FAST (Focused Assessment With Sonography in Trauma) Accurate for Cardiac and Intraperitoneal Injury in Penetrating Anterior Chest Trauma

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Objective. To evaluate the FAST (focused assessment with sonography in trauma) examination for determining traumatic pericardial effusion and intraperitoneal fluid indicative of injury in patients with penetrating anterior chest trauma. ***Methods.*** An observational prospective study was conducted over a 30-month period at an urban level I trauma center. FAST was performed in the emergency department by emergency physicians and trauma surgeons. FAST results were recorded before review of patient outcome as determined by 1 or more of the following: thoracotomy, laparotomy, pericardial window, cardiologic echocardiography, diagnostic peritoneal lavage, computed tomography, and serial examinations. ***Results.*** FAST was undertaken in 32 patients with penetrating anterior chest trauma: 20 (65%) had stab wounds, and 12 (35%) had gunshot wounds. Sensitivity of FAST for cardiac injury (n = 8) in patients with pericardial effusion was 100% (95% confidence interval, 63.1%–100%); specificity was 100% (95% confidence interval, 85.8%–100%). The presence of pericardial effusion determined by FAST correlated with the need for thoracotomy in 7 (87.5%) of 8 patients (95% confidence interval, 47.3%–99.7%). One patient with a pericardial blood clot on cardiologic echocardiography was treated nonsurgically. FAST had 100% sensitivity for intraperitoneal injury (95% confidence interval, 63.1%–100%) in 8 patients with views indicating intraperitoneal fluid but without pericardial effusion, again with no false-positive results, giving a specificity of 100% (95% confidence interval, 85.8%–100%). This prompted necessary laparotomy in all 8. ***Conclusions.*** In this series of patients with penetrating anterior chest trauma, the FAST examination was sensitive and specific in the determination of both traumatic pericardial effusion and intraperitoneal fluid indicative of injury, thus effectively guiding emergent surgical decision making. ***Key words:*** cardiac; chest; FAST; focused assessment with sonography in trauma; intraperitoneal; injury; pericardial effusion; trauma.

Abbreviations
CI, confidence interval; CT, computed tomography; FAST, focused assessment with sonography in trauma; IP, intraperitoneal; PE, pericardial effusion

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Evaluation of the patient with penetrating anterior chest trauma is uniquely complex and time sensitive because of the critical nature of the underlying organs and the need to identify or exclude the presence of hemorrhage in several cavities simultaneously. Before the use of sonography, invasive and surgical procedures were often required to evaluate those patients.[1] The trauma sonographic examination, popularly known as FAST (focused assessment with sonography in trauma), evaluates 3 dependent peritoneal spaces and 1 pericardial view, thus allowing rapid evaluation of more than 1 torso cavity with sonography.[2,3] The FAST examination has had widespread acceptance for the initial evaluation of patients with blunt abdominal trauma and isolated penetrating cardiac injury.[2–7] We sought to evaluate the 4-view FAST examination for discerning traumatic pericardial effusion (PE), intraperitoneal (IP) fluid, or both reflective of injury in a series of patients with penetrating anterior chest trauma.

Materials and Methods

This prospective observational study was performed over a 30-month period at an urban, regional level 1 trauma center emergency department. This emergency department has an annual volume of 105,000 patients with approximately 1800 trauma admissions per year. Patients with penetrating trauma to the chest are treated by a multidisciplinary trauma team of emergency physicians and trauma surgeons. Bedside focused trauma sonography of the torso, also known as the FAST examination, is usually performed after the primary or secondary survey depending on the clinical stability of the patient. Four quadrants are interrogated with the sonographic windows including the right flank, left flank, pelvic, and subcostal pericardial views. A gray scale Shimadzu SDU-400 sonography machine (Shimadzu Corporation, Kyoto, Japan) with a 3.5-MHz curvilinear transducer was used during this period. Trauma sonographic examinations were performed by emergency medicine or trauma resident or attending physicians and supervised by credentialed emergency medicine or trauma attending physicians.

Sequential patients with penetrating anterior chest trauma on whom FAST examinations were performed by emergency physicians or trauma surgeons were included in the study. Excluded from the eligible patient population were patients who had penetrating trauma to the chest without FAST examinations, patients transferred from other institutions, and patients with blunt trauma. Penetrating anterior chest trauma was defined as wounds on the anterior thorax below the clavicles and above the xiphoid process with lateral margins restricted by the respective anterior axillary lines. The FAST results were recorded as positive (presence of an anechoic stripe or a collection in the peritoneal space or within the pericardial sac) or negative. All sonographic examinations were performed within 10 minutes of arrival to the emergency department. The FAST interpretations were recorded before review of patient outcome as determined by 1 or more of the following: thoracotomy, laparotomy, pericardial window, cardiologic echocardiography, diagnostic peritoneal lavage, CT of the abdomen and pelvis (starting at the dome of the diaphragm), and serial physical examinations. Descriptive statistics were used with 95% confidence intervals (CIs) for all percentages.

Results

FAST examinations were performed in 130 patients with penetrating torso trauma, of whom 32 (24.6%) were classified as having penetrating anterior chest trauma. Of these 32 patients, 20 (65%) had stab wounds, and 12 (35%) had gunshot wounds.

Sensitivity of FAST for cardiac injury (n = 8) in patients with PE was 100% (95% CI, 63.1%–100%); specificity was 100% (95% CI, 85.8%–100%). The presence of FAST-determined PE correlated with the need for thoracotomy (sternotomy) in 7 of 8 patients (87.5% [95% CI, 47.3%–99.7%]). One patient with a pericardial blood clot from shotgun pellets was treated nonsurgically. Cardiac injuries found at thoracotomy for the 8 patients with PE included 1 right atrial laceration, 3 right ventricular lacerations, 3 isolated pericardial injuries, and 1 internal mammary injury. All patients with cardiac injuries were followed in the hospital by the trauma team to rule out IP injury with serial physical examinations for 48 hours.

Sensitivity of FAST was 100% for IP injury (95% CI, 63.1%–100%) in 8 patients with views indicating IP fluid but without PE, again with no false-positive results, giving a specificity of 100% (95% CI, 85.8%–100%). Intraperitoneal injuries found at laparotomy for the 8 patients with IP fluid

included 5 diaphragm lacerations, 3 liver lacerations, 3 spleen lacerations, 3 gastric perforations, 2 bowel perforations, and 1 adnexal injury. (Several patients had more than 1 peritoneal organ injured.) These patients with peritoneal injury were followed for signs of cardiac injury by serial examinations and monitoring for more than 48 hours.

Other testing to rule out injury in those 16 patients with completely negative FAST examination results included 2 patients with negative CT results in the abdomen and pelvis, 2 patients with negative diagnostic peritoneal aspiration and lavage results, and 2 patients with negative cardiologic echocardiographic results. The other 10 patients had serial physical examinations performed by the trauma service in the hospital to rule out further cardiac or peritoneal injuries. No patient in this series returned to the hospital system within 6 months with missed peritoneal or cardiac injuries.

Figures 1 and 2 show representative FAST examination images from patients in this series with a positive pericardial subcostal window and a positive hepatorenal window, respectively.

Figure 1. Subcostal pericardial window with effusion after penetrating trauma to the anterior chest.

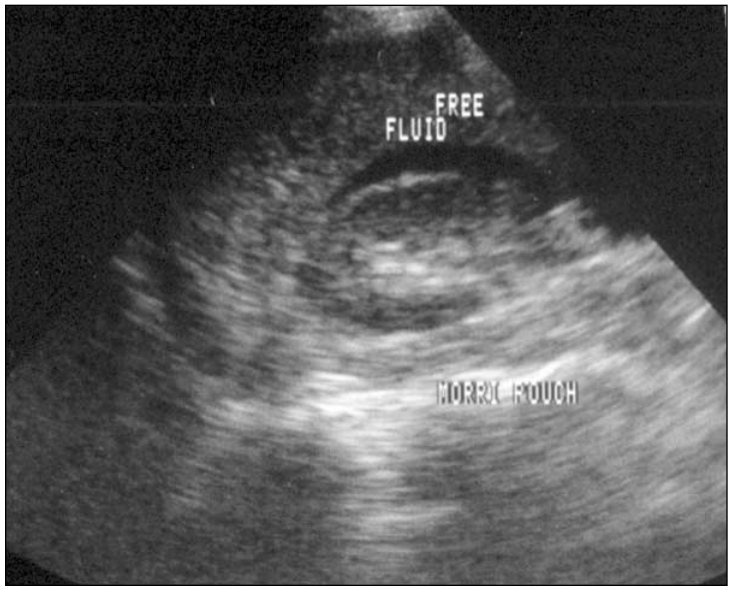
Discussion

The patient with penetrating trauma to the anterior chest presents unique challenges to initial trauma evaluation and treatment.[7,8] Although cardiac, pleural, and vascular injury are often suspected, it is not always clear which torso cavities have been transgressed in such patients with precordial wounds.[9,10] This potential violation of multiple body cavities contrasts with the condition of patients with blunt trauma, who often have solid organ IP injury but rarely concomitant blunt cardiac injury. Similarly, patients with isolated penetrating trauma to the abdomen have a preponderance of injuries isolated to the peritoneum.[1,11,12]

Penetrating trauma to the anterior chest may violate the mediastinal, thoracic, and peritoneal cavities.[7] The variable location of the diaphragm at injury may affect the presence of IP injury. During full expiration, a lower chest wound may create a high peritoneal injury affecting the liver, right kidney, spleen, stomach, and left kidney. Before the advent of FAST, many invasive diagnostic and therapeutic procedures were used in the treatment of these patients to determine the extent of injury.[8,13]

Several invasive options are available for isolated cardiac injury, including central venous pressure monitoring, pericardiocentesis, the pericardial window, and thoracotomy.[7] Penetrating peritoneal injuries are often diagnosed with local wound exploration, diagnostic peritoneal aspira-

Figure 2. Hepatorenal window at the level of the Morison pouch in a patient with IP hemorrhage after a penetrating wound to the anterior chest.



tion or lavage, abdominal and pelvic CT with oral and intravenous contrast material, and laparotomy.[1] None of these options is both rapid and noninvasive. In contrast, sonography can quickly and noninvasively identify pathologic fluid in the pericardium and peritoneum.

Sonography has been a sensitive tool for the evaluation of the patient with trauma. Specifically, it has been accepted as the initial diagnostic tool for torso injuries in patients with blunt abdominal trauma in multiple studies by many specialties.[6,14–16] For isolated penetrating cardiac injury, both the surgical literature and the emergency medicine literature have supported the use of focused cardiac sonography for isolated cardiac injury.[17–20] Although many have written extensively about isolated penetrating chest trauma with regard to cardiac injuries, it has not been clear from the literature that sonography has been helpful in evaluating the torso beyond ruling out cardiac injury.[19] Even the surgical sonographic literature describing truncal injury does not describe series of abdominal injuries in patients with penetrating chest trauma.[21] Our application of a 4-view FAST examination to the population with penetrating anterior chest injury revealed additional benefits.

Our technical approach used the 4-quadrant trauma sonographic series, also known as the FAST examination.[2,22] We used a curvilinear array abdominal transducer with a small, tightly curved radius, which allows the transducer head to fit in between ribs. The modal frequency may be considered average at 3.5 MHz but high for large adults. The lack of a phased array transducer may have limited optimal cardiac imaging, but our imaging of the cardiac chambers and function was not as technical as a typical comprehensive echocardiographic examination.[23] Our trauma sonographic windows were not conducted in any specific sequence, but usually the subcostal or right flank view was done first.[2] Paracolic views and the hemithoraces were not consistently viewed at that time in our experience but can add sensitivity to the sonographic examinations in some patients.[24,25]

In our series, all the cardiac lesions found at thoracotomy were in right-sided cardiac chambers (right atrium or right ventricle) or isolated pericardial injuries, which is consistent with the trauma literature regarding penetrating cardiac injury.[18,26,27] Although no left-sided cardiac injuries were detected in this series, we have had subsequent isolated cases of left ventricular laceration. Interestingly, penetration of only the pericardium caused hemopericardium in 3 patients. Because some surgeons may initiate a median sternotomy and cardiac bypass with suspected pericardial tamponade in the setting of penetrating injury, this series may suggest that pericardial exploration may be appropriate before bypass procedures.[28,29]

The cases of hemoperitoneum detected by the FAST examination were associated with peritoneal injuries adjacent to the anterior chest, including the diaphragm, liver, spleen, and stomach. Injury to these peritoneal structures emphasizes the need for complete torso evaluation of these patients. Also interestingly, there were multiple diaphragm injuries in this series, suggesting that careful exploration of the diaphragm during laparotomy is needed in this type of patient with trauma.[30] Although this series suggests that in this type of patient positive FAST abdominal windows may indicate diaphragm injury, sonography has not replaced other invasive procedures such as diagnostic peritoneal lavage, laparoscopy, and thoracoscopy.

The positive FAST examination was suggestive of the need for surgical treatment, including both thoracotomy and laparotomy, in this limited series. As contrasted with the need to factor stability into the decision making for a patient with positive FAST in blunt trauma, positive FAST in the patient with penetrating chest trauma essentially demands surgical treatment regardless of hemodynamic stability. Also, in contrast with the patient with isolated penetrating trauma to the abdomen, positive FAST in the patient with penetrating anterior chest trauma confirms violation of viscera that may cause primary hemodynamic instability or secondary complications such as cardiac tamponade or peritonitis.[8,28]

This series suggests that there is a role for the careful use of the traditional FAST examination in the patient with penetrating trauma to the anterior chest for detection of hemopericardium and hemoperitoneum. Furthermore, and more importantly, it suggests that positive results in such patients should be acted on with emergent procedures. Future studies should address larger series of patients, more formal decision-making analysis, and evaluation of other thoracic disorders such as hemothorax and pneumothorax in the evaluation of the patient with penetrating anterior chest trauma.

This series was limited by the number of patients included and the observational method of investigation. Uniform methods of follow-up testing other than serial physical examinations, including cardiologic echocardiography and CT of the torso, were not consistently used in this population. Further studies of the role of sonography in penetrating trauma to the torso are warranted.

In conclusion, in this series of patients with penetrating anterior chest trauma, the FAST examination was sensitive and specific in the determination of both traumatic PE and IP fluid reflective of injury, thus effectively guiding emergent surgical decision making.

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