AMERICAN COLLEGE OF EMERGENCY PHYSICIANS
SCIENTIFIC ASSEMBLY
1999

The Role of Ultrasound in Evaluation of the Trauma Patient

Ultrasound is emerging as an additional modality in the evaluation of abdominal trauma. The American College of Surgeons will be requiring ultrasound training for general surgery residents. The lecturer will review the literature on the use of ultrasound in the evaluation of patients with abdominal trauma and will compare the use of ultrasound with the use of peritoneal lavage and computed tomography scanning. Finally, recommendations will be made as to which, if any, clinical situations justify the use of ultrasound alone or in addition to other tests.

- Discuss the literature on the use of ultrasound in evaluating patients with abdominal trauma.
- Compare the sensitivity and specificity of ultrasound with those of abdominal computed tomography and peritoneal lavage.
- Identify the areas of the abdomen to scan using ultrasound.
- Suggest which clinical situations, if any, might be an indication for ultrasound evaluation of the abdomen in a trauma patient.

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FACULTY

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Introduction

The abdominal examination in trauma is an unreliable indicator for intra-abdominal injury and techniques to assist us include diagnostic peritoneal lavage (DPL), computed tomography (CT) and ultrasonography (U/S). Ultrasound has been used to evaluate emergency patients since the 1970s but only in the last 10 years has there been significant interest in the United States. In Europe, ultrasound has essentially replaced diagnostic peritoneal lavage at many referral centers and since 1988, German surgeons have been required to have ultrasound skills for board certification. Since this time multiple prospective studies done by North American emergency physicians and surgeons confirm this modality can be used by non-radiologists.

Author	*Year*	*# Patients*	*Sensitivity*	*Specificity*
Kimura	1991	72	86.7	100
Hoffman	1992	291	89	97
Tso	1992	163	91	99
Rothlin	1993	312	90	100
Rozycki	1993	476	79	96
Lucciarini	1993	726	92	97
Bode	1993	353	93	100
Goletti	1994	250	98	99
Ma	1995	245	90	99
Rozycki	1995	371	82	100
Healey	1996	800	88	98
McKenney	1996	1000	88	99
Boulanger	1996	400	81	97
Thomas	1997	300	81	99
Porter	1997	1631	93	90
Glaser	1997	1151	99	98
Yoshii	1998	1239	95	95
Rozycki	1998	1540	83	100

The above are a sample of studies thus far in trauma ultrasound. As you can see most of these clinician-performed studies show very good sensitivity with excellent specificity for detecting hemoperitoneum.

U/S vs. DPL vs. CT

Ultrasound has significant advantages over DPL and computed tomography (CT) for the rapid detection of intra-peritoneal bleeding in critically injured patients. U/S is a fast technique requiring <5 minutes for a full exam, is noninvasive, and can be used in unstable patients. Since 1965, DPL has gained popularity and remains an excellent method for detection of intra-peritoneal blood. Critics claim that it is overly sensitive causing “non-therapeutic” laparotomies and in addition, it is invasive, takes 10-15 minutes to complete and is complicated by pregnancy and previous laparotomy. CT scanning provides excellent organ detail including the retroperitoneum but remains an expensive modality and is not readily available. In addition, hollow viscus injuries still are poorly detected despite adequate preparation with oral contrast. CT is a relatively slow technique and with transport considered, often takes 45-60 minutes to complete and thus this modality can only be used in stable patients. As each method has its advantages and disadvantages, a combination of techniques may be both necessary and optimal. In many US centers, this has translated in ultrasound replacing DPL as the initial diagnostic study.

The main advantages of ultrasound can be summarized:

1. Non-invasive
2. No radiation/contrast agents
3. No adverse effects
3. Portable
4. Rapid
5. Repeatable
6. Cost-effective
7. Accurate

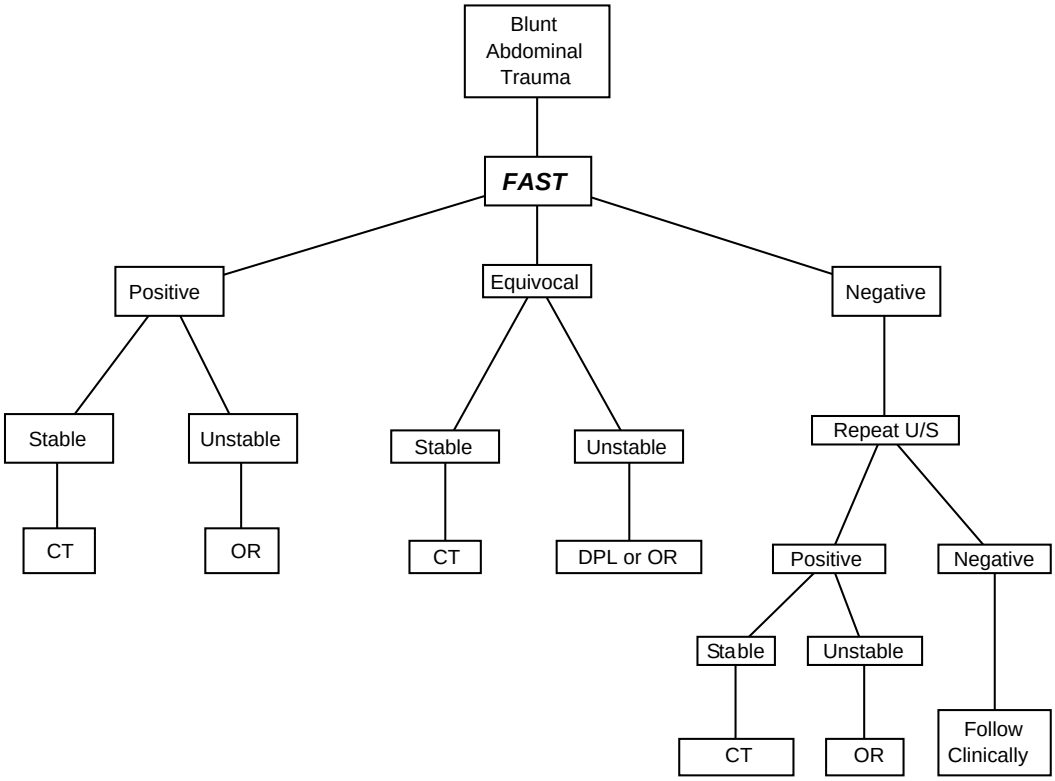
Ultrasound Indications and Limitations

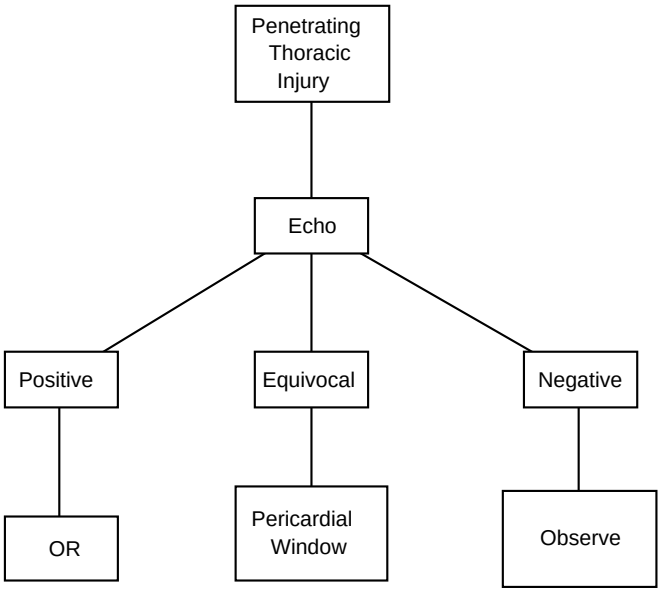
Bedside ultrasound is very useful for the rapid detection of:
1) hemoperitoneum,
2) pericardial effusions
3) pleural effusions.

Ultrasound's greatest utility is in the evaluation of blunt abdominal trauma for hemoperitoneum, and penetrating chest injuries for the detection of pericardial effusions. As a simple CXR detects pleural effusions reliably, the role of ultrasound for pleural effusion is limited to patients that may be unstable and have not had plain radiography. At times, ultrasound may be helpful in differentiating pulmonary contusion from a hemothorax. Ultrasound does have limitations. Notably those patients that are morbidly obese or those with massive subcutaneous emphysema can be difficult to image. Even in these patients you are usually able to obtain sufficient views for clinical decision making.

Incorporating Trauma Ultrasound

The below are suggested algorithms in the use of ultrasound in blunt abdominal trauma and in penetrating thoracic injury. Algorithms incorporating ultrasound will vary at different sites reflecting their experience and subsequent reliance on this technology.





Ultrasound Training

Multiple studies have shown that clinicians can reliably learn ultrasonography within a short training period, though this period is not well defined. Most studies have had training periods from a few hours to a few days though it appears that this technique can be taught within a day. It should be emphasized that *our use of ultrasound will be of focused exams only*. With focused examinations, the training and learning period is much shorter than that required by registered sonographers and radiologists.

For trauma abdominal sonography the focused exam will concentrate on the finding of free intraperitoneal fluid rather than delineation of specific organ injury. In fact, ultrasound will not reliably detect low-grade injuries without hemoperitoneum. For the echocardiographic exam, our focus will be the sole finding of a pericardial effusion. Other echocardiographic findings such as segmental wall abnormalities or valvular lesions as may done by ultrasound technologists or non-invasive cardiologists will not be part of this focused study.

The Society of Academic Emergency Medicine (SAEM) has training guidelines for emergency ultrasonography which includes cardiac, biliary, aortic, renal, pelvic and trauma ultrasound. A minimum of forty hours of ultrasound instruction and 150 proctored exams are required to meet SAEM guidelines for emergency ultrasonography. These requirements are for training in all aspects of emergency ultrasonography and therefore training only in trauma ultrasound would require less time.

Ultrasound Equipment

Since our goals for trauma ultrasonography are relatively simple, state of the art expensive ultrasound equipment is not necessary. Low end systems at $30,000-50,000 are sufficient for most of emergency ultrasonography. Though the initial cost may be steep for some departments, the cost per exam is minimal when the cost is amortized over thousands of exams. In fact, individual studies costs less the more you use the technology. This is in contrast to modalities such as computed tomography. Since a clinician is performing the exam there is no technical fee and since this same physician is interpreting the exam, there is no associated professional fee. In the age of cost containment, clinician performed ultrasound clearly makes fiscal sense.

The machine would ideally have 2 or more ultrasound probes and a 3.5MHz probe is a good "jack of all trades" probe. A small footprint probe that can allow intercostal scanning is ideal for most exams. The exams will need to be recorded so print and/or video capability are necessary. Many new machines include options for digital imaging and ethernet connection allowing images to be transferred via the hospital radiology network. Size, portability and durability of the machine are also important, as it is likely the machine will be moved to different areas on a frequent basis and encounter unusually heavy wear in

a busy emergency department. A number of different vendors manufacture excellent machines ideal for emergency use. For more information on this and other information to help start an ultrasound program, obtain the ACEP Ultrasound Resource document available through ACEP free of charge.

The Radiology Department

Unfortunately, despite the fact that clinician performed ultrasound helps in patient care, many radiology departments do not support their clinical colleagues in using this modality. This stance is often more political and “turf” related rather than having any meaningful credibility.

It is important to remember that our ultrasounds are *focused exams and goal specific*. In essence, we want a single answer to a clinical question - and the ultrasound answers this question. The literature clearly demonstrates that used in this manner, non-radiologists can perform emergency ultrasonography in a competent manner.

Natural allies in the evolution of emergency physician performed ultrasound include OB-GYN, cardiology and surgery. In addition, ultrasound technicians are often very helpful in clinical teaching, as they do the majority of sonography for radiologists.

It is important to remember that clinical considerations for patient care must supersede any economic and political concerns. With this said, in the majority of cases where the service is not available, this will mean clinician performed ultrasound.

FAST – Focused Abdominal Sonography for Trauma

Focused Abdominal Sonography for Trauma or FAST is a simple, quick ultrasound screening exam for hemoperitoneum. Again, the exam is a *focused* exam as our only objective is detection of free intraperitoneal fluid. Our goal is not to determine the source of the bleeding such as a ruptured spleen or a liver laceration, as the determination of the actual injury is often difficult and unreliable by ultrasound. If hemoperitoneum is detected by ultrasound, it is a strong predictor for the need of therapeutic laparotomy. If intra-peritoneal fluid is seen, most often it is hemoperitoneum but at times needle aspiration may be necessary to confirm the presence of blood. Ascites can be confused and may need to be differentiated from hemoperitoneum. Intestinal fluid and urine also will have positive findings on ultrasound, but both diagnoses also require operative intervention.

FAST consists of focused views of the abdomen including the pericardium. Multiple views greatly increase the sensitivity of ultrasonography and the areas examined include the following:

1. Morison's Pouch
2. Pericardium
3. Perispenic space
4. Paracolics
5. Suprapubic view

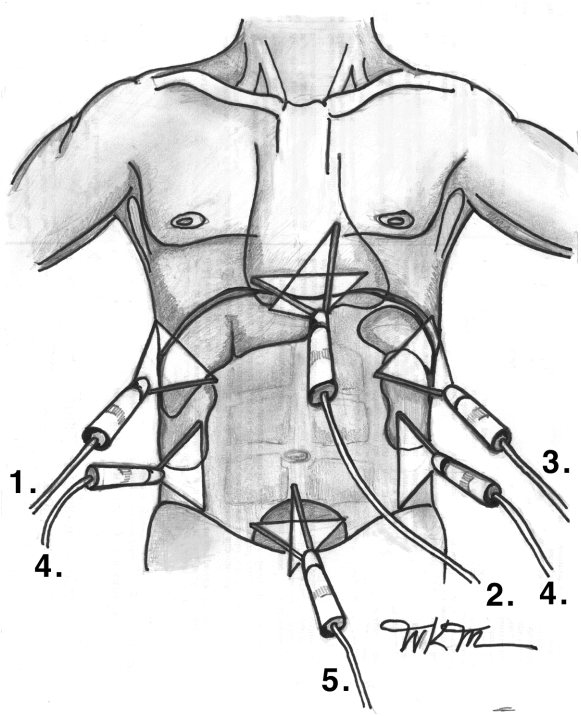


Figure 1 - Views in trauma scanning

1. Morison's Pouch

Morison's pouch is a very useful initial view in the ultrasound evaluation of the trauma victim. The exact amount of free fluid detected in Morison's pouch varies but is as little as 250cc. This view is easily obtained within 20-30 seconds as the landmarks are easy to find. The probe is place in the mid to posterior axillary line at the just below the nipple level. The liver is identified and the kidney will be caudad and adjacent. Morison's pouch is a dependent potential space that lies between the liver and the kidney. Free fluid appears as a anechoic or as a black stripe in this area. With time, hemoperitoneum loses its anechoic consistency and becomes more hyperechoic, thus the fluid will have a more gray color and an inconsistent appearence. Hyperechoic (white or gray areas) that surround the kidney represent normal perinephric fat and Gerota's fascia and are not to be confused with free fluid. Patient positioning in trendelenburg can improve sensitivity by making this area more dependent.

Once Morison's pouch is adequately examined, angle the probe cephalad and examine the diaphragm for fluid above or below. This will be evident by black areas and small hemothoraces can easily be detected with a little practice.

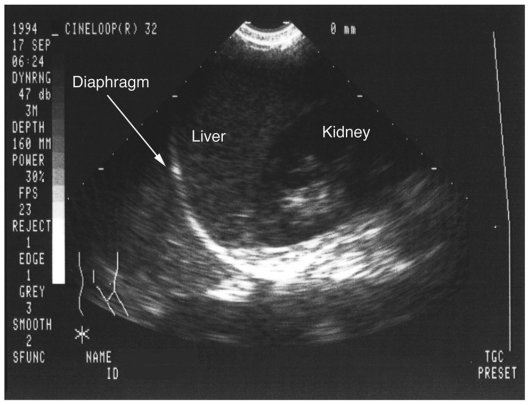


Figure 2 -Normal Morison's Pouch
Note there is a clean interface between the liver and kidney. There are no anechoic or black areas seen which would represent free fluid.

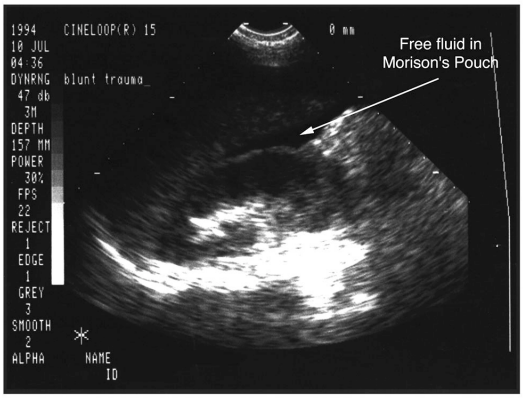


Figure 3 -Positive Morison's Pouch
Note that free fluid appears anechoic or black

2. Pericardium

The pericardium is especially important to evaluate in penetrating thoracic injuries to rule out a pericardial effusion and tamponade. For this view, the probe is placed in the subcostal area just to the right of the xiphisternum and the probe angled toward the patient's left shoulder. To view the heart adequately, you will need to increase the depth of penetration at this point. A coronal section of the heart should give you a good 4 chamber view of the heart. The normal pericardium is seen as a hyperechoic (white) line intimately surrounding the heart. A pericardial effusion is seen as an anechoic (or black area) surrounding the heart within the pericardium. A sagittal view should also be used for confirmation, as pulmonary effusions can be confused with pericardial effusions. Though beyond the scope of this handout, a long axis parasternal view of the heart is the best view to examine the pericardium to avoid any confusion with pleural fluid.

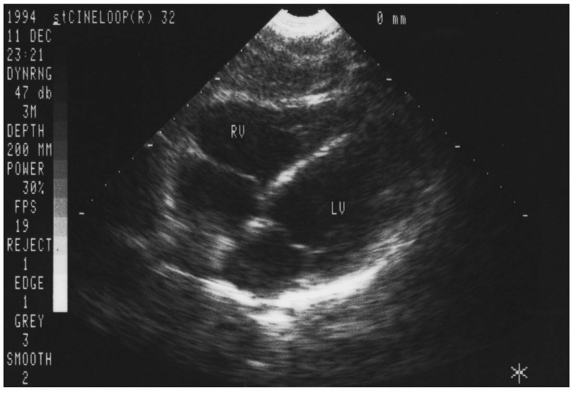


Figure 4 - Normal subcostal pericardium
Note the hyperechoic pericardium closely surrounding the heart

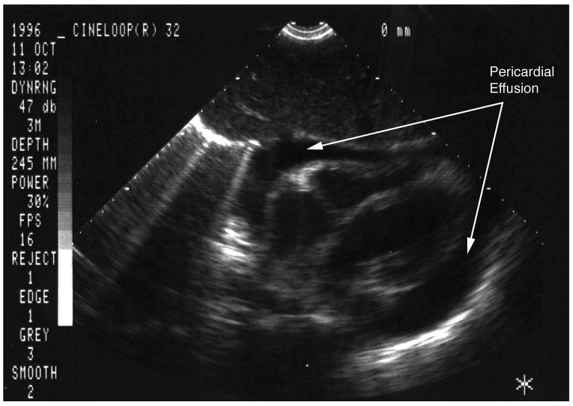


Figure 5 - Positive pericardial effusion
The anechoic area surrounding the heart represents fluid within the pericardial sac

3. Perisplenic Area

The perisplenic view is obtained by placing the probe at the posterior axillary line at the 9-10th interspace. A common mistake when doing this view is not placing the probe posterior enough to adequately see the kidney. Once the kidney is found, angle the probe slightly cephalad to find the spleen and carefully look for free fluid surrounding it.

Once the spleen and kidney are fully scanned, angle the probe more cephalad to examine the diaphragm. As with Morison's pouch, the diaphragm should be visualized to see a pulmonary effusion or subdiaphragmatic fluid.

4. Paracolic Views

The paracolic views can be done in conjunction with Morison's pouch and the perisplenic view. Simply place the probe in the paracolic area and examine for free fluid and/or free floating loops of bowel. Fluid is often detected first on other views limiting the usefulness of the paracolic view.

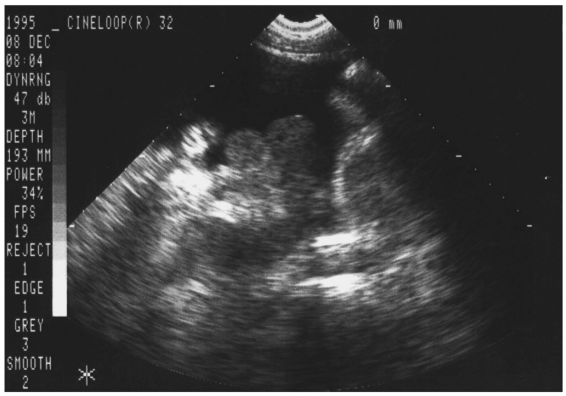


Figure 8 - Positive paracolic view

Note the free fluid and free floating loops of bowel. Normally no fluid should be visible

5. Suprapubic View

Ideally this exam is done prior to the placement of a foley catheter. The full bladder is easily found by placing the probe just cephalad to the pubis. Once the bladder is found, look for free fluid anterior, posterior and lateral to the bladder. In females, the uterus will be seen posterior to the bladder. The cul-de-sac is a very dependent area of the peritoneal cavity and should be carefully examined for free fluid.

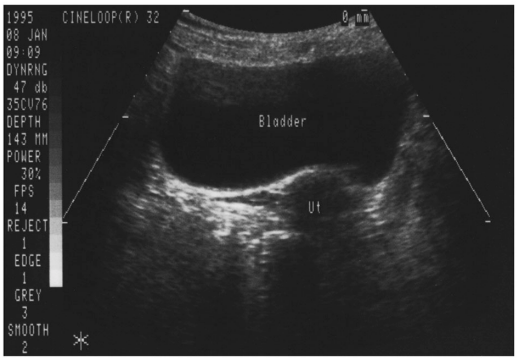


Figure 9 - Normal suprapubic view

Note the absence of free fluid outside of the bladder on this transverse suprapubic view

Figure 10 - Positive suprapubic view

In this sagittal suprapubic view, free fluid is seen in the cul-de-sac and anterior to the uterus

Pitfalls in Trauma Ultrasound

To best utilize clinical ultrasonography the clinician must understand the limitations of the technology. The sensitivity for detection of free fluid varies between 80-98% and is definitely operator dependent. In addition, extremely obese patients and those with extensive subcutaneous emphysema make difficult patients to examine.

Common mistakes when performing trauma ultrasound include the following:

1. Failure to do a multiple view examination. Sensitivity is highly dependent on the number of views obtained thus a full exam is necessary.

2. Failure to consider other etiologies of free intraperitoneal fluid. Intestinal fluid and intra-peritoneal bladder rupture mimic hemoperitoneum, but both require laparotomy. Ascites will mimic hemoperitoneum, but is easily differentiated with needle aspiration.

3. Failure to do serial exams when the initial examination is negative. Trauma patients are extremely dynamic and contained injuries may later release causing a positive ultrasound exam. Consider serial exams in those with high clinical suspicion and those with changing vital signs and/or hematocrits.

4. Overreliance on ultrasonography. Use ultrasonography as a single data point in the entire clinical picture. Use it in conjunction with other data such as mechanism of injury, vital signs, hematocrits, radiographs and clinical suspicion. Treat the patient, not the ultrasound.

Recommended texts

1. *Ultrasound in Emergency Medicine* by Heller & Jehle, WB Saunders, 1995.
2. *Ultrasound in Emergency and Ambulatory Medicine* by Simon & Snoey, Mosby 1996.

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