive. Initial imaging.

FAST can help triage patients and direct initial bedside and surgical procedures. Hemopericardium, pneumothorax, and free intraperitoneal fluid discovered at FAST have significant implications on next steps in management of the patient. Some trauma systems also use prehospital FAST to expedite management upon arrival to the hospital [14,16].

CT Chest, Abdomen, and Pelvis With IV Contrast
In hemodynamically stable patients who have nonballistic penetrating trauma of uncertain trajectory or multiple points of entry, CT of the chest, abdomen, and pelvis with IV contrast plays a vital role in management [29,49] Typically, CT is performed after initial triage imaging (radiography trauma series and FAST). However, Kondo et al [15] demonstrated that in-hospital mortality was not significantly different when FAST was bypassed in this patient population. CT is optimal for identifying the trajectory of the penetrating injury and predicting the organs and torso compartments that may be involved, and a recent international survey suggested that most radiologist use "cognitive" tractography rather than commercial software [2,30]. Radiodense markers are typically used to mark

the sites of skin violation, which is much more important with sharp object low energy penetrating trauma. Additional information should be sought regarding blade length or the presence of bruising or a "hilt mark" at the skin entry site when evaluating stab wounds. Single-acquisition whole torso-imaging is preferred over segmental imaging so that the tract of the wound can be followed [2].

CT Chest, Abdomen, and Pelvis Without And With IV Contrast
There is no relevant literature regarding the use of CT chest, abdomen, and pelvis without and with IV contrast for initial evaluation of penetrating torso trauma. The addition of a noncontrast does not provide additional information pertinent to penetrating trauma [31].

CT Chest, Abdomen, and Pelvis Without IV Contrast
There is no relevant literature regarding the use of CT chest, abdomen, and pelvis without IV contrast for initial evaluation of penetrating torso trauma. Although noncontrast CT may be helpful in determining trajectory, demonstration of internal injuries, specifically solid organs, is much more apparent with IV contrast. During the global shortage of contrast in 2022, unenhanced CT scans were used for acute and posttraumatic patients in emergency departments at some institutions [36].

CTA Chest, Abdomen, and Pelvis IV Contrast
In the hemodynamically stable patient population, multiphasic imaging can provide additional useful information regarding the source of active bleeding. Additionally, it is important to remember that imaging can be performed after damage control surgery to identify injuries that may need definitive treatment [29,33]. In their retrospective study, Nummela et al [29] found that arterial and venous phases of the chest, abdomen, and pelvis CT facilitated recognition of active bleeding in patients with penetrating thoracic trauma. Differentiating between arterial and venous hemorrhage may have treatment implications. For example, a hemodynamically stable patient with active arterial bleeding may be treated with an angioembolization procedure, whereas bleeding from a venous structure may result in supportive care [29,33].

MRI Chest, Abdomen, and Pelvis Without and With IV Contrast
There is no relevant literature regarding the use of MRI chest, abdomen, and pelvis without and with IV contrast for initial evaluation of patients with penetrating torso trauma.

MRI Chest, Abdomen, and Pelvis Without IV Contrast
There is no relevant literature regarding the use of MRI chest, abdomen, and pelvis without IV contrast for initial evaluation of patients with penetrating torso trauma with hypotension.

Radiography Trauma Series
Chest radiographs can recognize contusions, pneumothorax, hemothorax, rib fractures, retained foreign bodies, and mediastinal injuries, which should be treated immediately. Radiographic evaluation can also help identify retained foreign bodies and suggest trajectory, which may direct initial surgical exploration. The limitations of radiography, particularly chest radiography, should be understood in the setting of nonballistic trauma. Nguyen et al [50] showed that greater than one-third of patients in their study had additional findings on CT after a normal screening chest radiograph.

Variant 6: Adult. Nonballistic penetrating torso trauma, limited to chest, normotensive. Initial imaging.

Injuries that are considered limited to the chest occur outside of the thoracoabdominal zone. Anatomical landmarks can include above the nipple line in men or above the fourth rib. Wounds occurring below these anatomical landmarks could involve abdominal structures given significant diaphragmatic excursion.

FAST can help triage patients and direct initial bedside and surgical procedures. Hemopericardium, pneumothorax, and free intraperitoneal fluid discovered at FAST have significant implications on next steps in management of the patient. Some trauma systems also use prehospital FAST to expedite management upon arrival to the hospital [14,16].

CT Abdomen and Pelvis With IV Contrast
It is useful to get CT scans of the abdomen and pelvis if there is suspicion of peritoneal violation or possible diaphragmatic injuries.

CT Abdomen and Pelvis Without and With IV Contrast
There is no relevant literature regarding the use of CT abdomen and pelvis without and with IV contrast for initial evaluation of penetrating torso trauma isolated to the chest and does not provide additional information pertinent to penetrating trauma [31].

CT Abdomen and Pelvis Without IV Contrast
There is no relevant literature regarding the use of CT abdomen and pelvis without IV contrast for initial evaluation of penetrating torso trauma isolated to the chest. During the global shortage of contrast in 2022, unenhanced CT scans were used for acute and posttraumatic patients in emergency departments at some institutions [36].

CT Chest With IV Contrast
Contrast-enhanced chest CT is an effective screening tool for determining the wound trajectory and likelihood of injury to mediastinal structures. CT can guide the decision-making process in management of patients in whom immediate surgical intervention could be performed with positive findings at CT chest [51]. If CT shows no evidence of mediastinal injury or other thoracic injury requiring surgery, the patient can simply be observed [37].

CT Chest Without And With IV Contrast
There is no relevant literature regarding the use of CT chest without and with IV contrast for initial evaluation of penetrating torso trauma isolated to the chest. The addition of a noncontrast phase does not provide additional information pertinent to penetrating trauma [31].

CT Chest Without IV Contrast
Although noncontrast CT may be helpful in determining trajectory, demonstration of internal injuries, specifically solid organs, is much more apparent with IV contrast. Vascular injuries are also better depicted with IV contrast. CT chest without IV contrast can effectively excluded pneumothorax and hemothorax [50]. During the global shortage of contrast in 2022, unenhanced CT scans were used for acute and posttraumatic patients in emergency departments at some institutions [36].

CTA Abdomen and Pelvis With IV Contrast
In the hemodynamically stable patient population, multiphasic imaging can provide additional useful information regarding the source of active bleeding. Additionally, it is important to remember that imaging can be performed after damage control surgery to identify injuries that may need definitive treatment [29,33].

CTA Chest With IV Contrast
In the hemodynamically stable patient population, CTA can provide additional useful information regarding the source of active bleeding. Additionally, it is important to remember that imaging can be performed after damage control surgery to identify injuries that may need definitive treatment [29,33]. In their retrospective study, Nummela et al [29] found that arterial and venous phases of the chest, abdomen, and pelvis CT facilitated recognition of active bleeding in patients with penetrating thoracic trauma. Differentiating between arterial and venous hemorrhage may have treatment implications. For example, a hemodynamically stable patient with active arterial bleeding may be treated with an angioembolization procedure, whereas bleeding from a venous structure may result in supportive care [29,33].

MRI Abdomen and Pelvis Without and With IV Contrast
There is no relevant literature regarding the use of MRI chest, abdomen, and pelvis without and with IV contrast for initial evaluation of patients with penetrating torso trauma.

MRI Abdomen and Pelvis Without IV Contrast
There is no relevant literature regarding the use of MRI chest, abdomen, and pelvis without IV contrast for initial evaluation of patients with penetrating torso trauma with hypotension.

MRI Chest Without and With IV Contrast
There is no relevant literature regarding the use of MRI chest without and with IV contrast only for initial evaluation of patients with penetrating torso trauma.

MRI Chest Without IV Contrast
There is no relevant literature regarding the use of MRI chest without IV contrast only for initial evaluation of patients with penetrating torso trauma.

Radiography Trauma Series
Penetrating trauma occurring outside of the thoracoabdominal zones and the cardiac box maybe sufficiently imaged with radiography in clinically stable patients [51]. Normal radiographic appearance of the chest does not preclude significant thoracic trauma that may require procedural or surgical intervention [50].

Variant 7: Adult. Nonballistic penetrating torso trauma, limited to abdomen and pelvis, normotensive. Initial imaging.

FAST can help triage patients and direct initial bedside and surgical procedures. Hemopericardium, pneumothorax, and free intraperitoneal fluid discovered at FAST have significant implications on next steps in management of the patient.

CT Abdomen and Pelvis With IV Contrast
CT abdomen and pelvis with IV contrast is instrumental in decision making in this patient population. Literature supports the use of both "triple-contrast" (oral, IV, and rectal) and single-contrast (IV contrast) techniques [9,10,46]. Triple-contrast CT is especially helpful in identifying hollow viscus injury. CT imaging with physical examination allows for the nonoperative safe management of some patients [24,49].

CT Abdomen and Pelvis Without and With IV Contrast
There is no relevant literature regarding the use of CT abdomen and pelvis without and with IV contrast for initial evaluation of penetrating torso trauma isolated to the chest. The addition of a noncontrast phase adds radiation exposure to the patient and may delay definitive diagnosis and typically does not provide additional information pertinent to penetrating trauma [31].

CT Abdomen and Pelvis Without IV Contrast
There is no relevant literature regarding the use of CT abdomen and pelvis without IV contrast for initial evaluation of penetrating torso trauma. Although noncontrast CT may be helpful in determining trajectory, demonstration of internal injuries, specifically solid organs, is much more apparent with IV contrast. During the global shortage of contrast in 2022, unenhanced CT scans were used for acute and posttraumatic patients in emergency departments at some institutions [36].

CT Chest With IV Contrast
CT chest may be used if there is suspicion of supradiaphragmatic injury involving the lungs, heart, diaphragm, or pleural space.

CT Chest Without and With IV Contrast
There is no relevant literature regarding the use of CT chest without and with IV contrast for initial evaluation of penetrating torso trauma limited to the abdomen and pelvis.

CT Chest Without IV Contrast
There is no relevant literature regarding the use of CT chest without IV contrast for initial evaluation of penetrating torso trauma limited to the abdomen and pelvis. The addition of a noncontrast phase does not provide additional information pertinent to penetrating trauma [31].

CTA Abdomen and Pelvis With IV Contrast
In the hemodynamically stable patient population, multiphasic imaging can provide additional useful information regarding the source of active bleeding. Additionally, it is important to remember that imaging can be performed after damage control surgery to identify injuries that may need definitive treatment [29,33].

CTA Chest With IV Contrast
In the hemodynamically stable patient population, CTA can provide additional useful information regarding the source of active bleeding. Additionally, it is important to remember that imaging can be performed after damage control surgery to identify injuries that may need definitive treatment [29,33]. In their retrospective study, Nummela et al [29] found that arterial and venous phases of the chest, abdomen, and pelvis CT facilitated recognition of active bleeding in patients with penetrating thoracic trauma. Differentiating between arterial and venous hemorrhage may have treatment implications. For example, a hemodynamically stable patient with active arterial bleeding may be treated with an angioembolization procedure, whereas bleeding from a venous structure may result in supportive care [29,33].

MRI Abdomen and Pelvis Without and With IV Contrast
There is no relevant literature regarding the use of MRI abdomen and pelvis without and with IV contrast for initial evaluation of patients with penetrating torso trauma.

MRI Abdomen and Pelvis Without IV Contrast
There is no relevant literature regarding the use of MRI abdomen and pelvis without IV contrast for initial evaluation of patients with penetrating torso trauma with hypotension.

MRI Chest Without and With IV Contrast
There is no relevant literature regarding the use of MRI chest without and with IV contrast for initial evaluation of patients with penetrating torso trauma.

MRI Chest Without IV Contrast
There is no relevant literature regarding the use of MRI chest without IV contrast for initial evaluation of patients with penetrating torso trauma with hypotension.

Radiography Trauma Series
Radiography of the abdomen in stab wounds limited to the abdomen and pelvis have limited usefulness. If injuries occur in the thoracoabdominal region, chest radiography should be performed.

Summary of Highlights

- **Variant 1**: Even in hemodynamically unstable patients, radiographic examination is performed simultaneously with the initial resuscitation and primary clinical survey. Traditionally, and in most practices, patients with penetrating trauma demonstrating signs of hemodynamic instability would be operatively managed without CT or CTA imaging. However, the panel agrees that the decision to perform CT or CTA imaging in this scenario is highly dependent on the provider's practice environment. Whole-body CT or CTA while continuing resuscitation has been reported to help determine the optimal surgical approach and prevent delay of definitive management.
- **Variant 2**: In hemodynamically stable patients who have ballistic trauma of uncertain trajectory, CT or CTA of the chest, abdomen, and pelvis with IV contrast plays a vital role in management, in addition to traditional radiographic evaluation. CT or CTA is optimal for identifying the trajectory of the ballistic injury and predicting the organs and torso compartments that may be involved. Single-acquisition whole-torso imaging is preferred over segmental imaging so that the tract of the bullet can be followed.
- **Variant 3**: After radiographic evaluation, CT or CTA of the chest with IV contrast is the imaging modality of choice for characterizing penetrating thoracic injuries allowing for the visualization of soft tissues and vascular structures, including the heart, bony thorax, mediastinum, diaphragm, and lungs. Disagreement around the use of CT or CTA of the abdomen and pelvis arose in the panel, because some members disagree with the liberal use of these imaging tests in the variant described (ie, isolated to the chest). Those who supported the use of CT or CTA of the abdomen and pelvis pointed to the unpredictability of ballistic trauma trajectory as well as the position of the diaphragm at the time of injury.
- **Variant 4**: Traditionally, ballistic trauma to the abdomen and pelvis required laparotomy. Radiography is used to identify trajectory and retained ballistic fragments. However, recent literature suggests that "selective conservatism" can be accomplished with a combination negative CT (or CTA) imaging and clinical examination. Disagreement around the use of CT or CTA of the chest arose in the panel, as some members disagree with the liberal use of these imaging tests in the variant described (ie, isolated to the abdomen and pelvis). Those who supported the use of CT or CTA of the chest pointed to the unpredictability of ballistic trauma trajectory as well as the position of the diaphragm at the time of injury.
- **Variant 5:** In hemodynamically stable patients who have nonballistic penetrating trauma of uncertain trajectory or multiple points of entry, CT or CTA of the chest, abdomen, and pelvis with IV contrast plays a vital role in management. Typically, CT or CTA is performed after initial triage imaging (radiography trauma series and FAST). CT or CTA is optimal for identifying the trajectory of the penetrating injury and predicting the organs and torso compartments that may be involved. A recent international survey suggested that most radiologist use "cognitive" tractography rather than commercial software. Radiodense markers are typically used to mark the sites of skin violation, which is much more important with sharp-object low-energy penetrating trauma.

- **Variant 6**: In nonballistic penetrating trauma isolated to the chest, radiography and CT (or CTA) of the chest play a vital role in management. Typically, CT or CTA is performed after initial triage imaging (radiography trauma series and FAST). Disagreement around the use of CT and/or CTA of the abdomen and pelvis arose in the panel, because some members disagree with the liberal use of these imaging tests in the variant described (ie, isolated to the chest). Those who supported the use of CT or CTA of the abdomen pointed to the unpredictable location of the diaphragm at the time of injury.
- **Variant 7**: CT abdomen and pelvis with IV contrast is instrumental in decision making in this patient population, specifically the decision to manage the patient's injury operatively or conservatively. Disagreement around the use of CT or CTA of the chest arose in the panel, because some members disagree with the liberal use of these imaging tests in the variant described (ie, isolated to the abdomen and pelvis). Those who supported the use of CT or CTA of the chest pointed to the unpredictable location of the diaphragm at the time of injury.

Supporting Documents

The evidence table, literature search, and appendix for this topic are available at https://acsearch.acr.org/list. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

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

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

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, because of both 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 with 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 [52].

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."		

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The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.