IVC
‘The pro-BNP of ultrasound’

Dr Justin Bowra
Critical Care Ultrasound Course
IVC
‘More an art than a science’

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Critical Care Ultrasound Course
IVC SUMMARY

- 2 windows: subxiphoid, RUQ
- Combine a long axis and transverse view
- Maximum diameter (IVCD)
- Change with inspiration (IVCCI: IVC collapsibility index)
- Only really useful at extremes
The IVC
The inferior vena cava (IVC)

- Largest vein in the body.
- To the anatomical right of aorta
- Oval, thin walled
- Breathe in: diameter decreases (opposite if ventilated)
- Dehydration: ‘flattens out’.
- Downstream occlusion (eg tamponade) or fluid overload (eg CCF): ‘fattens up’.
Subxiphoid longitudinal: shocked & dry
Subxiphoid transverse: massive PE
The IVC can help us in the resus room.

**Diagnosis:** Is there fluid overload or a downstream occlusion (eg PE, tamponade)?

**Resuscitation:** Should I give more IV fluids to this shocked patient?
Parameters

Shape (fat or flat?)

Maximum IVC diameter (IVCD)

IVC collapsibility index (IVCCI) = (max – min)/max \times 100

Response to ‘sniff test’
IVCCI (hypovolaemia) = 69%
IVCCI (CCF) = 10%
IVC: the good news

Cheap
Easy to find & measure
Noninvasive
Rapid
Repeatable
IVC: the bad news

Poorly validated
Only useful at extremes
No-one really knows where or how to measure it
How to image the IVC

What probe?
What preset?
Where?
How?
What probe should we use?

No-one knows.

Curved or sector (cardiac) probably OK.
What preset?
No-one knows.

Abdo (FAST) probably beats cardiac preset.
Where should we put the probe?

How should we align it?
Thou shalt
Place the
probe
long axis
In subxiphoid
Window

About Here.
Or long axis in the mid-Axillary line

Just like
A fast exam
Where should we put the probe?

How should we align it?
Where should we put the probe?

How should we align it?

**NO-ONE KNOWS!**
Where can we put the probe?

- Subxiphoid long axis
- Subxiphoid short axis
- Midaxillary line long axis
- Midaxillary line short axis
- Transpyloric long axis
- Transpyloric short axis
Subxiphoid long axis
Subxiphoid long axis

- Most studies & experts measure here
- Probe sagittal
- Angled up through the liver
- Find the right atrium: confirm IVC entering RA
- Find the hepatic veins entering IVC
- ‘Hepatic vein confluence’
Subxiphoid long axis
Long axis pitfall #1

Cylinder effect
Long axis pitfall #1
cylinder effect
Long axis pitfall #2
IVC lateral movement
Subxiphoid short axis
Subxiphoid short axis

- RUSH protocol (& a small study by Akilli) recommend this one
- Probe in same spot as before
- But turned to transverse
- IVC imaged in short axis
Subxiphoid short axis
Short axis pitfall: IVC slides craniocaudally!
Midaxillary long axis: ACEP website recommends as an alternative.
Subxiphoid trans: MAX & MIN.
Watch **how** the IVC collapses (subxiphoid)
Watch **how** the IVC collapses (RUQ)
Subxiphoid long axis approach: probably OK (if you’re careful).

Midaxillary longitudinal approach: probably not OK.

Any transverse view: dunno.

Transpyloric window: dunno.

No-one’s really sure.
Where should we measure the IVC?
Thou shalt
Measure at the Hepatic vein confluence
Where should we measure the IVC?

No-one knows!
The IVC collapses non-uniformly
The IVC collapses non-uniformly
Most of us measure at/near the confluence with the hepatic veins.

This is where most of the numbers / guidelines come from.

Below the liver (eg transpyloric) might be OK, but is probably more prone to probe pressure.
Should I use M-mode?
Should I measure in M-mode?

Lots of fun.
Displays max & min diameter on the same image.

Many experts recommend it.

I like it.

But even experienced users can get the angles wrong…
M-mode pitfalls: wrong angle, and IVC moves
Top tip:

When starting out, avoid M-mode.
Should I do a sniff test?
Sniff test (great in healthy volunteers)
Should I perform a sniff test?

RUSH exam & American Society of Echo recommends it.

No evidence.

And half the time I lose sight of the IVC when the patient sniffs!

And I can’t help thinking…
If the patient is well enough to perform a sniff test, I probably don’t need to be looking at their IVC.
Myth 1: There’s an IVC table you can use to predict fluid status.
### IVC and IVCCI Classification

<table>
<thead>
<tr>
<th>IVC diameter (cm)</th>
<th>IVCCI</th>
<th>Estimated RA pressure (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1.7</td>
<td>&gt;50%</td>
<td>0-5</td>
</tr>
<tr>
<td>&gt;1.7</td>
<td>&gt;50%</td>
<td>6-10</td>
</tr>
<tr>
<td>&gt;1.7</td>
<td>&lt;50%</td>
<td>11-15</td>
</tr>
<tr>
<td>‘dilated’</td>
<td>none</td>
<td>&gt;15</td>
</tr>
</tbody>
</table>

*ASE guidelines 2005*
Not validated in critically ill patients.

Based on sonographer measurements (which don’t correlate with clinician measurements).

Performed on patients in the left decubitus position. But our patients are either sitting up (SOB) or supine (shock).
<table>
<thead>
<tr>
<th>IVC diameter (cm)</th>
<th>IVCCI</th>
<th>Estimated RA pressure (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>none</td>
<td>&gt;15</td>
</tr>
<tr>
<td>&gt;1.7</td>
<td>'dilated'</td>
<td>6-10</td>
</tr>
</tbody>
</table>

ASE guidelines 2005
Myth 2: The IVC Can predict volume Status
‘The IVC can predict fluid status’

- Empty IVC equals *empty* tank
- Full IVC equals *full* tank
- Logical: It makes sense.
Myth 3:
IVC ultrasound
Can predict
Fluid responsiveness
‘The IVC can predict fluid responsiveness’

- Empty IVC ➔ IV fluids ➔ improved end-organ perfusion
- Full IVC ➔ IV fluids won’t help
- Logical: It makes sense.
These statements are only true at extremes.
Flat, collapsing IVC

- A shocked patient is probably dry if:
  - IVCD<0.9cm, IVCCI >50% (spontaneously breathing)
  - IVCD<1.2cm, IVCCI >18% (ventilated)
  - (In small studies.)

- And if it stays that small after IVT, shock recurs in these patients. (In 1 study.)
Distended, non-collapsing IVC

- In ventilated patients: IVCD > 2.5cm, IVCCI < 10%
- In spontaneously breathing patients: IVCCI < 15%
- Might be ‘full tank’
- Might be RA pressure from other causes
  - Chronic cor pulmonale
  - Tricuspid disease
  - Obstruction (PE, PTX, tamponade)
Myth 4:
IVC ultrasound
Can predict
Fluid
tolerance

WEINGART,
ULTRASOUNDPODCAST,
LOTS OF OTHERS
Surely it’s **SAFE** to give fluids if the IVC is flat? And maybe it’s **BAD** to give fluids if the IVC is distended?

Well, it seems to make sense. And most of us follow this approach.
Surely it’s **SAFE** to give fluids if the IVC is flat? And maybe it’s **BAD** to give fluids if the IVC is distended?

Well, it seems to make sense. And most of us follow this approach.

But there’s no evidence for these statements.
Surely it’s **SAFE** to give fluids if the IVC is flat? And maybe it’s **BAD** to give fluids if the IVC is distended?

Well, it seems to make sense. And most of us follow this approach.

But there’s no evidence for these statements.

And there’s evidence that IVC is affected by a number of other factors.
What else can splint the IVC open?

Not just XS fluids

- Obstructive shock: tamponade, tension PTX, massive PE
- Raised intrathoracic pressure: e.g. status asthmaticus
- Chronic comorbidities: eg right heart disease
- Too close to the diaphragm may ‘artificially reduce’ IVC collapse?!? (Wallace 2010)
What else can cause the IVC to collapse?

1. Ventilation: ‘Diaphragmatic breathing’ (using abdominal wall muscles as well as the chest wall): (Kimura 2011)

2. Raised intra-abdominal pressure (in animal studies: Takata 1990)

3. Even pressure from the probe! (anecdotally)
Just because the IVC collapses, it doesn’t mean it’s safe to give fluids.

Most of us do, but that’s not evidence.
So what can the IVC really tell us?
<table>
<thead>
<tr>
<th></th>
<th>IVCD</th>
<th>IVCCI</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spontaneously breathing</td>
<td>&lt;0.9cm</td>
<td>&gt;50%</td>
<td>Probably empty / fluid responsive</td>
</tr>
<tr>
<td></td>
<td>?</td>
<td>&lt;15%</td>
<td>Probably full &amp; unresponsive</td>
</tr>
<tr>
<td>Anything else</td>
<td></td>
<td></td>
<td>Dunno</td>
</tr>
<tr>
<td>Ventilated</td>
<td>&lt;1.2cm</td>
<td>&gt;18%</td>
<td>Probably empty/ responsive</td>
</tr>
<tr>
<td></td>
<td>&gt;2.5cm</td>
<td>&lt;10%</td>
<td>Probably full/ unresponsive</td>
</tr>
<tr>
<td>Or PE/ PTX/ tamponade</td>
<td></td>
<td></td>
<td>Or other stuff that raises CVP</td>
</tr>
</tbody>
</table>
Why is this so?

1. IVC just isn’t that precise.

2. CVP isn’t great as a marker of fluid status
IVC ultrasound: summary
1: How to image the IVC

- Subxiphoid long axis (or midaxillary trans)
- Curved or sector probe
- Abdo (FAST) preset if possible
- Don’t use M mode
- Don’t do a sniff test
- Eyeball assessment is probably fine
2: How to assess the IVC

- Practise with calipers (IVCD, IVCCI)
- But once you get your ‘eye in’, eyeball assessment is fine
- Stick to extremes:
  - Flat & collapsing = probably empty
  - Full & not collapsing = probably full!!
3: Beware the ‘mimics’

- Flat & collapsing IVC
  - Probe pressure
  - Raised intra-abdo pressure
  - Manner of breathing

- Full & not collapsing
  - Tension PTX
  - Tamponade
  - Massive PE
  - Severe COPD, Status asthmaticus?
  - Any right heart disease
4. Be a doctor

- Clinical assessment is always the best
- Add lung US (wet or dry? PTX? Chunky?)
- Add basic echo (Tamponade? Massive RV?)
- And the rest: CXR, ECG, etc etc
- If US findings don’t match clinical assessment, turn off the machine
Thanks to

Dr Kylie Baker (for that literature review)
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Drs Mike Blaivas, Matt Dawson, Cliff Reid & Scott Weingart
(for their advice & input)
References

- ACEP http://www.acep.org/Content.aspx?id=80791


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References


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References


References
