Using Lung Ultrasound to Diagnose and Manage Acute Heart Failure

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What is acute heart failure?

“New onset or recurrence of gradually or rapidly worsening signs and symptoms of heart failure (HF) necessitating urgent or emergency therapeutic intervention”


Pulmonary congestion caused by elevated cardiac filling pressures

Martindale JL
The diagnosis of acute heart failure is often missed.

**H&P, CXR, ECG**

25%

Misclassification rate

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**+BNP**

14-29%

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Collins SP et al. The combined utility of S3 and BNP. J Cardiac Fail 2006.


Exam findings are insensitive.

Standard diagnostic tests help...somewhat.

<table>
<thead>
<tr>
<th>Condition</th>
<th>N</th>
<th>+ LR</th>
<th>- LR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonary Edema</td>
<td>4393</td>
<td>4.8 (3.6-6.4)</td>
<td>0.48 (0.39-0.58)</td>
</tr>
<tr>
<td>Pleural Effusions</td>
<td>1326</td>
<td>2.4 (1.6-3.6)</td>
<td>0.89 (0.80-0.99)</td>
</tr>
<tr>
<td>Reduced EF</td>
<td>325</td>
<td>4.1 (2.4-7.2)</td>
<td>0.24 (0.17-0.35)</td>
</tr>
</tbody>
</table>

Intermediate BNP values aren’t very useful.

Large grey zone.
Artifacts generated by lung ultrasound are useful.
Two bilateral lung zones with B-lines is a positive lung US.
Lung ultrasound has good discriminatory value.
2. You and I need to learn how to do lung ultrasound. But I am kind of old, and learning new things is hard for me, so I say. But, I have tried it and I agree with the jocular term I have heard that lung ultrasound is the "kindergarten of ultrasound." It is super easy to see the B lines used by 8 studies pooled in Table 5. The absence of B lines on lung ultrasound provides reasonable evidence to exclude heart failure [likelihood ratio negative = 0.16 (0.05–0.51)], and the presence of B lines strongly supports its diagnosis [likelihood ratio negative = 7.4 (4.2–12.8)]. This is good news for our patients and us.

So those are two surprises, but that is just two tiny pieces of this monolith, which covers other tests, such as bioimpedence, and also tells us how to integrate these tests in practice and with treatment decisions. This SRMA will empower you and your dyspneic patient to be more confident in your choice to treat for heart failure, or look for another cause.

Best wishes,
Jeffrey A. Kline, MD
Editor-in-Chief, Academic Emergency Medicine
Volume overload is only part of the picture.

- Decreased renal perfusion
- Increased vasoconstriction
- Increased sympathetic tone
- Endothelin
- Angiotensin
- Norepinephrine
- Vasopressin
- Venous congestion
- H2O retention
- Na+ retention
- Increased filling pressures
- Decreased cardiac output
- Cardiac Remodeling
- Increased sympathetic tone
Dyspnea occurs late in the course of AHF.

<table>
<thead>
<tr>
<th>Hemodynamic derangement</th>
<th>Pulmonary congestion</th>
<th>Clinical congestion</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Elevated filling pressures)</td>
<td></td>
<td>%</td>
</tr>
</tbody>
</table>
Our current measures of clinical improvement are limited.

**Weight Loss**

**Serial BNP**
- Singer et al. Rapid Emergency Department Heart Failure Outpatients Trial (REDHOT II) Circ Heart Failure 2009.

**Serum Creatinine**

**Self-reported Dyspnea**
Dyspnea is subjective. Measuring it is difficult.

Please rate your shortness of breath.

<table>
<thead>
<tr>
<th></th>
<th>No shortness of breath</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Mild shortness of breath</td>
</tr>
<tr>
<td>3</td>
<td>Moderate shortness of breath</td>
</tr>
<tr>
<td>4</td>
<td>Severe shortness of breath</td>
</tr>
<tr>
<td>5</td>
<td>Worst Possible shortness of breath</td>
</tr>
</tbody>
</table>
The sum of B-lines correlates with heart failure severity.


NT-proBNP  \( r=0.69, p<0.0001 \)

Extravascular Lung Water (Thermodilution)  \( r=0.42, p=0.001 \)
Pulmonary Capillary Wedge Pressure  \( r=0.48, p<0.0001 \)
Let the counting begin.
B-lines change in real-time.

Increase with exercise.

B-line score  5.9  \[\rightarrow\]  11
PCWP  14.2  \[\rightarrow\]  17.2


Decrease with dialysis.


B-Lines clear in response to inpatient AHF treatment.

<table>
<thead>
<tr>
<th>Thoracic area</th>
<th>Positive Zone (Admission US)</th>
<th>Positive Zone (Discharge US)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Right</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior superior</td>
<td>51 (73%)</td>
<td>3 (4.3%)</td>
</tr>
<tr>
<td>Anterior medium</td>
<td>54 (77%)</td>
<td>2 (2.9%)</td>
</tr>
<tr>
<td>Anterior basal</td>
<td>65 (93%)</td>
<td>4 (5.7%)</td>
</tr>
<tr>
<td>Lateral superior</td>
<td>64 (91%)</td>
<td>5 (7.1%)</td>
</tr>
<tr>
<td>Lateral medium</td>
<td>67 (96%)</td>
<td>10 (14%)</td>
</tr>
<tr>
<td>Lateral basal</td>
<td>68 (97%)</td>
<td>21 (30%)</td>
</tr>
<tr>
<td><strong>Left</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior superior</td>
<td>52 (74%)</td>
<td>6 (8.6%)</td>
</tr>
<tr>
<td>Anterior medium</td>
<td>58 (83%)</td>
<td>6 (8.6%)</td>
</tr>
<tr>
<td>Lateral superior</td>
<td>63 (90%)</td>
<td>6 (8.6%)</td>
</tr>
<tr>
<td>Lateral medium</td>
<td>70 (100%)</td>
<td>11 (16%)</td>
</tr>
<tr>
<td>Lateral basal</td>
<td>70 (100%)</td>
<td>20 (29%)</td>
</tr>
</tbody>
</table>

ED with CC: “dyspnea”

AHFS working dx
SBP ≥ 180 mmHg
B-Lines present bilaterally

AHF Treatment in ED

Vital Signs
Dyspnea Score

LS 1

20’ 20’

Dyspnea Score x-2 cm

Vital Signs

Lung Ultrasound 1

T1

T2

Disposition Decision

T3

Vital Signs

Lung Ultrasound 2

Lung Ultrasound 3

Repeated Assessment of Lung Edema with Sonography
Hypertensive AHF is about volume redistribution.

Pulmonary edema is severe.
Response to treatment is dramatic.
Clinical and sonographic improvement is rapid.

**Prehospital**

- SBP > 200 mmHg
- SL TNG x 6; NIV

**T₁**
- BP: 193/101
- HR: 88
- RR: 26
- O₂: 96% on BIPAP FIO₂ 0.35

**5PLS:** 4 Severe shortness of breath
- I can breathe normally

**T₂**
- BP: 164/83
- HR: 79
- RR: 24
- O₂: 93% on RA

**3 Moderate shortness of breath**
- I can’t breathe at all

Distance Measurements:
- 5PLS: 8.8 cm
- 3 Moderate: 6 cm
B-Lines BE-GONE!

96 min
Post-discharge outcomes are poor.

Rehospitalization

30-day

25%


Mortality

5-year

1-year

30-day

10.4% 22% 42.3%

Go et al. Heart Disease and Stroke Statistics. Circulation 2013
Residual congestion at discharge predicts re-hospitalization.


Future studies to plan for.

**Pilot Study**
- Hypertensive AHF Phenotype
- ED Course
- Effect Size
- Variability
- Inter-rater reliability

**Observational Study**
- All Phenotypes
- ED Course
- Hospitalization
- Different rates of B-line clearance

**Prognostic Measure**
- Readmission
- SPE Score at Discharge

**Randomized Trial**
- B-Line Resolution
- Standard Discharge Criteria
- Compare sonographic-targeted treatment to standard management