American College of Radiology
ACR Appropriateness Criteria®
Major Blunt Trauma

Variant 1: **Major blunt trauma. Hemodynamically unstable. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography trauma series	Usually Appropriate	☢☢☢
US FAST scan chest abdomen pelvis	Usually Appropriate	O
CT whole body with IV contrast	May Be Appropriate	☢☢☢☢
CT whole body without 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

Variant 2: **Major blunt trauma. Hemodynamically stable. Not otherwise specified. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
CT whole body with IV contrast	Usually Appropriate	☢☢☢☢
Radiography trauma series	Usually Appropriate	☢☢☢
US FAST scan chest abdomen pelvis	Usually Appropriate	O
CT whole body without IV contrast	May Be Appropriate	☢☢☢☢
Fluoroscopy retrograde urethrography	Usually Not 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

Variant 3: **Major blunt trauma. Hemodynamically stable. Suspected facial injury. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
CT maxillofacial without IV contrast	Usually Appropriate	☢☢
CT head without IV contrast	Usually Appropriate	☢☢☢
Radiography trauma series	Usually Appropriate	☢☢☢
CT whole body with IV contrast	May Be Appropriate (Disagreement)	☢☢☢☢
CT whole body without IV contrast	May Be Appropriate	☢☢☢☢
CT head with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CT maxillofacial with IV contrast	Usually Not Appropriate	☢☢
CT maxillofacial without and with IV contrast	Usually Not Appropriate	☢☢☢

Variant 4: **Major blunt trauma. Hemodynamically stable. Suspected extremity trauma. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography extremity	Usually Appropriate	Varies
CT whole body with IV contrast	Usually Appropriate	☢☢☢☢
Radiography trauma series	Usually Appropriate	☢☢☢
US FAST scan chest abdomen pelvis	Usually Appropriate	O
CT extremity without IV contrast	May Be Appropriate	Varies
CT whole body without IV contrast	May Be Appropriate (Disagreement)	☢☢☢☢
CTA extremity area of interest with IV contrast	May Be Appropriate (Disagreement)	Varies
CT extremity with IV contrast	Usually Not Appropriate	Varies
CT extremity without and with IV contrast	Usually Not Appropriate	Varies

Variant 5: **Major blunt trauma. Hemodynamically stable. Suspected bowel trauma. Initial imaging.**

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

Variant 6: **Major blunt trauma. Hemodynamically stable. Suspected urinary system, including urethra trauma. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Fluoroscopy retrograde urethrography	Usually Appropriate	☢☢☢
Radiography trauma series	Usually Appropriate	☢☢☢
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
CT whole body with IV contrast	Usually Appropriate	☢☢☢☢
CTA abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢☢
US FAST scan chest abdomen pelvis	Usually Appropriate	O
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
CT urography	May Be Appropriate (Disagreement)	☢☢☢☢
CT whole body without IV contrast	May Be Appropriate	☢☢☢☢
Radiography intravenous urography	Usually Not Appropriate	☢☢☢
US abdomen and pelvis	Usually Not Appropriate	O
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢
MR urography	Usually Not Appropriate	O
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O

Variant 7: **Major blunt trauma. Hemodynamically stable. Suspected chest trauma. Initial imaging.**

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

Variant 8: **Major blunt trauma. Hemodynamically stable. Pregnant patient. Initial imaging.**

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

MAJOR BLUNT TRAUMA

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Summary of Literature Review

Introduction/Background

This review covers imaging of major blunt trauma or polytrauma resulting in multiple organ injuries. Penetrating traumatic injuries, burn injuries, and injuries to pediatric patients are excluded. The panel recognizes that for scenarios related to hemodynamically stable patients with major blunt trauma (suspected cerebrovascular injury, and suspected cervical, thoracic, or lumbar spine injury), recommendations for initial imaging are covered in the ACR Appropriateness Criteria® topic on "Head Trauma" [1] and the ACR Appropriateness Criteria® topic on "Suspected Spine Trauma" [2].

Trauma is the leading cause of mortality for people in the United States who are <45 years of age, and it is the fourth leading cause of death overall [3]. Polytrauma can be defined as an injury to at least two body parts, including the head, neck, chest, abdomen, pelvis, and at least one extremity, with any one or a combination of these injuries being potentially fatal.

Special Imaging Considerations

The acquisition speed of CT has enabled protocols for whole-body trauma, considered as "CT whole body" in several variants and referred to as whole-body CT (WBCT) in this document. The acquisition entails CT imaging of the head and cervical spine without intravenous (IV) contrast, followed by CT imaging of the chest, abdomen, and pelvis after IV contrast administration. These images are acquired during a patient encounter with the department of radiology, and they typically include one bolus of contrast material. Selective CT imaging constitutes imaging of one or any combination of the head, neck, chest, abdomen, pelvis, and at least one extremity, short of whole-body imaging. Additional CT imaging can be obtained to identify and further characterize injuries to the face, thoracic and lumbar spine, vasculature, genitourinary system, and extremities. Radiographs and focused assessment with sonography in trauma (FAST) play an important role in triage [4,5], whereas MRI plays a complementary role in certain instances.

CT urography (CTU) is an imaging study that is tailored to improve the visualization of both the upper and lower urinary tracts. There is variability in the specific parameters, but it usually involves unenhanced images followed by IV contrast–enhanced images, including a nephrographic and excretory phase, acquired at least 5 minutes after contrast injection. Some institutions routinely include arterial phase. Alternatively, a split-bolus technique uses an initial loading of 50 mL dose of IV contrast and then obtains a combined nephrographic-excretory phase after a second IV contrast dose; some institutions include arterial phase. CTU should use thin slice acquisition. Oral hydration, IV saline hydration, compression bands, and low-dose furosemide have all been reported as methods to improve urinary distension. Reconstruction methods commonly include maximum intensity projection or 3-D volume rendering.

MR urography (MRU) is also tailored to improve imaging of the urinary tract system. Unenhanced MRU relies upon heavily T2-weighted imaging of the intrinsic signal from urine for evaluation of the urinary tract. IV contrast is administered to provide additional information regarding obstruction, urothelial thickening, focal lesions, and stones. A contrast-enhanced T1-weighted series should include corticomedullary, nephrographic, and excretory

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phase. Similar to CTU, hydration or low-dose furosemide can improve urinary tract distension and study quality. Thin slice acquisition and multiplanar imaging should be obtained. MRU is most commonly performed at 1.5T, but imaging at 3T has become more widely used; however, comparison of 3T MRU and CTU has not been published in the literature.

Discussion of Procedures by Variant

Variant 1: Major blunt trauma. Hemodynamically unstable. Initial imaging.

CT Whole Body

There is limited literature to support the use of WBCT in patients who are hemodynamically unstable [6,7]. Patients who remain hemodynamically unstable despite initial attempts at resuscitation and who have positive signs for abdominal trauma (eg, a positive FAST) should proceed directly to exploratory laparotomy, with CT imaging deferred until after operative intervention. Patients who have an abnormal chest radiograph in the setting of trauma have clinically significant rates of major injury on CT chest [8].

US FAST Scan Chest Abdomen Pelvis

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 [9,10]. Extended-FAST has been found to be effective in ruling out pneumothorax [11]. Although ultrasound (US) may be able to diagnose certain thoracic and abdominal injuries, its relatively lower specificity compared with CT does not make it a sufficient test to exclude injuries to these areas [5]. FAST has been found to have a high false-negative rate in patients with pelvic fractures [12].

Radiography Trauma Series

Trauma series radiographs in the unstable patient typically consist of portable radiographs of the chest and pelvis. A portable anteroposterior (AP) chest radiograph helps screen for immediately life-threatening findings, such as tension pneumothorax and significant mediastinal injury, as well as confirms line placement [13]. A portable radiograph of the pelvis can evaluate for unstable pelvic injuries and hip dislocation [4].

MRI Abdomen and Pelvis

There is no relevant literature to support the use of MRI in the initial evaluation of the unstable trauma patient. MRI is not performed because of the time required in the emergent setting.

Variant 2: Major blunt trauma. Hemodynamically stable. Not otherwise specified. Initial imaging.

CT Whole Body

Currently, there is no practice consensus or validated decision rules for deciding which patients should receive WBCT versus selective CT imaging for blunt trauma. Some studies have found a survival benefit to WBCT compared with selective CT [14], whereas others have found no survival benefit [15]. Meta-analyses have yielded conflicting results with respect to improvements in mortality [16-18]. Therefore, clinical judgement remains vital for determining which patients should obtain WBCT versus selective CT.

Indications that may warrant WBCT imaging as defined above, include high-velocity (>35 mph) motor vehicle collision (MVC), MVC resulting in rollover or passenger ejection, motorcycle trauma, bicycle injury, MVC-pedestrian collision, and a fall from a height of >15 feet. Additional considerations include patient age and functional status, hemodynamic stability, neurological status, and results of initial imaging from portable radiographs of the chest and pelvis, and/or FAST. CT of the chest, abdomen, and pelvis with IV contrast has greater sensitivity for detecting visceral organ and vascular injury compared with noncontrast CT, and contrast-enhanced CT of these areas should be primarily considered unless absolutely contraindicated [19,20]. Patients who have an abnormal chest radiograph in the setting of trauma have clinically significant rates of major injury on CT chest [8].

MRI Abdomen and Pelvis

There is no relevant literature to support the initial use of MRI in patients who are hemodynamically stable, not otherwise specified.

US FAST Scan Chest Abdomen Pelvis

The role of FAST is primarily one of triage; a positive FAST and signs of hemodynamic instability may lead to immediate surgical intervention rather than CT. Although US may be able to diagnose certain thoracic and abdominal injuries, its relatively lower specificity compared with CT does not make it a sufficient test to fully exclude injuries to these areas [5].

Fluoroscopy Retrograde Urethrography

There is no relevant literature to support the use of retrograde urethrography in patients with major blunt trauma who are hemodynamically stable, not otherwise specified. Refer to Variant 6 if there is suspicion of urinary tract injury.

Radiography Trauma Series

In the initial workup of a stable patient, trauma series radiographs include portable AP radiographs of the chest and pelvis. Portable AP chest radiographs evaluate for immediately life-threatening findings, such as tension pneumothorax and significant mediastinal injury, as well as confirm line placement [13]. Portable radiographs of the pelvis can evaluate for unstable pelvic injuries and hip dislocation [4]. Depending on the mechanism and patient's clinical status, cross-table lateral radiographs of the spine may also be obtained.

Variant 3: Major blunt trauma. Hemodynamically stable. Suspected facial injury. Initial imaging.

CT Head

Intracranial injury can coexist with a facial injury, and the ACR Appropriateness Criteria® topic on "Head Trauma" [1] should be reviewed for further information. For those who meet criteria for imaging based on mechanism and patients with a Glasgow Coma Score <13, a noncontrast CT of the head is a first-line imaging test in the initial clinical setting. CT imaging allows for the detection of hemorrhage, cerebral edema, and intracranial mass effect, with multiplanar reformation adding greater sensitivity for hemorrhage detection. Although skull radiographs are performed at some institutions, CT bone algorithm reconstructions provide greater sensitivity for detecting skull fractures. There is no relevant literature to support the use of IV contrast for this indication.

CT Maxillofacial

In patients who have suspected osseous or soft-tissue maxillofacial injuries as well as skull base injuries, a noncontrast CT through the maxillofacial region should be obtained [21,22]. Often, these images can be reconstructed from the head and cervical spine source data. Three-dimensional reformatted images improve the surgeon's confidence beyond that from source axial CT images alone [23]. There is no relevant literature to support the use of IV contrast for this indication.

CT Whole Body

The decision regarding which patients should receive WBCT versus selective CT imaging for blunt trauma will depend on factors beyond facial injury. Some studies have found a survival benefit to WBCT compared with selective CT [14], whereas others have found no mortality benefit [15]. Meta-analyses have found conflicting results with respect to improvements in mortality [16-18]. Therefore, clinical judgement remains vital for determining which patients should obtain selective CT versus WBCT.

Indications that may warrant WBCT imaging as defined above include high-velocity (>35 mph) MVC, MVC resulting in rollover or passenger ejection, motorcycle trauma, bicycle injury, MVC-pedestrian collision, and a fall from a height of >15 feet. Additional considerations include patient age and functional status, hemodynamic stability, neurological status, and results of initial imaging from portable radiographs of the chest and pelvis, and/or FAST. CT of the chest, abdomen, and pelvis with IV contrast has greater sensitivity for detecting visceral organ and vascular injury compared with noncontrast CT, and contrast-enhanced CT of these areas should be primarily considered unless absolutely contraindicated [19,20]. Patients who have an abnormal chest radiograph in the setting of trauma have clinically significant rates of major injury on CT chest [8].

Radiography Trauma Series

In the setting of blunt facial trauma, facial and cervical lateral radiographs may also be part of the initial trauma series radiographs, which also typically consists of portable radiographs of the chest and pelvis. Single cervical radiographs can rapidly evaluate for severe fracture, abnormal alignment, and prevertebral swelling, but it may miss nondisplaced fractures that are evident on CT. The portable AP chest radiograph helps screen for immediately life-threatening findings, such as tension pneumothorax and significant mediastinal injury, as well as confirms line placement [13]. A portable radiograph of the pelvis can evaluate for unstable pelvic injuries and hip dislocation [4].

Variant 4: Major blunt trauma. Hemodynamically stable. Suspected extremity trauma. Initial imaging.

The body regions covered in this clinical scenario are the upper extremity and lower extremity.

CT Whole Body

Currently, there is no practice consensus or validated decision rules for deciding which patients should receive WBCT versus selective CT imaging for blunt trauma, and extremity injuries alone will not determine which is appropriate. Some studies have found a survival benefit to WBCT compared with selective CT [14], whereas others have found no mortality benefit [15]. Meta-analyses have found conflicting results with respect to improvements in mortality [16-18]. Therefore, clinical judgement remains vital for determining which patients should obtain selective CT versus WBCT.

Indications that may warrant WBCT imaging as defined above include high-velocity (>35 mph) MVC, MVC resulting in rollover or passenger ejection, motorcycle trauma, bicycle injury, MVC-pedestrian collision, and a fall from a height of >15 feet. Additional considerations include patient age and functional status, hemodynamic stability, neurological status, and results of initial imaging from portable radiographs of the chest and pelvis, and/or FAST. CT of the chest, abdomen, and pelvis with IV contrast has greater sensitivity for detecting visceral organ and vascular injury compared with noncontrast CT, and contrast-enhanced CT of these areas should be primarily considered unless absolutely contraindicated [19,20]. Patients who have an abnormal chest radiograph in the setting of trauma have clinically significant rates of major injury on CT chest [8].

CT Extremity
In certain cases, CT may be appropriate for fracture characterization, detection of radiographically occult fractures, or operative planning.

CTA Extremity
CT angiography (CTA) of an upper or lower extremity injury may also be considered and could be obtained during the same acquisition period to evaluate for extremity arterial injury when clinically suspected [24].

US FAST Scan Chest Abdomen Pelvis
The role of FAST is primarily one of triage regardless of extremity injuries; a positive FAST and signs of hemodynamic instability may lead to immediate surgical intervention rather than CT. Although US may be able to diagnose certain thoracic and abdominal injuries, its relatively lower specificity compared with CT does not make it a sufficient test to exclude injuries to these areas [5].

Radiography Extremity
Single-view radiographs of the traumatized extremity take little time and are frequently included in this setting.

Radiography Trauma Series
Trauma series radiographs typically consist of portable radiographs of the chest and pelvis and/or cross table cervical spine. A portable AP chest radiograph helps screen for immediate life-threatening findings, such as tension pneumothorax and significant mediastinal injury, as well as confirms line placement [13]. A portable radiograph of the pelvis can evaluate for unstable pelvic injuries and hip dislocation [4]. Radiographs of the suspected injured extremity are the first-line examination to be obtained.

Variant 5: Major blunt trauma. Hemodynamically stable. Suspected bowel trauma. Initial imaging.

CT Abdomen and Pelvis
For blunt trauma, CT of the abdomen and pelvis with IV contrast is recommended, in the portal venous phase 70 seconds after contrast administration, for ideal characterization of solid organ injury. This may be obtained in conjunction with arterial phase images as well as delayed imaging of the abdomen and pelvis. The administration of oral contrast material has not been found to alter the sensitivity or specificity for blunt abdominal injuries and is not recommended because it can delay definitive diagnosis of other injuries [25]. Noncontrast CT of the abdomen and pelvis should ideally be avoided when possible because of its lower sensitivity for detecting both visceral organ and vascular injuries [19].

CT Whole Body
Currently, there is no consensus for deciding which patients should receive WBCT versus selective CT imaging of the abdomen and pelvis for blunt trauma with concern for bowel injury. Some studies have found a survival benefit to WBCT compared with selective CT [14], whereas others have found no mortality benefit [15]. Meta-analyses have found conflicting results with respect to improvements in mortality [16-18]. Therefore, clinical judgement remains vital for determining which patients should obtain selective CT versus WBCT.

Indications that may warrant WBCT imaging as defined above include high-velocity (>35 mph) MVC, MVC resulting in rollover or passenger ejection, motorcycle trauma, bicycle injury, MVC-pedestrian collision, and a fall from a height of >15 feet. Additional considerations include patient age and functional status, hemodynamic stability, neurological status, and results of initial imaging from portable radiographs of the chest and pelvis, and/or

FAST. CT of the chest, abdomen, and pelvis with IV contrast has greater sensitivity for detecting visceral organ and vascular injury compared with noncontrast CT, and contrast-enhanced CT of these areas should be primarily considered unless absolutely contraindicated [19,20]. Patients who have an abnormal chest radiograph in the setting of trauma have clinically significant rates of major injury on CT chest [8]

CTA Abdomen and Pelvis

CT in the arterial phase may be carried through the abdomen and pelvis to assess for active arterial bleeding to abdominopelvic viscera and soft tissues. If 3-D reconstructions are included, then it is considered a CTA study to more closely evaluate the arterial structures for findings such as pseudoaneurysm. CTA of the abdomen has been shown to detect more splenic vascular injuries than that of CT of the abdomen in the portal venous phase alone [26]. Unstable pelvic fractures, such as vertical shear and AP compression injury, are associated with higher rates of active hemorrhage, which can be accurately diagnosed by CTA and may require either surgical or vascular interventional treatment [27].

MRI Abdomen and Pelvis

Blunt abdominal trauma is not typically evaluated by MRI because of the time of acquisition. However, some sites are moving toward the use of MRI in selected patients [28].

US Abdomen

Although US may be able to diagnose certain abdominal injuries, its relatively lower specificity compared with CT does not make it a sufficient test to fully exclude abdominal injuries [29]. Bowel injury is a specific setting for which US is limited because of bowel gas.

US FAST Scan Chest Abdomen Pelvis

The role of FAST is primarily one of triage; a positive FAST and signs of hemodynamic instability may lead to immediate surgical intervention rather than CT. Although US may be able to diagnose certain thoracic and abdominal injuries, its relatively lower specificity compared with CT does not make it a sufficient test to exclude injuries to these areas [5]. US is not well suited for evaluation of bowel injury because significant fluid trapped in the mesentery may not be detected by FAST.

Radiography Trauma Series

Trauma series radiographs typically consist of portable radiographs of the chest and pelvis. A portable AP chest radiograph helps screen for immediately life-threatening findings, such as tension pneumothorax and significant mediastinal injury, as well as confirms line placement [13]. A portable radiograph of the pelvis can evaluate for unstable pelvic injuries and hip dislocation [4]. There is no literature to support the use of trauma series radiographs in the detection of bowel injury.

Variant 6: Major blunt trauma. Hemodynamically stable. Suspected urinary system, including urethra trauma. Initial imaging.

CT Abdomen and Pelvis

For blunt trauma, CT of the abdomen and pelvis with IV contrast is recommended, in the portal venous phase, 70 seconds after contrast administration for ideal characterization of solid organ injury, including the genitourinary system. This may be obtained in conjunction with CTA if there is a concern for renal infarction or arterial injury, as well as delayed imaging of the abdomen and pelvis if perinephric fluid suggests renal pelvis or ureteral trauma. The administration of oral contrast material has not been found to alter the sensitivity or specificity for blunt abdominal injuries and is not recommended because it can delay definitive diagnosis of other injuries [25]. Noncontrast CT of the abdomen and pelvis should ideally be avoided if there is no contraindication to IV contrast because of its lower sensitivity for detecting both visceral organ and vascular injuries [19].

CT Urography

There is no relevant literature to support the use of CTU in the initial evaluation of patients who are hemodynamically stable with suspected urinary system or urethral trauma.

CT Pelvis with Bladder Contrast (CT Cystography)

Gross hematuria in the setting of blunt traumatic injury necessitates further evaluation with CT cystogram [30]. Urinary bladder injury typically occurs because of trauma to a distended urinary bladder and may or may not be accompanied by pelvic fractures. The absence of gross hematuria generally excludes the possibility of urinary bladder injury [31]. Deck et al [32,33] reported sensitivities of 95% overall but only 78% for intraperitoneal rupture. In another study with 100% sensitivity and 99% specificity for intraperitoneal bladder rupture, the specific sites of dome injuries in 4 of 18 patients were identified only with multiplanar reconstructed images [34]. A bladder contusion may not be visible by CT cystography. Routine CT, using excreted contrast only, cannot be relied on entirely to diagnose bladder rupture, even with a urethral catheter inserted and clamped [35-37]. CT performed with excreted contrast only can demonstrate intraperitoneal or extraperitoneal fluid, but it cannot differentiate urine from ascites. However, the absence of pelvic ascites is strong evidence against an intraperitoneal bladder rupture [38,39]. As with IV urography (IVU), the bladder is usually inadequately distended to cause extravasation through a bladder laceration or perforation during routine abdominal and pelvic studies. A negative study does not exclude bladder injury [40]. Although CT is not the technique of choice for urethral injuries, it is performed so frequently that urethral injuries are often identified when CT is performed for pelvic trauma.

CT Whole Body

No practice consensus or validated decision rules currently exist for deciding which patients should receive WBCT versus selective CT imaging of the abdomen and pelvis for blunt trauma. Some studies have found a survival benefit to WBCT compared with selective CT [14], whereas others have found no mortality benefit [15]. Meta-analyses have found conflicting results with respect to improvements in mortality [16-18]. Therefore, clinical judgement remains vital for determining which patients should obtain selective CT versus WBCT.

Indications that may warrant WBCT imaging as defined above include high-velocity (>35 mph) MVC, MVC resulting in rollover or passenger ejection, motorcycle trauma, bicycle injury, MVC-pedestrian collision, and a fall from a height of >15 feet. Additional considerations include patient age and functional status, hemodynamic stability, neurological status, and results of initial imaging from portable radiographs of the chest and pelvis, and/or FAST. CT of the chest, abdomen, and pelvis with IV contrast have greater sensitivity for detecting visceral organ and vascular injury compared with noncontrast CT, and contrast-enhanced CT of these areas should be primarily considered unless absolutely contraindicated [19,20]. Patients who have an abnormal chest radiograph in the setting of trauma have clinically significant rates of major injury on CT chest [8].

CTA Abdomen and Pelvis

CTA of the abdomen and pelvis may be performed to assess for active arterial bleeding. CTA of the abdomen has been shown to detect splenic vascular injuries more often than CT of the abdomen in the portal venous phase alone [26]. However, arterial phase imaging without 3-D reformations can also detect bleeding. Unstable pelvic fractures, such as vertical shear and AP compression injury, are associated with higher rates of active hemorrhage and may require either surgical or vascular interventional treatment [27].

MRI Abdomen and Pelvis

There is no relevant literature to support the use of MRI of the abdomen and pelvis in the initial evaluation of patients who are hemodynamically stable with suspected urinary system or urethral trauma.

MR Urography

There is no relevant literature to support the use of MRU in the initial evaluation of patients who are hemodynamically stable with suspected urinary system or urethral trauma.

US Abdomen and Pelvis

Although US may be able to diagnose certain abdominal injuries, its relatively lower sensitivity compared with CT does not make it a sufficient test to exclude abdominal injuries [29,41,42]. Extraperitoneal and genitourinary injuries are more likely to be missed than intraperitoneal injuries [41,42].

US FAST Scan Chest Abdomen Pelvis

The role of FAST is primarily one of triage; a positive FAST and signs of hemodynamic instability may lead to immediate surgical intervention rather than CT. Although US may be able to diagnose certain thoracic and abdominal injuries, its relatively lower sensitivity compared with CT does not make it a sufficient test to exclude injuries to these areas, particularly extraperitoneal or genitourinary injuries [5,41,42]. In a series of 128 acute trauma patients, 11 of 19 injuries that were missed by emergent US involved the genitourinary system [41]. The detection of peritoneal fluid in the presence of normal viscera or the failure to visualize the bladder after the transurethral introduction of saline is considered highly suggestive of bladder rupture [35]. As a practical matter, US is not definitive in bladder or urethral trauma and is almost never used for this indication.

Radiography Intravenous Urography

There is no relevant literature to support the use of IVU in patients who are hemodynamically stable with suspected urinary system or urethral trauma. IVU has a low accuracy, on the order of 15% to 25% [43]. In one study, an accurate diagnosis of bladder rupture was made with IVU in only 5 of 23 (22%) patients [44]. Carroll and McAninch [45] found an accurate diagnosis for only 5 of 32 (16%) patients, and Werkman et al [46] found an accuracy rate for only 4 of 11 (36%) patients.

Fluoroscopy Retrograde Urethrography
In a male, gross blood at the urethral meatus may indicate a urethral injury, which warrants further evaluation with a retrograde urethrogram to evaluate urethral integrity [47].

Radiography Trauma Series
Trauma series radiographs typically consist of portable radiographs of the chest and pelvis. A portable radiograph of the pelvis can evaluate for unstable pelvic injuries and hip dislocation [4]. A pelvic injury is associated with genitourinary trauma. A portable AP chest radiograph helps screen for immediately life-threatening findings, such as tension pneumothorax and significant mediastinal injury, as well as confirms line placement [13].

Variant 7: Major blunt trauma. Hemodynamically stable. Suspected chest trauma. Initial imaging.

CT Chest
Noncontrast CT of the chest can detect most injuries, including rib fractures, pneumothorax, hemothorax, and pulmonary contusion, but has a lower sensitivity for detecting vascular injuries [20]. Contrast-enhanced CT of the chest is the preferred imaging workup of suspected chest trauma. Regardless of contrast administration, CT is more sensitive and specific for chest trauma than conventional radiographs [48,49]. Patients who have an abnormal chest radiograph in the setting of trauma have clinically significant rates of major injury on CT chest [8].

CT Whole Body
Currently, there is no practice consensus or validated decision rules for deciding which patients should receive WBCT versus selective chest CT imaging for blunt trauma with concern for a chest injury. Some studies have found a survival benefit to WBCT compared with selective CT [14], whereas others have found no mortality benefit [15]. Meta-analyses have found conflicting results with respect to improvements in mortality [16-18]. Therefore, clinical judgement remains vital for determining which patients should obtain selective CT versus WBCT.

Indications that may warrant WBCT imaging as defined above include high-velocity (>35 mph) MVC, MVC resulting in rollover or passenger ejection, motorcycle trauma, bicycle injury, MVC-pedestrian collision, and a fall from a height of >15 feet. Additional considerations include patient age and functional status, hemodynamic stability, neurological status, and results of initial imaging from portable radiographs of the chest and pelvis, and/or FAST. CT of the chest, abdomen, and pelvis with IV contrast have greater sensitivity for detecting visceral organ and vascular injury compared with noncontrast CT, and contrast-enhanced CT of these areas should be primarily considered unless absolutely contraindicated [19,20].

CTA Chest
CT of the chest is warranted in the arterial phase primarily when there is a concern for aortic or other major vessel injury [20]. A delayed scan may be obtained, depending on the findings on the arterial phase CT.

US Chest
There is no relevant literature to support the use of non-US FAST of the chest in patients who are hemodynamically stable with suspected chest trauma. Its use in detection of pleural fluid and pneumothorax is increasing, but it has not gained acceptance for comprehensive evaluation of blunt chest trauma because of its lack of sensitivity for pulmonary, aortic, cardiac, and musculoskeletal injury [49].

US FAST Scan Chest Abdomen Pelvis
The role of FAST is primarily one of triage; a positive FAST and signs of hemodynamic instability may lead to immediate surgical intervention rather than CT. Although US may be able to diagnose certain thoracic and abdominal injuries, its relatively lower specificity compared with CT does not make it a sufficient test to exclude injuries to these areas [5]. Its use in detection of pleural fluid and pneumothorax is increasing, but it has not gained acceptance for a comprehensive evaluation of blunt chest trauma because of its lack of sensitivity for pulmonary, aortic, cardiac, and musculoskeletal injury.

Radiography Trauma Series
Trauma series radiographs typically consist of portable radiographs of the chest and pelvis. In a patient with suspicion of chest trauma, a rapid assessment with chest radiographs plays a key role in initial workup. A portable AP chest radiograph helps screen for immediate life-threatening findings, such as tension pneumothorax and

significant mediastinal injury, as well as confirms line placement [13]. However, the chest radiograph is not an adequate test for evaluating thoracic injuries. Image quality could be reduced for a variety of reasons, including patient positioning, inspiratory effort, and overlying material. Chest radiographs have a lower sensitivity of detecting pneumothorax, hemothorax, lung contusions, rib fractures, and cardiac and vascular injury [50,51]. A retrospective study of 157 randomly selected, stable adult blunt trauma patients found that 40% of patients with a "normal" chest radiograph had injuries on CT, whereas 29% of patients with an "abnormal" chest radiograph were found to have no injury on CT [50]. In a study of 374 patients with blunt trauma, approximately half of all pneumothoraces, pulmonary contusions, and rib fractures, three-quarters of all hemothoraces, and all five cases of aortic injury were not identified on chest AP radiographs [52].

A portable radiograph of the pelvis can evaluate for unstable pelvic injuries and hip dislocation [4]. Compared with CT, pelvic radiographs also have lower sensitivity for detecting injury. In a study of 509 consecutive trauma patients, the sensitivity of the AP pelvic radiographs was 77% using CT as the reference standard [53]. The most common injury misses were the ones to the sacrum, sacroiliac joints, and loose bodies in the hip joints.

MRI Chest

There is no relevant literature to support the use of MRI for the initial evaluation of blunt chest trauma. It is not routinely performed because of the time required in the emergent setting. Use of MRI is mainly reserved for problem solving of findings identified on initial imaging studies.

Variant 8: Major blunt trauma. Hemodynamically stable. Pregnant patient. Initial imaging.

CT Abdomen and Pelvis

For blunt trauma in a pregnant woman, CT of the abdomen and pelvis with IV contrast may still be recommended when there is a life-threatening concern for the mother or fetus. The study is typically performed in the portal venous phase, 70 seconds after contrast administration, for ideal characterization of solid organ injury. This may be obtained in conjunction with CTA as well as delayed imaging of the abdomen and pelvis. The administration of oral contrast material has not been found to alter the sensitivity or specificity for blunt abdominal injuries and is not recommended because it can delay definitive diagnosis of other injuries [25]. Noncontrast CT of the abdomen and pelvis should ideally be avoided because of its lower sensitivity for detecting both visceral organ and vascular injuries [19].

CT Whole Body

Risks and benefits must be specifically weighed regarding CT imaging of the pregnant patient. No practice consensus or validated decision rules currently exist for deciding which patients should receive WBCT versus selective CT imaging for blunt trauma. Some studies in nonpregnant patients have found a survival benefit to WBCT compared with selective CT [14], whereas others have found no mortality benefit [15]. Meta-analyses have found conflicting results with respect to improvements in mortality [16-18]. Therefore, clinical judgement remains vital for determining which patients should obtain selective CT versus WBCT.

Indications that may warrant WBCT imaging as defined above include high-velocity (>35 mph) MVC, MVC resulting in rollover or passenger ejection, motorcycle trauma, bicycle injury, MVC-pedestrian collision, and a fall from a height of >15 feet. Additional considerations include patient age and functional status, hemodynamic stability, neurological status, and results of initial imaging from portable radiographs of the chest and pelvis, and/or FAST. CT of the chest, abdomen, and pelvis with IV contrast has greater sensitivity for detecting visceral organ and vascular injury compared with noncontrast CT, and contrast-enhanced CT of these areas should be primarily considered unless absolutely contraindicated [19,20]. Patients who have an abnormal chest radiograph in the setting of trauma have clinically significant rates of major injury on CT chest [8].

CTA Abdomen and Pelvis

CTA may be carried through the abdomen and pelvis to assess for active arterial bleeding to abdominopelvic viscera and soft tissues. CTA of the abdomen has been shown to detect more splenic vascular injuries than CT of the abdomen in the portal venous phase alone [26]. Unstable pelvic fractures, such as vertical shear and AP compression injury, are associated with higher rates of active hemorrhage and may require either surgical or vascular interventional treatment [27].

CTA Chest

CTA of the chest is warranted in the arterial phase primarily to assess for aortic or other major vessel injury, in addition to other injuries within the chest [20]. Noncontrast CT of the chest should be avoided because of its lower sensitivity for detecting vascular injuries [20].

MRI Abdomen and Pelvis

There is no relevant literature to support the use of MRI abdomen and pelvis in patients who are hemodynamically stable and pregnant.

US FAST Scan Chest Abdomen Pelvis

The role of FAST is primarily one of triage with added usefulness in the setting of pregnancy; a positive FAST and signs of hemodynamic instability may lead to immediate surgical intervention and avoidance of CT. Although US may be able to diagnose certain thoracic and abdominal injuries, its relatively lower specificity compared with CT does not make it a sufficient test to exclude injuries to these areas [5]. US is less sensitive for detecting traumatic abdominal injury in the pregnant patient compared with the nonpregnant patient [54].

US Pelvis

In pregnant patients with blunt abdominal trauma, both the health of the mother and fetus are of concern. The pelvic US can assess the uterus and evaluate the amniotic fluid level and measure the biophysical profile, as well as assess the extent of fetal injury and demise [55]. US can also assess for the presence of free fluid and retroplacental hemorrhage, although the sensitivity for detecting abruption may not exceed 40% to 50% [55]. The gravid uterus is at increased risk of rupture from blunt trauma and is a life-threatening emergency.

Radiography Trauma Series

Trauma series radiographs typically consist of portable radiographs of the chest and pelvis. A portable AP chest radiograph helps screen for immediately life-threatening findings, such as tension pneumothorax and significant mediastinal injury, as well as confirms line placement [13]. A portable radiograph of the pelvis can evaluate for unstable pelvic injuries and hip dislocation [4].

Summary of Recommendations

- **Variant 1:** Radiography trauma series and US FAST scan chest, abdomen, and pelvis are usually appropriate for the initial imaging of major blunt trauma in a hemodynamically unstable patient. These procedures are complementary (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).

- **Variant 2:** CT whole body with IV contrast, radiography trauma series, and US FAST scan chest, abdomen, and pelvis are usually appropriate for the initial imaging of major blunt trauma for a hemodynamically stable patient, not otherwise specified. These procedures are complementary (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).

- **Variant 3:** CT maxillofacial without IV contrast, CT head without IV contrast, or radiography trauma series is usually appropriate for the initial imaging of major blunt trauma in a hemodynamically stable patient with suspected facial injury. These procedures are complementary (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).

  The panel did not agree on recommending imaging with CT whole body with IV contrast in these patients. There is insufficient medical literature to conclude whether or not these patients would benefit from this procedure. Imaging with CT whole body with IV contrast in this patient population is controversial but may be appropriate.

- **Variant 4:** US FAST scan chest, abdomen, and pelvis can be useful as a limited bedside adjunct to the physical examination and is primarily used for triage in a hemodynamically stable patient with major blunt trauma and suspected extremity trauma.

  Radiography of the extremity, CT whole body with IV contrast, or radiography trauma series is usually appropriate in addition to US FAST for the initial imaging of these patients. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient’s care).

The panel did not agree on recommending imaging with CT whole body without IV contrast or CTA extremity with IV contrast. There is insufficient medical literature to conclude whether or not these patients would benefit from these procedures. Imaging with CT whole body without IV contrast or CTA extremity with IV contrast in this patient population is controversial but may be appropriate.

- **Variant 5:** US FAST scan chest, abdomen, and pelvis can be useful as a limited bedside adjunct to the physical examination and is primarily used for triage in a hemodynamically stable patient with major blunt trauma and suspected bowel trauma.

  CT abdomen and pelvis with IV contrast, CT whole body with IV contrast, or radiography trauma series is usually appropriate in addition to US FAST for the initial imaging of these patients. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).

  The panel did not agree on recommending imaging with CT whole body without IV contrast. There is insufficient medical literature to conclude whether or not these patients would benefit from this procedure. Imaging with CT whole body without IV contrast in this patient population is controversial but may be appropriate.

- **Variant 6:** US FAST scan chest, abdomen, and pelvis can be useful as a limited bedside adjunct to the physical examination and is primarily used for triage in a hemodynamically stable patient with major blunt trauma and suspected urinary system, including urethra trauma.

  Fluoroscopy retrograde urethrography, radiography trauma series, CT abdomen and pelvis with IV contrast, CT whole body with IV contrast, or CTA abdomen and pelvis with IV contrast is usually appropriate in addition to US FAST for the initial imaging of these patients. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).

  The panel did not agree on recommending imaging with CTU. There is insufficient medical literature to conclude whether or not these patients would benefit from this procedure. Imaging with CTU in this patient population is controversial but may be appropriate.

- **Variant 7:** CT chest with IV contrast, CT whole body with IV contrast, CTA chest with IV contrast, or radiography trauma series is usually appropriate for the initial imaging of major blunt trauma for hemodynamically stable patients with suspected chest trauma. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).

  The panel did not agree on recommending imaging with US FAST scan chest, abdomen, and pelvis in these patients. There is insufficient medical literature to conclude whether or not these patients would benefit from this procedure. Imaging with US FAST scan chest, abdomen, and pelvis in this patient population is controversial but may be appropriate.

- **Variant 8:** US FAST scan chest, abdomen, and pelvis can be useful as a limited bedside adjunct to the physical examination and is primarily used for triage in a pregnant patient with major blunt trauma.

  US pelvis, CT abdomen and pelvis with IV contrast, CT whole body with IV contrast, or radiography trauma series is usually appropriate in addition to US FAST for the initial imaging of major blunt trauma in a pregnant patient. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).

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.

Safety Considerations in Pregnant Patients

Imaging of the pregnant patient can be challenging, particularly with respect to minimizing radiation exposure and risk. For further information and guidance, see the following ACR documents:

- ACR–SPR Practice Parameter for the Safe and Optimal Performance of Fetal Magnetic Resonance Imaging (MRI) [56]
- ACR-SPR Practice Parameter for Imaging Pregnant or Potentially Pregnant Adolescents and Women with Ionizing Radiation [57]
- ACR-ACOG-AIUM-SMFM-SRU Practice Parameter for the Performance of Standard Diagnostic Obstetrical Ultrasound [58]
- ACR Manual on Contrast Media [59]
- ACR Guidance Document on MR Safe Practices: 2013 [60]

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 [61].

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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