Ultrasound basics
Part 2
"Ultrasound enhanced critical care medicine"

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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
Critical Care Ultrasound

A lines     Bat sign     B lines

B3 lines     B7 lines     BLUE protocol

BLUE points     Comet tails     Sinusoid sign

Jellyfish sign     Lung point     Merlin's space

PLAPS Point     Quad sign     Seashore sign

Shred sign     Stratosphere sign

Tissue like sign     Z lines
How to learn ICU ultrasound

Similar to how you learned physical exam skills

Pick one application or even part of an application (like how to evaluate for pneumothorax, or how to evaluate left ventricle function) and then focus only on that, find a bunch of normals, then when you hear of abnormal ones go and find it yourself

We do not suddenly become sonographers just like we don't suddenly become intensivists
How to learn ICU ultrasound

First step: once you learn to interpret lung sliding in normal patients, find a patient with confirmed pneumothorax and find the stratosphere sign.

Second step: now search for stratosphere sign in a patient with an acute problem but manage as you normally would (CT, etc) and thereby build your confidence.

Third step: now facing a similar patient but no time for CT, finding lung sliding (not putting in chest tube) and driving your thought process in other direction.
How to learn ICU ultrasound

*Wild ultrasound*

Working a night shift on a crashing patient and using it with your known limitations

Barely remembering one or two lectures about a specific topic
The ultrasound equipment

New machines does not equal better; not specifically designed for critical care and one of the most vital organs the lung

Small machines not necessarily more convenient

We need ultrasound dedicated to critical care: small width to go between ventilator, IV poles, etc; compact design with minimal nooks to clean easily between pts, short start up time, one microconvex probe, no Doppler
Who should get ultrasound?

In France: everyone at first admission to ICU and then subsequent specific problems

In ICU, folks who are hypotensive or hypoxic probably benefit most (few algorithms developed to evaluate these events)

On the horizon: Fever, cardiac arrest, oligoanuric, sepsis, ARDS, difficult airway, weaning from mechanical ventilation, abdominal pain
### Table 3.2 (continued)

#### Abdomen

- Examination: optimal/suboptimal (reasons: body habitus, gas, dressings, others). Fluid peritoneal effusion: absent OR×ELSE
- Pneumoperitoneum: absent (gut sliding present and/or splanchnogram) OR×ELSE
- Stomach: full empty gastric probe visible in situ OR×ELSE
- Small bowel: peristalsis present or abolished or not accessible Wall: thin OR×ELSE Caliper: normal OR×ELSE
- Contents: anechoic or echoic Inaccessible bowel
- Colon: Same items Search for air-fluid levels
- Aorta: regular OR×ELSE
- Inferior caval vein: Expiratory size at the left renal vein = xxx mm Patency:
  - Adrenal: analyzed OR×ELSE
  - Kidneys: nondilated pelvis OR×ELSE
  - Bladder: full empty correctly drained Uterus:
    - Gallbladder: No elective pain Not enlarged (mm × mm) Wall not thickened (mm) Wall regular homogeneous Contents anechoic, or sludge (％) No satellite peritoneal effusion OR×ABSENCE×OF THESE×ITEMS
    - Liver: no visible acute anomaly – no portal gas – on comprehensive or limited examination OR×ELSE
    - Biliary tract: fine OR×ELSE
    - Splenic: normal size OR×ELSE Homogeneous pattern OR×ELSE
    - Portal system: no anomaly OR×ELSE
    - Pancreas: normal in size and echostructure OR×ELSE
    - Retropertitoneum: analyzed OR×ELSE
- Other remarkable elements seen:

#### Miscellaneous

- Musculo-fat ratio. Thickness of the crural muscle (right thigh):

**SYNTHESIS**

A practical synthesis is written (time permitting) in a style allowing any physician, even without ultrasound culture, to understand the main points of the clinical situation. It focuses on immediate management changes.
Ultrasound Physics

Optimist:
Glass half-full

Pessimist:
Glass half-empty

Physicist:
\[ \frac{1}{\sqrt{2}} (\psi_{\text{full}} - \psi_{\text{empty}}) \]

3. Find \( x \).

Graph of overall mass vs time

I. Explain the shape of the graph.

It's curvy, with a little bit at the end and a rather aesthetically pleasing slope downwards towards a pretty flat straight bit. The actual graph itself consists of 2 straight lines meeting at the lower left hand corner of the graph and moving away at a 90° angle. Each line has an arrow head on the end.
Definitions and physics

Amplitude

Velocity

Frequency

Wavelength

Attenuation

Reflection, refraction, scattering, resolution

Acoustic power
Definitions and physics

**Amplitude**

hyperechoic and hypoechoic

Equals peak pressure of wave

'loudness of sound'

Correlates with intensity of returning echo
Understanding composition of image

Basic glossary: all the 'echoics'

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

<table>
<thead>
<tr>
<th>Material</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>4,500</td>
<td>Poor propagation, sound waves often scattered</td>
</tr>
<tr>
<td>Bone</td>
<td>870</td>
<td>Very echogenic (reflects most back, high attenuation)</td>
</tr>
<tr>
<td>Muscle</td>
<td>350</td>
<td>Echogenic (bright echo)</td>
</tr>
<tr>
<td>Liver/kidney</td>
<td>90</td>
<td>Echogenic (less bright)</td>
</tr>
<tr>
<td>Fat</td>
<td>60</td>
<td>Hypoechoic (dark echo)</td>
</tr>
<tr>
<td>Blood</td>
<td>9</td>
<td>Hypoechoic (very dark echo)</td>
</tr>
<tr>
<td>Fluid</td>
<td>6</td>
<td>Hypoechoic (very dark echo, low attenuation)</td>
</tr>
</tbody>
</table>

Definitions and physics

**Velocity**

speed of wave

1540 m/s in soft tissue

Ultrasound can use this to determine depth of structure

Like sonar use in submarines
Definitions and physics

**Frequency:**

Number of waves per cycle (cycles per second)
High frequency uses more energy so less penetration

Definitions and physics

*Wavelength*

distance wave travels in one cycle
Definitions and physics

**Attenuation**

progressive weakening of sound wave through medium

Many factors affect:  type of medium, number of interfaces

air is strong reflector and does not transmit

bone high attenuation

fat or fluid would be less attenuation
Definitions and physics

**Reflection** = redirection of part of sound wave back to source

**Refraction** = redirection of part of sound wave as it crosses different media

**Scattering** = when sound beam encounters a smaller or irregular shape

**Absorption** = when acoustic energy of sound wave is contained within medium

**Resolution** = ultrasound machines ability to discriminate between two close objects
Definitions and physics

**Acoustic power**

energy leaving transducer

ALARA = As Low As Reasonably Acceptable

Therapeutic is whole new lecture!
Few Points about Doppler

used to detect speed, presence of flow, and direction of flow

sound moves away from observer, frequency will decrease

‘positive doppler shift’ means blood flowing towards probe

doppler most accurate when angle of beam is parallel (like in apical heart view)

red means towards probe, blue means away (not red = artery, blue = vein)

velocity scale needs to be set low if looking for low velocity (like veins) (use the gain buttons with in color doppler mode)
Interpretation of image

Reading literature

Operator's familiarity with own field (without ultrasound)

Practice, practice, practice just like any other procedure