Ultrasound basics

Part 1

'Ultrasound enhanced critical care medicine'

Rohit Patel, MD
University of Florida Health
Director, Critical Care Ultrasound Surgical ICU
Center for Intensive Care
Gainesville, Florida
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

Simone van de Loo¹, Uwe Walter², Stefanie Behnke³, Johann Hagenah⁴, Matthias Lorenz¹,
Matthias Sitzer¹, Rüdiger Hilker¹⁺, Daniela Berg⁵⁺
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?

Cause?

Problem based?

Focused abdominal sonography in trauma

Focused assessment with sonography in trauma
Problem
Order
Tech
Reader
Back to you
Golden hour
Treatment
Thursday, June 2, 16
Golden hour

Problem

Order

Tech

Renderer

Back to you

Point of care

Treatment

Thursday, June 2, 16
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 part of screen = superficial (this can be altered)

Lower part of screen = deep (this can be altered)

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
improved resolution

Abdominal, phased array, or convex probe
improved frame rates

Thursday, June 2, 16
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
Gain: tradition uses the liver and gallbladder to set

Too less -------------------------------Too much
Understanding composition of image

Basic glossary: all the 'echoics'

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

<table>
<thead>
<tr>
<th>Material</th>
<th>Echogenicity</th>
</tr>
</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

due to body habitus, procedure itself, leads to appearance of structures that are not actually there

Acoustic shadowing

Reverberation: a lines, comet tails, b lines

Refraction

Mirror images

Posterior acoustic enhancement
Effects & Artifacts

Acoustic shadowing (ribs, bones, gallstones)

Effects & Artifacts

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 (liver, heart, usually due to hyperechoic structures like diaphragm or pericardium)

Effects & Artifacts

Posterior acoustic enhancement (cysts, bladder)

Scanning modes

A mode = amplitude mode

B mode = bright mode

M mode = motion mode

D mode = doppler mode (color doppler mode)

Power doppler mode
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
The room and lights

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!
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 (orange) or (purple), USE **red wipes**

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

Thursday, June 2, 16
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