POCUS for the Internist: Lungs & Pericardial Effusions

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Medical Illustrations courtesy of Robinson Ferre, MD, FACEP
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No Financial Disclosures
One Federal Grant Disclosure
Lots of Cognitive Disclosures
“I think its great, and I’m sure for those techies who can use it that it will revolutionize their practice in the right clinical circumstances. That being said, I am extremely doubtful that it will ever come into general use. To do it well takes too much time, and it can be a hassle for both the physician and the patient.”

-Unknown (or at least to be revealed)
POCUS Rule #1: Ultrasound is a tool.
POCUS Rule #2: Ultrasound is not a substitute for clinical judgment.
Ultrasound Basics
top = closest to probe brightness
Acoustic Impedance
(Tissues Reflect Soundwaves Differently)
POCUS
40yo patient presents to the office with the complaint of post-prandial abdominal pain, especially after eating at her favorite hot chicken establishment (even when ordered mild).

Does she have gallstones?
72yo m with COPD, CHF, 1ppd smoker complains of worsened dyspnea with exertion, orthopnea. Breath sounds with faint wheezing and diminished bilaterally, R > L.

Does he have a pleural effusion?
Lung Ultrasound
“The lungs should be seen and not heard.”

-Keith Wrenn, MD, FACP, FAAEM
“The lungs should be seen (with soundwaves).”

-never said by Keith Wrenn, MD, FACP, FAAEM
Lung Anatomy
Chest Wall

Skin

Parietal Pleura

Rib

Intercostal Muscle

Visceral Pleura

Skin

Parietal Pleura

Rib

Intercostal Muscle

Visceral Pleura
Costophrenic Angle

Diagram showing the costophrenic angle, spleen, kidney, diaphragm, spine, and acoustic shadow.
Costophrenic Angle
Probe Placement
Depends on the Clinical Question...
Pneumothorax
Pleural Effusion
Pulmonary Edema
Understanding Ultrasound Artifacts of the Lung
1. Mirror Artifact

2. Comet Tail Artifact
Requires 2 Conditions

1. Smooth surface
2. Doesn’t transmit sound
   - Lung
   - Bone
   - Air Filled Structure
“A-lines”
Dry Lung
many returning echos  1 returning echo
“B-lines”
Wet Lung
The B-Line

1. Arises from the pleura
2. “Laser Like”
3. Reaches the bottom of the ultrasound screen
4. Moves with respiration
5. Erases A-lines
Lung Pathology
Potential Pathology

1. **Pneumothorax =**
   Lung Sliding = Aerated lung is touching the chest wall

2. **Interstitial Edema =**
   A lines (Dry Lung) or B Lines (Wet Lung)

3. **Consolidation =**
   Fluid/Puss filled Alveoli

4. **Pleural Fluid**
Potential Pathology

1. Pneumothorax =
   Lung Sliding = Aerated lung is touching the chest wall

2. Interstitial Edema =
   A lines (Dry Lung) or B Lines (Wet Lung)

3. Consolidation =
   Fluid/Puss filled Alveoli

4. Pleural Fluid
Lung Sliding

Parietal Pleura

Visceral Pleura
Lung Sliding
Lung Point
Lung Point = Edge of the Pneumothorax
Potential Pathology

1. Pneumothorax = 
   Lung Sliding = Aerated lung is touching the chest wall

2. Interstitial Edema = 
   A lines (Dry Lung) or B Lines (Wet Lung)

3. Consolidation = 
   Fluid/Puss filled Alveoli

4. Pleural Fluid
A-Lines
A Lines with PTX
B-Lines
B-Lines
The Meaning of B-lines

- B-lines are not necessarily pathologic
- 3 or more is abnormal
- Scanning protocols help to understand significance
  - probe placement matters
Pathology (3 or More B-Lines)

Increased Lung Water
- ARDS/ALI
- Cardiogenic Pulmonary Edema
- Infection
  - PNA (viral or bacterial)
- Pneumonitis (i.e. HAPE)
- Contusion

Pulmonary Fibrosis
Location & Number
1 or 2 here can be normal
B-Lines = Lung Water
Scanning Protocols: Volpicelli
Scanning Protocols:
Lichtenstein
Potential Pathology

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4. Pleural Fluid
Consolidation
Consolidation
Consolidation
Potential Pathology

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4. Pleural Fluid
Normal CPA
Pleural Effusion

Spine Sign
Pleural Fluid

Normal
Pleural Effusion
Pleural Effusion with Consolidation
Pleural Effusion
Clinical Application
Evidence-Based Diagnostics

Diagnosing Acute Heart Failure in the Emergency Department: A Systematic Review and Meta-analysis

Jennifer L. Martindale, MD, Abel Wakai, MD, Sean P. Collins, MD, MSc, Phillip D. Levy, MD, MPH, Deborah Diercks, MD, Brian C. Hiestand, MD, Gregory J. Fermann, MD, Ian deSouza, MD, and Richard Sinert, DO

Included in systematic review

History and physical: n=31
ECG: n=11
CXR: n=18
BNP/NT-proBNP*: n=41
Bedside echo: n=4
Lung ultrasound: n=8
Bioimpedance: n=4
<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>n</th>
<th>% AHF (95% CI)</th>
<th>Sensitivity % (95% CI)</th>
<th>Specificity % (95% CI)</th>
<th>LR+ (95% CI)</th>
<th>LR- (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lung US</strong></td>
<td></td>
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<tr>
<td>Positive B-line scan*</td>
<td>8</td>
<td>1914</td>
<td>48.2 (46.0–50.5)</td>
<td>85.3 (82.8–87.5)</td>
<td>92.7 (90.9–94.3)</td>
<td>7.4 (4.2–12.8)</td>
<td>0.16 (0.05–0.51)</td>
</tr>
<tr>
<td>Pleural effusion(s)*</td>
<td>2</td>
<td>155</td>
<td>40.7 (33.2–48.5)</td>
<td>63.5 (50.4–75.3)</td>
<td>71.7 (61.4–80.6)</td>
<td>2.0 (1.4–2.8)</td>
<td>0.49 (0.22–1.10)</td>
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<tr>
<td><strong>Bedside echocardiography</strong></td>
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<tr>
<td>Restrictive mitral pattern*</td>
<td>1</td>
<td>125</td>
<td>43.2 (34.9–52.0)</td>
<td>81.5 (68.6–90.7)</td>
<td>90.1 (80.7–95.9)</td>
<td>8.3 (4.0–16.9)</td>
<td>0.21 (0.12–0.36)</td>
</tr>
<tr>
<td>Reduced EF*</td>
<td>3</td>
<td>325</td>
<td>41.2 (36.0–46.7)</td>
<td>80.6 (72.9–86.9)</td>
<td>80.6 (74.3–86.0)</td>
<td>4.1 (2.4–7.2)</td>
<td>0.24 (0.17–0.35)</td>
</tr>
<tr>
<td>Increased LV end-diastolic dimension*</td>
<td>1</td>
<td>84</td>
<td>58.3 (47.7–68.3)</td>
<td>79.6 (65.7–89.7)</td>
<td>68.6 (50.7–83.1)</td>
<td>2.5 (1.5–4.2)</td>
<td>0.30 (0.16–0.54)</td>
</tr>
</tbody>
</table>

Lung ultrasound: *defined as ≥ 2 bilateral lung zones with ≥ 3 B-lines per intercostal space.
Bedside echocardiography: *defined as E/A ratio > 2 or E/A between 1 and 2 and deceleration time (DT) < 130 msec; DT < 130 msec alone if atrial fibrillation. †Defined as LVEDD > 28.6 mm/mm2.
AHF = acute heart failure; EF = ejection fraction; LV = left ventricular; LR = likelihood ratio; N = number of studies; n = number of patients; US = ultrasound.
Test

- Test

+ Test

86%: + Lung US
81%: BNP 1200-1500 pg/mL
80%: Pulmonary Edema on CXR
78%: Reduced EF Bedside Echo
62%: BNP 400-500 pg/mL
29%: No Pulmonary Edema on CXR
11%: - Lung US
10%: BNP 0-100 pg/mL
6%: NT-PB, BNP 0-100 pg/mL
Pericardial Effusion
Anatomy

Pericardium
- Wraps around heart
- “ends” at major vessels

Pericardial fluid
- Normal = 15-50 cc

Best Windows
- Sitting = Subcostal
- Supine = PSLA
Top 5 Causes

1. Malignancy 30%
2. Idiopathic 15%
3. Acute MI / Post cath 15%
4. Infectious 15%
5. Uremia 10%
No Pericardial Effusion
Small Pericardial Effusion
Large Pericardial Effusion
Pericardial Effusion Size

< 1 cm = Small

1-2 cm = Moderate

> 2 cm = Large
Pericardial Effusion Size

Measure in Diastole = when the effusion is the smallest
If the heart is surrounded by fluid, how do I tell if it is pleural or pericardial fluid?
Tamponade?
5 Sonographic Signs

1. Pericardial effusion

2. Enlarged and plethoric IVC

3. Right atrial systolic collapse

4. RV Diastolic Collapse

5. All chambers underfilled & hyperdynamic
Tale of Two IVCs
5 Sonographic Signs

1. Pericardial effusion
2. Enlarged and plethoric IVC
3. Right atrial systolic collapse
4. RV Diastolic Collapse
5. All chambers underfilled & hyperdynamic
Pulsus Paradoxus?
Does This Patient With a Pericardial Effusion Have Cardiac Tamponade?

$LR^+ = 5.9$

$LR^- = 0.03$

Roy et al, JAMA 2007
(Remember Rule #1)
“I think it’s great, and I’m sure for those techies who can use it that it will revolutionize their practice in the right clinical circumstances. That being said, I am extremely doubtful that it will ever come into general use. To do it well takes too much time, and it can be a hassle for both the physician and the patient.”

-Unknown (or at least to be revealed)
“... I have no doubt whatever, from my own experience of its value, that it will be acknowledged to be one of the greatest discoveries in medicine by all those who are of a temper, and in circumstances, that will enable them to give it a fair trial. That it will ever come into general use, notwithstanding its value, I am extremely doubtful; because its beneficial application requires much time, and gives a good deal of trouble both to the patient and the practitioner...”

-John Forbes, FRCP, FRS
Ultrasound is a tool.
Ultrasound is a tool.
Use it wisely.
Thank you.
E-FAST Exam
But wait. There’s more…
Vascular Access
Vascular Access
Vascular Access
Vascular Access
Cardiac Arrest
Intubation