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American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Blunt Abdominal Trauma**

Variant 1: **Stable patient.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray abdomen supine and upright	8	CT and x-rays may be appropriate. See text for details.	Low
CT abdomen and pelvis	8	MDCT is preferable. CT and x-rays may be appropriate. See text for details.	High
INV angiography embolization for bleeding abdomen and pelvis	8	Not a screening procedure. Angiography is indicated to delineate and treat active bleeding or other lesions amenable to angiographic therapy, but only when this type of lesion is first detected or suspected, either by CT or by some other means.	IP
X-ray chest	8	CT and x-rays may be appropriate. See text for details.	Min
US screen for hemoperitoneum	4	Low sensitivity of ultrasound to injuries that require surgery (active hemorrhage, viscus perforation) and its inability to exclude injuries that require in-hospital observation lessen its usefulness for key triage decisions.	None
US organ	3		None
MRI organ evaluation	2		None
MRI diaphragm evaluation	2		None
Rating Scale: **1=Least appropriate, 9=Most appropriate**			***Relative Radiation Level**

Clinical Condition: **Blunt Abdominal Trauma**

Variant 2: **Unstable patient.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	7		Min
US screen for hemoperitoneum	7		None
X-ray abdomen supine and upright	6		Low
US organ	4		None
INV angiography embolization for bleeding abdomen and pelvis	4		IP
CT abdomen and pelvis	4	MDCT is preferable. Clinical judgment needed on stability of patient versus need for diagnostic information.	High
MRI organ evaluation	2		None
MRI diaphragm evaluation	2		None
Rating Scale: 1=Least appropriate, 9=Most appropriate			***Relative Radiation Level**

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

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	8	CT and x-rays may be appropriate. See text for details.	Min
X-ray abdomen supine and upright	8	CT and x-rays may be appropriate. See text for details.	Low
CT abdomen and pelvis	8	MDCT is preferable. CT and x-rays may be appropriate. See text for details.	High
CT cystography	7		High
X-ray retrograde urethrogram	7	If urethral injury is suspected.	Med
X-ray intravenous urography	4		Low
X-ray cystography	4		Med
INV angiography kidney	4		IP
US organ	3		None
US bladder	3		None
MRI kidneys and bladder	2		None
Rating Scale: 1=Least appropriate, 9=Most appropriate			***Relative Radiation Level**

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Summary of Literature Review

This review considers only the issue of blunt abdominal trauma in adults. Penetrating trauma and pediatric cases are not considered. Since the original summaries of literature in 1996 and 1999, a continued trend is noted in which imaging is used less for mere detection of 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 a period of close observation is needed 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 room 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 (become hemodynamically stable), *and* if they have clear clinical evidence of abdominal injury, they should go immediately to the operating room without imaging [10,11]. During resuscitive 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 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% [12,13]. More detailed ultrasound to check for organ injury takes too long in this setting and suffers from poor sensitivity [12]. 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 [12,14,15].

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. These patients 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 needed? (2) If surgery is not needed, is a period of close observation warranted? If computed tomography (CT) is to be performed, plain films 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 that predict that the surgery will be therapeutic: active hemorrhage, parenchymal "blush" or pseudoaneurysm in the spleen, or perforation of a hollow viscus (including the pancreatic duct) [16-27]. In patients with active hemorrhage or pseudoaneurysm of the spleen, angiographic embolization may also be therapeutic [16,17,28,29]. The decision to operate urgently does not solely depend on the identification of hemoperitoneum or the identification of parenchymal injury to the liver or spleen, because most patients in this category ultimately do not need surgery [2,3,30]. However, accurate identification of hemoperitoneum or organ injury is important [19,31,32] because patients with these findings require at least a period of close observation. Patients with multiple organ injury or significant active bleeding may need surgery even if they are hemodynamically stable [11,33,34]. Conversely, stable patients with isolated organ injury may not need surgery (or may need only angiography plus embolization) even with a large amount of hemoperitoneum [35,36].

Either way, time is available in such patients to obtain chest and abdominal radiographs, a hematocrit plus blood chemistries, and a urinalysis. If a reliable abdominal exam can be performed (the patient is conscious and does not need prolonged anesthesia for other procedures) and all the above preliminary tests are unremarkable, a period of close observation may be all that is needed. However, if a reliable abdominal exam cannot be performed (patient is

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unconscious or prolonged nonabdominal surgery is anticipated) or if a clinical evaluation suggests organ injury, hemoperitoneum, or peritonitis, further imaging is needed.

At this point, ultrasound is not a good modality for further imaging because it misses up to 25% of liver and spleen injuries, most renal injuries, and virtually all pancreatic, mesenteric, and gut injuries [10,37-47]. It also misses a high proportion of retroperitoneal hemorrhage and of bladder rupture. Combining the results for ultrasound in 1535 abdominal trauma patients from eight published series yields an average ultrasound sensitivity for hemoperitoneum of 88% and for organ injury of 74% [37,39,41,48-51]. Unfortunately, a negative ultrasound (absence of hemoperitoneum) does not rule out significant organ or viscus injury that might require surgery or observation [10,37,38,40,44,52-57].

Although ultrasound is 63% sensitive to moderate amounts of free intraperitoneal fluid (compared with CT), 400-600 cc are needed for ultrasound detection of fluid in the trauma setting [13,58]. Almost regardless of volume, an ultrasound diagnosis of free fluid alone does not predict that surgery is needed nor that surgery will be therapeutic [30,59]. In addition, in the best of hands, there is at least a 15% false negative rate for detecting hemoperitoneum with ultrasound [32]. Further, ultrasound is quite insensitive in detecting organ injury: 62% of spleen and 14% of liver injuries are missed compared with CT and operative findings [13,15,59]. Ultrasound poorly identifies active hemorrhage and also does not accurately predict the need for surgery in splenic injuries [59,60].

Ultrasound is also insensitive to perforation of gut and to pancreatic injury [32,60]. For these reasons, it is not very useful in deciding when a patient needs urgent therapeutic surgery or angiography [31,60,61]. For the same reasons, ultrasound is not an accurate modality to determine whether a patient needs a period of close observation; thus, if a negative ultrasound 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 [62,63]. It should be noted that 96% of trauma centers perform fewer than two trauma ultrasound exams per month, so there is currently little national experience with or teaching of trauma ultrasound [64].

In contrast, for category B trauma patients, CT accurately predicts if therapeutic surgery is urgently needed by identifying active hemorrhage, splenic injury (either parenchymal contrast blush or pseudoaneurysm), gut perforation, and pancreatic injury [16-23]. For these reasons, it is an excellent modality for deciding whether a patient needs urgent therapeutic surgery or is a candidate for therapeutic angiography [4,5,16,17,20,23-25,28,65]. Because CT is sensitive in detecting both hemoperitoneum [19,21,23,65-67] and injury to the liver (sensitivity 93%) and spleen (sensitivity 95%), it is an accurate modality for deciding if a patient needs a period of close observation. The trend toward placing helical CT 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 [23,66]. In most circumstances, results from a helical CT of the abdomen and pelvis can be obtained faster than results from a detailed ultrasound that includes evaluation of abdominal organs and gut [14].

If multidetector CT (MDCT) with rapid image display capability is available in or next to an emergency department, abdominal CT can be performed in about 2 minutes—excluding time needed for patient transport, CT scan setup, and archiving of images. Including all time requirements, patient turnaround with rapid-process MDCT CT can be less 10 minutes for a trauma patient. For single-slice incremental CT, turnaround time is somewhat longer, usually 20 minutes. Scanning multiple body regions increases these times variably.

An experienced radiologist should carefully examine images on film, PACS, or at the CT console, where images can be altered to seek bone injury, pneumoperitoneum, or subtle organ injury. Particular care should be taken to find minimal injury of the spleen because these patients may need observation for potential delayed hemorrhage [11,33,52,68]. In some instances, stable patients with more severe injuries of the liver or spleen plus hemoperitoneum may be managed conservatively with only close observation [11,34-36,52,53,69-74]. 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 exams, the patient may be taken to the operating room or undergo arteriography plus embolization to control the hemorrhage [24,25,36,75-77].

The CT exam should be carefully examined for subtle signs of pancreatic injury because these patients may need immediate surgery or close observation for signs of complication [44]. Duodenal perforation produces subtle but frequent findings on CT, e.g., typically extraluminal air or contrast in the retroperitoneum or elsewhere; these findings mandate surgical intervention [78]. Duodenal hematoma may not require surgery but does need close observation. Other gut injury or perforation produces direct or indirect findings on CT in 50% to 94% of cases [26,27,54,79,80]. However, if the CT is negative for gut injury in the face of a high clinical suspicion, DPL, laparoscopy, or a period of observation plus repeat CT may be used to further evaluate the patient [81].

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 ultrasound alone may be adequate to release the patient from observation at a lower cost than if CT had been used [32,60]. CT is necessary, however, if there are any positive findings on ultrasound.

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 at the completion of their investigation 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. Ultrasound has a substantially lower sensitivity to the kind of injuries that must be observed in the hospital. For this reason, a negative ultrasound is not adequate to safely release the patient to home. This weakness of ultrasound is reflected in the design of many outcomes-based investigations on the use of ultrasound in trauma: all keep patients with a negative ultrasound in the hospital for a period of observation of 12- 48 hours before release [31,62,63].

Category C

Patients with hematuria require some modification to the imaging workup. Patients with microscopic hematuria (less than 35 RBC per HPF) do not need specific urinary tract imaging. All patients with microscopic hematuria greater than 35 RBCs per HPF, with macroscopic hematuria, or with fracture/diastasis of the symphysis pubis and its rami plus any hematuria need imaging of the urinary tract [8,9,45,46,82-85]. If the urethral meatus has gross blood, if there is a floating prostate, or if a Foley catheter cannot be passed, a retrograde urethrogram should first be performed to rule out urethral injury [86,87]. However, if clinical evaluation or the urethrogram indicates no urethral injury, a CT cystogram should be added to the abdominal CT (see appendix). CT images should be examined carefully for evidence of renal perfusion, hemorrhage, or extravasation of contrast or urine from the kidney or bladder. Two studies have documented the poor ability of ultrasound to detect injuries of the kidney [13,88]. All but the worst renal injuries are treated with observation; intraperitoneal bladder rupture is usually treated with surgical repair.

Several new issues in the imaging of blunt abdominal trauma will certainly be investigated soon. Does magnetic resonance imaging (MRI) have any role in evaluating trauma patients? Might MR be more sensitive in detecting subtle organ injury that should lead to close observation of the patient for a period [89,90]? The advent of rapid MDCT placed in or very near to emergency departments may change the treatment of some unstable patients [91-93]. It is possible that information from a quick helical CT or MDCT, which localizes injury or hemorrhage in an unstable patient, will enable surgeons to directly approach a specific injury, rather than use the traditional techniques of surgical exploration. This might facilitate more rapid control of the patient in the operating room, improving outcome. Angiography with embolization of active hemorrhage has shown great capability for stopping bleeding while preserving organs [4,5,94]. Color Doppler ultrasound may ultimately prove useful, although ready availability and expertise of the sonologist/interpreter will be necessary [51,95].

Appendix

CT Technique

Good CT technique requires the use of water-soluble oral contrast when time is available (500 cc PO or per NG tube 20 minutes before scanning, 250 cc on the CT table) [54,69,78]. In unstable patients, administration of oral contrast should not delay scanning, but oral contrast often can be administered during transportation of the patient or during scan setup in the CT suite. Scanning without oral contrast or with water as the oral contrast agent has also been proposed [96,97]. Intravenous contrast is necessary, usually 140 to 180 cc administered at 3 to 5 cc per second 70-80 seconds before to starting MDCT. For single-slice CT, injection rate and delay may be modified to 2 cc per second and 50 seconds. Scanning should include the interior lung fields to the inferior aspect of the ischia at 2.5 mm to 10 mm intervals using 2.5 mm to 7 mm thick slice reconstructions. High-detector-count CT scanners (16, 32, and 64 slice) may make practical rapid single pass whole body CT with quick 3D image review [98].

For a CT cystogram, a Foley catheter is placed and 200 to 300 cc of 15% contrast is instilled before the abdomen and pelvic CT exam [71,83]. At the conclusion of the CT exam, the bladder should be drained through the Foley and repeat CT cuts obtained through the low pelvis to complete the CT cystogram.

References

1. 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.
2. 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):744-755.

3. Garber BG, Yelle JD, Fairfull-Smith R, et al. Management of splenic injuries in a Canadian trauma centre. *Can J Surg* 1996; 39(6):474-480.
4. Shanmuganathan K. Multi-detector row CT imaging of blunt abdominal trauma. *Semin Ultrasound CT MR* 2004; 25(2):180-204.
5. Poletti PA, Mirvis SE, Shanmuganathan K et al. CT criteria for management of blunt liver trauma: correlation with angiographic and surgical findings. *Radiology* 2000; 216(2):418-427.
6. Maull KI. Current status of nonoperative management of liver injuries. *World J Surg* 2001; 25(11):1403-1404.
7. 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.
8. Toutouzas KG, Karaiskakis M, Kaminski A, Velmahos GC. Nonoperative management of blunt renal trauma: a prospective study. *Am Surg* 2002; 68(12):1097-1103.
9. Smith JK, Kenney PJ. Imaging of renal trauma. *Radiol Clin North Am* 2003; 41(5):1019-1035.
10. Feliciano DV. Diagnostic modalities in abdominal trauma. Peritoneal lavage, ultrasonography, computed tomography scanning, and arteriography. *Surg Clin North Am* 1991; 71(2):241-256.
11. Gay SB, Sistrom CL. Computed tomographic evaluation of blunt abdominal trauma. *Radiol Clin North Am* 1992; 30(2):367-388.
12. Wherrett LJ, Boulanger BR, McLellan BA, et al. Hypotension after blunt abdominal trauma: the role of emergent abdominal sonography in surgical triage. *J Trauma* 1996; 41(5):815-820.
13. McGahan JP, Rose J, Coates TL, et al. Use of ultrasonography in the patient with acute abdominal trauma. *J Ultrasound Med* 1997; 16(10):653-662.
14. Healey MA, Simons RK, Winchell RJ, et al. A prospective evaluation of abdominal ultrasound in blunt trauma: is it useful? *J Trauma* 1996; 40(6):875-885.
15. Nordenholz KE, Rubin MA, Gularte GG, Laing HK. Ultrasound in the evaluation and management of blunt abdominal trauma. *Ann Emerg Med* 1997; 29(3):357-366.
16. 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.
17. Hagiwara A, Yukioka T, Ohata S, et al. Nonsurgical management of patients with blunt hepatic injury: efficacy of transcatheter arterial embolization. *AJR* 1997; 169(4):1151-1156.
18. 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.
19. Federle MP, Courcoulas AP, Powell M, et al. Blunt splenic injury in adults: clinical and CT criteria for management, with emphasis on active extravasation. *Radiology* 1998; 206(1):137-142.
20. Schurr MJ, Fabian TC, Gavant M, et al. Management of blunt splenic trauma: computed tomographic contrast blush predicts failure of nonoperative management. *J Trauma* 1995; 39(3):507-513.
21. Gavant ML, Schurr MJ, Flick PA, et al. Predicting clinical outcome of nonsurgical management of blunt splenic injury: using CT to reveal abnormalities of splenic vasculature. *AJR* 1997; 168(1):207-212.
22. 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.
23. 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.
24. 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.
25. 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.
26. Butela ST, Federle MP, Chang PJ, et al. Performance of CT in detection of bowel injury. *AJR* 2001; 176(1)129-135.
27. Killeen KL, Shanmuganathan K, Poletti PA et al. Helical computed tomography of bowel and mesenteric injuries. *J Trauma* 2001; 51(1):26-36.
28. 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):818-827.
29. Omert LA, Salyer D, Dunham CM, et al. Implications of the "contrast blush" finding on computed tomographic scan of the spleen in trauma. *J Trauma* 2001; 51(2):272-278.
30. Pearl WS, Todd KH. Ultrasonography for the initial evaluation of blunt abdominal trauma: a review of prospective trials. *Ann Emerg Med* 1996; 27(3):353-361.
31. McKenney MG, Martin L, Lentz K, et al. 1,000 consecutive ultrasounds for blunt abdominal trauma. *J Trauma* 1996; 40(4):607-612.
32. Bode PJ, Edwards MJ, Kruit MC, Vugt AB. Sonography in a clinical algorithm for early evaluation of 1671 patients with blunt abdominal trauma. *AJR* 1999; 172:905-911.
33. 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.
34. Hollands MJ, Little JM. Non-operative management of blunt liver injuries. *Br J Surg* 1991; 78(8):968-972.
35. Hammond JC, Canal DF, Broadie TA. Non-operative management of adult blunt hepatic trauma in a municipal trauma center. *Am Surg* 1992; 58(9):551-556.
36. 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.
37. Tso P, Rodriguez A, Cooper C, et al. Sonography in blunt abdominal trauma: a preliminary progress report. *J Trauma* 1992; 33(1):39-44.
38. Forster R, Pillasch J, Zielke A, et al. Ultrasonography in blunt abdominal trauma: influence of the investigators' experience. *J Trauma* 1993; 34(2):264-269.
39. Liu M, Lee CH, P'eng FK. Prospective comparison of diagnostic peritoneal lavage, computed tomographic scanning, and ultrasonography for the diagnosis of blunt abdominal trauma. *J Trauma* 1993; 35(2):267-270.
40. Rothlin MA, Naf R, Amgwerd M, et al. Ultrasound in blunt abdominal and thoracic trauma. *J Trauma* 1993; 34(4):488-495.
41. Rozycki GS, Ochsner MG, Jaffin JH, Champion HR. Prospective evaluation of surgeons' use of ultrasound in the evaluation of trauma patients. *J Trauma* 1993; 34(4):516-527.
42. Goins WA, Rodriguez A, Lewis J, et al. Retroperitoneal hematoma after blunt trauma. *Surg Gynecol Obstet* 1992; 174(4):281-290.
43. Ghahremani GG. Radiologic evaluation of suspected gastrointestinal perforations. *Radiol Clin North Am* 1993; 31(6):1219-1234.
44. Dodds WJ, Taylor AJ, Erickson SJ, Lawson TL. Traumatic fracture of the pancreas: CT characteristics. *J Comput Assist Tomogr* 1990; 14(3):375-378.
45. Werkman HA, Jansen C, Klein JP, Ten Duis HJ. Urinary tract injuries in multiply-injured patients: a rational guideline for the initial assessment. *Injury* 1991; 22(6):471-474.
46. Kristjansson A, Pedersen J. Management of blunt renal trauma. Br J Urol 1993; 72:692-696.
47. Richards JR, Schleper NH, Woo BD, et al. Sonographic assessment of blunt abdominal trauma: a 4-year prospective study. *J Clin Ultrasound* 2002; 30(2):59-67.
48. Hoffmann R, Nerlich M, Muggia-Sullam M, et al. Blunt abdominal trauma in cases of multiple trauma evaluated by ultrasonography: a prospective analysis of 291 patients. *J Trauma* 1992; 32(4):452-458.

49. Visvanathan R, Low HC. Blunt abdominal trauma: injury assessment in relation to early surgery. *J R Coll Surg Edinb* 1993; 38(1):19-22.
50. Jehle D, Guarino J, Karamanoukian H. Emergency department ultrasound in the evaluation of blunt abdominal trauma. *Am J Emerg Med* 1993; 11(4):342-346.
51. Bode PJ, Niezen RA, van Vugt AB, Schipper J. Abdominal ultrasound as a reliable indicator for conclusive laparotomy in blunt abdominal trauma. *J Trauma* 1993; 34(1):27-31.
52. Becker CD, Spring P, Glatti 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.
53. Farhat GA, Abdu RA, Vanek VW. Delayed splenic rupture: real or imaginary? *Am Surg* 1992; 58(6):340-345.
54. Mirvis SE, Gens DR, Shanmuganathan K. Rupture of the bowel after blunt abdominal trauma: diagnosis with CT. *AJR* 1992; 159(6):1217-1221.
55. Miller MT, Pasquale MD, Bromberg WJ, et al. Not so FAST. *J Trauma* 2003; 54(1):52-60.
56. 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.
57. Shanmuganathan K, Mirvis SE, Sherbourne CD, et al. Hemoperitoneum as the sole indicator of abdominal visceral injuries: a potential limitation of screening abdominal US for trauma. *Radiology* 1999; 212(2):423-430.
58. Branney SW, Wolfe RE, Moore EE, et al. Quantitative sensitivity of ultrasound in detecting free intraperitoneal fluid. *J Trauma* 1995; 39(2):375-380.
59. 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.
60. McGahan JP, Richards JR. Blunt abdominal trauma: the role of emergent sonography and a review of the literature. *AJR* 1999; 172:897-903.
61. 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):384-390.
62. Lingawi SS, Buckley AR. Focused abdominal US in patients with trauma. *Radiology* 2000; 217(2):426-429.
63. 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.
64. Self ML, Blake AM, Whitley M, et al. The benefit of routine thoracic, abdominal, and pelvic computed tomography to evaluate trauma patients with closed head injuries. *Am J Surg* 2003; 186(6):609-614.
65. Williams RA, Black JJ, Sinow RM, Wilson SE. Computed tomography assisted management of splenic trauma. *Am J Surg* 1997; 174(3):276-279.
66. Clancy TV, Weintritt DC, Ramshaw DG, et al. Splenic salvage in adults at a level II community hospital trauma center. *Am Surg* 1996; 62(12):1045-1049.
67. Shuman WP. CT of blunt abdominal trauma in adults. *Radiology* 1997; 205(2):297-306.
68. Watson CJ, Calne RY, Padhani AR, Dixon AK. Surgical restraint in the management of liver trauma. *Br J Surg* 1991; 78(9):1071-1075.
69. Jeffrey RB Jr, Olcot EW. Imaging of blunt hepatic trauma. *Radiol Clin North Am* 1991; 29(6):1299-1310.
70. Federico JA, Horner WR, Clark DE, Isler RJ. Blunt hepatic trauma. Non-operative management in adults. *Arch Surg* 1990; 125(7):905-909.
71. Bynoe RP, Bell RM, Miles WS, et al. Complications of non-operative management of blunt hepatic injuries. *J Trauma* 1992; 32(3):308-315.
72. Smith JS Jr, Wengrovitz MA, DeLong BS. Prospective validation of criteria, including age, for safe, nonsurgical management of the ruptured spleen. *J Trauma* 1992; 33(3):363-369.
73. Black JJ, Sinow RM, Wilson SE, Williams RA. Subcapsular hematoma as a predictor of delayed splenic rupture. *Am Surg* 1992; 58(12):732-735.
74. Tricarico A, Sicoli F, Calise F, et al. Conservative treatment in splenic trauma. *J R Coll Surg Edinb* 1993; 38(3):145-148.
75. Sofocleous CT, Hinrich C, Hubbi B, et al. Angiographic findings and embolotherapy in renal arterial trauma. Cardiovasc Intervent *Radiol* 2005; 28(1):39-47
76. Wahl WL, Ahrns KS, Chen S, et al. Blunt splenic injury: operation versus angiographic embolization. *Surgery* 2004. 136(4):891-899.
77. 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 1081-1082.
78. Kunin JR, Korobkin M, Ellis JH, et al. Duodenal injuries caused by blunt abdominal trauma: value of CT in differentiating perforation from hematoma. *AJR* 1993; 160(6):1221-1223.
79. Rizzo MJ, Federle MP, Griffiths BG. Bowel and mesenteric injury following blunt abdominal trauma: evaluation with CT. *Radiology* 1989; 173(1):143-148.
80. Nghiem HV, Jeffrey RB Jr, Mindelzun RE. CT of blunt trauma to the bowel and mesentery. *AJR* 1993; 160(1):53-58.
81. Townsend MC, Flancbaum 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):647-653.
82. Herschorn S, Radomski SB, Shoskes DA, et al. Evaluation and treatment of blunt renal trauma. *J Urol* 1991; 146(2):274-277.
83. Knudson MM, McAninch JW, Gomez R, et al. Hematuria as a predictor of abdominal injury after blunt trauma. *Am J Surg* 1992; 164(5):482-486.
84. Burbridge BE, Groot G, Oleniuk FF, et al. Emergency excretory urography in blunt abdominal trauma. *Can Assoc Radiol J* 1991; 42(5):326-328.
85. Eastham JA, Wilson TG, Ahlering TE. Radiographic evaluation of adult patients with blunt renal trauma. *J Urol* 1992; 148:266-267.
86. Fuhrman GM, Simmons GT, Davidson BS, Buerk CA. The single indication for cystography in blunt trauma. *Am Surg* 1993; 59(6):335-337.
87. Rehm CG, Mure AJ, O'Malley KF, Ross SE. Blunt traumatic bladder rupture: the role of retrograde cystogram. *Ann Emerg Med* 1991; 20(8):845-847.
88. McGahan JP, Richards JR, Jones CD, Gerscovich EO. Use of ultrasonography in the patient with acute renal trauma. *J Ultrasound Med* 1999; 18(3):207-216.
89. Fulcher AS, Turner MA, Yelon JA, et al. Magnetic resonance cholangiopancreatography (MRCP) in the assessment of pancreatic duct trauma and its sequelae: preliminary findings. *J Trauma* 2000; 48(6):1001-1007.
90. Terk MR, Rozenberg D. Gadolinium-enhanced MR imaging of traumatic hepatic injury. *AJR* 1998; 171(3):665-669.
91. Fried AM, Humphries R, Schofield CN. Abdominal CT scans in patients with blunt trauma: low yield in the absence of clinical findings. *J Comput Assist Tomogr* 1992; 16(5):717-721.
92. Wolfman NT, Bechtold RE, Scharling ES, Meredith JW. Blunt upper abdominal trauma: evaluation by CT. *AJR* 1992; 158(3):493-501.
93. Yoon W, Jeong YY, Kim JK, et al. CT in blunt liver trauma. *Radiographics* 2005; 25(1):87-104.
94. Baron BJ, Scalea TM, Sclafani SJ, et al. Non-operative management of blunt abdominal trauma: the role of sequential diagnostic peritoneal lavage, computed tomography, and angiography. *Ann Emerg Med* 1993; 22(10):1556-1562.
95. Nilsson A, Loren I, Nirhov N, et al. Power Doppler ultrasonography: alternative to computed tomography in abdominal trauma patients. *J Ultrasound Med* 1999; 18(10):669-672.
96. Allen TL, Mueller MT, Bonk RT, et al. Computed tomographic scanning without oral contrast solution for blunt bowel and mesenteric injuries in abdominal trauma. *J Trauma* 2004; 56(2):314-322.

97. Halsted MJ, Racadio JM, Emery KH, et al. Oral contrast agents for CT of abdominal trauma in pediatric patients: a comparison of dilute hypaque and water. *AJR* 2004; 182(6):1555-1559.

98. 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.