Introduction to Thoracic Ultrasound

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Pulmonary/Critical Care/Sleep
MetroHealth
Advantages

- Immediately available
  - Immediate results
- Dynamic images
  - Multiple times per day
  - Interventional support
- No cost to operate
  - Reduce cost of imaging studies
- Safe
  - Point-of-care
  - No ionizing radiation

Disadvantages

- In the thorax
- Air
- Operator dependent
- Full exam takes 8 min
Objectives

- Describe the appearance and the boundaries of u/s images of the pleura, the lungs, and the diaphragms.
- Analyze the differences in u/s findings of normal aeration pattern, pneumothorax, pulmonary congestion, alveolar interstitial pattern, and pleural effusion.
- Discuss the comparative performance of u/s in the differential diagnosis of acute respiratory failure.
- Participate in u/s examination of normal thorax.
Electricity conductor
Backing material
Piezoelectric crystals
Matching Layer
- High/low pressure
- 2–10 MHz
- Talking: 1-10%
- Listening: 90-99%
• Higher frequency
  → shorter wavelength
  – Resolution

• Lower frequency
  → longer wavelength
  – Penetration
Attenuation

- Reflection
- Scatter
- Refraction
- Absorption
<table>
<thead>
<tr>
<th>Structure</th>
<th>Gray Tone</th>
<th>Terminology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure fluid</td>
<td></td>
<td>Anechoic</td>
</tr>
<tr>
<td>Thick fluid</td>
<td></td>
<td>Hypoechoic</td>
</tr>
<tr>
<td>Thrombosis</td>
<td></td>
<td>Isoechoic</td>
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<tr>
<td>Consolidation</td>
<td></td>
<td>Hyperechoic</td>
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<tr>
<td>Parenchyma</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bone/calculus</td>
<td></td>
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<tr>
<td>Strong interface</td>
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</tbody>
</table>
1 - The Pleura

- Visceral pleura slides against parietal pleura
- Subtle shimmering white line
- Sync with respiratory cycle
- Lung Sliding
Loss of Lung Sliding

- The absence of sliding lung indicates the possibility of a PTX

- DDx:
  - Jet ventilation
  - Apnea
  - Airway occlusion
  - Pleural adhesions
  - Very severe parenchymal lung disease
“Because u/s energy is rapidly dissipated in air, u/s imaging is not useful for evaluating the pulmonary parenchyma.”

Harrison

“Lung ultrasonography is similar in yield to chest CT for detection of pneumothorax, normal aeration pattern, alveolar-interstitial pattern, consolidation, and pleural effusion.”

Lichtenstein
The “A B C” Continuum

- Pneumothorax
- Normal lung surface
- Interstitial syndrome
- Alveolar consolidation
- Pleural effusion

Air-fluid ratio:
- AIR/no fluid
- AIR/fluid
- AIR/fluid
- air/FLUID
- no air/FLUID
"A" Lines
Clinical Utility of A Lines

- A-line pattern with sliding lung = Normal
- A-line pattern without sliding lung ~ PTX
- A-line pattern with lung point = PTX
“B” Lines

- Terminal bronchiolovascular bundle:
  - p.a. & bronchiole

- Interlobular septa:
  - p.v.
B Lines

- Vertical reverberation lines
- Originate at pleura vs. interlobular septa
- Extend down
- Move with sliding lung
- Efface A lines
- Few are normal
- Comet tails, lung rockets
Clinical Utility of B Lines

- Strongly associated with:
  - Curley B lines on a CXR
  - Reticular pattern infiltrate on chest CT

- Indicate a “wet lung”: CHF and ARDS
“C”onsolidation

- Alveolar filling process
  - Fluid
  - Blood
  - Pus

- Hepatization
  - Pathologically
  - Ultrasonographically
3 - The In-Between

- **Chest wall**
  - Most superficial structure
  - Echogenic soft tissue
  - Variable thickness

- **Diaphragm**
  - May be high in supine patients
  - Caution post-op patients
  - Edema and obesity

- **Lung**
  - Snowstorm appearance
  - Compressed lung = tissue echogenicity
Putting it All Together
BLUE

- 260 ICU patients with acute respiratory failure
- Ultrasound Dx vs final ICU team Dx
- Assessed:
  - Horizontal A lines
  - Vertical B lines
  - Lung sliding
  - Alveolar consolidation
  - Pleural effusion
  - Venous analysis (for DVT)
<table>
<thead>
<tr>
<th>Ultrasound Signs</th>
<th>Dx</th>
<th>Sens.</th>
<th>Spec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predominant A Lines + Lung sliding</td>
<td>COPD / Asthma</td>
<td>89%</td>
<td>97%</td>
</tr>
<tr>
<td>Diffuse anterior B lines + Lung sliding</td>
<td>Pulm edema</td>
<td>97%</td>
<td>95%</td>
</tr>
<tr>
<td>Normal profile + DVT</td>
<td>Pulm Embolism</td>
<td>81%</td>
<td>99%</td>
</tr>
<tr>
<td>No lung sliding + A lines + Lung point</td>
<td>Pneumothorax</td>
<td>81%</td>
<td>100%</td>
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<tr>
<td>Anterior alveolar consolidations or</td>
<td>Pneumonia</td>
<td>89%</td>
<td>94%</td>
</tr>
<tr>
<td>Anterior diffuse B lines w/o sliding or</td>
<td></td>
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<tr>
<td>Anterior asymmetric interstitial pattern or</td>
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<tr>
<td>Posterior consolidations or</td>
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<tr>
<td>Effusions w/o anterior diffuse B lines</td>
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</tbody>
</table>

**Overall accuracy 90.5%**
Objectives

- Appearance of u/s images of the pleura, the lungs, and the diaphragms.
- The differences in u/s findings of normal aeration pattern, pneumothorax, pulmonary congestion, alveolar interstitial pattern, and pleural effusion.
- Performance of u/s in acute respiratory failure diagnosis.
- Hands-on u/s examination of normal thorax.
References