FAST
Focused Assessment with Sonography in Trauma

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OBJECTIVES

- Understand standard sonographic views of a FAST exam; and E-FAST evaluation
- Understand limitations of the FAST exam
- Review Basic Concepts of Ultrasound Physics
- Recognize sonographic appearance of intra-abdominal echogenicities
BLUNT ABDOMINAL TRAUMA (BAT) or Penetrating Injuries: Common Reasons for Presentation at ER

ALTERNATIVES FOR EVALUATION

DPL: Diagnostic Peritoneal Lavage
- historically used to detect bleeding or injury to hollow viscus
- invasive
- not used for serial assessments
- difficult in pregnant patients
- replaced by FAST and CT
- retains usefulness in the hemodynamically unstable trauma patient, with negative or equivocal FAST exam
BLUNT ABDOMINAL TRAUMA (BAT) or Penetrating Injuries:
Common Reasons for Presentation at ER

- ALTERNATIVES FOR EVALUATION

Abdominal CT exam

- better than DPL for intraabdominal injury
  (solid organ, bowel wall, mesentery, bladder)
- expensive; radiation
- in the hemodynamically stable patient, CT follows a positive or equivocal FAST scan
BLUNT ABDOMINAL TRAUMA (BAT) or Penetrating Injuries: Common Reasons for Presentation at ER

ALTERNATIVES FOR EVALUATION

FAST: focused sonography ** (widely used as initial exam)
- bedside sonography to DX hemoperitoneum and hemopericardium in abdominal trauma
- portable, low cost, high quality machines since 1990’s
- non invasive; no radiation; rapidly performed
- serial exams can be done
- safe in pregnant patients and children
## Comparison parameters for DPL, FAST, and CT

<table>
<thead>
<tr>
<th></th>
<th>DPL</th>
<th>FAST</th>
<th>CT</th>
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<tbody>
<tr>
<td><strong>TIME</strong></td>
<td>10 - 15 min</td>
<td>2 - 4 min</td>
<td>Variable</td>
</tr>
<tr>
<td><strong>REPEATABILITY</strong></td>
<td>Possible, rarely done</td>
<td>Easy and frequently done</td>
<td>Yes</td>
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<tr>
<td><strong>RELIABILITY</strong></td>
<td>Not organ specific</td>
<td>Operator dependent</td>
<td>Obesity; movement</td>
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<tr>
<td><strong>SENSITIVITY</strong></td>
<td>High</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td><strong>SPECIFICITY</strong></td>
<td>Low</td>
<td>High</td>
<td>High</td>
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<td><strong>ADVANTAGES</strong></td>
<td>Inexpensive; detects bowel injury</td>
<td>Noninvasive, rapid, portable; no radiation</td>
<td>Noninvasive; highly accurate</td>
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<td><strong>DISADVANTAGES</strong></td>
<td>Invasive; misses retroperitoneal, diaphragm injuries</td>
<td>Limited by subcutaneous or intra-abdominal air, obesity. Operator dependent</td>
<td>Radiation; expensive; may miss diaphragm, small bowel, pancreatic injuries</td>
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FAST : Sonography Screening in Major Trauma Patients

- Quick evaluation of intraperitoneal cavity and pericardium

- Detects free fluid: indirect sign of acute hemorrhage and organ injury

- Supine patient; convex 3.5 - 5 Mhz probe
FAST: Standard Projections

(1) Subxiphoid/Subcostal region: transverse view for pericardial effusion and left liver lobe

(2) RUQ: longitudinal view to assess Morison’s pouch: liver - right kidney space; rt. pleural space *

(3) LUQ: longitudinal view to assess spleen - left kidney space; lt. pleural space *

(4) Suprapubic space: long and transverse views; to assess fluid in pouch of Douglas
FAST: FOCUSED ASSESSMENT with SONOGRAPHY in TRAUMA

- When performed correctly, evaluation is done in 2-4 minutes.

- If difficulty arises performing the complete exam, the operator should not waste too much time with the FAST evaluation, if there is any suspicion of hemorrhage.

- If there is intraabdominal bleeding, probability of death increases about 1% for every 3 minutes that elapses before treatment.
Detectability of free fluid is dependent on the volume of fluid present.

Trendelenburg positions have been used to assess fluid pockets.

FAST may detect minimum 100 - 250 ml of free fluid.

(Variable reported sensitivity: 0.64 - 0.98; specificity: 0.86 - 1.00)

“Rule of thumb”:
- 5 mm rim of fluid at Morison’s pouch: 500 ml free fluid
- 10 mm rim of fluid at same level: 1,000 ml free fluid
Extended FAST : E-FAST

- **BASIC FAST includes**: detection of fluid in upper and lower peritoneal cavity; pericardial space, pleural spaces (subxiphoid, RUQ, LUQ, pelvic views)

- **Other sites incorporated**:
  - Sonographic evaluation at anterior 2\textsuperscript{nd} or 3\textsuperscript{rd} intercostal spaces: to assess for pneumothorax
  - Right and Left Pericolic gutter views: free fluid adjacent to bowel along flanks
  - Inferior Vena Cava views: intravascular volume status
KNOWLEDGE of BASIC ULTRASOUND CONCEPTS will aid in the performance and in the interpretation of the FAST exam.
- GOOD CONTACT IS IMPORTANT, BETWEEN PATIENT’S SKIN AND PROBE, with ACOUSTIC GEL (to facilitate sound transmission)

- SELECT THE APPROPRIATE PROBE with proper frequency
  Curved probes for abdomen; with penetration of sound up to 20 cm
  = adults: 3.5 MHz - 5 MHz
  = children: 5 MHZ or higher frequency

Curved or linear probes for pneumothorax evaluation

- KNOW THE NORMAL ANATOMY OF THE AREA BEING EXAMINED

NOTE: You will interpret exams best, when you can supervise images done; or if you obtain images yourself **

** ULTRASOUND IS 100% OPERATOR DEPENDENT **
Ultrasound equipment

US transducers/probes

Ultrasound Transmission Gel
HOW DOES ULTRASOUND WORKS

1- Ultrasound transducer receives a short electrical impulse, and generates a pressure wave pulse

2- Pulsed wave propagates down through the tissue

3- Tissue absorbs, scatters, reflects and refracts the wave

4- Reflected waves (at 90 degrees, perpendicular to probe) return to the transducer **

5- Transducer switches to receive mode, and converts the received pressure waves into electrical pulses (seen in monitor as echoes)**

6- After a fixed period of time, the transducer stops receiving, and transmits the next pressure wave
ACOUSTIC FREQUENCY

- Frequency represents cycles per second

- The unit of acoustic frequency is the hertz (Hz):
  - 1 cycle / second = 1 Hz
  - 1000 cycles / second = 1 KHz
  - 1,000,000 cycles / second = 1 MHz **

- Sound frequencies used for diagnostic applications typically range from 2 - 15 MHz
To produce an echo, a reflecting interface must be present.

At the junction of tissues with different physical properties, acoustic interfaces are present.

The amount of reflection is determined by difference in acoustic impedances of materials at interface.

Acoustic impedance is determined by properties of the tissue, and is independent of the frequency.
RESOLUTION

Higher frequency: best resolution / lower penetration of sound waves

Lower frequency: better penetration of waves / lower resolution

- Best image resolution is obtained by using highest frequency possible, although higher frequencies have limited ability to penetrate tissue.

- In order to assess deeper anatomic regions in the body, lower frequencies are used, although with some loss of resolution.
Velocity of propagation

Velocity of sound = frequency x wavelength

- The more closely packed the molecules of the tissues, the faster the speed of sound:
  - = lowest in gases **
  - = faster in fluids
  - = faster yet in soft tissues
  - = fastest in bones **
The average propagation velocity of sound in soft tissues is 1,540 m/sec. Bone and air create the largest artifacts in sonography.
ATTENUATION

- **Attenuation** occurs with the transfer of energy to the tissue (heating, absorption); as well as with the removal of energy by reflection and scattering.***

- As sound passes through tissue it **looses energy**, and the pressure waves decrease in amplitude as they travel further from the source.

- **Attenuation depends on the insonating frequency;** higher frequencies are attenuated more rapidly than lower frequencies.***
A technique used to compensate for attenuation is time gain compensation curve adjustment (TGC).

EXAMPLE:

- (A) Image through liver shows central band of dark echoes caused by faulty adjustment of TGC curve.

- (B) Proper adjustment of TGC curve produces a uniform appearance: operator adjusts the curve.
Ultrasound Terminology

- Echo-free fluid
- Particulate fluid
- Echogenic/solid tissue with acoustic interfaces: echoes
  - = hypoechoic
  - = hyperechoic
  - = isoechoic
- Complex texture
  = fluid
  = plus solid material
- Air/Gas artifacts (dirty shadow)
- Bone/calcium/calculi (sharp acoustic shadow)
FLUID

- ECHO - FREE FLUID
- PARTICULATE FLUID
  (blood or infection)

Images showing bladder and cyst.
ECHOCENTIC solid tissue: reflective echoes / acoustic interfaces (hypoechoic; hyperechoic; isoechoic)
Complex texture: mixture of fluid plus echogenic tissue

Example: large ovarian dermoid cyst
AIR / DIRTY “ring down” SHADOW

BONE / CALCULUS : SHARP ACOUSTIC SHADOW
Normal

FAST: Subxiphoid Subcostal view

- Echo free
- Fluid in Pericardial Space
- RV
- LV
- LA
- PERICARDIAL EFFUSION

Subcostal View of Pericardial Effusion
RUQ longitudinal view

Normal Right Upper Quadrant View

Abnormal Right Upper Quadrant View with Fluid in Morison’s Pouch
PERIHEPATIC PARTICULATE FLUID ( CLOTTED BLOOD )

- Complex fluid collection with low level echoes and septations
- Most likely dx is hematoma in setting of trauma ( D/D biloma ; abscess )
- Subcapsular location
- Infected hematoma or abscess if air present
LUQ longitudinal view

Normal Left Upper Quadrant View

Abnormal Left Upper Quadrant View Showing Fracture of Spleen

Pleural Fluid
Do not confuse posterior sacral promontory and bone absorption, with free fluid
PELVIC “PSEUDOMASS” : REVERBERATION ARTIFACT MAY BE CONFUSED WITH FREE FLUID or CYST
A) BOWEL GAS ARTIFACT : REVERBERATION ****

The strong reflection adjacent to the urinary bladder, and the “squared” appearance of the cul de sac hypoechoic region should make one suspicious of “pseudolesion”; not a cyst, and not free fluid.

B) DO NOT CONFUSE PELVIC CYSTIC LESIONS WITH FREE FLUID

A true cyst has walls on every side.
SOLID ORGAN INJURIES

Role of FAST in the diagnosis of injuries to solid organs is limited

- **LIVER**: Lacerations range from hypo to hyperechoic
  
  Extensive scanning to assess subtle changes would take too much time
  
  Sensitivity reported: 0.15 - 0.88

- **SPLEEN**: Lacerations have variable US appearance; sensitivity 0.37-0.85

- **KIDNEYS**: Injuries not as common as in spleen and liver
  
  Cross sectional imaging needed to assess extent of injury, for treatment
SOLID ORGAN INJURIES

- PANCREAS: Injuries in less than 2% of abdominal trauma cases. Subtle changes, best evaluated with CT.

- BOWEL, MESENTERY, BLADDER: Difficult to detect with US.
SOLID ORGAN INJURIES: LIVER seen best in CT exams
RENAL TRAUMA
EXTENDED FAST : E-FAST PNEUMOTHORAX

- CT exam remains the gold standard to detect anterior pneumothorax in trauma patients **

- Ultrasound has higher sensitivity than supine chest X - Rays **
  (sensitivity 95% ; specificity 91% ; has been reported in ICU cases )

- Probe placed at 2nd - 3rd intercostal space MC line , between two ribs
EXTENDED FAST : E-FAST PNEUMOTHORAX
EXTENDED FAST : E-FAST PNEUMOTHORAX

- Normal pleura (visceral and parietal) slide on each other in normal lung
  “LUNG SLIDING sign” : No Pneumothorax

- M-mode at same site: anterior - motionless wall: horizontal waves
  posterior sliding: granular pattern: sand
  “SEASHORE sign” : No Pneumothorax
EXTENDED FAST : E-FAST
PNEUMOTHORAX

Normal

Pneumothorax

Normal

Pneumothorax

M - mode
**LIMITATIONS OF FAST EXAM IN MAJOR TRAUMA**

- Detection of free fluid in some injured children
- Detection of mesenteric, diaphragmatic, or hollow viscus injury
- Detection of retroperitoneal hemorrhage
- Technically limited due to patient’s obesity; bowel gas; degree of injury; rate of bleeding
LIMITATIONS OF FAST EXAM IN MAJOR TRAUMA

- Bright ambient light in Trauma suite, limits visibility of US monitor

- Patient movement; either due to manual chest compressions also being done or combative patient

- Subcutaneous emphysema: air causes great US artifact

- Other diagnostic evaluations being done at same time; small space
LIMITATIONS OF FAST EXAM IN MAJOR TRAUMA

**FALSE POSITIVE** diagnosis of free-trauma fluid:

- ascites (chronic liver disease; renal failure patients)
- ovarian cyst rupture
- inflammatory process of abdomen
- ventriculoperitoneal shunts
- peritoneal dialysis
- pre-existing pericardial effusion
- pre-existing pleural fluid
TRAINING

- Physicians / Sonologists from a variety of medical specialties may perform the FAST examination (Trauma Surgeons; EMERG-MED physicians; ER Radiologists).

- Supervised, properly trained sonographers can also obtain the ultrasound images.

- Image interpretation should be performed by a supervising physician.
Recommended FAST Educational Curriculum and Credentialing

- **Educational Phase (4 - 8 hours)**
  
  = didactic course: 1-2 hours; principles of sonography; indications, and how to perform and interpret FAST exams
  
  = hands on practical session: 3 - 4 hrs; should include performance of FAST on models, either simulated or living; with or without intraperitoneal free fluid (peritoneal dialysis models); video sessions of positive and negative FAST exams

- **Proctored exams**

  = EM and Surgical series, usual proposal 20 - 50 FAST exams (10 exams should not be enough)
  
  = Competency based certification: non numerical model

** Technical skill is crucial to obtain adequate images **
As with all sonograms, focused sonograms require appropriate documentation.

Images should be stored as part of the medical record.

Description and interpretation of findings is required.
SUMMARY: FAST

- Widely available, quick exam for “first look”
- Acceptable sensitivity for detection of free fluid (standard sites)
- Poor sensitivity for diagnosis of injury to solid organs
- Strongly dependent on the operator’s skill and experience
- If initially negative exam, can be repeated
RECOMMENDATIONS

- Don’t waste time ** (2 - 4 minute evaluation)
- Scan for free fluid and pericardial effusion first (Basic FAST)
- Look for pneumothorax, in patients at risk (E-FAST)
- If there is time, look for injuries to solid organs
  (although role of FAST for solid organ evaluation is limited **)
- Use FAST for overview, not for a definite diagnosis of site of injury

Stable patient: CT exam

Positive or equivocal FAST:

Unstable patient: OR
REFERENCES

1. AIUM Practice Parameters for the Performance of Focused Assessment with Sonography for Trauma (FAST) Examination; in collaboration with American College of Emergency Physicians; 2014

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5. Logan P., Lewis D., FAST: Emergency Ultrasound UK 2004