A Potential Pitfall of Using Focused Assessment With Sonography for Trauma in Pediatric Trauma

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Prospective studies have shown sensitivities of 73% to 88% and specificities of 98% to 100% for using the focused assessment with sonography for trauma (FAST) examination to identify free fluid in adult trauma patients. However, the efficacy of FAST examinations for pediatric trauma patients has not been well defined, and studies looking at diagnostic performance have had varied results. We describe 3 cases of the potential pitfalls of the pediatric FAST examination in pediatric trauma patients using an advanced-processing ultrasound machine. We hypothesize several etiologies for these false-positive findings in the setting of advanced image-processing capabilities of point-of-care ultrasound. We also discuss the reevaluation of clinical algorithms and interpretation practices when using the FAST examination in pediatric trauma.

Key Words—emergency medicine; focused assessment with sonography for trauma; pediatric; trauma; ultrasound

Video online at jultrasoundmed.org

Since the introduction of the focused assessment with sonography for trauma (FAST) examination in Europe in the 1970s, it has become a routine part of the initial trauma assessment to facilitate rapid and efficient triage and identification of free fluid in the abdomen.[1,2] Large prospective studies in adult patients have shown overall sensitivities of 73% to 88% and specificities of 98% to 100% for the FAST examination in identifying free fluid.[3] However, the efficacy of FAST in the pediatric trauma patient is not as well defined in the literature, and studies looking at diagnostic performance have had varied results with sensitivities ranging from 55% to 81%, specificities ranging from 94% to 98%, and negative predictive values ranging from 0.5 to 0.97.[1,2,4,5] It is also important to consider that approximately 26% to 34% of intra-abdominal injuries in pediatric patients with blunt trauma do not have hemoperitoneum, and a FAST examination would, therefore, fail to identify those injuries without hemoperitoneum.[6] In a large meta-analysis, Holmes et al[6] noted pooled sensitivity for identifying children with hemoperitoneum by using abdominal ultrasound (US) of around 80%, which is somewhat lower than findings in adult studies. Additionally, high positive likelihood ratios for intra-abdominal injuries have been reported in the literature when intraperitoneal fluid is noted on a US examination, which increases the posttest probability of injury and supports the decision to perform abdominal computed tomography (CT) for otherwise stable patients in the pediatric trauma setting.[7]

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Abbreviations
CT, computed tomography; FAST, focused assessment with sonography for trauma; US, ultrasound

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The current recommendations for advanced trauma life support for pediatric trauma state that a FAST examination should not be relied on as the sole diagnostic test to rule out the presence of an intra-abdominal injury, and if a small amount of fluid is identified in an otherwise hemodynamically stable child, CT should be performed.[8,9] Traditional portable US technology continues to improve, incorporating many of the image-processing algorithms of traditional radiologic US systems, and physicians are obtaining increasingly detailed images using point-of-care US in the emergency department setting. As such, physicians need to be aware of imaging differences due to advanced image-processing algorithms, which may lead to changes in the sensitivity and specificity of the FAST examination, particularly in pediatric patients.

We describe 3 pediatric trauma cases with potential false-positive FAST findings with the use of a curvilinear probe from a fourth-generation US machine: the Affinity 70 (Philips Healthcare, Bothell, WA), which uses advanced multibeam technology and image-processing algorithms. Based on Institutional Review Board policies pertaining to case studies of fewer than 5 patients, no formal review was required for the purposes of discussing this case series. It is also important to note that our institutional protocol during the time frame of these cases coincides with recommendations from advanced trauma life support, and a positive FAST finding in an otherwise stable pediatric trauma patient prompts a follow-up evaluation with CT.

Case Descriptions

Case 1

A 3-year-old boy presented after being involved in a motor vehicle collision with driver side impact, in which there was airbag deployment without intrusion into the vehicle. He was unrestrained, sitting in the front passenger seat with his brother. On arrival, he was hemodynamically stable, and the physical examination was notable for lacerations and edema to the right side of his face. Neurologic examination findings were normal, and the patient had a nontender, nondistended abdomen. Laboratory study results were within normal limits. Findings from a FAST examination performed while the patient was supine as part of the initial survey were interpreted as positive after showing hypoechoic fluid collections between the diaphragm and liver in the right upper quadrant (Figure 1A) as well as in the subphrenic space of the left upper quadrant (Figure 1B). All other views, including the pelvic view, showed negative findings for free fluid. Findings from subsequent contrast-enhanced CT of the patient's abdomen were negative for free fluid or intraabdominal injuries. The patient was admitted to the pediatric surgery team for overnight observation.

Case 2

A 5-year-old girl presented after being involved in the same motor vehicle collision described above. She was an unrestrained passenger sitting in the back seat of the same vehicle. On arrival, she was hemodynamically stable, and her examination was notable for a small abrasion on her back. She had normal neurological examination findings with a Glasgow Coma Scale score of 15 and a soft, nontender abdomen. Laboratory study results were within normal limits. Her FAST examination was performed with the patient resting supine, and the findings were interpreted as positive, noting free fluid in the subphrenic space of the left upper quadrant (Figure 2 and Video 1). All other views, including the pelvic view, showed negative findings for free fluid. Findings from contrast-enhanced CT of her abdomen were negative for free fluid and intra-abdominal injuries. She was discharged home with close follow-up with her primary care physician.

Case 3

A 7-year-old boy presented after being involved in a motor vehicle collision while wearing a seat belt. On arrival, he was hemodynamically stable with no apparent injuries noted on the initial trauma survey. His neurologic examination findings were normal. He had a soft, nontender, and nondistended abdomen, and the remainder of his physical examination was unremarkable. Laboratory study results were within normal limits. Findings from a FAST examination performed while the patient was supine as a part of the initial survey were interpreted as positive after showing free fluid in the perisplenic space (Figure 3 and Video 2). All other views, including the pelvic view, showed negative findings for free fluid. The patient was subsequently evaluated with contrast-enhanced CT of his abdomen, which yielded negative findings for free fluid and intra-abdominal injuries. He was discharged home with follow-up with his primary care physician.

Discussion

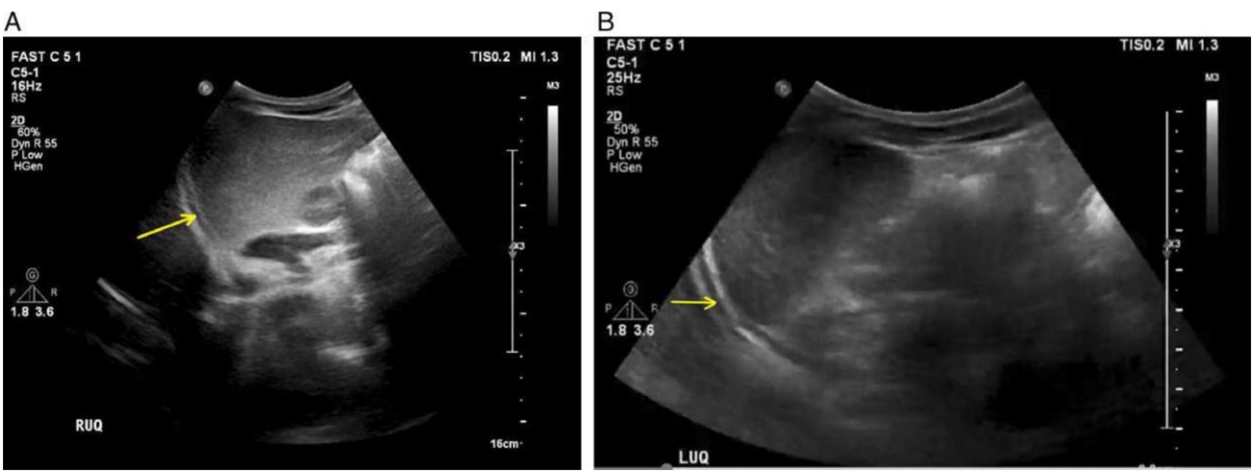
There have been recent reports of false-positive FAST findings in the literature, involving both adult and pediatric cases. An adult case described by Sierzenski et al[10] showed a false-positive FAST finding in which the right perinephric fat pad was incorrectly interpreted as free fluid in the Morison pouch. Similarly, a pediatric case report in 2015 described a trauma patient with false-positive findings from a FAST examination that was performed 12 hours after presentation, which was later attributed to fluid resuscitation and ascites.[11] A third study evaluating hemodynamically stable pediatric trauma patients reported 2 FAST examinations that each visualized a small amount of free pelvic fluid in patients who were later found to have normal findings on CT.[5]

Here we have described 3 trauma patients with US findings that were interpreted as consistent with free fluid in the perisplenic and subphrenic regions in both right and left upper quadrants; however, subsequent imaging with CT in each scenario showed negative findings for free fluid and intra-abdominal injuries. One hypothesis for these findings is the misidentification of hypoechoic fat as free fluid. Although the appearance of fat with US is classically described as hyperechoic, there are certain types of fat in anatomic locations where the appearance is hypoechoic. Sites where hypoechoic fat has previously been described in the literature include the perinephric space, anterior abdominal wall, and pericardium.[11,12] Ultrasound techniques are available that have previously been used to differentiate the appearance of free fluid from hypoechoic fat, including linear symmetric echoes and compressibility in real time.

The FAST examination in pediatric patients presents additional factors that should be addressed during the interpretation of the US image. Pediatric patients are generally smaller, allowing a higher-frequency transducer to be used to examine the Morison pouch and the splenorenal recess. Although using a higher frequency can improve the sensitivity of the test, potentially detecting smaller amounts of fluid, it may detect physiologic collections or an otherwise clinically trivial finding. As such, Rathaus et al[13] showed the presence of minimal pelvic fluid in 7% of a group of 396 asymptomatic children.

In a study by Nance et al,[14] it was shown that the pelvis was the most common location to see a

Figure 1. A, Subphrenic fluid in the right upper quadrant (RUQ). The image was obtained while the patient was supine with a curvilinear probe from the Philips Affinity 70 US machine. B, Subphrenic fluid in the left upper quadrant (LUQ). The image was obtained while the patient was supine with a curvilinear probe from the Philips Affinity 70 US machine.



free fluid collection on CT scans of children with isolated blunt liver or spleen injury. Conversely, in another study by Rathaus et al,[15] 183 children with blunt abdominal trauma were divided into 3 groups: those with normal FAST findings, those having only pelvic fluid, and those in whom peritoneal fluid was found outside the pelvis. There was no significant difference in the detection of organ injury between the normal group and the pelvic fluid–only group, although the presence of peritoneal fluid outside the pelvis had a significant association with organ injury.

Figure 2. Subphrenic fluid in the left upper quadrant. The image was obtained while patient was supine with curvilinear probe from the Philips Affinity 70 US machine.

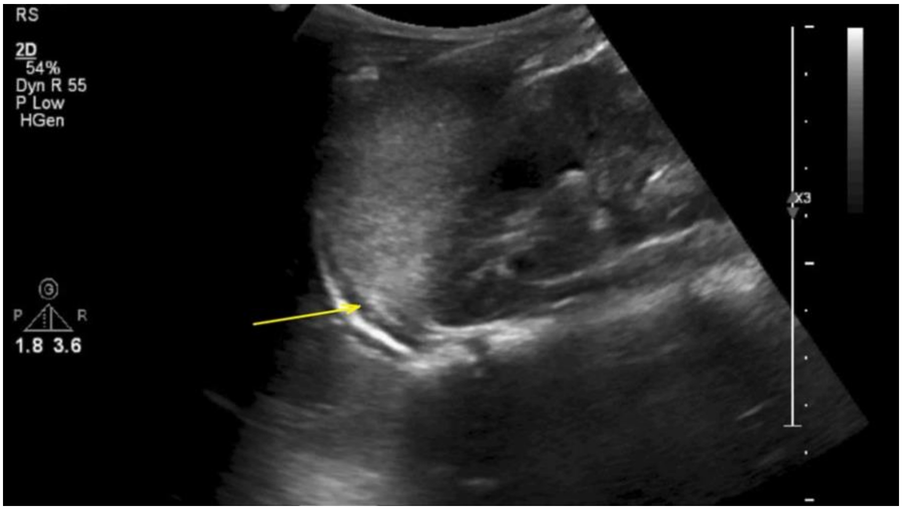
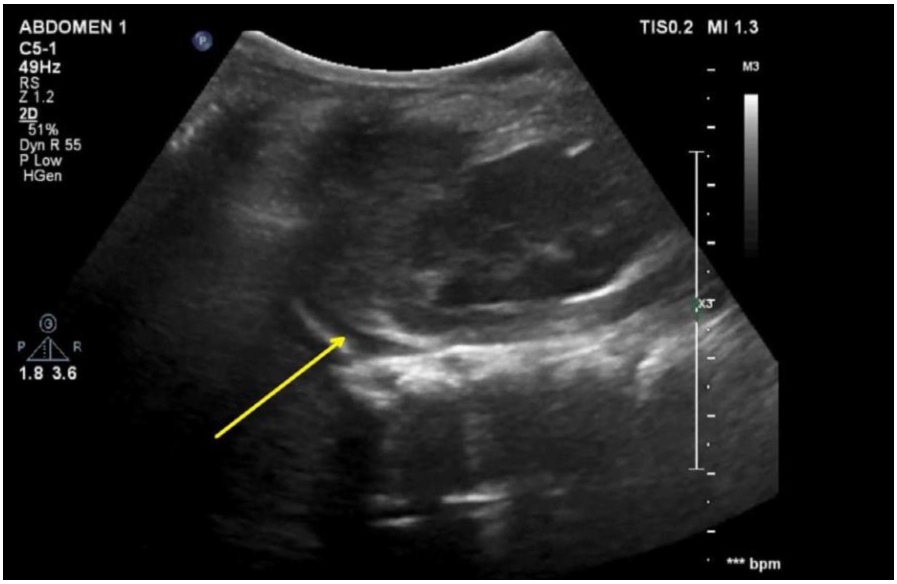


Figure 3. Perisplenic fluid in the left upper quadrant. The image was obtained while patient was supine with a curvilinear probe from the Philips Affinity 70 US machine.



An important limitation to the review of the cases presented in this series is that it is unknown how generalizable the findings from the US machine we used can be to other US machines. Ultrasound technology is rapidly progressing and has brought increased access to an even greater variety of US machines. Several of these newer-generation machines are equipped with advanced processing capabilities, which leads to the discussion of another hypothesis: that substantial image-processing algorithms of machines (such as the Philips Affinity 70 machine used in our study) may create difficulties with interpretation in pediatric patients compared to imaging algorithms of traditional point-of-care US machines. Although these image-processing algorithms improve image quality, it is possible that artifacts (such as edge artifacts) are altered, causing confusion to the physician-sonographer. Traditional FAST views only require longitudinal imaging of the Morison pouch and the splenorenal recess; however, with the use of machines with advanced processing, obtaining cross-sectional images of these areas may improve the specificity of findings and mitigate confusion from image processing. As technology improves resolution, it is possible that the already-enhanced resolution derived from visualizing at shallower depths in pediatric patients may show structures that are not visible in adults with a comparable machine. Hence, potential spaces are actually resolved, whereas in adults, these spaces cannot be visualized unless fluid is present.

A recent randomized controlled trial published in *JAMA* revealed no significant improvement in the rate of abdominal CT scans, time in the emergency department, cost, or missed diagnosis of intra-abdominal injuries between pediatric trauma patients receiving a FAST examination and those who did not receive a FAST examination during their evaluations.[6] Findings such as these and cases similar to the ones we have described support a growing need for investigation into how we are currently using and interpreting data from US, particularly with FAST examinations, in the emergency setting. Implementation of advanced US techniques such as contrast-enhanced US or adding decision criteria, such as serial examinations before CT in an otherwise stable patient, to augment the current use of FAST in children may improve the performance of the test as a diagnostic tool in the pediatric trauma setting in the future.

The landscape of US practice is both an exciting and a rapidly evolving environment; therefore, it is paramount that implementation of the technology is equally as adaptive and adequately supported for use in modern-day evidence-based medicine.

References

1. Soundappan SV, Holland AJ, Cass DT, Lam A. Diagnostic accuracy of surgeon-performed focused abdominal sonography (FAST) in blunt paediatric trauma. Injury 2005; 36: 970–975.
2. Friedman LM, Tsung JW. Extending the focused assessment with sonography for trauma examination in children. Clin Pediatr Emerg Med 2011; 12:1–17.
3. Hoff WS, Holevar M, Nagy KK, et al. Practice management guidelines for the evaluation of blunt abdominal trauma: the EAST Practice Management Guidelines Work Group. J Trauma 2002; 53:602–615.
4. Scaife ER, Rollins MD, Barnhart DC, et al. The role of focused abdominal sonography for trauma (FAST) in pediatric trauma evaluation. J Pediatr Surg 2013; 48:1377–1383.
5. Coley BD, Khaled MH, Martin LC, et al. Focused abdominal sonography for trauma (FAST) in children with blunt abdominal trauma. J Trauma 2000; 48:902–906.
6. Holmes JF, Kelly KM, Wooton-Gorges SL, et al. Effect of abdominal ultrasound on clinical care, outcome and resource use among children with blunt torso trauma: a randomized clinical trial. JAMA 2017; 317:2290–2296.
7. Tsung JW. Rules for the road: an evidence-based approach to understanding diagnostic test performance of point-of-care ultrasound for pediatric abdominal emergencies. Crit Ultrasound J 2010; 1:101–103.
8. American College of Surgeons Committee on Trauma. Pediatric trauma. In: Advanced Trauma Life Support ATLS Student Course Manual. 9th ed. Chicago, IL: American College of Surgeons; 2012:246–261.
9. Schöenberg C, Tampier S, Hussman B, Lendemans S, Waydhas C. Diagnostic management in paediatric blunt abdominal trauma: a systemic review with metaanalysis [in German]. Zentralbl Chir 2014; 139:584–591.
10. Sierzenski PR, Schofer JM, Bauman MJ, Nomura JT. The double-line sign: a false positive finding on focused assessment with sonography for trauma (FAST) examination. J Emerg Med 2011; 40):188–189.
11. Imamedjian I, Baird R, Dubrovsky AS. False-positive focused abdominal sonography in trauma in a hypotensive child: case report. Pediatr Emerg Care 2015; 31:451–453.
12. Spencer GM, Rubens DJ, Roach DJ. Hypoechoic fat: a sonographic pitfall. AJR Am J Roentgenol 1995; 164:1277–1280.

13. Rathaus V, Gruenbaum M, Konen O, et al. Minimal pelvic fluid in asymptomatic children: the value of the sonographic finding. J Ultrasound Med 2003; 22:13–17.
14. Nance ML, Mahboubi S, Wickstrom M, Prendergast F, Stafford PW. Pattern of abdominal free fluid following isolated blunt spleen or liver injury in the pediatric patient. J Trauma 2002; 52:85–87.
15. Rathaus V, Zissen R, Werner M, et al. Minimal pelvic fluid in blunt abdominal trauma in children: the significance of this sonographic finding. J Pediatr Surg 2001; 36:1387–1389.