Bedside Ultrasound

US Guided Fluid Resuscitation

Michiel J. van Veelen, Emergency Physician, DTM&H
Outline

• Shock and Fluid Resuscitation in ICU
• Ultrasound in Shock
• **Ultrasound Guided Fluid Resuscitation**
• Other Ultrasound applications in ICU
Shock in ICU

“Cellular and tissue hypoxia due to reduced oxygen delivery and/or increased oxygen consumption or inadequate oxygen utilization”
Fluid Resuscitation in ICU
Fluid Resuscitation in ICU

Inadequate fluid resuscitation results in tissue hypoperfusion and worsening end-organ dysfunction

vs.

Overresuscitation leading to a positive fluid balance is associated with worsened mortality
Shock in ICU
Fluid responsiveness

- Non-invasive hemodynamics
- Physical examination
- Invasive hemodynamics; PAC, CVP, PPV, SVV...
- Passive leg raise test
- Fluid bolus
Fluid responsiveness

Fluid responder
Cardiac output (CO) increases by 10-15% in response to a fluid bolus

Non-responder
Decreased CO or minimal increase
Several US Shock protocols

- Goal Directed Echocardiography (GDE)
- Rapid Ultrasound in Shock (RUSH)
- Rapid Assessment by Cardiac Echo (RACE)
Pros:

• Effective, noninvasive, rapid and accurately assess hemodynamically unstable patients at the bedside \(^{1-3}\)

• Differentiate between hypovolemic, cardiogenic, obstructive, and distributive shock \(^{2-6}\)

• Serial exams for monitoring \(^{4,5}\)
RUSH exam\(^2\)

A) Parasternal Views
   - Long / Short Axis
B) Subxiphoid View
C) Apical View

A) IVC Long Axis
B) FAST / RUQ
   - Add Pleural View
C) FAST / LUQ
   - Add Pleural View
D) FAST / Pelvis
E) Pneumothorax
   - Pulmonary Edema

A) Suprasternal Aorta
B) Parasternal Aorta
C) Epigastric Aorta
D) Supraumbilical Aorta
E) Femoral DVT
F) Popliteal DVT

Easy?
Alternative?

Just 2 views:
- Inferior Vena Cava
- The Lungs

Development of a fluid resuscitation protocol using inferior vena cava and lung ultrasound

*Journal of Critical Care*, Volume 33, June 2016
Development of a fluid resuscitation protocol using inferior vena cava and lung ultrasound

Systematic review of current literature

Evaluation of Ultrasound guided resuscitation studies using two (2) views:
  • Inferior Vena Cava
  • Lung Ultrasound

Proposal of an easy to use algorithm
Why Inferior Vena Cava

**Spontaneous breathing**
> intrathoracic pressure with inspiration draws blood from the vena cava into the heart, leading to collapse

**Positive pressure ventilation**
> intrathoracic pressure pushes blood from the heart into the vena cava, leading to distention of the vessel.
Interpretation

Static measurement of IVC diameter and variation with *spontaneous respiration* correlates with central venous pressure (CVP) \(^3,^4\)

A change in IVC diameter with respiration of 12 -18% is associated with fluid responsiveness in *mechanically ventilated* patients \(^4-^6\)
Leerdoelen

IVC

Ultrasound Guided Fluids
Why Lung Ultrasound?

- "BLACK"
- "BLACK AND WHITE"
- "WHITE"

Normal
Mild/moderate interstitial edema
Severe interstitial edema/alveolar edema

Air
Ultrasound Guided Fluids

A

B

LUNG S
Ultrasound Guided Fluids

<table>
<thead>
<tr>
<th>Authors</th>
<th>Patients</th>
<th>Standard</th>
<th>Sens</th>
<th>Spec</th>
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<td>Wedge pressure</td>
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<td>NT-proBNP</td>
<td>71</td>
<td>94</td>
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</tbody>
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Ultrasound Guided Fluids

Point of Care Ultrasound **Fluid Resuscitation Guide**
- using IVC and lung ultrasound -

**Underfilled**

< 1.5 cm

- **Intubated**
  - Passive
    - Fluid Resuscitate
      - Give Crystalloid*
      - *Septic patients, consider dynamic fluid responsiveness test
  - Triggering
    - 1,2

**Normal**

1.5 - 2.5 cm

- **Not Intubated**
  - A-line predominance
    - Fluid Test
      - Consider Crystalloid
      - Crystalloid may help and unlikely to harm
      - Dynamic fluid responsiveness test indicated if available
  - B-line predominance
    - Fluid Restrict**
      - Hold Crystalloid
      - Vasoactive agents indicated to support shock

**Distended**

> 2.5 cm, non-varying IVC

**Exceptions:**
Elevated RA pressure e.g. tamponade, pHTN, etc. or B-line etiologies other than pulmonary edema.
May still be fluid responsive.


Arntfield, Lee, Kory 2015
Ultrasound Guided Fluids

IVC

Ultrasound Inferior Vena Cava Long Axis
Ultrasound Guided Fluids

Measure diameter

<1.5cm Underfilled
>2.5cm Distended
1.5-2.5cm Normal
Ultrasound Guided Fluids

Pitfalls

Beam placement

Screen image

True diameter

False diameter
IVC Diameter

>2.5cm: Hold Fluids

<1.5cm: FLUIDS

Normal: Step 2
Intubated?

Yes: Respiratory variation

No/Triggering:
Lung Ultrasound
Respiratory variation:
\[
\left[ \frac{D_{\text{max}} - D_{\text{min}}}{D_{\text{max}}} \right] \times 100\% > 12\% ?
\]
Respiratory variation

>12%: FLUIDS

<12%: Lung Ultrasound
LUNGS

Ultrasound Guided Fluids
Ultrasound Guided Fluids

Right anterior chest wall

Left anterior chest wall

Right anterior axillary line

Left anterior axillary line

LUNGS 2B
Ultrasound Guided Fluids

A Lines
Fluid Test

B Lines
Hold Fluids

2B
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- using IVC and lung ultrasound -

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Arntfield, Lee, Kory 2015
Other applications in ICU:
Vascular access
Pneumothorax?
Infiltrate or Effusion?
Leerdoelen

Treatable causes in CPR

Ultrasound in ICU
Ultrasound in ICU

Rhythm check: FEER

- No wall motion: True PEA
- Wall motion: Pseudo PEA

Or termination of CPR
Free fluid in trauma
Ectopic Pregnancy
AAA
Bladder
Galbladder
Kidneys
....
Take home messages

- US is a reliable, affordable and rapid bedside test to evaluate for fluid responsiveness in the ICU patient in shock

- CAVE: Do not forget the entire clinical picture!

- US is operator dependent and requires practice

- US has many potential applications in ICU
References


Bedside Ultrasound Course

16th of June

Full day course

Pre-course material

- E-FAST
- DVT
- Cardiac and IVC
- Aorta
- Central Venous Access

Certificate EMSSA

1250 Pula

What
One-day SA college of EM accredited introduction course provided by international faculty: E-FAST, DVT, Cardiac, Aorta and IV access.

Target Audience
Doctors of all specialties interested in improving their bedside diagnostic skills using US, especially in acute settings.

When and where
Friday 16th of June 2017, Faculty of Health Sciences 246, Room XXX

Costs
1250 Pula, incl. online study material, certificate, food and drinks

Registration
Payment is made at Vote P0129, please mention Ultrasound course. Deliver receipt to UB teaching Hospital, ground floor, Office 1004. Training is done on first come first serve basis and ONLY after payment is made.
Questions: michielvanveelen@hotmail.com