Clinical Policy: Critical Issues in the Evaluation of Adult Patients Presenting to the Emergency Department With Acute Blunt Abdominal Trauma

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ABSTRACT

This clinical policy from the American College of Emergency Physicians is an update of the 2004 clinical policy on the critical issues in the evaluation of adult patients presenting to the emergency department with acute blunt abdominal trauma.[1] A writing subcommittee reviewed the literature as part of the process to develop evidence-based recommendations to address 4 key critical questions: (1) In a hemodynamically unstable patient with blunt abdominal trauma is ultrasound the diagnostic modality of choice? (2) Does oral contrast improve the diagnostic performance

of computed tomography (CT) in blunt abdominal trauma? (3) In a clinically stable patient with isolated blunt abdominal trauma, is it safe to discharge the patient after a negative abdominal CT scan result? (4) In patients with isolated blunt abdominal trauma, are there clinical predictors that allow the clinician to identify patients at low risk for adverse events who do not need an abdominal CT? Evidence was graded and recommendations were based on the available data in the medical literature related to the specific clinical question.

INTRODUCTION

Review of the National Trauma Database reveals that abdominal trauma accounts for 13% of all injuries and is associated with a case rate mortality of 8%.[2] Blunt abdominal trauma is the leading cause of these injuries. Because this database only reports data entered from specific trauma centers, it inherently underrepresents the true burden of abdominal injuries, especially from blunt trauma, that present to emergency departments (EDs) across the United States. It has been reported that blunt abdominal trauma is one of the leading causes of morbidity and mortality in trauma victims. Therefore, the management and disposition of these patients is routine in the ED. This policy is an update of the 2004 American College of Emergency Physicians' (ACEP) clinical policy on acute blunt abdominal trauma.[1]

Despite the high prevalence of patients with blunt abdominal trauma, these patients present a clinical challenge. Physical examination may not be accurate because patients may have altered mental status or distracting injuries.[3] During the last 20 years, there have been substantial changes in the diagnostic modalities used for the evaluation of these patients. Diagnostic peritoneal lavage (DPL) was introduced as a diagnostic modality to identify hemoperitoneum in 1965.[4] This invasive modality was an integral component of the diagnostic algorithm for the evaluation of trauma victims; however, its role has been almost entirely eliminated because there has been increased reliance on abdominal computed tomography (CT). Focused Assessment with Sonography in Trauma (FAST) and extended FAST (eFAST) have also been added to the diagnostic algorithm for patients with blunt abdominal trauma. Because the abundance of literature reviewed for this policy used the FAST protocol, the term *FAST* has been used throughout the policy.

This policy will address current challenges in the diagnosis and disposition of patients with blunt abdominal trauma in the era of improved technology of CT imaging, increased skill in FAST scanning by the emergency physician, and continued need for rapid and accurate disposition of patients with blunt abdominal trauma.

METHODOLOGY

This clinical policy was created after careful review and critical analysis of the medical literature. Multiple searches of MEDLINE and the Cochrane database were performed. All searches were limited to English-language sources, human studies, and adults. Specific key words/phrases and years used in the searches are identified under each critical question. In addition, relevant articles from the bibliographies of included studies and more recent articles identified by committee members or peer reviewers were included.

The reasons for developing clinical policies in emergency medicine and the approaches used in their development have been enumerated.[5] This policy is a product of the ACEP clinical policy development process, including expert review, and is based on the existing literature; when literature was not available, consensus of emergency physicians was used. Expert review comments were received from individual physicians in the fields of emergency medicine, surgery, and radiology and from individual members of the American College of Surgeons Committee on Trauma, the Society for Academic Emergency Medicine, ACEP's Emergency Medical Services Committee, ACEP's Emergency Ultrasound Section, ACEP's Quality and Performance Committee, and ACEP's Trauma and Injury Prevention Section. Their responses were used to further refine and enhance this policy; however, their responses do not imply endorsement of this clinical policy. Clinical policies are scheduled for revision every 3 years; however, interim reviews are conducted when technology or the practice environment changes significantly. ACEP is the funding source for this clinical policy.

All articles used in the formulation of this clinical policy were graded by at least 2 subcommittee members for strength of evidence and classified by the subcommittee members into 3 classes of evidence on the basis of the design of the study, with design 1 representing the strongest evidence and design 3 representing the weakest evidence for therapeutic, diagnostic, and prognostic clinical reports, respectively (Appendix A). Articles were then graded on 6 dimensions thought to be most relevant to the development of a clinical guideline: blinded versus nonblinded outcome assessment, blinded or randomized allocation, direct or indirect outcome measures (reliability and validity), biases (eg, selection, detection, transfer), external validity (ie, generalizability), and sufficient sample size. Articles received a final grade (Class I, II, III) on the basis of a predetermined formula, taking into account design and quality of study (Appendix B). Articles with fatal flaws were given an "X" grade and not used in formulating recommendations in this policy. Evidence grading was done with respect to the specific data being extracted and the specific critical question being reviewed. Thus, the level of evidence for any one study may vary according to the question, and it is possible for a single article to receive different levels of grading as different critical questions are answered. Question-specific level of evidence grading may be found in the Evidentiary Table included at the end of this policy.

Clinical findings and strength of recommendations regarding patient management were then made according to the following criteria:

Level A recommendations. Generally accepted principles for patient management that reflect a high degree of clinical

certainty (ie, based on strength of evidence Class I or overwhelming evidence from strength of evidence Class II studies that directly address all of the issues).

Level B recommendations. Recommendations for patient management that may identify a particular strategy or range of management strategies that reflect moderate clinical certainty (ie, based on strength of evidence Class II studies that directly address the issue, decision analysis that directly addresses the issue, or strong consensus of strength of evidence Class III studies).

Level C recommendations. Other strategies for patient management that are based on Class III studies, or in the absence of any adequate published literature, based on panel consensus.

There are certain circumstances in which the recommendations stemming from a body of evidence should not be rated as highly as the individual studies on which they are based. Factors such as heterogeneity of results, uncertainty about effect magnitude and consequences, and publication bias, among others, might lead to such a downgrading of recommendations.

When possible, clinically oriented statistics (eg, likelihood ratios [LRs], number needed to treat) will be presented to help the reader better understand how the results can be applied to the individual patient. For a definition of these statistical concepts, see Appendix C.

This policy is not intended to be a complete manual on the evaluation and management of adult patients with acute blunt abdominal trauma but rather a focused examination of critical issues that have particular relevance to the current practice of emergency medicine.

It is the goal of the Clinical Policies Committee to provide an evidence-based recommendation when the medical literature provides enough quality information to answer a critical question. When the medical literature does not contain enough quality information to answer a critical question, the members of the Clinical Policies Committee believe that it is equally important to alert emergency physicians to this fact.

Recommendations offered in this policy are not intended to represent the only diagnostic and management options that the emergency physician should consider. ACEP clearly recognizes the importance of the individual physician's judgment. Rather, this guideline defines for the physician those strategies for which medical literature exists to provide support for answers to the crucial questions addressed in this policy.

Scope of Application. This guideline is intended for physicians working in hospital-based EDs.

Inclusion Criteria. This guideline is intended for nonpregnant adult patients presenting to the ED with acute, blunt abdominal trauma.

Exclusion Criteria. This guideline is not intended to address the care of pediatric patients or pregnant women.

CRITICAL QUESTIONS

1. In a hemodynamically unstable patient with blunt abdominal trauma is bedside ultrasound the diagnostic modality of choice?

Level A recommendations. None specified.

Level B recommendations. In hemodynamically unstable patients (systolic blood pressure ≤90 mm Hg) with blunt abdominal trauma, bedside ultrasound, when available, should be the initial diagnostic modality performed to identify the need for emergent laparotomy.

Level C recommendations. None specified.

Key words/phrases for literature searches: abdomen, ultrasound, sonography, abdominal injuries, nonpenetrating wounds, blunt abdominal trauma or injury, spleen trauma or injury, bladder trauma or injury, liver trauma or injury, splenic rupture, bowel or intestinal trauma or injury, kidney or renal trauma or injury, focused assessment sonography, focused abdominal sonography for trauma, and variations and combinations of the key words/phrases, years 1990-August 2008. In addition, relevant articles from the bibliographies of included studies and more recent articles identified by committee members and peer reviewers were included.

Detection of injury from blunt abdominal trauma can be a challenge. Unfortunately, physical signs and symptoms that indicate the presence of intra-abdominal trauma are unreliable.[6-8] In addition, physical examinations are often complicated by multisystem injuries and/or the presence of mind- or mood-altering substances. Use of diagnostic tools to identify patients who might benefit from surgical intervention is key. Both false-positive and false-negative findings bear the risk of severe complications. Physicians in Germany and Japan use ultrasound as the primary diagnostic modality in unstable patients with blunt abdominal trauma.[9,10] The diagnostic approach for unstable patients with blunt abdominal trauma in the United States is an issue of debate. DPL and CT are diagnostic modalities used in hemodynamically unstable patients with blunt abdominal trauma in the United States. Multiple studies have documented that DPL is a sensitive test for the detection of intraperitoneal blood, resulting historically in DPL being identified as the criterion standard. However, DPL is associated with complications. CT has the advantage of being very sensitive and specific for solid-organ blunt abdominal trauma injuries and provides information not supplied by other diagnostic modalities; however, it is expensive, time consuming, and requires that the unstable patient leave the resuscitation room to be transported to the radiology suite. Additionally, the patient is at risk for complications from ionizing radiation and contrast-induced nephropathy. Ultrasound can be performed rapidly at the bedside, is inexpensive, and has no known associated risks, in addition to having favorable test characteristics.

Ultrasound has become a commonly used diagnostic tool in the assessment of hemodynamically unstable blunt abdominal trauma patients. In a 1994 Class I study of 200 acutely ill

trauma patients with suspected injury from blunt abdominal trauma, McKenney et al[11] prospectively evaluated the utility of ultrasound in detecting intra-abdominal injuries. Radiology residents, attending physicians, or technicians performed the ultrasounds in the resuscitation room. Resuscitation efforts were concurrent with the performance of the bedside ultrasound. The ultrasound examination was performed to look for free intraperitoneal fluid, as well as parenchymal injuries to the liver or spleen. Interpretations were recorded immediately and before performance of a CT scan or DPL. Ultrasound was 83% sensitive in identifying these intra-abdominal injuries and 100% specific (negative likelihood ratio [LR-] 0.17). One patient of 200 had a significant amount of blood seen on DPL but missed by ultrasound. The timing of the DPL with respect to the ultrasound was not documented. Ultrasound failed to detect 4 injuries detected on CT. Three were small liver lacerations and 1 was a small splenic hematoma. None of these injuries required treatment. One limitation of this study is the eligibility criteria. Trauma criteria patients who were hemodynamically stable and hemodynamically unstable (systolic blood pressure ≤90 mm Hg) were considered together in the analysis. The FAST scan performed by emergency physicians is not used to specifically identify parenchymal injury, but is used to identify the presence or absence of free fluid, secondarily diagnosing intra-abdominal injury associated with bleeding; so generalizing this study to emergency medicine could be problematic.

In a prospective Class II study by McKenney et al,[12] published in 1996, 1,000 patients with blunt abdominal trauma were evaluated by ultrasound for injuries. The sensitivity of ultrasound was 88%, specificity was 99%, and the LR- was 0.12 in detecting intra-abdominal injuries as confirmed by CT, DPL, laparotomy, or observation. In another Class II study, Lentz et al[13] studied 54 unstable patients with suspected blunt abdominal trauma who underwent an ultrasound followed by either DPL or laparotomy. The sensitivity and specificity of ultrasound for detecting free intraperitoneal fluid were 87% and 100%, respectively (LR- 0.14). Wherrett et al[14] published a Class II study in 1996 involving a retrospective subgroup analysis of 69 hypotensive patients in the ED. Researchers reported that ultrasound had a sensitivity of 100%, specificity of 94%, positive predictive value (PPV) of 86%, and negative predictive value (NPV) of 100% for detecting patients with intra-abdominal injuries requiring a laparotomy. In a Class III retrospective study of 30 hypotensive trauma patients, Rozycki et al[15] documented a sensitivity and specificity of 100% for ultrasound in identifying intra-abdominal injuries. This study must be interpreted with caution because patients who were in extremis and patients with unobtainable blood pressures were excluded from the study.

In 2004, Holmes et al[16] published a Class II retrospective study evaluating the test performance of ultrasound in 447 blunt abdominal trauma patients with out-of-hospital or ED hypotension (systolic blood pressure ≤90 mm Hg). Ultrasound views looking for free fluid in the right upper quadrant, left upper quadrant, bilateral pericolic gutters, and pelvis were performed in the ED by registered diagnostic medical sonographers. Dedicated images of abdominal organs were not performed. CT, DPL, or laparotomy results were used as the criterion standard in this study. Four hundred six patients received a criterion standard diagnostic study. Forty-one patients (9%) had observation only with clinical follow-up as a means to evaluate for the presence of intra-abdominal injury. One hundred forty-eight of the 447 patients (33%) in the study had documented intra-abdominal injuries, and of these injured patients, 116 (78%) had hemoperitoneum. Ultrasound correctly identified free intraperitoneal fluid in 83% of patients. There were 18 patients of 105 therapeutic laparotomy patients (17%) who had a negative ultrasound result. The injuries of these patients varied but included injuries to the spleen, bowel, liver, diaphragm, mesentery, stomach, gallbladder, and kidneys. Investigators found that ultrasound had a sensitivity of 79%, specificity of 95%, PPV of 86%, and NPV of 93% (positive LR [LR+] 15.8; LR- 0.22).

Despite previously mentioned advantages, bedside ultrasonography does have limitations. Ultrasound is able to identify the presence of free fluid but not the etiology of the fluid, or more specifically, the injury. There must be a minimum volume of fluid present before the fluid can be detected by ultrasound. In addition, fluid takes time to accumulate, so it is possible that an initial beside ultrasound result may be negative, but if the examination is repeated later, the test result may be positive. Hence, serial ultrasounds can be helpful in patients with blunt abdominal trauma. Ultrasound should not be considered the sole test for evaluating patients with blunt abdominal trauma. A negative ultrasound result in hemodynamically unstable patients does not preclude the need for further diagnostic testing. In addition, diagnostic accuracy of bedside ultrasound may vary depending on ultrasonographer skill and equipment.

2. Does oral contrast improve the diagnostic performance of CT in blunt abdominal trauma?

Level A recommendations. None specified.

Level B recommendations. Oral contrast is not required in the diagnostic imaging for evaluation of blunt abdominal trauma.*

*All of the studies reviewed included the use of intravenous (IV) contrast.

Level C recommendations. For patients with a negative CT scan result with IV contrast only, in whom there is high suspicion of bowel injury, further evaluation or close follow-up is indicated.

Key words/phrases for literature searches: blunt abdominal trauma or injury, abdomen, nonpenetrating wounds, noncontrast CT, oral contrast CT, contrast media, and variations and combinations of the key words/phrases; years

2002-August 2008. In addition, relevant articles from the bibliographies of included studies and more recent articles identified by committee members or peer reviewers were included.

When this same critical question was addressed in the 2004 clinical policy,[1] many trauma centers were noted to frequently administer oral contrast before each CT scan. Patients received the contrast through various means (eg, oral ingestion, nasogastric tube, rectal). Although many trauma centers have discontinued the use of oral contrast (preferring only IV contrast), there remain centers that use oral contrast; thus, the importance of updating this question.

Since the literature review in the 2004 policy[1] there have been few articles that have addressed this question specifically about blunt abdominal trauma. The study by Stafford et al[17] (Class II study) continues to be the only prospective randomized trial comparing outcomes of patients who did or did not receive oral contrast. In this study, there were 500 trauma patients enrolled, 394 of whom were randomized. Of the 394 patients, 199 received oral contrast through a nasogastric tube, and 195 patients were randomized to no oral contrast (had IV contrast only).

When analyzing only small bowel injuries, the authors reported a sensitivity of 86% (6 of 7 injuries discovered, 95% confidence interval [CI] 42.1% to 99.6%; LR+ 3.74; LR- 0.19) for CT with oral contrast, and a sensitivity of 100% (3 of 3 injuries discovered; 95% CI 29.2% to 100%; LR+ 3.69; LR- 0) for CT without oral contrast (IV contrast only).[17] Stafford et al[17] reported that for solid-organ injuries there was no difference between the oral contrast and no contrast groups. For oral contrast, 16 of 19 injuries identified=84.2% sensitivity (95% CI 60.4% to 96.6%; LR+ 14.27; LR- 0.17). For patients with solid-organ injury who did not receive oral contrast (IV contrast only), 8 of 9 injuries identified=88.9% sensitivity (95% CI 51.8% to 99.7%; LR+ 2.07; LR- 0.19). The limited number of bowel injuries makes extrapolation of the data difficult. They also examined the time to CT as a factor of nasogastric tube placement and oral contrast administration. The average time from nasogastric tube placement to CT scan was 39±18 minutes for the IV-contrast-only group and 46±24 minutes for the oral contrast group. The authors believed that the small time interval did not allow for transit of the contrast in the intestines, thus limiting the utility of oral contrast.

In 2004, Allen et al[18] (Class III study) performed a prospective, blinded, nonrandomized study evaluating IV-contrast-only CT for blunt abdominal trauma. Their outcome measure was (1) laparotomy- or autopsy-identified injury, or (2) both blinded CT read and injury described in the hospital discharge summary. They found that IV-contrast-only CT had a sensitivity of 95.0% (19 of 20 patients; 95% CI 75.1% to 99.9%; LR+ 237.5) and specificity of 99.6% (478 of 480 patients; 95% CI 98.5% to 99.9%; LR- 0.05). The study is limited by the fact that surrogate measures for outcomes were used and the IV-contrast-only scans were not directly compared with oral-contrasted CT.

Also in 2004, Stuhlfaut et al[19] (Class III study) published a retrospective chart review of patients admitted for blunt abdominal trauma who received CT of the abdomen/pelvis with IV contrast only to assess for the ability to detect bowel or mesenteric injury requiring operative intervention. They evaluated the patients' hospital course, follow-up CT scans, and laparotomy reports to perform the chart review. They found a sensitivity of 81.8% (9 of 11; 95% CI 52% to 95%; LR+ 409.0) and specificity of 99.8% (1,066 of 1,068; 95% CI 99.3% to 99.9%; LR- 0.18), a PPV of 64%, and an NPV of 99%. Although this study was retrospective and did not directly evaluate the use of oral contrast, it adds to the body of evidence that IV-contrast-only CT was a useful tool in detecting bowel injuries that required operative management.

In summary, when evaluating blunt abdominal trauma, the initial CT may be performed with IV contrast only, even if there is suspicion of bowel injury.

3. In a clinically stable patient with isolated blunt abdominal trauma, is it safe to discharge the patient after a negative abdominal CT scan result?

Level A recommendations. None specified.

Level B recommendations. Clinically stable patients with isolated blunt abdominal trauma can be safely discharged after a negative result for abdominal CT with IV contrast (with or without oral contrast).

Level C recommendations. Further observation, close follow-up, and/or imaging may be warranted in select patients based on clinical judgment.

Key words/phrases for literature searches: blunt abdominal trauma or injury, abdominal injuries, nonpenetrating wounds, CT, patient admission, hospitalization, patient discharge, patient disposition, prognosis, injury severity score, predictive value of tests, outcome, risk, and variations and combinations of the key words/phrases; years 1990-August 2008. In addition, relevant articles from the bibliographies of included studies and more recent articles identified by committee members or peer reviewers were included.

Guidelines for the specific disposition of patients with blunt abdominal trauma from the ED are lacking. Current practices are based on local standards. The Eastern Association for the Surgery of Trauma (EAST) guidelines do not specifically mention those patients with isolated blunt abdominal trauma, but recommend that patients with multiple injuries in the setting of a negative abdominal CT result warrant further observation.[20] Multiple studies have been conducted that report the sensitivity and specificity for the CT in detecting abdominal injuries in patients with blunt abdominal trauma[21-24]; however, this question will focus on a subgroup of patients with isolated trauma who are hemodynamically stable.

Few studies have directly evaluated hemodynamically stable patients.[3,25,26] In a Class II study, Livingston et al[3] performed a subgroup analysis of patients presenting to 4 Level 1 trauma centers with symptoms of abdominal pain after trauma or

mechanism for abdominal trauma. Of the study cohort, the result for abdominal CT with IV and oral contrast was negative for 2,082 patients. For patients followed for 20 hours, 0.2% (4/1,864) developed abdominal injuries including intestinal injury, bladder injury, renal injury, and a diaphragm injury. The NPV of the CT scan to detect need for celiotomy in the intent-to-treat group was 99.63% (95% CI 99.31% to 99.96%). The specific injuries were not documented. This study did not specifically focus on patients with isolated abdominal trauma, and a large number of patients were excluded from analysis because of other comorbidities. In another Class III trial, Brasel et al[25] evaluated a subgroup of patients with minor abdominal trauma who received a negative result for CT scan with IV and oral contrast. For 228 patients with a negative CT scan result, no patient had an abdominal injury.

Jacobs et al,[26] in a retrospective Class III study, evaluated 2,630 patients presenting with traumatic mechanism from April 1996 to March 1997. In the cohort of 566 of 1,147 (49.3%) patients with no previous testing and no CT scan performed, 0.3% had an abdominal injury. Of these 566 patients with a negative result for CT scan with IV contrast, 0.5% (2/422) had delayed diagnosis of an abdominal injury. This study was limited by the fact that patients were not excluded by Glasgow Coma Scale score, and it is unclear what the Glasgow Coma Scale score was of those patients with missed injuries.

The majority of the studies that evaluate the use of CT imaging with blunt abdominal trauma were conducted in the 1990s. Technologic advances have occurred in the last 10 years that may impact the diagnostic accuracy of CT. In particular, the use of 64-slice CT scans may have improved the diagnosis of traditionally difficult-to-detect injuries such as pancreatic injuries. Because it is hypothesized that the diagnostic accuracy of the newer CT scans will be improved, it is anticipated that future research will further support these studies that suggest patients have a low risk of an abdominal injury with a negative result for CT scan with at least IV contrast.

4. In patients with isolated blunt abdominal trauma, are there clinical predictors that allow the clinician to identify patients at low risk for adverse outcome who do not need an abdominal CT?

Level A recommendations. None specified.

Level B recommendations. None specified.

Level C recommendations. Patients with isolated abdominal trauma, for whom occult abdominal injury is being considered, are at low risk for adverse outcome and may not need abdominal CT scanning if the following are absent: abdominal tenderness, hypotension, altered mental status (Glasgow Coma Scale score <14), costal margin tenderness, abnormal chest radiograph, hematocrit <30% and hematuria.*

*Hematuria is defined variably in different studies, with the lowest threshold being greater than or equal to 25 RBCs/high-power field (HPF).

Key words/phrases for literature searches: blunt abdominal trauma or injury, abdominal injuries, nonpenetrating wounds, CT, physical examination, clinical decision rules, risk stratification, treatment outcome, predictor, risk assessment, low risk adverse events or complications, decisionmaking, and variations and combinations of the key words/phrases; years 1990-August 2008. In addition, relevant articles from the bibliographies of included studies and more recent articles identified by committee members and peer reviewers were included.

Evaluation of patients who have sustained blunt abdominal trauma and the diagnosis of intra-abdominal injury can be a challenge for the emergency physician. Physical examination alone does not identify all patients with intra-abdominal injury.[7,27-29] A number of studies have shown that physicians cannot rely on the physical examination in patients with altered mental status secondary to severe head trauma or intoxicants.[30-32] These confounders are often found in patients with blunt abdominal trauma. Multitrauma patients may have distracting extra-abdominal injuries that may make the physical examination unreliable for the detection of intra-abdominal injury.[7,33] Routine CT scanning of patients with blunt abdominal trauma carries potential risks of exposure to unnecessary radiation, increased cost, prolonged evaluation time, and increased resource utilization. Studies have shown that only 10% to 24% of patients who have had CT scans for blunt abdominal trauma are found to have an intra-abdominal injury.[30,34-36] Identification of patients at very low risk for intra-abdominal injury can possibly decrease overutilization of CT scanning.

No study could be found that evaluated clinical indicators for CT scanning in patients with isolated blunt abdominal trauma. In a Class II prospective observational cohort, Holmes et al[37] derived and validated a clinical prediction rule to identify very low-risk patients for intra-abdominal injury after blunt torso injury. Holmes et al[37] enrolled adult patients aged 18 years or older and with blunt torso trauma who underwent a definitive diagnostic test (CT scan, DPL, laparoscopy, or laparotomy) to determine the presence or absence of intra-abdominal injury. Patients with penetrating trauma, pregnant patients, patients presenting in cardiopulmonary arrest, and patients with blunt torso trauma who did not undergo a definitive diagnostic test were excluded. The study examined 2 outcome measures: patients with intra-abdominal injury requiring acute intervention and patients with intra-abdominal injury. Intra-abdominal injury was considered to be any injury documented on the spleen, liver, gallbladder, pancreas, kidney, ureter, urinary bladder, gastrointestinal tract, or intra-abdominal vascular structures. Patients with intra-abdominal injury were considered to have undergone acute intervention if they had a therapeutic laparotomy or angiographic embolization of an injured abdominal vessel or organ. The derivation phase of the study included 3,435 patients. Three hundred eleven (9.1%) of the patients had intra-abdominal injury, with 109 (35%) requiring acute intervention (either therapeutic laparotomy or angiographic embolization of an injured organ or vessel) for

Table 1. Test performance of clinical prediction rule to identify patients with intra-abdominal injury requiring acute intervention.*

	Derivation Phase, % (95% CI)		Validation Phase, % (95% CI)	
Sensitivity	100	97.2–100	100	93.4–100
Specificity	24.8	23.3–26.3	30.7	28.4–33.1
PPV	4.2	3.4–5	3.9	2.9–5.2
NPV	100	99.6–100	100	99.4–100

*The clinical prediction rule for intra-abdominal injury undergoing acute intervention consists of hypotension, Glasgow Coma Scale score less than 14, costal margin tenderness, abdominal tenderness, hematuria level greater than or equal to 25 RBCs/HPF, and hematocrit level less than 30%.[37] This article was published in *Annals of Emergency Medicine*, 54, Holmes JF, Wisner DH, McGahan JP, et al. Clinical prediction rules for identifying adults at very low risk for intra-abdominal injuries after blunt trauma, 575-584, Copyright from the American College of Emergency Physicians, (2009).

Table 2. Test performance of clinical prediction rule to identify patients with intra-abdominal injury.*

	Derivation Phase, % (95% CI)		Validation Phase, % (95% CI)	
Sensitivity	98.1	95.8–99.3	95.8	91.1–98.4
Specificity	26.2	24.6–27.8	29.9	27.5–32.3
PPV	11.7	10.5–13.0	11.9	10.1–13.9
NPV	99.3	98.4–99.7	98.6	97.1–99.5

*The prediction rule for any intra-abdominal injury consists of Glasgow Coma Scale score less than 14, costal margin tenderness, abdominal tenderness, femur fracture, hematuria level greater than or equal to 25 RBCs/HPF, hematocrit level less than 30%, and abnormal chest radiograph result (rib fracture or pneumothorax).[37] This article was published in *Annals of Emergency Medicine*, 54, Holmes JF, Wisner DH, McGahan JP, et al. Clinical prediction rules for identifying adults at very low risk for intra-abdominal injuries after blunt trauma, 575-584, Copyright from the American College of Emergency Physicians, (2009).

intra-abdominal injury. Of 1,546 patients enrolled who had no abdominal tenderness and a Glasgow Coma Scale score greater than or equal to 14, 72 patients (4.7%) had intra-abdominal injuries. The validation phase included 1,595 patients, of whom 143 (9.0%) had intra-abdominal injuries. Of the 143 patients with intra-abdominal injuries, 43 (30%) underwent acute intervention. Two prediction rules were derived. The derived clinical prediction rule for intra-abdominal injury undergoing acute intervention consisted of hematuria (≥25 RBCs/HPF), hypotension (systolic blood pressure <90 mm Hg), abdominal tenderness, Glasgow Coma Scale score less than 14, costal margin tenderness, hematocrit level less than 30%. Test performance of the clinical prediction rule to identify patients with intra-abdominal injury who were undergoing acute intervention in the derivation and validation phases had sensitivities of 100% (95% CI 97.2% to 100%) and 100% (95% CI 93.4% to 100%), and NPVs of 100% (95% CI 99.6% to 100%) and 100% (95% CI 99.4% to 100%), respectively (Table 1). The derived prediction rule for identifying any intra-abdominal injury included the following variables: hematuria (≥25 RBCs/HPF), abnormal chest radiograph result (defined as pneumothorax or rib fracture), Glasgow Coma Scale score less than 14, abdominal tenderness, costal margin tenderness, femur fracture, and hematocrit level less than 30%. Test performance of the clinical prediction rule to identify patients with any intra-abdominal injury in the derivation and validation phases had sensitivities of 98.1% (95% CI 95.8% to 99.3%) and 95.8% (95% CI 91.1% to 98.4%), and NPVs of 99.3% (95% CI 98.4% to 99.7%) and 98.6% (95% CI 97.1% to 99.5%), respectively (Table 2). With the above prediction rules, a negative prediction result would have avoided the use of CT scans in one third of the patients in the study. Use of the clinical prediction rules identified all patients with intra-abdominal injury who had undergone acute intervention, which would have resulted in misidentification of 12 of 5,081 patients with negative results who ultimately were found to have intra-abdominal injury. None of the 12 patients required therapeutic laparotomy or angiographic embolization. However, it is unknown whether these patients required any other therapeutic interventions.

In a Class III study, Richards and Derlet[38] evaluated stable patients with blunt abdominal trauma to determine the criteria for ordering abdominal CT and identifying patients at high risk for intra-abdominal injury. Intra-abdominal injury was defined as either a potentially serious or life-threatening abdominal injury detected either by CT or laparotomy, or an abdominal injury that changed the management and disposition of a patient. Of the 196 patients enrolled, 22 (11%) were found to have intra-abdominal injury. Eight of the 22 patients with intra-abdominal injury required laparotomy; all of these patients had abdominal tenderness on examination. Of the 14 remaining patients with intra-abdominal injury, 4 did not have abdominal tenderness. A closer look at the 4 patients without abdominal tenderness but with intra-abdominal injury showed that all 4 patients had distracting injuries. Distracting injuries included closed head injury, pulmonary contusion, rib fractures, pelvis and clavicle fracture, and methamphetamine intoxication. Abdominal examination showed a sensitivity of 82% (95% CI 60% to 95%) and NPV of 95% (95% CI 87% to 99%) for detection of intra-abdominal injury. Change in hematocrit level greater than or equal to 5 did not show statistically significant results as a screening test for intra-abdominal injury. Hematuria was defined as greater than or equal to 50 RBCs/HPF. Of the 22 patients with intra-abdominal injury, 6 (27%) did not have hematuria. As a screening test for intra-abdominal injury, hematuria had a sensitivity of 73% (95% CI 50% to 89%) and NPV of 96% (95% CI 92% to 99%). The authors found an improvement in specificity and NPV with combination of the abdominal examination and evaluation for hematuria. However, 2 patients with intra-abdominal injury would have still been missed, with negative findings for both abdominal tenderness and hematuria.

In a Class III study, Poletti et al[35] studied hemodynamically stable patients with blunt abdominal trauma who received helical CT scanning to identify clinical criteria that could

exclude intra-abdominal injury. Injuries qualifying for intra-abdominal injury included any contusion or laceration of an intra- or retroperitoneal viscera and/or the presence of free intra- or retroperitoneal fluid, unless another logical explanation was present. Major injuries were defined as those requiring surgery or embolization, as well as splenic grade II injury or liver grade III injury or higher. Eighty-five of 714 patients evaluated had positive CT scan results. Thirty-nine patients had major injuries, of which 26 required surgery or embolization. Using clinical indicators (Glasgow Coma Scale score <14, guarding, tenderness) and laboratory values (serum glutamic oxaloacetic transaminase/aspartate aminotransferase [SGOT/AST] >50 IU/L, hematocrit level <36, and WBC count $>10{,}000$ mm^3) as a screen for intra-abdominal injury, the study showed a sensitivity of 99%, specificity of 19%, PPV of 14%, NPV of 99%, and LR of 1.2. Knowledge of the FAST examination results could have biased clinician documentation of clinical indicators and falsely increased the diagnostic accuracy of these tests. Application of this screening test would have accounted for a reduction of 117 CT scans for patients in the study and would have misdiagnosed 1 patient with intra-abdominal injury.

Relevant industry relationships: There were no relevant industry relationships disclosed by the subcommittee members or committee members.

Relevant industry relationships are those relationships with companies associated with products or services that significantly impact the specific aspect of disease addressed in the critical question.

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Evidentiary Table.

Study	Year	Design	Intervention(s)/Test(s)/Modality	Outcome Measure/Criterion Standard	Results	Limitations/Comments	Class
Livingston et al[3]	1998	Prospective, multicenter	Patients >16 y with blunt trauma who were scheduled for an abdominal CT from November 1995 to September 1996; after abdominal CT, standardized physical examinations were performed at 4 to 8 h	Major outcomes at 20 h after admission were death, need for early or late celiotomy, and clinical deterioration	Of the 6,409 blunt trauma patients 3,822 had concern for abdominal injury, and after exclusion 2,744 patients were enrolled; in patients without physical findings 11% had an abnormal CT result; of those with a negative CT result 4/2,082 developed abdominal injuries; NPV 99.6%	Large number of patients were excluded	II
McKenney et al[11]	1994	Prospective	Ultrasound	CT, DPL, laparotomy	200 patients; sensitivity 83%; specificity 100%; accuracy 97%; LR+ 136.71; LR- 0.17	Hemodynamic instability patients mixed with other "trauma criteria" patients; entry criteria included at least 1 of the following: 1) SBP ≤90 mm Hg 2) RR <10 or >29 per min 3) GCS ≤12 4) paralysis after blunt trauma 5) ejection from motor vehicle 6) death of another occupant in motor vehicle 7) fall >20 feet; definition of positive ultrasound included free fluid or parenchymal injury	I

Evidentiary Table (continued).

Study	Year	Design	Intervention(s)/Test(s)/Modality	Outcome Measure/Criterion Standard	Results	Limitations/Comments	Class
McKenney et al[12]	1996	Prospective	Ultrasound	CT, DPL, laparotomy, clinical follow-up	1,000 patients; sensitivity 88%; specificity 99%; accuracy 97%; LR+ 93; LR- 0.12; PPV 94%; NPV 98%	Hemodynamic instability patients mixed with other "trauma criteria" patients; entry criteria included at least 1 of the following: 1) SBP ≤90 mm Hg 2) RR <10 or >29 per min 3) GCS ≤12 4) paralysis after blunt trauma 5) ejection from motor vehicle 6) death of another occupant in motor vehicle 7) fall >20 feet; all patients did not get criterion standard; definition of positive ultrasound result included free fluid or parenchymal injury	II

Evidentiary Table (continued).

Study	Year	Design	Intervention(s)/Test(s)/Modality	Outcome Measure/Criterion Standard	Results	Limitations/Comments	Class
Lentz et al[13]	1996	Prospective	Ultrasound	DPL/laparotomy	54 patients; sensitivity 87%; specificity 100%; accuracy 96%; LR+ 33.80; LR- 0.14	Unstable=broad definition which included: 1) SBP ≤90 mm Hg 2) RR <10 or >29 per min 3) GCS ≤12 4) paralysis after blunt trauma 5) ejection from motor vehicle 6) death of another occupant in motor vehicle 7) fall >20 ft 8) extrication ≥20 min 9) hit by vehicle >20 mph 10) all motorcycle crashes; included children >14 y	II
Wherrett et al[14]	1996	Retrospective	Ultrasound	CT or DPL	69 patients; sensitivity 100%; specificity 100%; PPV 86%; NPV 100%	Retrospective review of cohort of patients with low SBP	II
Rozycki et al[15]	1998	Retrospective chart review	Ultrasound	Operating room	Sensitivity and specificity of 100% for hypotensive patients	Excluded patients in extremis with an unobtainable blood pressure and indications for immediate laparotomy	III
Holmes et al[16]	2004	Retrospective	Ultrasound	CT, laparotomy, or clinical follow-up	447 patients; sensitivity 79%; specificity 95%; LR+ 17.50; LR- 0.22; PPV 86%; NPV 93%	Inclusion criteria: out-of-hospital or arrival to the ED, SBP ≤90 mm Hg; typical criterion standard not used in all patients, 41 patients just followed clinically; included children >6 y	II

Evidentiary Table (continued).

Study	Year	Design	Intervention(s)/Test(s)/Modality	Outcome Measure/Criterion Standard	Results	Limitations/Comments	Class
Stafford et al[17]	1999	Prospective, randomized	Oral contrast plus IV contrast vs IV contrast only	Abnormal CT scan results, need for laparotomy, missed gastrointestinal tract and solid-organ injuries, nausea and vomiting	500 patients enrolled, 394 completed; all received NG tube; 199 oral contrast,195 no oral contrast; specificity for solid-organ injury: 94% oral contrast, 57.1% no oral contrast; sensitivity: 84.2% oral contrast, 88.9% no oral contrast; limited number of bowel injuries	Randomized trial on this subject, set the stage for no oral contrast to be used; limited number of bowel injuries, therefore difficult to extrapolate; time to CT longer after NG placement in oral contrast group compared with no oral contrast	II
Allen et al[18]	2004	Prospective, blinded, nonrandomized	IV-contrast-only CT for blunt abdominal trauma	Laparotomy or autopsy identified blunt bowel and mesenteric injuries or both blinded CT read and hospital discharge summary described blunt bowel and mesenteric injuries	Noncontrast CT had sensitivity 95.0% (95% CI 75.1%-99.9%); specificity 99.6% (95% CI 98.5%-99.9%)	Surrogate measures used, not directly compared with contrasted CT; consecutive patients enrolled only receiving noncontrast scans	III

Evidentiary Table (continued).

Study	Year	Design	Intervention(s)/Test(s)/Modality	Outcome Measure/Criterion Standard	Results	Limitations/Comments	Class
Stuhlfaut et al[19]	2004	Retrospective chart review	Chart review of patients admitted for blunt trauma who received CT scan of abdomen/pelvis with IV contrast only to assess for ability to detect bowel or mesenteric injury requiring operative intervention	Hospital course, follow-up CT scan, laparotomy reports	Sensitivity 82% (95% CI 52% - 95%); specificity 99% (95% CI 98%-99%); PPV 64%; NPV 99%	Although retrospective, this study evaluated the performance of noncontrasted CT in detecting bowel injuries that required operative management; it did not assess the use of oral contrast	III
Brasel et al[25]	1996	Retrospective cohort	All patients with minor trauma undergoing CT scan admitted from July 1991 to June 1995; study presents a subgroup of the 238 patients with normal admission abdominal CT result	Cost saved and number of missed injuries	Of the 238 patients with a normal CT result there were no missed injuries; cost saving was $32,874	Only 50% had outpatient follow-up; small sample size with a selected group	III
Jacobs et al[26]	2000	Retrospective cohort	2,630 patients presenting with traumatic mechanism from April 1996 to March 1997; of these, 1,147 had no previous diagnostic evaluation; before this study an algorithm was instituted that allowed patients with GCS score >7, a reliable examination, who were not going to the operating room, and who had normal serial Hct and examination results to be discharged home without imaging	Intra-abdominal injuries diagnosed 12 h after presentation	566 patients were managed by physical examination alone; of these, 2 had injuries diagnosed 12 h after admission	Frequency of serial examinations was dictated by physicians	III

Evidentiary Table (continued).

Study	Year	Design	Intervention(s)/Test(s)/Modality	Outcome Measure/Criterion Standard	Results	Limitations/ Comments	Class
Poletti et al[35]	2004	Prospective	Abnormal: hypotension: SBP ≤100 mm Hg, DBP ≤60 mm Hg; pulse ≥100 beats/min; RR ≥16 breaths/min; GCS <14; Hct <36; WBC >10,000 mm^3; lactate >2.2 mmol/L; SGOT >50 IU/L; amylase >125 IU/L; abnormal chest radiograph result: fracture rib, fracture spine, pleural effusion, pneumothorax, pneumomediastinum, or parenchymal findings consistent with contusion; abnormal FAST: free fluid in any scanned region; abnormal pelvis radiograph result: pelvic and spine fracture	Intra-abdominal injury; major intra-abdominal injury=requiring surgery or embolization, or splenic laceration ≥grade II, or liver laceration ≥grade III; all other injuries considered minor; CT defined as positive: 1) intra-abdominal injury regardless of severity; 2) contusion or laceration intra/retroperitoneal viscera; 3) presence free intra/retroperitoneal fluid; 4) laceration intra/retroperitoneal viscera; CT defined as negative: 1) nontrauma-related pathology; 2) isolated bone lesion (spinal or pelvic fracture) without associated soft organ injury	900 protocol forms provided on consecutive patients; 714 patients included in study; 12% of patients had CT scan results positive for intra-abdominal injury; 85 patients had CT positive results; 39 major injuries; 26 required surgical or angiographic embolization; clinical score=GCS, guarding, tenderness, missed 27 positive CT results (5 needing surgery or embolization), sensitivity 68%, specificity 55%, PPV 17%, NPV 93%; laboratory score=WBC, Hct, SGOT, missed 30 patients CT positive results (5 needed surgery or embolization), sensitivity 94%, specificity 34%, PPV 17%, NPV 98%; clinical score+laboratory score: sensitivity 99%, specificity 19%, PPV 14%, NPV 99%	Not isolated blunt abdominal trauma; selection bias; 186/900 protocol forms discarded for missing information and hemodynamic instability or directly to operating room; knowledge of FAST examination results can bias clinical score; abdominal examination and distracting injury are subjective findings	III

Evidentiary Table (continued).

Study	Year	Design	Intervention(s)/Test(s)/ Modality	Outcome Measure/Criterion Standard	Results	Limitations/ Comments	Class
Holmes et al[37]	2009	Prospective observational cohort	Abnormal: 1) hypotension SBP <90 mm Hg; 2) costal margin tenderness; 3) abdominal tenderness; 4) abdominal "seatbelt sign"; 5) GCS <14; 6) clinical evidence of alcohol intoxication; 7) distracting painful injury; 8) initial Hct <30; 9) hematuria ≥25 RBCs/HPF; 10) abnormal chest radiograph result (rib fracture, pneumothorax); 11) femur fracture; 12) pelvic fracture on initial pelvic radiograph	Intra-abdominal injury undergoing acute intervention: acute intervention=therapeutic laparotomy or angiographic embolization of injured abdominal vessel or organ; any intra-abdominal injury: intra-abdominal injury=injury to spleen, liver, gallbladder, pancreas, kidney, ureter, urinary bladder, GI tract, intra-abdominal vascular structure; blinded outcome determination	Derivation phase: 3,435 patients, 311 intra-abdominal injuries (9.1% CI 8.1%-10.1%), 103 underwent acute intervention for intra-abdominal injury (35% CI 29.7%-40.6%), 45% (1,546/3,435) no abdominal tenderness and GCS ≥14: this included 72 patients (4.7%) with intra-abdominal injury; 72/3,435 had no abdominal tenderness, GCS score ≥14 and had intra-abdominal injury (4.7%); validation phase: 1,595 patients, 143 had intra-abdominal injury (9% CI 7.6%-10.5%), 44/143 underwent acute interventions; performance of clinical rule for identifying patients with intra-abdominal injury requiring acute intervention: hypotension, GCS ≤14, costal margin tenderness, hematuria >25 RBCs/HPF, initial Hct <30%, abdominal tenderness; performance of clinical rule for identifying patients with intra-abdominal injury: GCS >14, costal margin tenderness, abdominal tenderness, femur fracture, hematuria >25 RBCs/HPF, Hct <30, abnormal chest radiograph (rib fracture or pneumothorax)	Not isolated blunt abdominal trauma; did not enroll all eligible patients; selection bias	II

Evidentiary Table (continued).

Study	Year	Design	Intervention(s)/Test(s)/ Modality	Outcome Measure/Criterion Standard	Results	Limitations/ Comments	Class
Richards and Derlet[38]	1998	Prospective data collection	Abdominal tenderness, hematuria >50 RBC/HPF, change in hematocrit ≥5, distracting injury	Intra-abdominal injury = potentially serious or life-threatening injury detected by CT or laparotomy or injury that changed management or patient care	22/196 (11%) had positive CT scan indicating intra-abdominal injury; 8/196 (4%) had exploratory laparotomy, all had positive CT scan results; 14/196 (7%) had intra-abdominal injury managed nonoperatively; physical examination: 18/22 with intra-abdominal injury had abdominal tenderness on palpation, sensitivity 82% (CI 60% to 95%), specificity 41% (CI 34% to 49%), PPV 15% (CI 9% to 23%), NPV 95% (CI 87% to 99%), all missed intra-abdominal injury without tenderness had distracting injury, intoxication, or closed head injury but 55% of patients had distracting injury; hematuria: sensitivity 65% (CI 41% to 83%), specificity 94% (CI 89% to 97%), PPV 56% (CI 35% to 76%), NPV 95% (CI 91% to 98%)	Not isolated blunt abdominal trauma; n = small number of patients; physical examination and distracting injury were subjective; hematuria detection plus confounders; Hct detection plus confounder's CT used as ultimate outcome; patients followed only until time of discharge; selection bias	III

CI, confidence interval; *CT*, computed tomography; *DBP*, diastolic blood pressure; *DPL*, diagnostic peritoneal lavage; *ED*, emergency department; *FAST*, focused assessment with sonography in trauma; *GI*, gastrointestinal; *GCS*, Glasgow Coma Scale; *h*, hour; *Hct*, hematocrit; *IV*, intravenous; *LR+*, positive likelihood ratio; *LR-*, negative likelihood ratio; *min*, minute; *mph*, miles per hour; *NG*, nasogastric; *NPV*, negative predictive value; *PPV*, positive predictive value; *RBC/HPF*, red blood cells/high power field; *RR*, respiratory rate; *SBP*, systolic blood pressure; *SGOT*, serum glutamic oxaloacetic transaminase; *vs*, versus; *WBC*, white blood cell; *y*, year.

Appendix A. Literature classification schema.*

Design/Class	Therapy†	Diagnosis‡	Prognosis§
1	Randomized, controlled trial or meta-analyses of randomized trials	Prospective cohort using a criterion standard or meta-analysis of prospective studies	Population prospective cohort or meta-analysis of prospective studies
2	Nonrandomized trial	Retrospective observational	Retrospective cohort Case control
3	Case series Case report Other (eg, consensus, review)	Case series Case report Other (eg, consensus, review)	Case series Case report Other (eg, consensus, review)

*Some designs (eg, surveys) will not fit this schema and should be assessed individually.
†Objective is to measure therapeutic efficacy comparing interventions.
‡Objective is to determine the sensitivity and specificity of diagnostic tests.
§Objective is to predict outcome, including mortality and morbidity.

Appendix B. Approach to downgrading strength of evidence.

	Design/Class		
Downgrading	**1**	**2**	**3**
None	I	II	III
1 level	II	III	X
2 levels	III	X	X
Fatally flawed	X	X	X

Appendix C. Likelihood ratios and number needed to treat.*

LR (+)	LR (–)	
1.0	1.0	Useless
1–5	0.5–1	Rarely of value, only minimally changes pretest probability
10	0.1	Worthwhile test, may be diagnostic if the result is concordant with pretest probability
20	0.05	Strong test, usually diagnostic
100	0.01	Very accurate test, almost always diagnostic even in the setting of low or high pretest probability

*Number needed to treat (NNT): number of patients who need to be treated to achieve 1 additional good outcome; NNT=1/absolute risk reduction×100, where absolute risk reduction is the risk difference between 2 event rates (ie, experimental and control groups).