Hand-Held Thoracic Sonography for Detecting Post-Traumatic Pneumothoraces: The Extended Focused Assessment With Sonography For Trauma (EFAST)

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Background: Thoracic ultrasound (EFAST) has shown promise in inferring the presence of post-traumatic pneumothoraces (PTXs) and may have a particular value in identifying occult pneumoraces (OPTXs) missed by the AP supine chest radiograph (CXR). However, the diagnostic utility of hand-held US has not been previously evaluated in this role.

Methods: Thoracic US examinations were performed during the initial resuscitation of injured patients at a provincial trauma referral center. A high frequency linear transducer and a 2.4 kg US attached to a video-recorder were used. Real-time EFAST examinations for PTXs were blindly compared with the subsequent results of CXRs, a composite standard (CXR, chest and abdominal CT

scans, clinical course, and invasive interventions), and a CT gold standard (CT only). Charts were reviewed for in-hospital outcomes and follow-up.

Results: There were 225 eligible patients (207 blunt, 18 penetrating); 17 were excluded from the US examination because of battery failure or a lost probe. Sixty-five (65) PTXs were detected in 52 patients (22% of patients), 41 (63%) being occult to CXR in 33 patients (14.2% whole population, 24.6% of those with a CT). The US and CXR agreed in 186 (89.4%) of patients, EFAST was better in 16 (7.7%), and CXR better in 6 (2.9%). Compared with the composite standard, the sensitivity of EFAST was 58.9% with a likelihood ratio of a positive test (LR+) of 69.7 and a specificity of 99.1%. Comparing EFAST

directly to CXR, by looking at each of 266 lung fields with the benefit of the CT gold standard, the EFAST showed higher sensitivity over CXR (48.8% versus 20.9%). Both exams had a very high specificity (99.6% and 98.7%), and very predictive LR+ (46.7 and 36.3).

Conclusion: EFAST has comparable specificity to CXR but is more sensitive for the detection of OPTXs after trauma. Positive EFAST findings should be addressed either clinically or with CT depending on hemodynamic stability. CT should be used if detection of all PTXs is desired.

Keywords: Pneumothorax, Occult pneumothorax, Ultrasound, Hand-held ultrasound, Resuscitation.

Pneumothoraces (PTXs) are the most common serious intra-thoracic injury following blunt trauma,[1,2] and a notable cause of preventable death for which relatively simple interventions may be life-saving.[2–5] PTXs are found in at least one in five major blunt trauma victims found alive.[6] PTXs also cause disproportionately severe cardiopulmonary derangements compared with other chest injuries of compa-

rable anatomic severity.[6] They are dynamic, and even small PTXs may become life-threatening, especially when mechanical ventilation with positive pressure is used, or during aeromedical transport at altitude.[4,7–11] Despite the availability of the Advanced Trauma Life Support Course guidelines for over two decades, contemporary reviews of preventable trauma deaths still identify deficiencies predominantly related to the in-hospital management of airway and chest injuries.[12] Large or symptomatic PTXs should be diagnosed clinically, but they are all too often missed even when radiography is available. Furthermore, the simple supine antero-posterior chest radiograph (CXR), has been demonstrated to be a relatively insensitive test for the detection of PTXs when compared with computed tomography (CT).[13–17]

We and others have previously investigated the use of a thoracic sonographic examination to detect pneumothoraces.[9,15,18–28] Our investigations were originally intended to answer an operational space medicine question regarding whether sonography was a practical contingency option to detect pneumothoraces when there are limited diagnostic options. These studies have suggested that a sonographic examination of the pleural interface may be an accurate means of inferring the presence or absence of PTXs.[15,18–20,29] Thus, thoracic sonography may pro-

vide a safe, portable, non-invasive test with improved diagnostic accuracy compared with the CXR. We here within report the results of a prospective evaluation of the utility of adding a thoracic examination with hand-held sonography as an extension of the physical examination to detect PTXs during the initial resuscitation of injured patients.

METHODS

At the Vancouver Hospital and Health Sciences Centre (VHHSC) critically injured patients are resuscitated by a trauma team led and/or supervised by an attending trauma surgeon. Patients in physiologic extremis and suspected of having PTXs on physical examination undergo immediate tube or needle thoracostomy without awaiting imaging studies. In those patients who do not require immediate invasive interventions, a hand-held ultrasound examination is performed as an extension of the physical examination. From July 2000 to October 2002, sonographic examinations of the thorax for the purpose of inferring the presence or absence of PTXs were performed in addition to the standard FAST examination, in an examination designated the extended FAST, or EFAST.[30] All EFAST examinations were performed by the attending trauma surgeon before obtaining and/or interpreting any other imaging studies. While the EFAST encompasses the both the standard FAST and expanded thoracic examination, this analysis concerns the thoracic component only. The operators learned to recognize the sonographic appearances of pneumothoraces through the use of an animal laboratory, review of video-taped images, and proctoring by the most experienced investigator.

The examination was carried out using a 2.4 kg hand-held ultrasound unit (Sonosite 180, Sonosite Corporation, Bothell, WA) using a L38 broadband linear array 10.0 – 5.0 MHz transducer. The transducer was placed longitudinally on the chest, perpendicular to the ribs to identify the pleural interface in reference to the overlying (and acoustically impervious) ribs. Thereafter the transducer was rotated transversely between the ribs to bring the echogenic pleural stripe into profile (Figs. 1 and 3). The EFAST assessed whether respiratory motion of the interface could be detected, a movement termed lung "sliding" or "gliding," and for the presence of comet tail artifacts. An additional sonographic sign that was sought was the "comet-tail" artifact, a hyperechoic reverberation artifact which extends from the pleural interface to the most distal aspect of the field of view, and which is present in normally opposed pleural surfaces (Figs. 1 and 3), but absent in PTX.[27] The absence of these signs was inferred to correspond to a sonographic diagnosis of a pneumothorax (Fig. 2). In April 2001 an enhanced demonstration of the pleural sliding with color power Doppler (CPD), known as the "power-slide" was described and added as a standard diagnostic criteria to be assessed (Fig. 4).[21] While the presence of pleural fluid was noted when present during EFAST examinations, it was not considered in the diagnostic criteria for PTXs. The protocol incorporated a sonographic evalua-
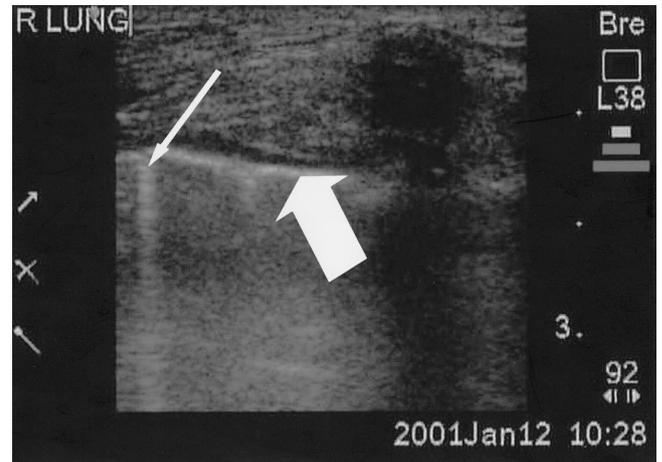

Fig. 1. *Thoracic sonogram of normal right chest of 60-year-old pedestrian struck by car. Physiologic sliding could be easily seen at the interface of the visceral and parietal pleura (thick arrow). A comet-tail artifact originating from the visceral pleura was also seen to slide back and forth with respiration (thin arrow), refered to a "lung sliding."*

tion of the anteromedial chest at the 2nd intercostal space in the mid-clavicular line and of the anterolateral chest at the 4 or 5th intercostal space in the mid-axillary line, although the examination was not limited to these sites. Both thoraces were routinely examined to provide a measure of internal control for each specific patient.

All examinations were recorded using either digital still images which were saved on a computer hard-drive as JPEG images, or recorded real-time as digital video-tapes on a video-recorder (GV-D800 NTSC, Sony Corp, Japan). Diagnostic sonographic phenomenon are best viewed in real-time.
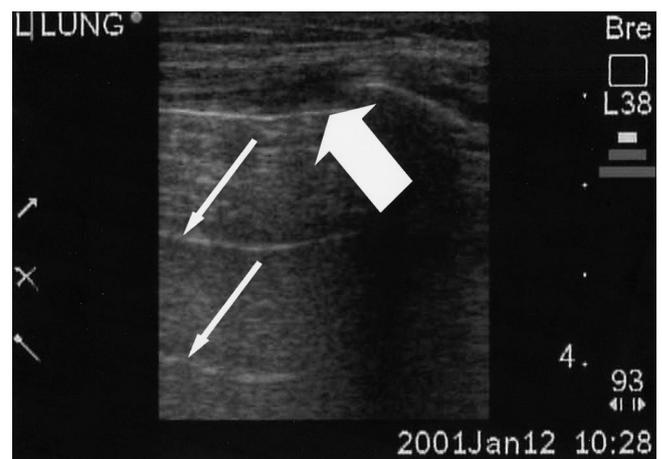

Fig. 2. *Thoracic sonogram of left chest with pneumothorax of same 60-year-old pedestrian before tube thoracostomy. No sliding or moving comet tail artifacts were seen at the visceral/parietal pleural interface (thick arrow). Echogenic lines repeated at fixed inervals represent reverberation between the pneumothorax (with high acoustic impedance, resulting in a "horizontal artifact."*
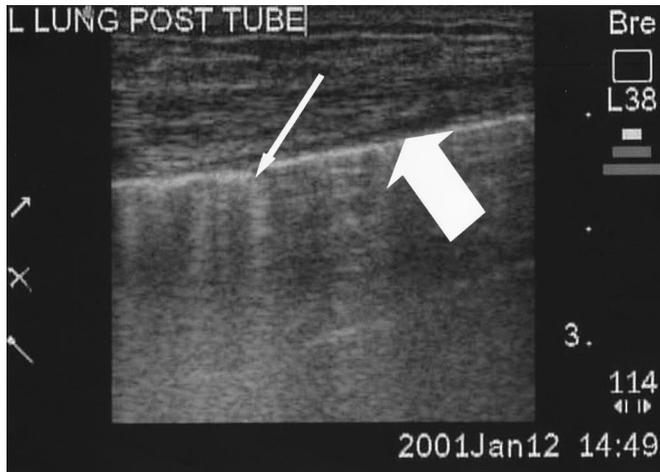
Fig. 3. *Thoracic sonogram of left chest of same 60-year-old pedestrian after placement of tube thoracostomy. The sonographic suspicion of a left pneumothorax was confirmed with a chest radiograph. After placement of a left tube thoracostomy physiologic sliding could be easily seen at the interface of the visceral and parietal pleura (thick arrow). A comet-tail artifact originating from the visceral pleura was also seen to slide back and forth with respiration (thin arrow), representing re-apposition of the visceral with parietal pleura.*

Illustrative video images may be viewed on-line at http://tac.medical.org/videolinks.htm. Patients with chest drains placed at referring hospital or in the prehospital setting, or those with gross subcutaneous emphysema that obscured the acoustic window for visualization of the pleural interface, were excluded.
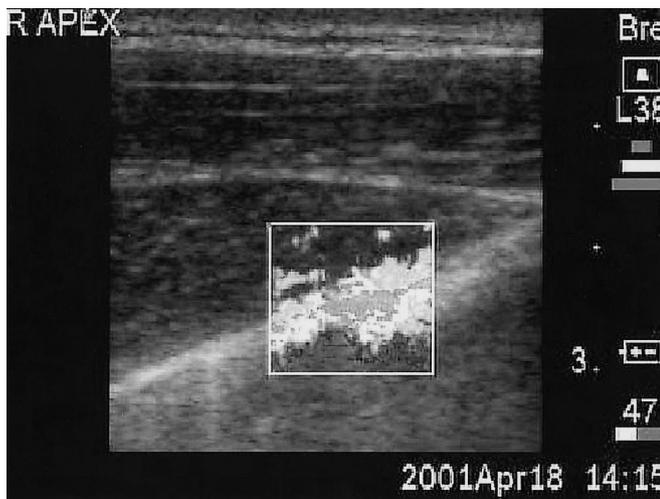

Fig. 4. *Color-Power Doppler depiction used to accentuate the normal pleural sliding at the visceral/parietal pleural interface. Color enhancement with in the sampling area represents differential motion of the visceral pleura with the thoracic cage. A true color image of the above may be viewed directly at www.tac.medical.org/Attachments/doppler.jpg.*

To derive test performances for the EFAST examination, a composite standard regarding the best known standard of truth for each case from all information about the true status of intra-pleural air in either hemithorax was used. The composite standard might or might not include CT scanning depending on the case. This standard was considered positive as per the methodology of Di Bartolomeo if the escape or aspiration of intra-pleural air at the time of drainage was documented, or if a PTX was identified on either CXR or CT scan.[6] A second analysis was performed for those patients who had CT results to constitute a definitive CT gold standard, allowing calculation of the comparative performance of the EFAST to the CXR. For this comparison, a true positive PTX was one seen on CT, whereas a true negative PTX was absent on all CT scans. An occult pneumothorax (OPTX) was defined as a PTX not suspected on the basis of clinical examination or plain radiography that was ultimately detected with thoracoabdominal CT.[13]

Data on patient demographics, physiologic status, and EFAST results was prospectively collected. Shock was defined as documented systolic blood pressure less than 90 mm Hg. Severity of injury was described using the Injury Severity Score (ISS).[31] The ultimate hospital course was determined by collating information from the British Columbia Trauma Registry with a complete chart review. The study was approved by the ethics and research committees of the University of British Columbia, and the VHHSC. Statistical comparisons were performed using Stata 8.0 (Stata Corp, College Station, TX). Group demographics and overall agreement between EFAST and CXR were analyzed on patient level, while imaging of the pleural cavities for each hemithorax was considered separately as an independent measure. Group means were compared using Student's *t* test, medians using the Mann Whitney *U* test, and proportions using Fisher's exact test. Test performance characteristics were defined as per Sackett.[32]

RESULTS
Demographics

Two-hundred and twenty five (225) patients were examined after acute traumatic injuries. The median ISS was 14 with an inter-quartile range (IQR) of 5 to 27. The group was 74% male, median age 37, with an IQR of 25–52.5 years. Eighteen (8%) were injured by penetrating mechanisms and 207 (92%) through blunt trauma. Forty-one patients (21%) presented with shock.

Sonographic Findings

The US unit allowed for a rapid bedside assessment to be performed during the initial trauma resuscitation, and proved adequate to quickly visualize the visceral/parietal pleural interface in most patients (Figs. 1 and 3). Normal determinations could typically be made in under a minute. PTXs were diagnosed when sliding and comet-tail artifacts could not be seen (Fig. 2). Although these examinations typically took
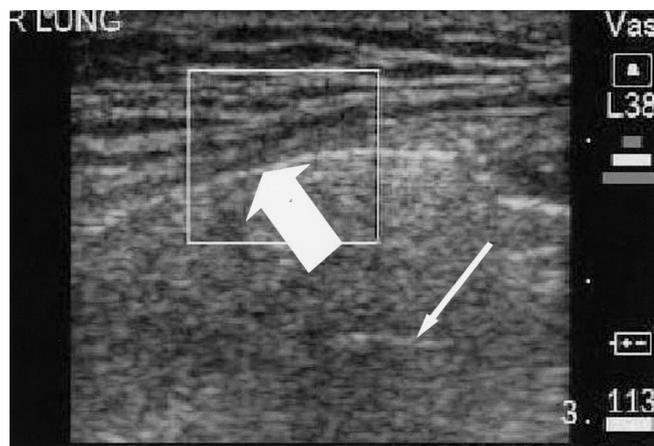
Fig. 5. *Absent color-power Doppler sign and horizontal reverberation artifact seen at apex of same 85-year-old female involved in a motor vehicular crash. Large arrow indicates visceral/parietal pleural interface demonstrates absence of comet tail artifact and lung sliding. The absence of power sliding increases the suspicion of pneumothorax. Thin arrow indicates horizontal reverberation artifact between the pneumothorax and the adjacent skin due to high acoustic impedance.*

longer to appreciate, they were completed of necessity within several minutes. Horizontal mirror artifacts identified at regular intervals were also frequently seen when PTXs were present (Figs. 2 and 5). Figure 5 further demonstrates the absence of the CPD and a horizontal reverberation artifact at the apex of a thorax shown to contain an occult hemo/pneumothorax on CT scan.

Pneumothoraces

Sixty-five (65) PTXs were diagnosed in 52 patients (22% of all patients), in whom 13 were bilateral, and 39 were unilateral. In only one of the 13 bilateral PTX cases were both PTXs detected using the EFAST examination. In 5 cases of bilateral PTXs, one PTX was missed, and in 7 cases both PTXs were missed. There was a trend toward patients with PTXs presenting in shock ($p = 0.06$). This was largely related to those patients with bilateral PTXs, who were 2.95 times

[95% confidence interval – (CI) 1.64 – 5.31] more likely to have shock than those without PTX.

Occult Pneumothoraces

Occult PTXs were present in 14.6% (33/226) of all patients of all patients as determined by the composite standard, and 24.6% (33/134) using the CT gold standard. The median ISS was significantly higher in those with OPTXs being 33 (IQR 20 – 38), compared with those without (median – 14, IQR 5 - 26) ($p < 0.001$). Patients with an ISS > 16 were 8.1 (95% CI 2.56 – 33.15) times more likely to have OPTXs than patients with lower ISS scores ($p < 0.0001$). No other factors (mechanism of injury, age, gender, or presence of shock) were different.

Apparent EFAST Performance

Two-hundred and eight patients had at least one lung field examined with EFAST, as 17 (7.5%) did not undergo EFAST due a missing high-frequency probe (6 – 2.6%), or battery failure (11 – 4.9%). A total of 411 lung fields were examined. Of the lung fields not examined, three were due to presence of a previously placed chest tube and dressings, and two were because obvious subcutaneous emphysema. The EFAST correctly identified 33 out of 56 PTXs, while falsely inferring 3 PTXs for a sensitivity of 58.9%, specificity of 99.2%, positive predictive value (PPV) of 91.7%, negative predictive value (NPV) of 93.9%, accuracy of 93.7%, likelihood ratio of a positive test (LR+) of 69.7, likelihood ratio of a negative test (LR-) of 0.41 (Table 1). The rate of EFAST errors showed no correlation with the length of time the study was ongoing ($p = 0.2$).

Comparative EFAST and CXR Performance

There were 186 patients in whom the EFAST and the CXR agreed (regardless of whether true or not) regarding the presence or absence of PTXs as compared with the composite standard. There were 6 cases in which the CXR was better, with either an indeterminate or false EFAST diagnosis. There were 16 cases in which the EFAST was better than the CXR, with false negative or false positive diagnoses being made by

Table 1 Diagnostic Test Performances in the Detection of Post-Traumatic Pneumothoraces

Test	EFAST (95% CI)		EFAST (95% CI)		CXR (95% CI)	
	(%)	(%)	(%)	(%)	(%)	(%)
Gold Standard	Composite		CT scan		CT scan	
Number of Lung fields	411		266		266	
Sensitivity	58.9	(45.0–71.9)	48.8	(33.3–64.5)	20.9	(10.0–36.0)
Specificity	99.1	(97.6–99.8)	98.7	(96.1–99.7)	99.6	(97.5–100.0)
Positive predictive value	91.6	(77.5–98.2)	87.5	(67.6–97.3)	90.0	(55.5–99.7)
Negative predictive value	93.8	(90.9–96.1)	90.9	(86.6–94.2)	86.7	(81.9–90.6)
Accuracy	93.6	(90.9–95.8)	90.6	(86.4–93.8)	93.9	(90.1–96.5)
Likelihood ratio of a positive test	69.7	(20.5–361.6)	36.3	(10.0–194.7)	46.7	(6.1–2054.0)
Likelihood ratio of a negative test	0.41	(0.23–0.70)	0.52	(0.29–0.92)	0.79	(0.47–1.33)

EFAST, extended focused assessment with sonography for trauma; CXR, antero-posterior supine chest radiograph; CT scan, computed tomographic scan (chest or abdomen).

the CXR. In the 14 patients with a PTX inferred by EFAST but not seen on CXR, 11 had an OPTX seen on CT scan.

CT Gold Standard

One hundred and thirty-four (134) patients had consecutive EFAST, CXR, and CT examinations: 266 lung fields were examined consecutively by all three tests. The EFAST detected 21 of 43 PTXs, while falsely inferring 3 PTXs that were not present on CT scan. Test specifics are given in Table 1. In this same group, the CXR detected 9 of these PTXs and falsely inferred 1 false positive diagnosis. While the specificity was comparable to the EFAST, CXR was of lower sensitivity.

DISCUSSION

The basis of using sonography to exclude or infer the presence of a pneumothorax comes from the fact that if the two pleural surfaces are confirmed to be in apposition, then by definition an intra-pleural collection of air cannot separate these two surfaces. In the absence of previous pleural disease or illness, spontaneous or mechanically assisted ventilation is associated with the movement of the visceral against the parietal pleura. For this sliding or gliding of the pleural surface to be seen, both surfaces must be either contiguous (Figs. 1 and 3), or else separated by fluid. Examining the pleural interface with the unit in color power Doppler mode can enhance the depiction of this sliding movement due to power Doppler's ability to detect motion.[21] CPD is superior to regular color Doppler in determining the presence or absence of flow at the expense of direction and speed information.[33,34] Comet tail or ring down artifacts are reverberation artifacts that arise from distended water-filled interlobular septa surrounded by air in the visceral pleura and are presumed to be the equivalent of the familiar "Kerley B lines" seen on chest radiographs.[35] They seem to be related to the visceral pleura and thus can only be seen when the pleura are in apposition or separated by fluid[27](Figs. 1 and 3). Hence, neither lung sliding, nor comet-tail artifacts will be seen if a pneumothorax is present (Figs. 2 and 5). The "horizontal artifact" likely corresponds to reverberation artifacts between the skin surface and the PTX and is a repetitive equally spaced series of horizontal hyperechoic (bright horizontal) lines that are not associated with lung sliding.[27] Lung sliding seen in the presence of horizontal artifacts can represent the normal situation however.[27]

Utilizing these principles, the EFAST proved a rapid and useful test to detect pneumothoraces. Compared with CT scan, the EFAST performed with an overall greater accuracy than the CXR, emphasizing how the CXR is an inadequate standard of comparison for research in this area. In addition to our clinical impression, the LR+ and the PPV of the EFAST compared with both the composite standard and to the CT gold standard, confirmed that the EFAST was a very statistically useful test when it was positive. Likelihood ratios are felt to give a better assessment of the value of a diagnostic

test than the sensitivity, specificity, positive and negative predictive, and accuracy.[36] No diagnostic test is perfect, and recognizing this, likelihood ratios indicate by how much a given diagnostic test will raise or lower the pretest probability of the target disorder. As a rough guide LRs greater than 10 or less than 0.1 typically generate large and often conclusive changes from pretest to post-test probability.[36,37]

There were 3 false positive diagnoses of a PTX by EFAST. One was found to be associated with subcutaneous emphysema that was not clinically obvious. There were two cases in which false positive diagnoses of left sided pneumothoraces were inferred from the sonographic examination of intubated trauma patients, as lung sliding and the CPD signs could not be identified with confidence. Subsequent chest radiographs identified right main-stem endotracheal intubations. Withdrawal of the ETT back to the carina was followed by the return of sliding. This serendipitous observation thus suggested another application of hand-held trauma sonography, that being the corroboration of correct ETT tube placement in operational environments where examination, especially auscultation, is difficult or impossible.[38]

Using CT corroboration, there were 22 false negative studies with EFAST compared with 34 with CXR. The negative predictive values and negative likelihood ratio of the EFAST were not as high as was anticipated by the investigators based on previous studies. An explanation for this might be that the group was severely injured and the nature of the injuries precluded determination of an "unaffected" from an "affected" side before scanning, as was possible in other trauma studies.[19] False negative studies may have been related to caution in the clinician's interpretation of partially abnormal sonographic findings, wherein there was a hesitancy to designate these as abnormal, and a tendency to infer the normal. We believe though, that the lowered sensitivity may be most related to the large proportion of smaller occult PTXs, in which we hypothesize there may have been intermittent pleural sliding, a phenomenon previously described as the "lung point" of Lichtenstein,[39] or the "partial sliding" of Sargsyan.[18]

Although the supine CXR yields a wealth of diagnostic information after trauma, the sensitivity for detecting PTXs is low. While a number of other subtle radiographic signs of PTX have been described such as the deep sulcus sign, double diaphragm sign, pericardial fat tag sign, a overly distinct cardiac apex, and a hyperlucent hemithorax,[40-43] these signs are not often appreciated in the acute trauma resuscitation. The typical determination of a PTX has relied on the appreciation of a visible pleural stripe. Presumably, EFAST results would greatly improve if only these obvious PTXs were considered, but this would entail ignoring at least half of the PTXs present. It is becoming apparent that in the seriously injured a majority of pneumothoraces present are missed on the supine CXR, yet are detected on CT.[13,13-17,44-48]

The EFAST offers a simple means of detecting many of these OPTXs. We believe the EFAST technique has inherent

advantages over plain radiology because of the physiologic behavior of PTXs in the supine patient. Due to the effect of gravity, the supine lung tends to hinge dorsally, with free air collecting anteromedially.[40,43,49–51] Supine PTXs were reported to be most commonly located at the anteromedial sulci (38%), as well at the subpulmonic recesses (26%), apicolateral (22%), and posteromedially (11%).[51] The standard imaging anatomic sites for the EFAST were chosen to correspond to the recommended auscultatory locations from the Advanced Trauma Life Support course.[1] Fortunately, these imaging locations also corresponded to the anteromedial chest and to the anterior costophrenic sulcus.

An important attribute of the EFAST is its simplicity. Once basic familiarity with sonography is attained, the examination can be quickly learned by recognizing the salient diagnostic features of normal pleural movement. As there did not appear to be a learning curve over the duration of the study, we believe the majority of the false negatives were related to patient factors, rather than the examiners. The examiners first observed the diagnostic criteria in controlled circumstances in an animal lab, where normal and abnormal findings could be easily confirmed. Test interpretation consists of evaluating for 2 simple sonographic signs; lung sliding and the presence or absence of comet-tail artifacts; the CPD sign is simply a technical means of emphasizing lung sliding. These signs are further accentuated when normal on one side and abnormal on the other side of an injured patient. The EFAST performed poorly in cases with bilateral PTXs, presumably because this intrinsic standard of comparison was lost; 62% of such cases revealed at least one PTX, but in only one of 13 were both PTXs detected. The obvious contrast between normal and abnormal lung fields in cases of unilateral PTXs presumably aided the examiners, a diagnostic feature that was lost with bilateral injuries. All diagnostic techniques have known pitfalls such as diaphragmatic injuries and diagnostic peritoneal lavage,[52] bowel injuries and computed tomography,[53] and occult PTXs and the CXR.[13] An insensitivity to the detection of bilateral PTXs should be considered a known pit-fall of the EFAST.

The importance of completing a full chest examination was reinforced upon reviewing our results. One false negative EFAST occurred when the examiner abbreviated the study and only examined the 2nd intercostal space bilaterally. An OPTX was later identified involving the anterolateral lung, which might have been detected if the full EFAST examination had been carried out. No cases of pre-existing pleural disease caused false determinations in this series, although we had previously noted a false positive study in a patient with bullous emphysema.[15]

We feel that based on our results, the sonographic findings of absent sliding and comet tail artifacts after traumatic injury should be promptly addressed. If found on the left chest, the positioning of any ETT tube should be quickly verified. If the patient is stable, chest radiography or preferably CT scanning of the chest should be obtained. If the patient is unstable, chest drainage should be performed. The complications of chest drainage are not negligible,[54] but are far outweighed by the consequences of an untreated tension pneumothorax.

The current study should be considered as an effectiveness rather than an efficacy study. It is unknown whether complete thoracic CT scan will diagnose more OPTXs than the portions of the lung typically seen on abdominal CT scans. Future work is planned to address this question. The examiners were practicing trauma surgeons with an interest in trauma sonography, but without formal radiologic training. While the hand-held US was extremely convenient to use and transport, it has a small screen, which was often hard to view in the course of a resuscitation in which the lights could not be turned off, and there were numerous conflicting priorities of management for the trauma surgeon to manage. Many patients could not be imaged either due to battery failure, or because the thoracic probe was misplaced. Image quality was noticeably degraded throughout the study as crystals in the scanning probe failed. With the current pace of technological development, and commercial pressure, it is almost assured that even lighter and cheaper units with greater fidelity will become increasingly available in the future.

Thoracic sonography has the advantages of portability, repeatability, absence of radiation, ease of use, and increased sensitivity in the detection of PTXs compared with supine CXRs, in assessing victims of trauma. In many remote and operational settings, sonography also constitutes the only potential imaging modality. Our group has been actively involved in evaluating the utility of sonography in weightlessness for these reasons, as sonography will be the only imaging modality aboard the International Space Station where there is no radiography, no CT, and no MRI.[55,56] Closer to home, many trauma systems patients must be transported great distances before receiving definitive care and thus may benefit from pre-hospital thoracic interventions. A prospective review of the potential utility of trauma radiographs that might have been transmitted electronically revealed frequent inattention to the treatment and prophylaxis of such PTXs in prehospital transports.[57] As ultrasound units are becoming increasingly portable, they lend themselves to pre-hospital evaluation.[58]

Recent practice management guidelines from the Eastern Association of Trauma recommend that the FAST be considered as the initial diagnostic modality to exclude hemoperitoneum.[59] We feel that examining the chest to diagnose pneumothoraces is a natural progression of this acceptance of trauma sonography performed by clinicians. Whereas only a surgeon can perform a laparotomy when guided by a positive FAST in an unstable patient, almost any clinician or paramedical personnel with appropriate training can insert a chest drain to treat a pneumothorax. Clinicians should examine the chest with sonography after trauma, especially if they utilize a FAST approach to trauma ultrasound. The EFAST will not detect all PTXs, but is more sensitive

than CXR, and may detect occult PTXs. The CXR and EFAST should be considered complementary, while CT is the test of choice to detect all PTXs.

ACKNOWLEDGMENTS

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