Ultrasound basics
Part 1
'Ultrasound enhanced critical care medicine'

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Ultrasound in the past
Through water bath medium

Life Magazine, 1954
Ultrasound in the past
Brief History

Developed from principles of sonar in World War 1

1947: First sonographic images of human skull

1958: Images of abdominal disease published

Cardiology, radiology, and obstetrics opened arms over next several decades

Now due to better imaging and more portable equipment various specialties have opened their arms
Reproducibility and diagnostic accuracy of substantia nigra sonography for the diagnosis of Parkinson’s disease

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Ultrasound in the present

- Compact
- Higher quality
- Less expensive
- More availability
- Less radiation exposure
- Reproducibility
Future.....
Critical Care Ultrasound

New discipline, not same as radiology, cardiology, or even emergency medicine

New applications *adapted* to use in critical care

Old applications with *point of care* focus

Critical care ultrasound is a *real-time* discipline
Who owns ultrasound?
What are the questions?

- System based?
  - Focused abdominal sonography in trauma
- Cause?
- Problem based?
  - Focused assessment with sonography in trauma
Golden hour

Problem
Order
Tech
Reader
Back to you

Treatment
Golden hour

Problem

Order

Tech

Reader

Back to you

Treatment

Point of care
Functions for starting
converts any complex machine into simple stethoscope

1. The switch **ON** button

2. The **gain** setting (we have optimize button)

3. The image **depth**

4. The **M-mode**: for demonstrating dynamic questions

**Freeze** button: critical ultrasound is a real time discipline
Spatial learning
Weakness and a strength

Sonographer obtains imaging and also makes bedside clinical decision

Upper = superficial

Lower = deep

Left/right depends on probe marker icon (reversed in Echocardiography VS. Other body ultrasounds)

Probe marker in critical care should always be to the right of the patient or towards cephalad
Piezoelectric effect
Linear array
Convex
Intracavitary

Figure 3.3. Components of the array transducer: (A) PZT crystals, multiple crystals (active elements), can be activated separately; (B) matching layer; (C) backing material; (D) wires to each PZT element; (E) case; (F) cable all wires are still separated within the cable.
Ultrasound Knobology

Linear array or 'vascular' probe

Abdominal, phased array, or convex probe
How to hold the probe
Like a fountain pen

Decreases fatigue

Minimizes pressure placed (important for vascular structures and optic nerve)

Operators hand must remain still especially with dynamic evaluations

Don't hold the probe too tight --> can fatigue you (another person should be able to withdraw it from your grip)
Movements

Fanning (variant of this: *Carmen maneuver* uses gliding of skin over the underskin)

Rotation (clockwise or counterclockwise)

Sliding (hand moves like changing gear on car)
The second hand
& ultrasound unit positioning

Always position unit on your side so can use your second hand to make adjustments

Can use hand to lift patient or push bed down for posterior lung analysis

To squirt more jelly for next part of body to scan!
Understanding composition of image

**Gain**: tradition uses the liver and gallbladder to set

**Basic glossary**: all the 'echoics'

**Artifacts**: structures that spoil the image or not!

**Dynamic dimension (M-mode)**: peritoneal effusion, pneumoperitoneum, mesenteric infarction, normal lung, pneumothorax, pneumonia, atelectasis
Understanding composition of image

**Gain**: tradition uses the liver and gallbladder to set

Too less ---------------------------------Too much
Basic glossary: all the 'echoics"

- Anechoic or Hypoechoic (no echoes)
- Hyperechoic (strong echoes)

<table>
<thead>
<tr>
<th>Material</th>
<th>Echogenicity</th>
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</thead>
<tbody>
<tr>
<td>Air</td>
<td>Poor propagation, sound waves often scattered</td>
</tr>
<tr>
<td>Bone</td>
<td>Very echogenic (reflects most back, high attenuation)</td>
</tr>
<tr>
<td>Muscle</td>
<td>Echogenic (bright echo)</td>
</tr>
<tr>
<td>Liver/kidney</td>
<td>Echogenic (less bright)</td>
</tr>
<tr>
<td>Fat</td>
<td>Hypoechoic (dark echo)</td>
</tr>
<tr>
<td>Blood</td>
<td>Hypoechoic (very dark echo)</td>
</tr>
<tr>
<td>Fluid</td>
<td>Hypoechoic (very dark echo, low attenuation)</td>
</tr>
</tbody>
</table>

Effects & Artifacts

Acoustic shadowing

Reverberation: a lines, comet tails, b lines

Refraction

Mirror images

Posterior acoustic enhancement
Effects & Artifacts

Acoustic shadowing

Reverberation: a lines, comet tails, b lines

Effects & Artifacts

Refraction

Figure 3.24. Aortic duplication due to the refraction artifact (white arrows). Due to incomplete nature of duplication, the position of the artifact vs. anatomical position of the true reflector can be identified. This is not always the case. (Image courtesy of D. Adams, RDCS.)

Effects & Artifacts

Mirror images

Effects & Artifacts

Posterior acoustic enhancement

Understanding composition of image

**Dynamic dimension (M-mode):** peritoneal effusion, pneumoperitoneum, mesenteric infarction, normal lung, pneumothorax, pneumonia, atelectasis

The gels
sticky, messy, slippery

Don't fear cleaner solutions on the horizon

Please clean off patient poor etiquette in ultrasound to not do
An ultrasound tech once told me he can tell the experts from the beginners just by walking in the room. Experts dim or turn the shades down!
Scanning modes

A mode = amplitude mode

B mode = bright mode

M mode = motion mode

D mode = doppler mode

Power doppler mode
Impediments to ultrasound exam
Things that fog the novice

Ribs and gas

Gas: try shifting with your second hand

Ribs: use rotation of probe or sliding between ribs

Obese patients

Pt with extensive dressings, drains, or wounds
Specific problems in critical care

Positioning of patient usually has to remain supine

Many different pieces of equipment around patient (ventilator, dialysis, IV poles, etc.

Strengths: can increase tidal volume somewhat to improve abdomen views, tpn=decreased bowel gas, fluid overload makes lungs easier to analyze

Cleaning the equipment: MUST do to prevent infection spread!!
More on cleaning

Should not be using the chloro wipes (purple thing)

Best way is to use alcohol spray (special one we have for ultrasound machine) and clean small hand towels

We will have 'closed area' on ultrasound carts so that they are available -- please replace if finished

Clean from probe down cord

Must not have probe cords hanging on floor, there are hooks to place them
Interpretation of image
How to get better?

Reading literature

Operator's familiarity with own field (without ultrasound)

Practice, practice, practice just like any other procedure