

**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 and abnormal air collection. Patient condition permitting.	Min
US chest abdomen and pelvis (FAST scan)	8	Rapid assessment of free fluid. Patient condition permitting.	None
X-ray abdomen and pelvis	8	To evaluate for fracture and abnormal air collection. Patient condition permitting.	Med
CT chest abdomen and pelvis with contrast	7		High
Arteriography with possible embolization abdomen and pelvis	5		NS
US abdomen and pelvis	3		None
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 2: Stable patient.

Radiologic Procedure	Rating	Comments	RRL*
CT chest abdomen and pelvis with contrast	9		High
X-ray chest	8		Min
Arteriography with possible embolization abdomen and pelvis	5		NS
US chest abdomen and pelvis (FAST scan)	5		None
X-ray abdomen and pelvis	4	Information provided by CT.	Med
US abdomen and pelvis	3		None
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

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

Radiologic Procedure	Rating	Comments	RRL*
CT chest abdomen and pelvis with contrast	9		High
X-ray chest	8		Min
X-ray abdomen and pelvis	7	To identify pelvic or spinal fracture.	Med
CT pelvis with bladder contrast (CT cystography)	6	Refer to text for indications.	High
X-ray retrograde urethrography	6	Refer to text for indications.	Med
Arteriography with possible embolization kidney	5	If CT identifies active site of bleed or arterial injury.	NS
X-ray cystography	4	CT cystography preferred.	Med
X-ray intravenous urography	3		Med
US abdomen and pelvis	3		None
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

BLUNT ABDOMINAL TRAUMA

Expert Panels on Vascular Imaging and Gastrointestinal Imaging: Gary S. Sudakoff, MD¹; E. Kent Yucel, MD²; Max Paul Rosen, MD, MPH³; Isaac R. Francis, MD⁴; Richard A. Baum, MD⁵; W. Dennis Foley, MD⁶; Spencer B. Gay, MD⁷; Frederick L. Greene, MD⁸; M. Ashraf Mansour, MD⁹; Frank J. Rybicki, MD, PhD.¹⁰

Summary of Literature Review

This review covers only the issue of blunt abdominal trauma in adults. Penetrating trauma and pediatric cases are not considered. A continued trend is noted in which imaging is used less for mere detecting intraperitoneal fluid (which correlates with injury but does not predict the need for therapeutic surgery) and more for detection of specific findings that do predict the need for therapeutic surgery or for angiographic embolization or that predict the need for a period of close observation for an injured patient. This trend in imaging parallels a strong trend in trauma therapy toward nonoperative management of injuries of the spleen, liver, and kidney even when hemoperitoneum is present. This new approach decreases the frequency of nontherapeutic surgery [1-9].

Category A

Hemodynamically unstable patients presenting to the emergency department with clinically 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. Ultrasound (US) 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 at least 15% [10-15]. More detailed US to check for organ injury takes too

long in this setting and suffers from poor sensitivity [16]. There is now general agreement that routine diagnostic peritoneal lavage (DPL) is obsolete because of its invasive nature, lack of specificity, and inability to predict the need for therapeutic surgery [17]. Those patients for whom emergency department resuscitation is successful can be evaluated by contrast-enhanced computed tomography (CT) before surgery. In those 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 identified during surgery.

Category B

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: 1) Is urgent therapeutic surgery or angiography (invasive therapy) 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, or disruption of the pancreas and or pancreatic duct) [18-30]. The decision to operate urgently does not solely depend 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 [22,31] 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 [32,33]. 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 [34].

At this point, US is not a good modality for imaging evaluation because it misses up to 25% of liver and spleen injuries, most renal injuries, and virtually all pancreatic, mesenteric, and gut injuries [35-37]. Studies have shown that US is quite insensitive in detecting organ injury: it missed 62% of spleen and 14% of liver injuries that were found by CT and surgery [13,17,38]. It also misses a high proportion of retroperitoneal hemorrhage and of bladder rupture. 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

¹Principal Author, Medical College of Wisconsin, Milwaukee, Wisconsin.

²Chair, Expert Panel on Vascular Imaging, Tufts Medical Center, Boston, Massachusetts.

³Chair, Expert Panel on Gastrointestinal Imaging, Beth Israel Hospital, Boston, Massachusetts.

⁴Chair, Expert Panel on Urologic Imaging, University of Michigan, Ann Arbor, Michigan.

⁵Brigham and Women's Hospital, Boston, Massachusetts.

⁶Froedtert Hospital East, Milwaukee, Wisconsin.

⁷University of Virginia Health Science Center, Charlottesville, Virginia.

⁸Carolinas Medical Center, Charlotte, North Carolina, American College of Surgeons.

⁹Vascular Associates, Grand Rapids, Michigan, Society for Vascular Surgery.

¹⁰Brigham and Women's Hospital, Boston, Massachusetts.

The American College of Radiology seeks and encourages collaboration with other organizations on the development of the ACR Appropriateness Criteria through society representation on expert panels. Participation by representatives from collaborating societies on the expert panel does not necessarily imply society endorsement of the final document.

Reprint requests to: Department of Quality & Safety, American College of Radiology, 1891 Preston White Drive, Reston, VA 20191-4397.

74% for organ injury [39]. Unfortunately, a negative US (absence of hemoperitoneum) does not rule out significant organ or viscus injury that might require invasive therapy or observation [40-44].

US is also insensitive to perforation of gut and to pancreatic injury [31,45]. For these reasons, it is not very useful in deciding when a patient needs urgent surgery or angiography [45,46]. 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 [47,48]. It should be noted that 96% of trauma centers perform fewer than two trauma US examinations per month, so there is currently little national experience with or teaching of trauma US [49].

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 [13,50]. Almost regardless of volume, an US diagnosis of free fluid alone does not predict that surgery is needed or that surgery will be therapeutic [38]. In addition, in the best of hands, there is at least a 15% false negative rate for detecting hemoperitoneum with US [31]. US poorly identifies active hemorrhage and also does not accurately predict the need for surgery in splenic injuries [38,45].

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 [18,20-25]. For these reasons, CT is the primary imaging modality for deciding whether a patient needs urgent surgery, therapeutic angiograph [6,7,21,24,25,27,28,30,51] or close observation.

The trend toward placing multidetector CT (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 less than 40 seconds [25,52]. 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 less than 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 [53]. Particular care should be taken to find injury of the spleen because these patients may need observation for potential delayed hemorrhage [32,40,54]. In some instances, stable patients with more severe injuries of the liver or spleen plus hemoperitoneum may be managed conservatively with close observation only [33,34,40,41,55,56]. 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 [27,28,34,57-59].

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 [60]. 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 [19,26,61]. 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 [62-64].

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 promptly 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 kind 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 keep patients with a negative US in the hospital for a period of observation of 12- 48 hours before release [47,48].

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 [31,45]. CT is necessary; however, if there are any positive findings on US.

Category C

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) [65]. 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. Patients with 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 [8,9,36,65-67].

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 bladder imaging with CT or fluoroscopic cystography include: suprapubic pain and tenderness, inability to void, low urine output or clots in urine, signs of major perineal trauma such as perineal swelling, hematoma, or blood per meatus [65]. 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 [65]. 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 [68].

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 with urethral and suprapubic catheter drainage.

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[13,69].

Appendix

CT Technique

CT evaluation of the abdomen and pelvis for blunt trauma does not require the use of oral contrast. The use of intravenous contrast (approximately 150 cc at 2-4 cc per second with a 60-second scan delay) is essential to identify visceral, vascular, or bowel injury. Scanning includes the lower lung fields through the floor of the pelvis, including the inferior aspect of the ischia, with image reconstruction at 2.5-3.0 mm image thickness. Delayed imaging through the pelvis (5 minutes) is generally performed if the patient is stable to allow better visualizing of the bladder [70].

For a CT cystogram, a Foley catheter is placed into the urinary 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.

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. 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*	Effective Dose Estimate Range
None	0
Minimal	< 0.1 mSv
Low	0.1-1 mSv
Medium	1-10 mSv
High	10-100 mSv

*The 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, the region of the body exposed to ionizing radiation, the imaging guidance that is used, etc). The RRLs for these examinations are designated as NS (not specified).

Supporting Document(s)

- [ACR Appropriateness Criteria® Overview](#)
- [Evidence Table](#)

References

1. Croce MA, Fabian TC, Menke PG, et al. Nonoperative management of blunt hepatic trauma is the treatment of choice for hemodynamically stable patients. Results of a prospective trial. *Ann Surg* 1995; 221(6):744-753; discussion 753-745.
2. Delgado Millan MA, Deballon PO. Computed tomography, angiography, and endoscopic retrograde cholangiopancreatography in the nonoperative management of hepatic and splenic trauma. *World J Surg* 2001; 25(11):1397-1402.
3. Garber BG, Yelle JD, Fairfull-Smith R, Lorimer JW, Carson C. Management of splenic injuries in a Canadian trauma centre. *Can J Surg* 1996; 39(6):474-480.
4. Maull KI. Current status of nonoperative management of liver injuries. *World J Surg* 2001; 25(11):1403-1404.
5. Pachter HL, Knudson MM, Esrig B, et al. Status of nonoperative management of blunt hepatic injuries in 1995: a multicenter experience with 404 patients. *J Trauma* 1996; 40(1):31-38.
6. Poletti PA, Mirvis SE, Shanmuganathan K, Killeen KL, Coldwell D. CT criteria for management of blunt liver trauma: correlation with angiographic and surgical findings. *Radiology* 2000; 216(2):418-427.
7. Shanmuganathan K. Multi-detector row CT imaging of blunt abdominal trauma. *Semin Ultrasound CT MR* 2004; 25(2):180-204.
8. Smith JK, Kenney PJ. Imaging of renal trauma. *Radiol Clin North Am* 2003; 41(5):1019-1035.
9. Toutouzas KG, Karaiskakis M, Kaminski A, Velmahos GC. Nonoperative management of blunt renal trauma: a prospective study. *Am Surg* 2002; 68(12):1097-1103.
10. Farahmand N, Sirlin CB, Brown MA, et al. Hypotensive patients with blunt abdominal trauma: performance of screening US. *Radiology* 2005; 235(2):436-443.
11. Kirkpatrick AW, Sirois M, Laupland KB, et al. Prospective evaluation of hand-held focused abdominal sonography for trauma (FAST) in blunt abdominal trauma. *Can J Surg* 2005; 48(6):453-460.
12. Ma OJ, Gaddis G, Steele MT, Cowan D, Kaltenbronn K. Prospective analysis of the effect of physician experience with the

- FAST examination in reducing the use of CT scans. *Emerg Med Australas* 2005; 17(1):24-30.
13. McGahan JP, Rose J, Coates TL, Wisner DH, Newberry P. Use of ultrasonography in the patient with acute abdominal trauma. *J Ultrasound Med* 1997; 16(10):653-662; quiz 663-654.
 14. Nural MS, Yordan T, Guven H, Baydin A, Bayrak IK, Kati C. Diagnostic value of ultrasonography in the evaluation of blunt abdominal trauma. *Diagn Interv Radiol* 2005; 11(1):41-44.
 15. Salera D, Argalia G, Giuseppetti GM. Screening US for blunt abdominal trauma: a retrospective study. *Radiol Med (Torino)* 2005; 110(3):211-220.
 16. Valentino M, Serra C, Zironi G, De Luca C, Pavlica P, Barozzi L. Blunt abdominal trauma: emergency contrast-enhanced sonography for detection of solid organ injuries. *AJR* 2006; 186(5):1361-1367.
 17. Nordenholz KE, Rubin MA, Gualarte GG, Liang HK. Ultrasound in the evaluation and management of blunt abdominal trauma. *Ann Emerg Med* 1997; 29(3):357-366.
 18. Breen DJ, Janzen DL, Zwirewich CV, Nagy AG. Blunt bowel and mesenteric injury: diagnostic performance of CT signs. *J Comput Assist Tomogr* 1997; 21(5):706-712.
 19. Butela ST, Federle MP, Chang PJ, et al. Performance of CT in detection of bowel injury. *AJR* 2001; 176(1):129-135.
 20. Cox CS, Jr., Geiger JD, Liu DC, Garver K. Pediatric blunt abdominal trauma: role of computed tomography vascular blush. *J Pediatr Surg* 1997; 32(8):1196-1200.
 21. Davis KA, Fabian TC, Croce MA, et al. Improved success in nonoperative management of blunt splenic injuries: embolization of splenic artery pseudoaneurysms. *J Trauma* 1998; 44(6):1008-1013; discussion 1013-1005.
 22. Federle MP, Courcoulas AP, Powell M, Ferris JV, Peitzman AB. Blunt splenic injury in adults: clinical and CT criteria for management, with emphasis on active extravasation. *Radiology* 1998; 206(1):137-142.
 23. Gavant ML, Schurr M, Flick PA, Croce MA, Fabian TC, Gold RE. Predicting clinical outcome of nonsurgical management of blunt splenic injury: using CT to reveal abnormalities of splenic vasculature. *AJR* 1997; 168(1):207-212.
 24. Hagiwara A, Yukioka T, Ohta S, et al. Nonsurgical management of patients with blunt hepatic injury: efficacy of transcatheter arterial embolization. *AJR* 1997; 169(4):1151-1156.
 25. Jhirad R, Boone D. Computed tomography for evaluating blunt abdominal trauma in the low-volume nondesignated trauma center: the procedure of choice? *J Trauma* 1998; 45(1):64-68.
 26. Killeen KL, Shanmuganathan K, Poletti PA, Cooper C, Mirvis SE. Helical computed tomography of bowel and mesenteric injuries. *J Trauma* 2001; 51(1):26-36.
 27. Willmann JK, Roos JE, Platz A, et al. Multidetector CT: detection of active hemorrhage in patients with blunt abdominal trauma. *AJR* 2002; 179(2):437-444.
 28. Yao DC, Jeffrey RB, Jr., Mirvis SE, et al. Using contrast-enhanced helical CT to visualize arterial extravasation after blunt abdominal trauma: incidence and organ distribution. *AJR* 2002; 178(1):17-20.
 29. Omert LA, Salyer D, Dunham CM, Porter J, Silva A, Protetch J. Implications of the "contrast blush" finding on computed tomographic scan of the spleen in trauma. *J Trauma* 2001; 51(2):272-277; discussion 277-278.
 30. Sclafani SJ, Shaftan GW, Scalea TM, et al. Nonoperative salvage of computed tomography-diagnosed splenic injuries: utilization of angiography for triage and embolization for hemostasis. *J Trauma* 1995; 39(5):818-825; discussion 826-817.
 31. Bode PJ, Edwards MJ, Kruit MC, van Vugt AB. Sonography in a clinical algorithm for early evaluation of 1671 patients with blunt abdominal trauma. *AJR* 1999; 172(4):905-911.
 32. Croce MA, Fabian TC, Kudsk KA, et al. AAST organ injury scale: correlation of CT-graded liver injuries and operative findings. *J Trauma* 1991; 31(6):806-812.
 33. Hollands MJ, Little JM. Non-operative management of blunt liver injuries. *Br J Surg* 1991; 78(8):968-972.
 34. Sclafani SJ, Weisberg A, Scalea TM, Phillips TF, Duncan AO. Blunt splenic injuries: nonsurgical treatment with CT, arteriography, and transcatheter arterial embolization of the splenic artery. *Radiology* 1991; 181(1):189-196.
 35. Goins WA, Rodriguez A, Lewis J, Brathwaite CE, James E. Retroperitoneal hematoma after blunt trauma. *Surg Gynecol Obstet* 1992; 174(4):281-290.
 36. Kristjansson A, Pedersen J. Management of blunt renal trauma. *Br J Urol* 1993; 72(5 Pt 2):692-696.
 37. Richards JR, Schleper NH, Woo BD, Bohnen PA, McGahan JP. Sonographic assessment of blunt abdominal trauma: a 4-year prospective study. *J Clin Ultrasound* 2002; 30(2):59-67.
 38. Krupnick AS, Teitelbaum DH, Geiger JD, et al. Use of abdominal ultrasonography to assess pediatric splenic trauma. Potential pitfalls in the diagnosis. *Ann Surg* 1997; 225(4):408-414.
 39. Visvanathan R, Low HC. Blunt abdominal trauma--injury assessment in relation to early surgery. *J R Coll Surg Edinb* 1993; 38(1):19-22.
 40. Becker CD, Spring P, Glatli A, Schweizer W. Blunt splenic trauma in adults: can CT findings be used to determine the need for surgery? *AJR* 1994; 162(2):343-347.
 41. Farhat GA, Abdu RA, Vanek VW. Delayed splenic rupture: real or imaginary? *Am Surg* 1992; 58(6):340-345.
 42. Miller MT, Pasquale MD, Bromberg WJ, Wasser TE, Cox J. Not so FAST. *J Trauma* 2003; 54(1):52-59; discussion 59-60.
 43. Ochsner MG, Knudson MM, Pachter HL, et al. Significance of minimal or no intraperitoneal fluid visible on CT scan associated with blunt liver and splenic injuries: a multicenter analysis. *J Trauma* 2000; 49(3):505-510.
 44. Shanmuganathan K, Mirvis SE, Sherbourne CD, Chiu WC, Rodriguez A. Hemoperitoneum as the sole indicator of abdominal visceral injuries: a potential limitation of screening abdominal US for trauma. *Radiology* 1999; 212(2):423-430.
 45. McGahan JP, Richards JR. Blunt abdominal trauma: the role of emergent sonography and a review of the literature. *AJR* 1999; 172(4):897-903.
 46. Thomas B, Falcone RE, Vasquez D, et al. Ultrasound evaluation of blunt abdominal trauma: program implementation, initial experience, and learning curve. *J Trauma* 1997; 42(3):384-388; discussion 388-390.
 47. Lingawi SS, Buckley AR. Focused abdominal US in patients with trauma. *Radiology* 2000; 217(2):426-429.
 48. Sirlin CB, Brown MA, Andrade-Barreto OA, et al. Blunt abdominal trauma: clinical value of negative screening US scans. *Radiology* 2004; 230(3):661-668.
 49. Self ML, Blake AM, Whitley M, Nadalo L, Dunn E. The benefit of routine thoracic, abdominal, and pelvic computed tomography to evaluate trauma patients with closed head injuries. *Am J Surg* 2003; 186(6):609-613; discussion 613-604.
 50. Branney SW, Wolfe RE, Moore EE, et al. Quantitative sensitivity of ultrasound in detecting free intraperitoneal fluid. *J Trauma* 1995; 39(2):375-380.
 51. Williams RA, Black JJ, Sinow RM, Wilson SE. Computed tomography-assisted management of splenic trauma. *Am J Surg* 1997; 174(3):276-279.
 52. Clancy TV, Weintritt DC, Ramshaw DG, Churchill MP, Covington DL, Maxwell JG. Splenic salvage in adults at a level II community hospital trauma center. *Am Surg* 1996; 62(12):1045-1049.
 53. Ahvenjarvi L, Niinimaki J, Halonen J, Tervonen O, Ojala R. Reliability of the evaluation of multidetector computed tomography images from the scanner's console in high-energy blunt-trauma patients. *Acta Radiol* 2007; 48(1):64-70.
 54. Watson CJ, Calne RY, Padhani AR, Dixon AK. Surgical restraint in the management of liver trauma. *Br J Surg* 1991; 78(9):1071-1075.
 55. Black JJ, Sinow RM, Wilson SE, Williams RA. Subcapsular hematoma as a predictor of delayed splenic rupture. *Am Surg* 1992; 58(12):732-735.
 56. Tricarico A, Sicoli F, Calise F, Iavazzo E, Salvatore M, Mansi L. Conservative treatment in splenic trauma. *J R Coll Surg Edinb* 1993; 38(3):145-148.
 57. Mohr AM, Lavery RF, Barone A, et al. Angiographic embolization for liver injuries: low mortality, high morbidity. *J Trauma* 2003; 55(6):1077-1081; discussion 1081-1072.
 58. Sofocleous CT, Hinrichs C, Hubbi B, et al. Angiographic findings and embolotherapy in renal arterial trauma. *Cardiovasc Intervent Radiol* 2005; 28(1):39-47.
 59. Wahl WL, Ahms KS, Chen S, Hemmila MR, Rowe SA, Arbabi S. Blunt splenic injury: operation versus angiographic embolization. *Surgery* 2004; 136(4):891-899.
 60. Kunin JR, Korobkin M, Ellis JH, Francis IR, Kane NM, Siegel SE. Duodenal injuries caused by blunt abdominal trauma: value of CT

- in differentiating perforation from hematoma. *AJR* 1993; 160(6):1221-1223.
61. Nghiem HV, Jeffrey RB, Jr., Mindelzun RE. CT of blunt trauma to the bowel and mesentery. *AJR* 1993; 160(1):53-58.
 62. Saku M, Yoshimitsu K, Murakami J, et al. Small bowel perforation resulting from blunt abdominal trauma: interval change of radiological characteristics. *Radiat Med* 2006; 24(5):358-364.
 63. Stuhlfaut JW, Lucey BC, Varghese JC, Soto JA. Blunt abdominal trauma: utility of 5-minute delayed CT with a reduced radiation dose. *Radiology* 2006; 238(2):473-479.
 64. Townsend MC, Flancaum L, Choban PS, Cloutier CT. Diagnostic laparoscopy as an adjunct to selective conservative management of solid organ injuries after blunt abdominal trauma. *J Trauma* 1993; 35(4):647-651; discussion 651-643.
 65. Iverson AJ, Morey AF. Radiographic evaluation of suspected bladder rupture following blunt trauma: critical review. *World J Surg* 2001; 25(12):1588-1591.
 66. Eastham JA, Wilson TG, Ahlering TE. Radiographic evaluation of adult patients with blunt renal trauma. *J Urol* 1992; 148(2 Pt 1):266-267.
 67. Knudson MM, McAninch JW, Gomez R, Lee P, Stubbs HA. Hematuria as a predictor of abdominal injury after blunt trauma. *Am J Surg* 1992; 164(5):482-485; discussion 485-486.
 68. Fuhrman GM, Simmons GT, Davidson BS, Buerk CA. The single indication for cystography in blunt trauma. *Am Surg* 1993; 59(6):335-337.
 69. McGahan JP, Richards JR, Jones CD, Gerscovich EO. Use of ultrasonography in the patient with acute renal trauma. *J Ultrasound Med* 1999; 18(3):207-213; quiz 215-206.
 70. Ptak T, Rhea JT, Novelline RA. Radiation dose is reduced with a single-pass whole-body multi-detector row CT trauma protocol compared with a conventional segmented method: initial experience. *Radiology* 2003; 229(3):902-905.

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.