Cardiac Ultrasound and The RUSH Exam:
Bedside Ultrasound in Resuscitation and Shock

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Intro Case

- 80 year old woman
- Hx: Grandma's not herself today
- General: Moaning
- BP= 80/40, HR=110, T=99, RR=22, SaO2=94%
- Exam: otherwise non-focal

Outline
What We’ll Cover

- Why use ultrasound in shock and resuscitation?
- Literature and Protocols
- Echo and IVC Technique & Findings
- Cases

What we won’t cover

- Detailed bedside echocardiography (We will have to move quickly)
- eFAST exam or Aorta
- Lung ultrasound for pulmonary edema
- DVT
Why?

- Physical exam is inaccurate
- X-rays and CTs are slow or impossible
- Treatments for shock vary by etiology
- Literature supports it
- You don’t have time for trial and error

The Literature

A Decade of Acronyms

2001

- RCT of ultrasound in hypotension: Jones AE et al, Crit Care Med 2004
- FATE: Focused Assessment with Sonography in Trauma: Jensen et al, Eur J Anaesthesiol 2004
- CAUSE: Cardiac Arrest Ultrasound Exam: Hernandez et al, Resuscitation 2008

2010

- CAUSE: Cardiac Arrest Ultrasound Exam: Hernandez et al, Resuscitation 2008

1. Heart
   (LV function and large effusion)
2. Morison’s Pouch
   (Free Fluid)
3. Aorta
   (AAA)

Randomized, controlled trial of immediate versus delayed goal-directed ultrasound to identify the cause of nontraumatic hypotension in emergency department patients

Alan E. Jones, MD; Vivek S. Tayal, MD; D. Matthew Sullivan, MD; Jeffrey A. Kline, MD

2004

1. Heart
   (LV fxn, RV size, effusion, tamponade)
2. Morison’s Pouch
   (Free Fluid)
3. Aorta
   (AAA)
4. IVC
   (Collapse with Inspiration)
RUSH Exam #1
Rapid Ultrasound for Shock and Hypotension
Mnemonic: “HI-MAP”
- Heart
- IVC
- Morison’s
- Aorta
- Pneumothorax

RUSH Exam #2
The RUSH Exam: Rapid Ultrasound in SShock in the Evaluation of the Critically Ill
Pump
- Tank
- IVC
- Morison’s
- PTX
- Pulm Edema

Pipes
- LV Function
- Effusion
- Tamponade
- RV Dilation
- AAA
- Dissection
- DVT

The RUSH Exam
Mnemonic: “HI-MAP”
- Heart
- IVC
- Morison’s
- Aorta
- Pneumothorax
Bedside Echo Technique

- Requires good understanding of anatomy and 3D spatial orientation
- Requires practice
- Here are the fundamentals

Bedside Echo Anatomy
Windows + Planes = Views

Bedside Echo Views

<table>
<thead>
<tr>
<th>Window</th>
<th>Plane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parasternal</td>
<td>Long Axis</td>
</tr>
<tr>
<td>Parasternal</td>
<td>Short Axis</td>
</tr>
<tr>
<td>Apical</td>
<td>4 Chamber</td>
</tr>
<tr>
<td>Subxiphoid</td>
<td>4 Chamber</td>
</tr>
</tbody>
</table>

Bedside Echo: Sonographic Windows

- 3 Windows
- Parasternal
- Apical
- Subxiphoid
Bedside Echo: Cardiac Planes

- 3 Primary Planes
- Long Axis
- Short Axis
- Four Chamber

Bedside Echo: Probe Selection

- Small footprint
- Low frequency

Bedside Echo Anatomy: Windows and Axes

- Windows & axes vary
  - First: Find your Window
  - Then: Adjust the Axis

Controversy: Echo Probe Orientation

- General Radiology/EM
  - Indicator Screen
  - Scan from pts LEFT

- Cardiology
  - Indicator Screen
  - Scan from pts RIGHT

Parasternal Long Axis View
(The only one that differs)

I teach this

Parasternal Short Axis View

Apical 4 Chamber View
Bedside Echo

Findings

• What am I looking for?

LV function

1. LV function

• General estimate

• Dead → Hyperdynamic

• Parasternal long and short axes, look at

• Anterior mitral valve leaflet
  (should come within 1 cm of septal wall)

• General contraction of LV

Bedside Echo: LV Function

2. Pericardial effusion/Tamponade

3. RV dilation and strain

4. Aortic root dilation/dissection

Liver

RA

RV

LA

LV

Subxiphoid 4 Chamber View
Bedside Echo

1. LV function
   - Hyperdynamic
   - Normal
   - Moderately Depressed
   - Severely Depressed
   - Agonal
   - Standstill

2. Pericardial effusion/Tamponade
3. RV dilation and strain
4. Aortic root dilation/dissection

Pericardial Effusions

- Anechoic signal (Black)
- Between myocardium and pericardium
- Effusion should be dependent
- Except in trauma or post-op, clinically significant effusions are circumferential
Pericardial Effusions
False Positives

- Epicardial fat pad
- Left pleural effusion
- Ascites

Pericardial Effusions
False Positive: Fat Pad

- Echogenic
- Moves with myocardium
- Not displaced heart motion
- Usually not dependent

Pericardial Effusions
False Positive: L Pleural Effusion

- Only seen posterior/lateral views
- In parasternal long axis, extends deep to the descending thoracic aorta (not between DTA and heart)
- Use FAST splenorenal view to confirm

Pericardial Effusions
False Positive: Ascites

- Only seen in subxiphoid view
- Will often disappear with deep inspiration
- Confirm ascites in abdominal views
Pericardial Effusions
False Negative: Blood Clot

- Clotting blood can appear from anechoic to hyperechoic, to mixed.
- Look for your landmarks
- Check multiple views

Yeah, but is it tamponade?

- 1) In tamponade, intrapericardial pressure restricts atrial filling, therefore IVC WILL (ALMOST ALWAYS) BE DISTENDED (More soon)
- 2) You may see diastolic RA or RV collapse Concave-inward displacement free wall

Bedside Echo

1. LV function
   - Hyperdynamic
   - Normal
   - Moderately Depressed
   - Severely Depressed
   - Agonal
   - Standstill

2. Pericardial effusion/Tamponade

3. RV dilation and strain

4. Aortic root dilation/dissection

RV Dilation and Strain

- Most advanced component of this protocol
- Takes experience
- Pattern recognition
- Suggests pulmonary hypertension, which may suggest massive PE in the right patient
- With massive PE, IVC is also plethoric
**RV Dilation and Strain**
- RV dilation (RV:LV >1:1 on apical 4)
- Septum flattens and pushes into LV
- LV appears underfilled
- Free wall of RV barely contracts
- Free wall of RV is thin
  (In chronic pulm HTN, RV wall is > 4mm)
- IVC is plethoric

**Ascending Aortic Dissection**
- Usually associated with dilated aortic root
- Normal Aortic root < 4cm
- Parasternal long axis
- Measure 2 cm distal to aortic valve, wall to wall
- Neither sensitive nor specific, but may push you along towards the diagnosis

**Aortic Root Dilation**
- 5.4cm

**The RUSH Exam HI-MAP**
- Heart
- **IVC**
- Morison’s
- Aorta
- Pneumothorax
- Assess for IVC fullness (size)
- Assess for collapse with inspiration
- 2-3cm inferior to right atrial junction
**IVC and CVP**

<table>
<thead>
<tr>
<th>IVC Distension</th>
<th>Inspiratory collapse</th>
<th>CVP</th>
</tr>
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<tbody>
<tr>
<td>Small</td>
<td>Complete</td>
<td>&lt;5 cm H20</td>
</tr>
<tr>
<td>Moderate to Full</td>
<td>&gt;50%</td>
<td>5-10</td>
</tr>
<tr>
<td>Moderate to Full</td>
<td>&lt;50%</td>
<td>10-15</td>
</tr>
<tr>
<td>Large (&gt;2.5 cm)</td>
<td>Minimal</td>
<td>15-20 cm H20</td>
</tr>
<tr>
<td>Large (&gt;2.5 cm)</td>
<td>None</td>
<td>&gt;20 cm H20</td>
</tr>
</tbody>
</table>

- However, don’t need numbers
- Give a general estimate
- Is the CVP... extremely low, low, moderate, high, or extremely high?

**IVC vs Aorta**

- Empties into heart
- Flows through liver
- Undulating Pulsation
- Flows deep to heart
- Flows deep to liver
- Bounding Pulsation

**Pitfalls:**

**Bedside Echo & the RUSH Exam**

- Putting it all together
- Lets do some cases and see how it affects our management of the hypotensive patient
The RUSH Exam
HI-MAP

- Heart
- IVC
- Morison’s
- Aorta
- Pneumothorax

Cases