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Pediatric Trauma Evaluations: Current Challenges and Controversies

Clinicians working in the acute care setting will certainly encounter many pediatric patients who have been injured. Injury remains the most common cause of death and disability for pediatric patients. Motor-vehicle-related injury events still rate as the most common cause of death for children across all age groups.[1] In a recent joint policy statement endorsed by more than 20 organizations representing a variety of disciplines, guidelines for the care of children presenting for care in an emergency department (ED) setting were outlined.[2] Although the guidelines do not outline specific details for the care of injured children in regard to testing, the guidelines certainly emphasize monitoring the overall care provided, with mechanisms in place for quality improvement to take place. Specifically, physicians who staff the ED are encouraged to have "the necessary skill, knowledge, and training in emergency evaluation and treatment of children of all ages who may be brought to the ED consistent with the services provided by the hospital."[2] This expectation applies not only to physicians, but also to nurses and other ED healthcare providers.

This review article is intended to address specific controversial areas, including both the initial evaluation and treatment decisions regarding the acutely injured child. Specific areas to be covered include personnel providing care for the pediatric patient, the appropriate use of imaging tests, and the appropriate use of laboratory testing. As more is learned about the unique aspects of pediatric trauma patients, guidelines for evaluation and treatment should be modified to strike the balance between the many factors involved in identifying injuries with minimization of risk to the patient and potential side effects of the diagnostic testing.

—The Editor

Introduction

Those who provide acute care to pediatric patients — especially trauma patients — will certainly encounter a wide variety of challenges. The developmental stage of the patient, lack of verbal skills, and lack of accurate prehospital care information create limitations for those who are the primary recipients of an acutely injured child. The healthcare provider faces the difficult task of addressing these issues by improving the quality of information provided through the prehospital care system and providing a thorough evaluation of the patient in the acute care setting.

An organized approach to the evaluation of the injured pediatric patient certainly should be a goal of each ED to provide timely and accurate care.[3] In lieu of a comprehensive history and physical examination, in an effort to uncover the full extent of each individual patient's injury, the clinician may be inclined to order a variety of laboratory tests, radiographic images, and

Executive Summary

- A child with a head injury who is younger than 2 years of age, is acting normally, and who has:
  - ✓a GCS of 15,
  - ✓no altered mental status,
  - ✓no signs of a palpable skull fracture,
  - ✓no occipital or temporal scalp hematoma,
  - ✓no history of LOC for ≥ 5 seconds, *and*
  - ✓no severe mechanism of injury

  does not require a head CT.
- Consider carefully risks versus benefits of an abdominal CT in a child who has suffered a traumatic injury.
- A child with a head injury who is older than 2 years of age and has:
  - ✓a GCS of 15,
  - ✓no altered mental status,
  - ✓no signs of a basilar skull fracture,
  - ✓no history of LOC, vomiting, or headache, *and*
  - ✓no severe mechanism of injury

  does not require a head CT.
- If a child who presents to a community ED will potentially require transfer to another facility for definitive care, carefully consider, if clinically appropriate, delaying imaging until the child is at the tertiary care center.

consultations with subspecialty services. The patient with hemodynamic instability, multiple organ injuries, or clear changes in mental status clearly warrants many of these resources.

However, a critical evaluation of the application of radiographic and laboratory testing must take place in an effort to avoid testing that would not change the patient's overall management, outcome, or disposition. The patient who is hemodynamically stable and has a normal mental status and who comes with accurate prehospital care information may not warrant a comprehensive evaluation involving multiple laboratory and imaging studies. The purpose of this report is *not* to review the initial evaluation and management of trauma as it relates to pediatric anatomy and the child's unique physiologic response to trauma. Instead, it will focus on current challenges and controversies within the pediatric trauma system and the ED evaluation and management of pediatric trauma patients. Specifically, it will review the approach to controversial clinical areas such as cervical spine clearance, head trauma, and abdominal trauma, as well as organization of the pediatric trauma system, access to trauma centers with pediatric expertise, and resource utilization in the trauma activation.

This article will review information that will help the clinician determine the most appropriate care for the injured pediatric patient. A discussion regarding radiographic and laboratory testing, as well as utilization of personnel and facilities, will be provided. The reader is encouraged to apply the information here to his or her individual practice with a focused plan on improving the quality of care provided through evaluation of current practices and reevaluation of these practices over time.

Epidemiology

Pediatric trauma continues to have a significant impact on the health and well-being of children in the United States. In 2006, trauma continued to be the leading cause of death in children 1 to 18 years of age and accounted for more than 14,000 deaths among all children 0 to 18 years of age.[4] In 2008, there were more than 8.6 million nonfatal injuries among newborn to 18-year-olds, with an injury rate of greater than 1 in 10.[4] There is little debate that a coordinated effort and pediatric-specific advances in pediatric trauma systems, prehospital care and hospital care, and injury prevention can have a positive impact on pediatric trauma outcomes in the United States.[5] However, there are still gaps in access to centers that deliver pediatric-focused trauma care, especially in rural areas.[6] Furthermore, there are differing views between different centers regarding the optimal approach to the initial evaluation and management of the pediatric trauma patient.

Routine Imaging Studies for Pediatric Trauma Patients

The utilization of imaging studies for the pediatric trauma patient certainly is an important area to review. The main goal of imaging studies is to accurately identify the extent of injuries for all pediatric trauma patients. However, a careful evaluation of the need for "routine" radiographs should be critically evaluated, as not all pediatric trauma patients require the entire "trauma series," which typically includes radiographs of the cervical spine, chest, and pelvis.

The approach to imaging must balance many different factors however. Accuracy certainly plays a role in choosing which imaging study is most appropriate. The techniques applied as well as the personnel performing the studies are variables that may impact the value of the study ordered. For example, a "babygram" of the entire torso might not provide the necessary detail to identify a particular injury as well as a devoted chest x-ray. This issue is highlighted when reviewing series in which missed injuries are evaluated. The timeliness of imaging studies is certainly also a factor. If personnel are not available or comfortable with the unique aspects of pediatric imaging studies, early transfer to a designated institution should be considered. This is especially important for EDs where staffing or personnel may be at a premium. Deferring imaging tests for those patients who will be transferred to other centers should be considered. Both the pediatric trauma patient as well as the other patients in a particular ED, must be considered when discussing which imaging test if any should be undertaken for the pediatric trauma patient.

Cervical Spine Clearance

The diagnostic challenges of evaluating pediatric trauma patients are difficult to overcome. This hurdle is most often evident when the clinician attempts to clear a pediatric trauma patient's cervical spine. The relative infrequent occurrence of cervical spine injuries in children as well as limitations with obtaining historical information and a comprehensive physical exam make it challenging to come to definite conclusions about the potential for cervical spine injuries in children. The criteria often utilized for older patients and adults (e.g., report of potential neurologic problems prior to arrival to care) are often not known or uncertain in the preverbal child.

In a prospective multicenter study of cervical spine injury in children, all patients who presented to the participating ED underwent clinical evaluation of their cervical spine before any radiographic imaging.[7] The study involved a subgroup of the NEXUS criteria that deals with blunt trauma patients who were younger than 18 years of age. The presence or absence of the following criteria were noted: midline cervical tenderness, altered level of alertness, evidence of intoxication, neurologic abnormality, and presence of painful distracting injury. The decision to obtain radiographs in a patient was at the physician's discretion and not driven by any previous criteria. The presence or absence of cervical spine injury was based on the final interpretation of all radiographic studies obtained. There were 3,065 patients younger than 18 years of age, which represented 9.0% of the total group of patients in the study population. Thirty of these children (0.98%) sustained a cervical spine injury. Compared with the adult population, a larger percentage of the children (19.7% [603]) was considered to be at low risk by the decision instrument. None of the children in the low-risk group had a cervical spine injury. Of those children with fractures, the lower cervical vertebrae (C5-C7) accounted for 45.9% of the total number. In this series, no case of spinal cord injury without radiographic abnormality was reported. Only four of the 30 injured children were younger than 9 years of age and none were younger than 2 years of age. Tenderness and distracting injury were the two most common abnormalities noted in patients with and without cervical spine injury. The application of these NEXUS criteria correctly identified all pediatric cervical spine injury victims with a sensitivity of 100% (95% confidence interval [CI]: 87.8%–100.0%) and correctly identified 603 patients as low risk for cervical spine injury with a negative predictive value of 100% (95% CI: 99.2%–100.0%). Included in the study were 88 children younger than 2 years of age, 817 who were between 2 and 8 years of age, and 2,160 who were between the ages of 8 and 17 years. The authors concluded that the NEXUS decision instrument performed well in children and its use could reduce pediatric cervical spine imaging by nearly 20%. The authors suggested caution in application of the NEXUS criteria in toddlers given the lack of cervical spine injury found for this age group in their series.

In a more recent article, trauma registries from 22 Level I or Level II trauma centers were reviewed for a 10-year period.[8] Blunt trauma patients younger than 3 years of age were identified through these trauma registries. Cervical spine injury was the measured outcome and independent predictors of cervical spine injury were identified. Of the 12,537 patients younger than 3 years of age, cervical spine injury was identified in only 83 patients or 0.66%. Eight children had spinal cord injury. Four independent predictors of cervical spine injury were identified for this young age group: Glasgow Coma Scale (GCS) less than 14, GCS eye=1, motor vehicle crash, and age 2 years or older. A weighted score was calculated by assigning 1, 2, or 3 points for each of these independent predictors according to the magnitude of their effect. If a score of less than 2 based on the scoring system was found, a negative predictive value of 99.93% (95% CI: 99.85%–99.97%) for excluding cervical spine injury was found. They concluded that a total of 8,707 patients (69.5% of all patients) had a score of less than 2 and were eligible for cervical spine clearance without imaging. There were no missed cervical spine injuries in this study. The authors concluded that these four simple clinical predictors could be used in conjunction with the physical examination to substantially reduce the use of radiographic imaging in this patient population.

Head Trauma

Clinicians are often challenged to make decisions regarding imaging studies in children with head trauma. Again, there are multiple factors involved in the evaluation of the child with an acute head injury. The lack of first-hand knowledge regarding the mechanism of injury, the challenges of the physical exam, and the anxieties of the care providers add to uncertainty regarding which patient requires imaging to identify a clinically significant head injury. Certainly, much controversy surrounds this issue.

In a recent multicenter study from the Pediatric Emergency Care Applied Research Network (PECARN), patients younger than 18 years of age who presented within 24 hours of head trauma and had a GCS score of 14 to 15 were analyzed.[9] These patients presented for care to 25 North American EDs. Computed tomography (CT) scans were obtained in 14,969 of the 42,412 patients enrolled. A low percentage of patients were found to have clinically important traumatic brain injury (0.9%) and an even smaller number underwent neurosurgical procedures (0.1%). A prediction rule for children younger than 2 years of age was created and included the following criteria: normal mental status, no scalp hematoma except frontal, no loss of consciousness or loss of consciousness for less than 5 seconds, non-severe injury mechanism, no palpable skull fracture, and acting normally according to the parents. The negative predictive value for clinically important traumatic brain injury using this prediction rule was 100.0% (95% CI: 99.7%–100.0%, 1,176/1,176) and sensitivity of 100% (CI: 86.3%–100.0%, 25/25). A prediction rule for children 2 years of age and older was also created and included the following: normal mental status, no loss of consciousness, no vomiting, non-severe injury mechanism, no signs of face or skull fracture, and no severe headache. The prediction rule for these older children had a negative predictive value of 99.95% (CI: 99.81%–99.99%, 3,798/3,800) and a sensitivity of 96.8% (CI: 89.0%–99.6%, 61/63). Neither of these rules missed any patients requiring neurosurgery in validation populations. The rules outlined here are fairly simple and straightforward allowing the clinician to use readily available findings to establish a very high negative predictive value for identifying children without clinically important traumatic brain injuries for whom CT scans could actually be omitted. The authors estimated that among all children enrolled, those with none of the six variables in the rules for whom CT scans could routinely be avoided accounted for 25% of CTs in those younger than 2 years and 20% of CTs in those age 2 years and older. It is important to note that the authors excluded children with GCS scores of less than 14, as this population has a substantially higher risk of traumatic brain injury. Application of these rules certainly will reduce the overall rate of CT for evaluation of the pediatric trauma patient with head injury. *(See Figure 1.)*

Intra-abdominal Injuries

The presence of comorbid findings or injuries can help predict which children have abdominal injuries. In a study by Holmes and colleagues,[10] the presence of a femur fracture was thought to predict the presence of a more serious intra-abdominal injury with an odds ratio (OR) of 1.3 (95%, CI: 0.5–3.7). Other findings from this study included that a low systolic blood pressure had an OR of 4.1 (95%, CI: 1.1–15.2), and a GCS of less than 13 was a mild indicator of intra-abdominal injury with an OR of 1.7 (95%, CI: 0.8–3.4). This prospective study was performed in a group of 1,095 children and found that abdominal tenderness had an OR of 5.8 (95%, CI: 3.2–10.4) in the prediction of intra-abdominal injury. The positive predictive value was 17% (95%, CI: 14–20) whereas the negative predictive value was 93% (95%, CI: 99%–100%).

Another group identified several clinical factors as positive predictors of intra-abdominal injury.[11] Abdominal tenderness had an OR of 40.7 (95%, CI: 10.7–155.0). Abdominal ecchymosis had an OR of 15.8 (95%, CI: 1.7–142.3), and abdominal abrasions were found to have an OR of 16.8 (95%, CI: 3.4–83.8). The authors found that these physical exam findings in combination with limited laboratory tests were helpful in their prediction of intra-abdominal injuries in children.

A retrospective review of 285 pediatric trauma patients found that an abnormal physical exam plus an abnormal urinalysis were a highly sensitive screen for intra-abdominal injury.[12] The sensitivity, specificity, positive predictive value, and negative predictive value were 100%, 64%, 13%, and 100% (the CI values were not included in the study), respectively.

Another series specifically evaluated small bowel injuries; 94% of patients demonstrated an abnormal physical exam.[13] In this study, 13 CT scans were performed on patients who were found to have small bowel injury, but only one of these scans was positive.

In a retrospective review conducted at a free-standing children's hospital Level I trauma center, specific attention was given to the pattern of CT evaluations. Over approximately a five-year period, 1,653 children with traumatic injuries were evaluated by the trauma team, with 1,422 patients undergoing 2,361 CT scans.[14] Overall, 54% of the obtained scans were interpreted as normal. Fifty percent of treated patients were transferred from referring hospitals. Approximately half arrived with previous CT scans, and 9% of these required further imaging. Of the 897 patients who underwent abdominal CT imaging, only 2% were taken to the operating room for an exploratory laparotomy. Of those patients who had abnormal findings on abdominal CT scan, only 5% underwent surgical exploration. The authors concluded that abdominal CT imaging may be used too frequently.

In a study by Jindal and colleagues, 108 pediatric patients younger than 7 years of age were matched according to mechanisms of injury, Injury Severity Score

Figure 1. Suggested CT Algorithm with GCS of 14-15 after Head Trauma

A. For children < 2 years

If one of the following:

- GCS = 14
- Altered mental status
- Palpable skull fracture

YES → **CT RECOMMENDED**

13.9% of population
4.4% risk of CITBI

NO ↓

If one of the following:

- Occipital or temporal scalp hematoma
- History of LOC ≥ 5 seconds
- Severe mechanism of injury
- Not acting normally per parent

YES → **Observation or CT based on:**

- MD experience
- Multiple vs "isolated" findings
- Worsening symptoms or signs after ED observation
- Age < 3 months
- Parental preference

32.6% of population
0.9% risk of CITBI

NO ↓

53.5% of population
< 0.02% risk of CITBI

CT NOT RECOMMENDED

B. For children > 2 years

If one of the following:

- GCS = 14
- Altered mental status
- Signs of basilar skull fracture

YES → **CT RECOMMENDED**

14.0% of population
4.3% risk of CITBI

NO ↓

- History of LOC
- History of vomiting
- Severe mechanism of injury
- Severe headache

YES → **Observation or CT based on:**

- MD experience
- Multiple vs "isolated" findings
- Worsening symptoms or signs after ED observation
- Parental preference

27.7% of population
0.9% risk of CITBI

NO ↓

58.3% of population
< 0.05% risk of CITBI

CT NOT RECOMMENDED

Key: GCS = Glasgow Coma Scale; CITBI = clinically important traumatic brain injury; LOC = loss of consciousness; "isolated" = isolated LOC, headache, vomiting, certain types of isolated scalp hematomas in infants > 3 months

Adapted from Kuppermann N, et al. Identification of children at very low risk of clinically important brain injuries after head trauma: A prospective cohort study. *Lancet* 2009;374:1160-1170.

(ISS), and the six individual body-region Abbreviated Injury Scores for comparison with adult patients admitted over the same two-year period of time.[15] The matched pairs of pediatric and adult patients had identical ISS measures (3.3 ± 3.4), with a range from 1 to 15, and identical mechanisms of injury (74% road traffic accidents and 26% falls). Pediatric patients had significantly more CT scans than adults, and the authors felt that this was mainly because of a more liberal use of abdominal CT. The authors also concluded that CT scans of multiple body areas on the same patient were used more frequently in children, but failed to identify more injuries compared to adults. None of the pediatric patients required an operation for abnormalities identified by CT. The authors concluded that the liberal use of CT scanning for pediatric patients with a low ISS led to increased resource consumption with no obvious diagnostic or treatment benefit.

Risk of CT Scanning

The number of CT examinations performed in the United States has been estimated to be as high as nearly 60 million.[16] In a recent review, Brenner estimated that there was a 600% increase in all CT examinations for the decade spanning the mid-1980s to the mid-1990s.[17] In this same review, there was shown to be an estimated increase in the CT scanning examinations in the pediatric population from approximately 4% to greater than 11% of all CT examinations. Special attention to the utilization of CT imaging is important because the organs and tissues in younger children are felt to be more susceptible to radiation-induced cancer.

CT is a large source of radiation exposure for children. It accounts for the largest component of medical radiation and, other than background or natural sources, represents the greatest source of exposure to the population. Although CT scan is thought to represent only 5% of all x-ray imaging, the radiation from CT examinations is estimated as between 40% and 67% of all medical radiation.[18] The dose of radiation from CT imaging can vary greatly depending upon the number of series completed and whether pre- and post-contrast examinations are included. In one review,a range of < 1.0 mSv to > 27.0 mSv from a single CT examination was reported, compared to the dose of approximately 3.0 mSv each year from natural background exposure.[19]

In a study of the radiology records of all children admitted directly to a trauma center in 2002, the authors calculated a total effective dose of radiation based upon age-adjusted effective doses to account for biologic effects of radiation.[20] Of the 506 patients who were admitted over the one-year study period, 394 (78%) underwent at least one radiologic study. The study group underwent a total of 1,228 radiologic studies, with head CT studies being the most commonly performed (280 studies). There were also 201 cervical spine x-rays done, 199 chest x-rays, and 142 abdominal and pelvic CT scans done. The mean total effective dose per patient was 14.9 mSv (median: 7.l2 mSv; interquartile range: 2.2-27.4 mSv). In their study, 97.5% of the total effective dose was attributed to CT. The authors found that neither age nor ISS was predictive of total effective dose. The authors recommended that the current practices for imaging of pediatric trauma patients should be evaluated critically in an effort to maintain an awareness of the lifetime risks associated with radiation exposure.

Children also potentially receive a greater radiation dose than larger children or adults if CT scanning is not adjusted. The dosing of medications for children are typically based upon an amount per unit of weight with a ceiling placed upon reaching a maximum or "adult" dose amount. Similar adjustments in CT technique have not been traditionally made to account for variations in children's sizes.[21] A survey of pediatric radiologists indicates that although some adjustments are being made, there is a substantial need for size-based adjustments in pediatric body CT scanning.[22]

Several strategies have been suggested for minimizing radiation exposure to children, including a limit on the number of CT examinations and adjustments in technique, especially as it relates to individual scan parameters.[19] *(See Table 1.)*

Exposure to both radiation and contrast materials are certainly issues that have become more prominent in both the medical and lay literature. The joint policy statement on the guidelines for the care of children in the ED specifically outlines that medical imaging policies be developed that address both age- and weight-appropriate dosing for children receiving studies that impart ionizing radiation consistent with As Low As Reasonably Achievable (ALARA) principles. [2]

Cost plays a factor in the decision-making regarding imaging studies as well. Certainly, the care of the patient should not suffer as a result of cost alone. Whenever possible, clinical exams without the utilization of imaging may be the most cost-effective approach. Repeat physical exams over time with pediatric patients may allow for appropriate evaluation without exposing the patient to unnecessary radiation. As a factor in the cost of imaging studies for the pediatric trauma patient, repeat imaging should be avoided as much as possible. Imaging studies performed prior to transfer to a higher level of care should be discouraged if they don't impact on the patient's care. If at all possible, systems which allow for review of imaging studies done at referring institutions are encouraged. This approach would allow not only for the avoidance of repeat imaging studies, but also for a timely evaluation at the receiving institution when critical decision-making is a priority.

Clinicians are reminded that most injuries to pediatric trauma patients do not require operative intervention. At the same time, grading systems and management algorithms do often depend upon CT findings as criteria for short- and long-term recommendations.

The Use of CT Scanning

The most recent edition of the ATLS guidelines highlights that "CT scanning should be immediately available, performed early, and must not delay further treatment."[1] Although the availability of CT scanning is widespread, there is a concern that the CT scanning may not change the patient's clinical outcome and may expose the patient to unnecessary radiation and contrast. In adult patients, rapid detection of intraperitoneal fluid within the ED is often a goal. If sizable amounts of free fluid are detected in an adult trauma patient, laparotomy is often recommended.[23] However, a child with blunt abdominal trauma often does not require operative interventions. The volume of intraperitoneal free fluid is often not an indication for operative interventions for most pediatric surgeons. Taylor and Sivit examined amounts of post-traumatic peritoneal fluid by CT scan and correlated this to the presence and severity of associated intra-abdominal injury in children.[24] In this study, the authors found no peritoneal fluid collections in 121 of 326 (37%) visceral injuries in children, 18 of of which had injury to more than one organ. Of the 1,486 children with peritoneal fluid, 80% had intra-abdominal injury including solid viscera (68%); hollow viscus or mesenteric injury (11%); pelvic fracture (4%); and hypoperfusion syndrome (5%). Thirty-one patients (12%) had injury to more than one site.

One of the indications for laparotomy in the pediatric trauma patient has been the findings of the rupture of a hollow viscus. The use of CT scan with enteral contrast has been utilized to look for evidence of perforation. However, in one review, seven patients with intestinal perforations were not found with the use of CT imaging as 2,167 CT scans showed no instances of detected extraluminal contrast.[25] Another group reviewed pediatric gastrointestinal perforations and correlated them with preoperative CT scan findings.[26] Extraluminal air within the peritoneal cavity or the bowel wall itself was found in 10 of 22 CT imaged perforations. There was one false-positive diagnosis of extraluminal air. The authors concluded that extraluminal air, intraperitoneal fluid, bowel wall thickening, bowel wall enhancement and bowel dilatation were helpful signs in the diagnosis of gastrointestinal perforation. At least one of these signs of bowel injury on CT scan was found for all patients with perforation. However, only 18% of patients with perforations had all five findings. None of the patients with perforation were found to have a false-negative CT study.

The other issue with CT imaging of pediatric trauma patients is the avoidance of repeat scans. A retrospective review of a Level I Trauma Center database over a three-year period found a distinction between Level I and Level II trauma patients who had undergone outside CT scan of the head or abdomen compared to the group that had these CT scans at the study institution.[27] The authors found that a duplicate CT scan within four hours of transfer was obtained in 91% of transfer patients, whereas no patient who received an initial CT scan at the study institution required a duplicate scan. Studies from referring hospitals were repeated if they were not available for review or were considered inadequate in technique. This was a statistically significant finding and there was no significant difference within the groups for weight, age, or intensive care unit length of stay. Because of the significant number of patients who required duplicate scans of the same anatomic field after transfer to a Level I pediatric trauma center (PTC), the authors

Table 1. Summary of Strategies to Reduce CT Radiation Dose

Judicious Use of CT

- Is CT scan necessary?
- Are alternative modalities such as sonography or magnetic resonant imaging possible?

Adjust CT Technique

- Can multiple scans be avoided? (e.g., Can both pre- and post-contrast scans be avoided?)
- Can the coverage area be limited to answer the clinical question at hand?
- Has breast shielding been considered?
- Have individual settings been adjusted based upon indication (e.g., initial vs. follow-up examination)?
- Have individual settings been adjusted based upon body region scanned?
- Have individual settings been adjusted based on the size of the child?
- Has newer technology that makes automatic regional adjustments in radiation dose during scanning been applied?

Adapted from Hollingsworth CL, et al. Helical CT of the body: A survey of techniques used for pediatric patients. *AJR Am J Roentenol* 2003;180:401-406.

concluded that this was leading to an increased potential for radiation exposure and expense.

The Use of Ultrasound

The use of bedside ultrasound tests by those providing acute care evaluations has increased as an adjunct to clinical decision making. A survey of attending pediatric and general emergency medicine physicians and trauma surgeons found that ultrasound was available to 169 of 234 (72%) of these physicians and that 122 of 169 (72%) were performing the focused assessment by sonography for trauma (FAST) examinations to evaluate trauma patients.[28] Seventy-three percent (110 of 150) of the general emergency physicians and trauma surgeons reported that ultrasound was equally or more available than CT scans. In contrast, only 26% (5 of 19) of pediatric emergency medicine attendings considered ultrasound equally as available as CT scan and none considered it more readily available than CT scan. In their response to questions about the utility of ultrasound for assessing adult trauma patients, 92% (137 of 149 of general emergency and trauma attendings) rated this technology as "somewhat useful" to "extremely useful." Seventy-seven percent of these clinicians considered it useful for pediatric patients. Only 12 of 21 (57%) of pediatric emergency attending physicians responding to the same question perceived ultrasounds as useful for pediatric trauma evaluations.

The application of bedside ultrasound studies has certainly been helpful in terms of expediting patient care as it relates to vascular access, lumbar puncture, and detection of retained foreign bodies. The application of bedside ultrasound, however, has been less successful in the evaluation of children with abdominal trauma.

The use of the FAST exam may be a potential alternative screening tool for pediatric trauma patients. Potentially, this approach may save time, cost, and exposure to unnecessary radiation. The patient also may remain within the ED as the study is being completed to allow for continued close monitoring as opposed to being transferred to the radiology department for evaluation using CT. Sensitivity of the FAST examination in the pediatric population has been lower than in adult studies. False-negative examinations in children are thought to be secondary to small amounts of free peritoneal fluid which is later detected with abdominal CT but without clinical significance to require a laparotomy. One review compared the use of ultrasound to CT studies on 24 children with blunt abdominal trauma.[29] The CT studies found 23 of 24 children with organ injuries, whereas ultrasound identified only 12 organ-specific injuries in this study.

In a study looking at the accuracy of ultrasound in examination of pediatric trauma patients by emergency physicians, patients younger than age 18 years who presented to the ED of a Level I trauma center after their injuries were prospectively examined with bedside ultrasound as part of their secondary survey during trauma resuscitation.[30] These exams were performed by emergency medicine residents as well as attending physicians who had completed an eight-hour course on the use of ultrasound in the setting of trauma. The trauma physicians providing care to the patients were blinded to the results of the ultrasound examinations. CT of the abdomen and pelvis or laparotomy were performed and served as the gold standards to verify the presence or absence of free fluid in the abdomen. The sensitivities, specificity, and accuracy of the ultrasound exam for the detection of free fluid in the abdominal cavity were 75%, 97%, and 92%, respectively. The positive predictive value was 90% while the negative predictive value was 92%. An emergency physician and radiologist agreed on blinded interpretations in 83% of the examinations ($\kappa = 0.56$). The authors conclude that bedside ultrasonography is a reliable and rapid method for screening traumatized children for the presence or absence of free fluid in the peritoneum, even in the hands of relatively inexperienced sonographers.

Laboratory Testing

It is not unusual for the pediatric trauma patient to have a "trauma panel" obtained during their initial evaluation and resuscitation. Certainly, the evaluation of the injured child can be challenging due to the limited ability of the child to communicate effectively with the care providers. Based upon these challenges and in an effort to monitor patients' progress over time, screening blood tests are often recommended. These laboratory tests are often grouped together in an effort to prevent exclusion of any tests and insure that a wide variety of laboratory parameters are not overlooked. There may or may not be much value added with the routine use of laboratory tests for the pediatric trauma patient. The laboratory tests might not be reviewed prior to selection of imaging studies being ordered. The laboratory tests themselves may not be sensitive predictors for the potential injuries present, especially in the initial stages of the patient's evaluation. Finally, for patients being hospitalized for further observation, clinical parameters including hemodynamics and physical findings may allow the clinician to make further decisions regarding imaging tests or interventions rather than rely upon laboratory tests alone.

In a study reporting on laboratory panels (complete blood count, comprehensive metabolic profile, coagulation studies, and urinalysis) obtained on 240 children younger than 16 years of age who met trauma system criteria, the authors found that organ-specific chemistries were poorly predictive of injury.[31] Only when liver transaminase levels exceeded 400 U/L was there correlation with liver injury. Only two children (1%) with elevated amylase levels were found to have abdominal injuries. Only 25 children (10%) had interventions for test abnormalities. Complete trauma laboratory panels that included 17 tests were obtained in 125, or 52%, of the children who presented for care. Each specific test was obtained in more than 75% of the children, with a range of 75%–92%. Eighty-five percent of the children had transaminase and amylase testing. Coagulation profiles were obtained in fewer children, with only 77%, or 186 children, tested. Only 9%, or 22 patients, of the entire study cohort presented without any laboratory test abnormality. The presence of laboratory abnormalities correlated with ISS [(4.0 ± 6.9 vs 8.6 ± 9.6), mean injury severity score, normal laboratory test versus abnormal laboratory test, respectively ($P<0.05$)]. Elevations of one or both transaminase levels were observed in 87 of the 205 children tested (elevated AST 43%, elevated ALT 35%). Certainly, children with transaminase abnormalities were more likely to have liver injury than children presenting with normal levels [(12% vs 0%, 17% vs 0%, $P < 0.05$) elevated AST versus normal AST, elevated ALT versus normal ALT, respectively]. Only transaminase levels in excess of 400 U/L, however, were predictive of liver injury identifiable with abdominal imaging. Sixty-seven percent of the children with AST levels greater than 400 U/L and 78% with ALT levels greater than 400 U/L were found to have a grade 1 or higher liver injury ($P < 0.05$). The authors note that in each child presenting with a transaminase level in excess of 400 U/L, abdominal imaging was deemed necessary because of injury mechanism and physical exam findings (decreased level of consciousness, abdominal tenderness, or shock), and was not influenced by these laboratory results. Ten children (4%) had liver injury in their cohort. Amylase levels were felt to be of less utility in predicting intra-abdominal injury; elevated amylase levels were identified in only five children (2%) during the two-year study. Only two of the children (1%) had elevated amylase level and were found to have intra-abdominal injuries. No child with an elevated amylase level had pancreatic injury identified on abdominal imaging. No child was subsequently found clinically to have traumatic pancreatitis or complications specific to this organ injury.

Serum Amylase or Lipase Levels. A retrospective study of 1,821 pediatric trauma patients over a 64-month period evaluated the use of serum amylase or lipase levels.[32] A total of 293 (16%) of the patient population studied suffered trauma to the torso and 195 (11%) of these patients had confirmed intra-abdominal injury. In this series, eight pancreatic injuries, representing 4% of abdominal injuries, were identified. Five of these patients underwent surgery for pancreatic ductal injury. One patient was found to have a pseudocyst that required later drainage. During the study, serum amylase or lipase levels were measured in 507 (28%) of the patients. A total of 116 (23%) had elevated serum pancreatic enzyme levels. Six of eight patients with proven pancreatic injury had serum pancreatic enzyme testing and five had elevated values. Forty-eight percent of the patients with elevated enzyme levels had no evidence of intra-abdominal injury. Seventy-four of 116 (64%) with elevated enzyme levels underwent abdominal and pelvic computed tomography scanning with only 38 (51%) of these patients demonstrating completely normal scans. The authors report that many patients with elevated enzyme levels underwent screening CT scans, based on the results of the test results alone. In this study, no patient with elevated enzyme levels but without clinical suspicion was proven to have pancreatic injury. The authors concluded that serum amylase and lipase levels may support a clinical suspicion with a diagnosis of pediatric pancreatic trauma. The authors did not feel that these tests, however, were reliable or cost-effective as screening tools. The cost incurred from routine serum amylase and lipase or from imaging tests as a result of elevated values were felt to be significant and most likely unjustified. The authors report that the retrospective nature of this study was a limitation in determining what role laboratory values play in the physician's decision to order a CT scan. They found that CT scanning generally was obtained in stable patients suspected to have abdominal injury, and that some of their patients underwent CT scanning based on elevated laboratory values alone. For most patients, the decision to obtain a CT scan was made again before the return of initial laboratory values.

Hepatic Transaminases and Abuse. In an effort to determine the utility of hepatic transaminases as a way in which to recognize abuse in children, one group completed a prospective multicenter observational study of all children younger than 60 months referred for subspecialty evaluation of possible physical abuse.[33] The child abuse team at each center recommended screening transaminases be completed routinely as standard of care for all cases with a reasonable concern for physical abuse. Of 1,676 consultations, 1,272 (76%) patients underwent transaminase testing and 54 (3.2%) had identified abdominal injuries. Using a threshold level of 80 IU/L for either AST or ALT yielded a sensitivity of 77% and a specificity of 82%. Of injuries with elevated transaminase levels, 14 (26%) were clinically occult, lacking abdominal bruising, tenderness, or distention. The authors concluded that in the population of children with concern for physical abuse, abdominal injury was an important cause of morbidity and mortality, but not so common as to warrant universal imaging. They recommend that abdominal imaging be considered for potentially abused children when either the AST or ALT level is greater than 80 IU/L or with clinical findings of abdominal bruising, distention, or tenderness. The endpoint in this study, however, appears to differ from that of other studies looking at the value of liver enzyme testing for pediatric trauma patients. The findings in this study are based upon providing documentation of potential injury that would identify abuse compared with other studies that focus on the potential impact for medical interventions, decisions regarding hospital admission, or length of stay.

Complete Blood Cell Count. A closer look at the use of a complete blood count (CBC) is also revealing. In the study by Holmes and colleagues, an initial hematocrit of less than 30 had an OR of 2.6 (95%, CI 0.9–7.5) for intra-abdominal injury.[10] The study by Issacman and colleagues found that serial hematocrit was a poor test to detect intra-abdominal injury.[12] It appears that initial hemoglobin is also not useful to determine whether to perform any further imaging studies.

Urinalysis. Urinalysis is often a routine test obtained in children with abdominal trauma. The degree of hematuria found often dictates whether further imaging studies are obtained. One study evaluated abdominal CT scans of 412 children and found that 48 had renal injuries identified on CT scan.[34] All of the children with what was felt to be significant renal injuries presented with hematuria. Sixty-eight percent (17 of 25) of patients had microscopic hematuria and 32% (8 of 25) had gross hematuria. The authors concluded that any child who presented with blunt abdominal trauma and any degree of hematuria should undergo abdominal and pelvic CT.

A retrospective chart review was conducted of 256 children with blunt abdominal trauma.[35] One hundred six children presented with hematuria, complete blood count, comprehensive metabolic profile, coagulation studies, and urinalysis and 35 had renal injury diagnosed by abdominal CT. The authors concluded that normotensive children with less than 50 RBC/HPF were not found to have significant renal injury.

A study by Isaacman and colleagues showed a negative urinalysis (< 5 RBCs per HPF) and normal physical examination had a negative predictive value of 100%.[12] (This study had multiple analyses based upon several factors, including PE + U/A, PE + screening using a variety of tests with a variety of cutoff values, and PE + screening using a variety of tests with a different set of cutoff values.) Holmes and colleagues performed a prospective analysis of laboratory testing in pediatric blunt abdominal trauma, considering microscopic hematuria to be greater than 5 RBC/HPF.[10] They concluded that hematuria greater than this value was an important predictor of intra-abdominal injury in pediatric blunt trauma patients (OR 4.8 [95%], CI: 2.7–8.4).

It appears that the role of urinalysis as a screening tool for evidence of renal injury is somewhat controversial. Its use as a screening test should be weighed along with the patient's physical exam to determine if further imaging studies should be completed.

These studies on the use of laboratory testing for the pediatric trauma patient reveal that there are limitations to the information added by their results. In isolation, laboratory tests do not appear to be helpful to determine which patient has more severe intra-abdominal injuries. If utilized as part of a decision-making process to determine which child would potentially benefit from imaging studies, closer observation over time, or potential transfer to a higher level of care, elevated liver enzyme tests, the presence of red blood cells in the urine, or a declining hematocrit may be helpful.

Pediatric Trauma Systems

The current pediatric trauma system in the United States consists of local and regional emergency medical systems and hospitals that function together in the care of the pediatric trauma patient.[36] Designated PTCs are typically the central component of this system for both clinical care and non-clinical activities such as pediatric trauma education. It is difficult, however, to truly define the extent of this system, since there is no standardized process for the determination of a particular ED as a PTC or regional system. Many providers who care for trauma patients are likely familiar with the verification process that is sponsored by the American College of Surgeons Committee on Trauma (ACS-COT). The ACS is clear, however, that their verification process is voluntary and that actual designation as a trauma center is a process undertaken by empowered entities such as government agencies.[37] There does not appear to be an objective method to evaluate and determine uniform, quality care across institutions providing care for the pediatric trauma patient.

In fact, a recent cataloging of PTCs in the United States revealed the limitations of identifying PTCs by ACS trauma verification alone. Only 87 of the 170 identified PTCs were verified by the ACS. The remaining 83 PTCs were designated as pediatric-capable trauma centers through the American Trauma Society or were designated as PTCs by state-level verification or accrediting bodies.[6] The study also identified an additional 24 candidate centers that self-designated as PTCs through the National Association of Children's Hospitals and Related Institutions (NACHRI). This lack of a standard trauma center designation process and model for a regional trauma system has potential implications in terms of patient care and the investigation of pediatric trauma best practices and outcomes. Recognizing this challenge, the American Academy of Pediatrics has recommended that each pediatric trauma system develop triage, transfer, and treatment protocols and a robust continuous improvement process.[36] At this point, however, it is difficult to assess whether most regional systems have been successful in implementing protocols and improvement programs, and more importantly, what the effect of these processes is on patient outcomes.[38]

Access to Pediatric Trauma Care

Even if all of the PTCs verified or designated through various processes are included, access to care is still an issue for a significant proportion of the pediatric population. An estimated 17.4 million pediatric patients (28.5% of the total U.S. population younger than 15 years of age) do not have access to a PTC within 60 minutes by ground or air ambulance. The numbers are even more concerning when considering access within 60 minutes by ground only (57% without access) or access within 60 minutes by any method for patients in rural areas (77.1% without access).[6] These results support the observation that most injured pediatric patients are treated at community emergency departments.[39]

Some would argue that lack of access to a PTC is not a major issue as long as a patient has access to a trauma center, even if it is verified only as an adult center. The controversy in this assertion is whether outcomes are the same at PTCs and adult trauma centers (ATCs). In their review of the literature, Ochoa and colleagues argue that the question of difference in outcomes is still unanswered.[39] The authors do summarize, however, that outcomes were better at trauma centers compared to non-trauma centers and that patients treated at PTCs may have improved survival and functional outcomes compared to ATCs.[39]

In this debate, there are two particular studies that conclude that patient outcomes and other care-related measures are indeed better at trauma centers with a pediatric designation than adult trauma centers. In a review of pediatric outcomes at state-accredited trauma centers in Pennsylvania, overall survival was significantly better at PTCs and ATCs with added qualifications to treat children compared to ATCs. Furthermore, severely injured patients with head, spleen, and liver injuries had better overall outcomes and lower surgical exploration rates for spleen and liver injuries at the PTCs.[40] In a review of the 2000 Kids' Inpatient Database, in-hospital mortality, total length of stay, and costs were lower for injured pediatric patients treated at children's hospitals versus adult hospitals.[41] Importantly, injury severity was found to be similar in the comparison groups in both studies.

Regardless of whether outcomes are truly different at PTCs versus ATCs, access issues and the relative scarcity of pediatric subspecialists such as surgeons, emergency medicine physicians, and intensivists means that most pediatric trauma patients will continue to receive treatment outside of PTCs. This fact highlights the importance of several summary points. First, pediatric patients can be very difficult to assess depending on their developmental age and psychological response to trauma. Furthermore, they have unique anatomic and physiologic responses to trauma compared to adults. These factors mandate that members of the pediatric trauma team have specific training and ongoing knowledge and skills maintenance. Second, the development of and adherence to an integrated system that appropriately triages pediatric patients and transfers them to facilities with suitable expertise and equipment will lead to quality management and improved outcomes.[5] Lastly, dissemination of optimal treatment strategies (such as the non-operative management of liver and spleen injuries) and benchmark outcome data by experts in pediatric trauma can potentially elevate care within an entire trauma system.[42]

Table 2. Major Pediatric Trauma Resuscitation Criteria

- **Respiratory compromise or obstruction unrelieved by intubation**
- **Confirmed age-specific hypotension**
- **Transfer patients receiving blood**
- **GCS ≤ 8 or deteriorating by 2**
- **Gunshot wound to chest, abdomen, or neck**
- **ED physician discretion**

Adapted from American College of Surgeons, Committee on Trauma. *Resources for the Optimal Care of the Injured Patient.* Chicago, IL:American College of Surgeons; 2006..

Resource Utilization in Trauma Activation

Even though the organization of the pediatric trauma system and triage/transfer decisions appear complex and challenging, the controversy does not end once the patient reaches the PTC. Instead, the optimal process whereby pediatric trauma patients are initially evaluated in the ED is hotly debated. Specifically, there is significant discussion regarding the composition of the trauma team and its leadership during trauma activations.

Traditionally, pediatric trauma evaluations were led and managed by surgeons, typically trained in pediatric surgery or trauma surgery. This practice was supported by high rates of operative intervention in the past, and the lack of other specialties with the expertise to care for trauma patients.[43] With the development of emergency medicine and pediatric emergency medicine programs with training in trauma, however, ED physicians have taken on an increased role in initial trauma evaluations and management. In addition to their training and skills in initial trauma resuscitation and interventions, there are obvious advantages to emergency medicine involvement in trauma care because of emergency medicine physicians' immediate availability. These historical factors serve as the framework for the debate of whether surgeon presence is necessary during the initial trauma team activation in most circumstances.

On one side, there is the argument that trauma is a surgical disease and that trauma surgeon presence is essential for all major trauma resuscitations. This viewpoint is evident in the ACS verification requirement for trauma surgeon presence at arrival or within 15 minutes for patients meeting major trauma resuscitation criteria at Level I and II centers.[44] *(See Table 2.)* While these criteria are fairly limited in number, surgeons respond to trauma activations for criteria beyond those required by the ACS at many centers.[43] There is a wealth of evidence documenting the success of this verification process and its requirements on outcomes, specifically mortality.[45] Further published support for surgeon presence during pediatric trauma resuscitations includes an analysis of pediatric patients from the National Trauma Data Bank. In this study, more than 30% of all trauma admissions needed operative management, with more than half of these operations occurring emergently (< 4 hours from admission).[46] The background, experience, and training of those performing these operations were not defined in this study, making it difficult to interpret the application of the results to other institutions.

The other viewpoint is that trauma surgeon presence in ED management is not necessary in most circumstances, since emergency medicine has established itself as a specialty capable of performing acute trauma resuscitation management and many life-saving procedures, even in many patients who meet major trauma resuscitation criteria.[43,47,48] Furthermore, an increase in non-operative management of blunt abdominal injuries has led to very low pediatric operative intervention rates by pediatric or trauma surgery. In fact, a closer look at the above analysis of patients from the National Trauma Data Bank reveals that most of the emergent and overall surgeries were for orthopedic injuries, with less than 5% of blunt trauma patients requiring a general surgery operation.[46] Another analysis of admitted pediatric trauma patients at three PTCs showed a laparotomy rate of only 0.3% at any time during the admission.[49] Bearing in mind that both of these analyses did not include patients discharged from the ED, the overall need for non-orthopedic and non-neurosurgical surgery is very low in the pediatric population. Thus, requiring immediate trauma surgeon presence for the very small proportion of pediatric trauma patients who will need general surgical intervention can place an undue strain on a limited physician resource in many centers.[50]

To optimize resource utilization and patient outcomes, many PTCs have now successfully implemented trauma responses that recognize the resuscitation skills of ED personnel and utilize the expertise and skills of their surgical colleagues when needed. There are numerous studies describing systems and processes that effectively identify which patients would benefit from immediate surgeon presence while maintaining excellent patient outcomes in cases when a surgeon is not immediately present during the evaluation and resuscitation.[50-53] These systems rely on physiologic, anatomic, and mechanism-of-injury information from the prehospital arena to activate a tiered response. The trauma surgery physician was only involved in the highest activation level reserved for patients with significant physiologic or anatomic abnormalities. In all of these studies, patient outcomes for patients managed by ED physicians were as good as or better than expected.

Regardless of the individual interpretation of the necessity of surgeon presence during trauma evaluations, there is one major conclusion that can be drawn from the discussion surrounding this controversy: Available local and regional resources will dictate the composition of the trauma team and system. Successful centers and systems will provide pediatric trauma patients with the necessary surgical and non-surgical resources in an efficient manner that optimizes outcomes. These systems can only be created through collaboration among all involved specialists, including surgeons (pediatric, trauma, and other subspecialties), emergency medicine physicians, hospitalists, and intensivists.

Conclusion

Clinicians caring for the pediatric trauma patient are encouraged to think critically about the care they provide for these patients within their own healthcare systems. In an effort to optimize the care that is delivered for these children, clinicians will face many challenges to implement a best-practices approach. With attention to the information that is currently available in the literature, clinicians can apply some initiatives to provide consistent care for these patients and, at the same time, reduce unnecessary testing and risks of radiation exposure. By evaluating their own healthcare system in an organized and collaborative fashion, clinicians can be an integral part of an improved process. Further research and evaluation of current systems are also an important part of improving the care provided for the pediatric trauma patients.

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Pediatric Emergency Medicine Reports

CME Objectives

Upon completion of this educational activity, participants should be able to:

1. recognize specific conditions in pediatric patients presenting to the emergency department;
2. describe the epidemiology, etiology, pathophysiology, historical and examination findings associated with conditions in pediatric patients presenting to the emergency department;
3. formulate a differential diagnosis and perform necessary diagnostic tests;
4. apply up-to-date therapeutic techniques to address conditions discussed in the publication;
5. discuss any discharge or follow-up instructions with patients.

CME Instructions

Physicians participate in this continuing medical education program by reading the article, using the provided references for further research, and studying the questions at the end of the article. Participants should select what they believe to be the correct answers, then refer to the list of correct answers to test their knowledge.

To clarify confusion surrounding any questions answered incorrectly, please consult the source material. After completing this activity, you must complete the evaluation form that will be provided at the end of the semester and return it in the reply envelope provided to receive a credit letter. When your evaluation is received, a credit letter will be mailed to you.

CME Questions

51. Orthopedic procedures are the most common operative interventions in admitted pediatric trauma patients.
    A. True
    B. False

52. The approximate percentage of the pediatric population in the United States that has air or ground access to a pediatric trauma center within 60 minutes is:
    A. 20%
    B. 50%
    C. 70%
    D. 90%

53. Pediatric trauma centers can be verified or designated through all of the following bodies *except*:

A. The American Academy of Pediatrics
B. The American College of Surgeons Committee on Trauma
C. Self-designation
D. State-level accrediting bodies

54. Major pediatric trauma resuscitation criteria as defined by the American College of Surgeons include all of the following *except:*
A. GCS ≤ 8 or deteriorating by 2
B. Proximal extremity amputation
C. Respiratory compromise or obstruction unrelieved by intubation
D. Gunshot wound to chest, abdomen, or neck
E. Transfer patients receiving blood

55. Trauma is the second leading cause of death in the pediatric population.
A. True
B. False

56. Which of the following is predictive of intra-abdominal injury in pediatric patients?
A. Abdominal tenderness
B. Ecchymosis
C. Abdominal abrasions
D. All of the above

57. Which of the following are effective strategies to reduce the radiation dose from CT scanning?
A. Consider alternative imaging modalities such as ultrasound or MRI
B. Avoid pre- and post-contrast scans
C. Adjust individual CT settings based upon indication, body region, and size of the child
D. All of the above

58. Serum hepatic transaminase testing for the pediatric trauma patient:
A. is an accurate method of detecting significant liver injury if greater than 75 U/L.
B. is an essential part of every "trauma panel."
C. can be helpful in discovering intra-abdominal injury in children who have been abused.
D. is useful for all children younger than the age of 10 years with complaints of abdominal pain after trauma.

59. Clinical clearance of the cervical spine in the pediatric trauma patient:
A. can be accomplished in the cooperative patient with no distracting injuries.
B. cannot be relied upon, as historical information regarding the injury is not reliable.
C. should only be attempted in children older than 2 years of age.
D. should not be attempted, as cervical spine injuries are rare in young children.

60. Intraperitoneal free fluid in the pediatric trauma patient:
A. is an absolute indication for laparotomy.
B. indicates the rupture of a hollow viscous.
C. indicates a solid organ injury.
D. is not predictive of the degree of intra-abdominal injury.

Answers: 51. A, 52. C, 53. A, 54. B, 55 B, 56. D, 57. D, 58. C, 59. A, 60. D

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Pediatric Emergency Medicine Reports

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CME Evaluation — Vol. 15, Nos. 1-6, January-June 2010

Please take a moment to answer the following questions to let us know your thoughts on the CME program. Fill in the appropriate space and return this page in the envelope provided. **You must return this evaluation to receive your letter of credit. ACEP members — Please see reverse side for option to mail in answers.** Thank you.

CORRECT ⬬ INCORRECT

1. If you are claiming physician credits, please indicate the appropriate credential: ◯ MD ◯ DO Other____________________

	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
After participating in this program, I am able to:						
2. recognize specific conditions in pediatric patients presenting to the emergency department.	◯	◯	◯	◯	◯	◯
3. describe the epidemiology, etiology, pathophysiology, historical, and examination findings associated with conditions in pediatric patients presenting to the ED.	◯	◯	◯	◯	◯	◯
4. formulate a differential diagnosis and perform necessary diagnostic tests.	◯	◯	◯	◯	◯	◯
5. apply up-to-date therapeutic techniques to address conditions discussed in this publication.	◯	◯	◯	◯	◯	◯
6. discuss discharge or follow-up instructions with patients	◯	◯	◯	◯	◯	◯
7. The test questions were clear and appropriate.	◯	◯	◯	◯	◯	◯
8. I am satisfied with customer service for the CME program	◯	◯	◯	◯	◯	◯
9. I detected no commercial bias in this activity.	◯	◯	◯	◯	◯	◯
10. This activity reaffirmed my clinical practice.	◯	◯	◯	◯	◯	◯
11. This activity has changed my clinical practice.	◯	◯	◯	◯	◯	◯

If so, how?____

12. How many minutes do you estimate it took you to complete this activity? Please include time for reading, reviewing, answering the questions, and comparing your answers with the correct ones listed. _______ minutes.

13. Do you have any general comments about the effectiveness of this CME program?______________________________

____

I have completed the requirements for this activity.

Name (printed)________________________________ Signature ________________________________

Optional for ACEP members: In accordance with ACEP requirements, below we provide the option for ACEP members to submit their answers for this CME activity. If you wish to submit answers for this activity, please refer to Vol. 15, Nos. 1-6, or to the answer sheet included in Vol. 15, No. 6, and circle the correct responses.

Jan 2010

1. A B C D
2. A B C D
3. A B C D
4. A B C D
5. A B C D
6. A B C D
7. A B C D
8. A B C D
9. A B C D
10. A B C D

Feb 2010

11. A B C D E
12. A B C D E
13. A B C D E
14. A B C D E
15. A B C D E
16. A B C D E
17. A B C D E
18. A B C D E
19. A B C D E
20. A B C D E

March 2010

21. A B C D
22. A B C D
23. A B C D
24. A B C D
25. A B C D
26. A B C D
27. A B C D
28. A B C D
29. A B C D
30. A B C D

April 2010

31. A B C D E
32. A B C D
33. A B C D E
34. A B C D
35. A B C D
36. A B C D
37. A B C D
38. A B C D
39. A B C D
40. A B C D

May 2010

41. A B C D
42. A B C D E
43. A B
44. A B C D
45. A B C D
46. A B C D
47. A B
48. A B C D
49. A B C D
50. A B C D

June 2010

51. A B
52. A B C D
53. A B C D
54. A B C D E
55. A B
56. A B C D
57. A B C D
58. A B C D
59. A B C D
60. A B C D

Pediatric Emergency Medicine Reports
The Practical Journal of Pediatric Emergency Medicine

Evaluating Pediatric Trauma

Suggested CT Algorithm with GCS of 14-15 after Head Trauma

A. For children < 2 years

If one of the following:

- GCS = 14
- Altered mental status
- Palpable skull fracture

YES → 13.9% of population, 4.4% risk of CITBI → **CT RECOMMENDED**

NO ↓

If one of the following:

- Occipital or temporal scalp hematoma
- History of LOC ≥ 5 seconds
- Severe mechanism of injury
- Not acting normally per parent

YES → 32.6% of population, 0.9% risk of CITBI → **Observation or CT based on:**

- MD experience
- Multiple vs "isolated" findings
- Worsening symptoms or signs after ED observation
- Age < 3 months
- Parental preference

NO ↓ 53.5% of population, < 0.02% risk of CITBI → **CT NOT RECOMMENDED**

B. For children > 2 years

If one of the following:

- GCS = 14
- Altered mental status
- Signs of basilar skull fracture

YES → 14.0% of population, 4.3% risk of CITBI → **CT RECOMMENDED**

NO ↓

- History of LOC
- History of vomiting
- Severe mechanism of injury
- Severe headache

YES → 27.7% of population, 0.9% risk of CITBI → **Observation or CT based on:**

- MD experience
- Multiple vs "isolated" findings
- Worsening symptoms or signs after ED observation
- Parental preference

NO ↓ 58.3% of population, < 0.05% risk of CITBI → **CT NOT RECOMMENDED**

Adapted from Kuppermann N, et al. Identification of children at very low risk of clinically important brain injuries after head trauma: A prospective cohort study. *Lancet* 2009;374:1160-1170.

Key: GCS = Glasgow Coma Scale; CITBI = clinically important traumatic brain injury; LOC = loss of consciousness; "isolated" = isolated LOC, headache, vomiting, certain types of isolated scalp hematomas in infants > 3 months

Major Pediatric Trauma Resuscitation Criteria

- Respiratory compromise or obstruction unrelieved by intubation
- Confirmed age-specific hypotension
- Transfer patients receiving blood
- GCS ≤ 8 or deteriorating by 2
- Gunshot wound to chest, abdomen, or neck
- ED physician discretion

Adapted from American College of Surgeons, Committee on Trauma. *Resources for the Optimal Care of the Injured Patient 2006.*

Summary of Strategies to Reduce CT Radiation Dose

Judicious Use of CT

- Is CT scan necessary?
- Are alternative modalities such as sonography or magnetic resonant imaging possible?

Adjust CT Technique

- Can multiple scans be avoided? (e.g., Can both pre- and post-contrast scans be avoided?)
- Can the coverage area be limited to answer the clinical question at hand?
- Has breast shielding been considered?
- Have individual settings been adjusted based upon indication (e.g., initial vs. follow-up examination)?
- Have individual settings been adjusted based upon body region scanned?
- Have individual settings been adjusted based on the size of the child?
- Has newer technology that makes automatic regional adjustments in radiation dose during scanning been applied?

Adapted from Hollingsworth CL, et al. Helical CT of the body: A survey of techniques used for pediatric patients. *AJR Am J Roentenol.* 2003; 180:401-406.

Supplement to *Pediatric Emergency Medicine Reports*, June 2010: "Pediatric Trauma Evaluations: Current Challenges and Controversies." *Authors:* **Mark Mannenbach, MD**, Assistant Professor of Pediatrics and Adolescent Medicine, and **Christopher D. Spahr, MD**, Instructor in Emergency Medicine, Department of Emergency Medicine, College of Medicine, Mayo Clinic, Rochester, MN. *Peer reviewer:* **Jeffrey Linzer Sr., MD, FAAP, FACEP**, Assistant Professor of Pediatrics and Emergency Medicine, Emory University School of Medicine; Associate Medical Director for Compliance, Emergency Pediatric Group, Children's Healthcare of Atlanta at Egleston and Hughes Spalding, Atlanta, GA.
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