American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Blunt Abdominal Trauma**

Variant 1: **Unstable patient.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	8	To evaluate for fracture, pneumomediastinum, and abnormal air collection or gas collections, patient condition permitting. Chest radiograph, KUB, and FAST scan are complementary examinations. All are commonly performed in this setting, patient condition permitting.	☢
US chest abdomen and pelvis (FAST scan)	8	Rapid assessment of free fluid, patient condition permitting. Chest radiograph, KUB, and FAST scan are complementary examinations. All are commonly performed in this setting, patient condition permitting.	O
X-ray abdomen and pelvis (KUB)	8	To evaluate for fracture, free intraperitoneal air or abnormal fluid or gas collections. Chest radiograph, KUB, and FAST scan are complementary examinations. All are commonly performed in this setting, patient condition permitting.	☢ ☢
Arteriography with possible embolization abdomen and pelvis	5	Not appropriate as initial imaging modality but may become more appropriate if additional clinical information or imaging suggests possibility of active hemorrhage.	Varies
CT abdomen and pelvis without IV contrast	3	Not appropriate for critically unstable patients. Appropriateness rating may increase if clinical condition of patient improves and becomes hemodynamically stable. Would only consider in setting of prior severe contrast reaction or renal failure.	☢ ☢ ☢
CT abdomen and pelvis with IV contrast	3	Not appropriate for critically unstable patients. Appropriateness rating may increase if clinical condition of patient improves and becomes hemodynamically stable.	☢ ☢ ☢
CT abdomen and pelvis without and with IV contrast	3	Not appropriate for critically unstable patients.	☢ ☢ ☢ ☢
CT chest without IV contrast	3	Not appropriate for critically unstable patients. Appropriateness rating may increase if clinical condition of patient improves and becomes hemodynamically stable. Would only consider noninfused scanning in setting of prior severe contrast reaction or renal failure.	☢ ☢ ☢

CT chest with IV contrast	3	Not appropriate for critically unstable patients. Appropriateness rating may increase if clinical condition of patient improves and becomes hemodynamically stable.	☢ ☢ ☢
CT chest without and with IV contrast	3	Not appropriate for critically unstable patients. Appropriateness rating may increase if clinical condition of patient improves and becomes hemodynamically stable.	☢ ☢ ☢
US abdomen and pelvis	2		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Variant 2: **Stable patient.**

Radiologic Procedure	Rating	Comments	RRL*
CT abdomen and pelvis with IV contrast	9	May also consider CT angiography followed by routine portal venous phase sequences if visceral injury (eg, hepatic, splenic, pancreatic, renal, mesenteric, or vascular injury) suspected clinically or in patients with significant pelvic and/or vertebral fractures.	☢ ☢ ☢
CT chest with IV contrast	8	May be appropriate for patients who have sustained significant abdominal trauma. The decision of whether to include infused chest CT should be based on the patient's clinical findings and known mechanism of injury.	☢ ☢ ☢
CT abdomen and pelvis without and with IV contrast	7		☢ ☢ ☢ ☢
CT chest without and with IV contrast	7	The decision of whether to include chest CT should be based on the patient's clinical findings and known mechanism of injury.	☢ ☢ ☢
X-ray chest	7		☢
CT chest without IV contrast	6	The decision of whether to include chest CT should be based on the patient's clinical findings and known mechanism of injury. Consider for patients with known severe contrast allergy or renal failure.	☢ ☢ ☢
CT abdomen and pelvis without IV contrast	6	Consider noninfused CT only if patient has known severe contrast reaction or renal failure (eGFR <40).	☢ ☢ ☢
US chest abdomen and pelvis (FAST scan)	5		O
X-ray abdomen and pelvis (KUB)	5	May be useful to initially evaluate the patient for free intraperitoneal air and/or fractures of the pelvis and vertebral column.	☢ ☢
Arteriography with possible embolization abdomen and pelvis	4		Varies
US abdomen and pelvis	2		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Clinical Condition: **Blunt Abdominal Trauma**

Variant 3: **Hematuria >35 RBC/hpf (stable).**

Radiologic Procedure	Rating	Comments	RRL*
CT abdomen and pelvis with IV contrast	9	Recommend CT cystogram immediately following CT of abdomen and pelvis in patients with known acute pelvic fractures and/or penetrating injury to the pelvis with hematuria.	☢ ☢ ☢
CT chest with IV contrast	8	The decision of whether to include infused chest CT should be based on the patient's clinical findings and known mechanism of injury.	☢ ☢ ☢
X-ray chest	8		☢
CT abdomen and pelvis without and with IV contrast	7		☢ ☢ ☢ ☢
CT chest without and with IV contrast	7	The decision of whether to include chest CT should be based on the patient's clinical findings and known mechanism of injury.	☢ ☢ ☢
CT chest without IV contrast	6	The decision of whether to include chest CT should be based on the patient's clinical findings and known mechanism of injury. Consider if patient has known history of severe contrast allergy or renal failure.	☢ ☢ ☢
CT abdomen and pelvis without IV contrast	6	Consider noninfused CT only if patient has known severe contrast reaction or renal failure (eGFR <40).	☢ ☢ ☢
CT pelvis with bladder contrast (CT cystography)	6	Appropriate when performed immediately following CT of abdomen and pelvis. Refer to text for indications.	☢ ☢ ☢ ☢
X-ray retrograde urethrography	6	Appropriate in stable patients following blunt or penetrating trauma demonstrating gross blood coming from urethral meatus. Refer to text for indications.	☢ ☢ ☢
X-ray abdomen and pelvis (KUB)	5	May be useful to initially evaluate the patient for free intraperitoneal air and/or fractures of the pelvis and vertebral column.	☢ ☢
X-ray cystography	5	CT cystography preferred to follow initial CT of abdomen and pelvis.	☢ ☢ ☢
Arteriography with possible embolization kidney	4		Varies
X-ray intravenous urography	3		☢ ☢ ☢
US abdomen and pelvis	3		O
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

BLUNT ABDOMINAL TRAUMA

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Summary of Literature Review

Introduction/Background

This review covers only blunt abdominal trauma in adults. Penetrating trauma and pediatric trauma are excluded. In the past 10 years technological advances in multidetector computed tomography (MDCT) has significantly improved the detection of both vascular and visceral injuries following blunt abdominal trauma. With the quicker examination times and improved spatial resolution of current MDCT scanners, sites of parenchymal injury and/or active extravasation are increasingly detected. Detection of extravasation sites from solid organs (eg, liver, spleen, and kidney), bowel, mesentery, or vascular structures may necessitate therapeutic intervention by either surgery or angiography (with coil embolization or intravascular stent placement). However, not all sites of active extravasation may require intervention, and a trend toward conservative management by trauma surgeons is evolving based not only on the presence of active extravasation but also on its location, its size, and demonstration of enlargement over time. Similar trends are also evolving in the management of isolated peritoneal or pelvic fluid collection following blunt abdominal/pelvic trauma. Small, isolated fluid collections of low Hounsfield density may be observed and managed conservatively, whereas surgical exploration may be considered for larger, higher-density fluid collections [1-18].

Hemodynamically Unstable Patients

Hemodynamically unstable patients presenting to the emergency department with obvious major abdominal trauma and with unresponsive profound hypotension need rapid clinical evaluation and immediate resuscitation with volume replacement. If such unstable patients do not respond to resuscitation *and* if they have clear clinical or suspected evidence of abdominal injury, they should go immediately to the operating room without imaging. During resuscitative efforts, if time and circumstances permit, conventional radiographs of the chest and abdomen are often obtained as part of trauma protocols. This may help identify a pneumothorax, pneumoperitoneum, or significant bone injury. Focused abdominal sonography for trauma (FAST) performed by an experienced sonologist to check for intraperitoneal free fluid may quickly provide information that can support a decision to operate immediately, with the caveat that the false negative rate is ≥15% [19-26]. More detailed ultrasound (US) to check for organ injury takes too long in this setting and suffers from poor sensitivity [27].

There is now general agreement that routine diagnostic peritoneal lavage is obsolete because of its invasive nature, lack of specificity, and inability to predict the need for therapeutic surgery [28]. Those patients for whom emergency department resuscitation is successful can be evaluated by contrast-enhanced CT before surgery. In patients who cannot be stabilized with fluid and/or pharmacologic intervention, surgery should generally not be delayed by imaging. If the patient becomes hemodynamically stable after surgical intervention, CT scanning with intravenous (IV) contrast should be performed to identify other potential injuries not detected during surgery.

Hemodynamically Stable Patients

Hemodynamically stable patients, patients with mild to moderate responsive hypotension presenting to the emergency room after blunt abdominal trauma, and unstable patients who stabilize after initial resuscitation are in a separate category. They typically have a history of significant trauma and have at least moderate suspicion of intra-abdominal injury based on clinical signs and symptoms. For these patients, two decisions need to be made:

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1) Is urgent surgery or therapeutic endoscopic retrograde needed? 2) If not, is a period of close observation warranted? If CT is to be performed, radiographs will offer little if any incremental help with those questions. Rather, the decision to proceed with urgent surgery depends on the identification of specific CT criteria (eg, active hemorrhage, parenchymal blush or pseudoaneurysm in the spleen, perforation of a hollow viscus, disruption of the pancreas and or pancreatic duct, or arterial or venous injury to the aorta or vena cava or their major branches) [18,29-40]. The decision to operate urgently does not depend solely on the identification of hemoperitoneum or of parenchymal injury to the liver or spleen, because most patients in this category ultimately do not need surgery [1,3]. However, accurate identification of hemoperitoneum or organ injury is important [33,41] because patients with these findings require at least a period of close observation. Patients with multiple organ injury or significant active bleeding may require intervasive therapy even if they are hemodynamically stable [42,43]. Conversely, stable patients with isolated organ injury may not need surgery or may need only angiography with embolization, even with a large amount of hemoperitoneum [44].

Ultrasound

Currently US is not an appropriate modality to evaluate these patients, as it may miss up to 25% of liver and spleen injuries, most renal injuries, and virtually all pancreatic, mesenteric, and gut injuries [45-47]. Multiple studies have shown that US can be insensitive in detecting organ injury, missing up to 62% of spleen and 14% of liver injuries that were found by CT and surgery [22,28,48]. US also misses a high proportion of retroperitoneal hemorrhages or bladder ruptures. Combining the results for US in 1,535 abdominal trauma patients from eight published series yields an average US sensitivity of 88% for hemoperitoneum and 74% for organ injury [49]. In a more recent study of 4,029 patients with blunt abdominal trauma, FAST scanning yielded a sensitivity, specificity, and accuracy for the patients with hypotension (87 patients) of 85%, 60%, and 77%, respectively, and in the normotensive group (3,583 patients) yielded a sensitivity, specificity, and accuracy of 85%, 96%, and 95%, respectively. The authors concluded that hypotensive patients with positive findings with FAST may be triaged directly to surgery and bypass CT depending on the suspected injury [25]. Unfortunately, a negative US (absence of hemoperitoneum) does not rule out significant organ or viscus injury that might require invasive therapy or observation [50-54].

US is also insensitive to perforation of gut and to pancreatic injury [41,55]. For these reasons, it is not very useful in deciding when a patient needs urgent surgery or angiography [55,56]. For the same reasons, US is not an accurate modality to determine whether a patient needs a period of close observation; thus, if a negative US is the sole imaging modality used to triage a patient, for safety reasons it must be followed by a 12-24-hour period of in-hospital observation [57,58].

Although US is 63% sensitive to moderate amounts of free intraperitoneal fluid (compared with CT), 400-600 cc are needed for US detection of fluid in the trauma setting [22,59]. Regardless of volume, US diagnosis of free fluid alone does not predict that surgery is needed or that surgery will be therapeutic [48]. In addition, in the best of hands, there is at least a 15% false negative rate for detecting hemoperitoneum with US [41]. US poorly identifies active hemorrhage and also does not accurately predict the need for surgery in splenic injuries [48,55]. The use of contrast-enhanced US for this purpose is not approved in the United States, but it is increasingly used in monitoring patients suspected of possible solid organ injury following blunt trauma who are considered hemodynamically stable [60-62].

Computed Tomography

In hemodynamically stable patients (category B trauma patients), CT accurately predicts whether invasive therapy is urgently needed by identifying active hemorrhage or hepatobiliary, splenic (either parenchymal contrast blush or pseudoaneurysm), pancreatic, genitourinary, intestinal, or diaphragmatic injury [29,31-36]. For these reasons, CT is the primary imaging modality for deciding whether a patient needs urgent surgery, therapeutic angiography [6,7,18,32,35,36,38,40,63], or close observation.

The trend toward placing MDCT scanners close to or in emergency departments has substantially diminished the delay in getting patients to the CT scanner and has decreased actual scan time to <40 seconds [36,64]. In nearly all circumstances, results from MDCT of the abdomen and pelvis can be obtained faster than results from a detailed US of the abdomen or pelvis. In most cases patient turnaround with rapid-process MDCT can be <10 minutes for a trauma patient.

The radiologist should carefully examine images on the picture archiving and communication system (PACS) or at the CT console, where images can be altered to identify bone injury, pneumoperitoneum, or subtle organ injury

[65]. Particular care should be taken to find injury of the spleen because these patients may need observation for potential delayed hemorrhage [42,50,66]. In some instances, stable patients with more severe injuries of the liver or spleen plus hemoperitoneum may be managed conservatively with close observation only [43,44,50,51,67,68]. It should be noted, however, that various schemes for using CT to grade liver or spleen lacerations are not helpful in deciding whether a patient needs surgery. This decision must be based on the clinical status of the patient in combination with the image findings. If evidence of active hemorrhage is discovered on CT examinations, the patient may undergo arteriography plus embolization or surgery to control the hemorrhage [18,38,44,69-71].

The CT image should be carefully examined for subtle signs of pancreatic injury because these patients may need immediate surgery or close observation for signs of complication. Duodenal perforation produces subtle but typical findings on CT, such as extraluminal air or fluid in the retroperitoneum or periportal region. Identifying these findings generally mandates surgical intervention [72]. Duodenal hematoma may not require surgery but does mandate close observation. Other gut injury or perforation produces direct or indirect findings on CT in 50%-94% of cases [30,37,73]. However, if the CT is negative for gut injury in the face of a high clinical suspicion, laparoscopy, surgical exploration, or a period of observation plus repeat CT may be used to further evaluate the patient [74-76].

It may also be reasonable to use CT, in conjunction with the clinical information, to decide whether to observe patients in the hospital for a day or send them home after evaluation in the emergency department. The high sensitivity of CT in detecting injuries that require observation in the hospital means that a negative CT may be adequate to release the patient to home in selected cases. US, however, has a substantially lower sensitivity to the kinds of injuries that must be observed in the hospital. For this reason, a negative US is not adequate to safely release the patient to home. This weakness of US is reflected in the design of many outcomes-based investigations on the use of US in trauma: all recommend keeping patients with a negative US in the hospital for a period of observation of 12-48 hours before release [57,58].

There may be a rationale for creating a subcategory of stable patients with trivial trauma, a low clinical index of suspicion, and no signs or symptoms of intra-abdominal injury. In such patients, a negative US alone may be adequate to release them from observation at a lower cost than if CT had been used [41,55]. CT is necessary; however, if there are any positive findings on US.

Patients with Hematuria

Patients with hematuria after blunt abdominal trauma require some modification to the imaging workup. All patients with gross hematuria and pelvic fracture require additional imaging of the bladder to exclude bladder rupture (absolute indication) [77]. A hemodynamically stable patient being evaluated with MDCT can easily undergo CT cystography using gravity drip infusion of dilute 2% contrast (300-500 cc) via an indwelling Foley catheter. Detection of microscopic or gross hematuria without evidence of pelvic fracture or suspected pelvic injury should be considered as a relative, not absolute indication for additional CT cystography [8,9,46,77-79].

Identification of clinical indicators of bladder rupture is important when determining if additional bladder imaging is needed in trauma patients with gross hematuria without pelvic fracture or major pelvic injury. Clinical indicators of bladder rupture that may indicate the need for additional imaging with either CT or fluoroscopic cystography include: suprapubic pain and tenderness, inability to void, low urine output or clots in urine, and signs of major perineal trauma such as perineal swelling, hematoma, or blood per meatus [77]. Patients with concomitant head injury, intoxication, altered sensorium, or previous history of bladder outlet obstruction or bladder surgery should be viewed with increased suspicion for bladder injury [77]. If gross blood is identified from the urethral meatus or the prostate is mobile on digital examination (floating) a retrograde urethrogram should be performed first to rule out urethral injury [80].

CT images should be examined carefully for evidence of renal perfusion, hemorrhage, or extravasation of contrast or urine from the kidney or bladder. All but the worst renal injuries (renal pedicle and pelvis) are generally treated with observation; intraperitoneal bladder rupture is treated with surgical repair. Extraperitoneal bladder rupture is managed initially with urethral and suprapubic catheter drainage, whereas intraperitoneal bladder rupture requires prompt surgical therapy.

US plays little if any role in the evaluation of genitourinary trauma. Several studies have documented the inability of US to detect injuries of the kidney or bladder in trauma patients [22,81].

CT Technique

CT evaluation of the abdomen and pelvis for blunt trauma does not require the use of oral contrast. The use of low or iso-osmolar IV contrast (approximately 110-140 cc at 3-5 cc per second with a 60-70-second scan delay) is essential to identify visceral, vascular, or bowel injury. Scanning includes the lower lung fields through the floor of the pelvis. Delayed imaging through the pelvis (5 minutes) is generally performed if the patient is stable to allow better visualizing of the bladder and distal ureters [82].

For a CT cystogram, a Foley catheter is placed into the bladder, and 500 cc of dilute contrast is instilled into the bladder via the catheter, using gravity drip technique, after completion of the abdomen and pelvic CT examination. Imaging of the pelvis commences once the rate of bladder contrast has decreased significantly or stopped. At the conclusion of the CT cystogram, the bladder should be drained through the Foley.

Summary

- Hemodynamically unstable patients presenting with blunt abdominal trauma commonly require assessment with chest radiographs, FAST scanning and kidney-ureter-bladder abdominal radiography (KUB).
- MDCT with IV contrast may not be appropriate for patients who are hemodynamically unstable following blunt abdominal trauma.
- MDCT with IV contrast is the imaging modality of choice for evaluating hemodynamically stable patients following blunt abdominal trauma.
- Patients who are hemodynamically stable following blunt (or penetrating) trauma to the abdomen or pelvis with pelvic fracture, gross hematuria, or >35,000 red blood cells per high-power field (RBC's/hpf) require evaluation of the bladder to rule out bladder perforation or urethral injury. This is most easily performed by CT cystography following initial assessment of the abdomen and pelvis with MDCT using IV contrast.

Relative Radiation Level Information

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

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

Supporting Documents

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

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