

Critical Care Ultrasound Course

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**CCUS Manual 3:
Scanning the IVC**

Inferior vena cava (IVC): diameter and collapse

The IVC

- The largest vein in the body.
- Receives all the blood from below the diaphragm.
- Runs adjacent to the aorta, pierces the diaphragm & enters the right atrium (RA).
- As we breathe in, its diameter decreases (NB opposite in ventilated patients).
- As we become dehydrated, it 'flattens out'.
- With downstream occlusion or fluid overload (eg CCF), it 'fattens up'.

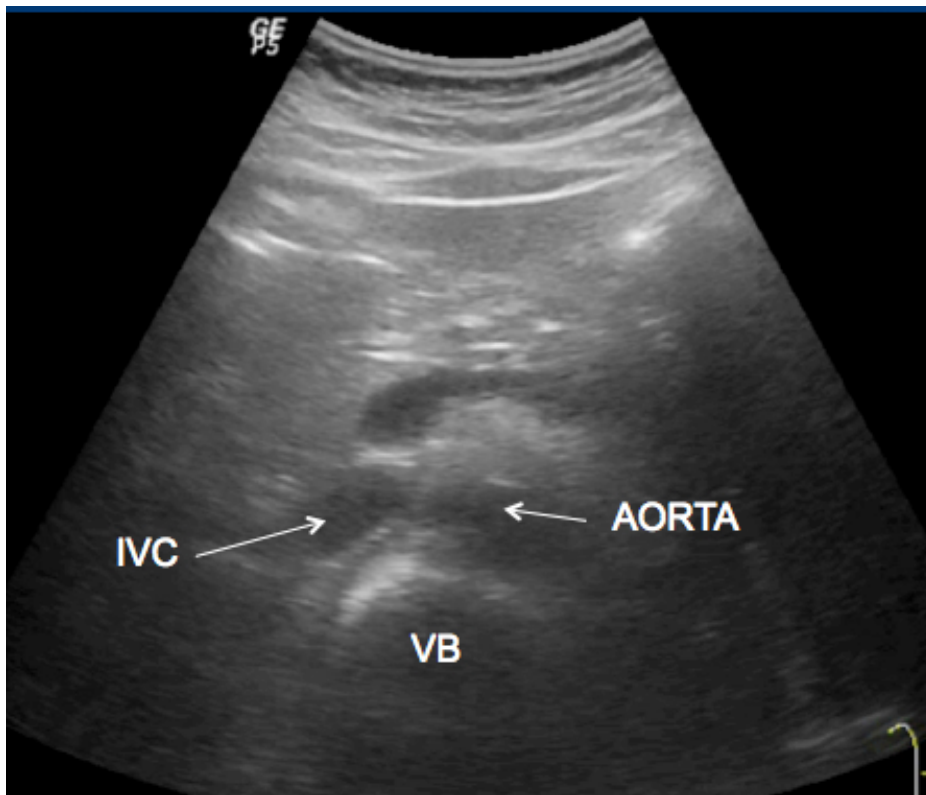


figure. IVC, aorta, vertebral body (VB). Transverse subcostal image.

Why scan the IVC?

- Non-invasive surrogate for central venous pressure (CVP) measurement
- Rough estimate of fluid status. It can help answer the questions:
 - Should I give more IV fluids in this shocked patient? i.e. is the patient likely to be **fluid responsive**?
 - Is there fluid overload or a downstream occlusion (eg PE, tamponade)?

Terminology

- IVCCI = IVC collapsibility index: = (maximum diameter – minimum diameter)/max diameter x100
- IVCD = Maximum IVC diameter
- HV = hepatic veins
- RAP = right atrial pressure = CVP

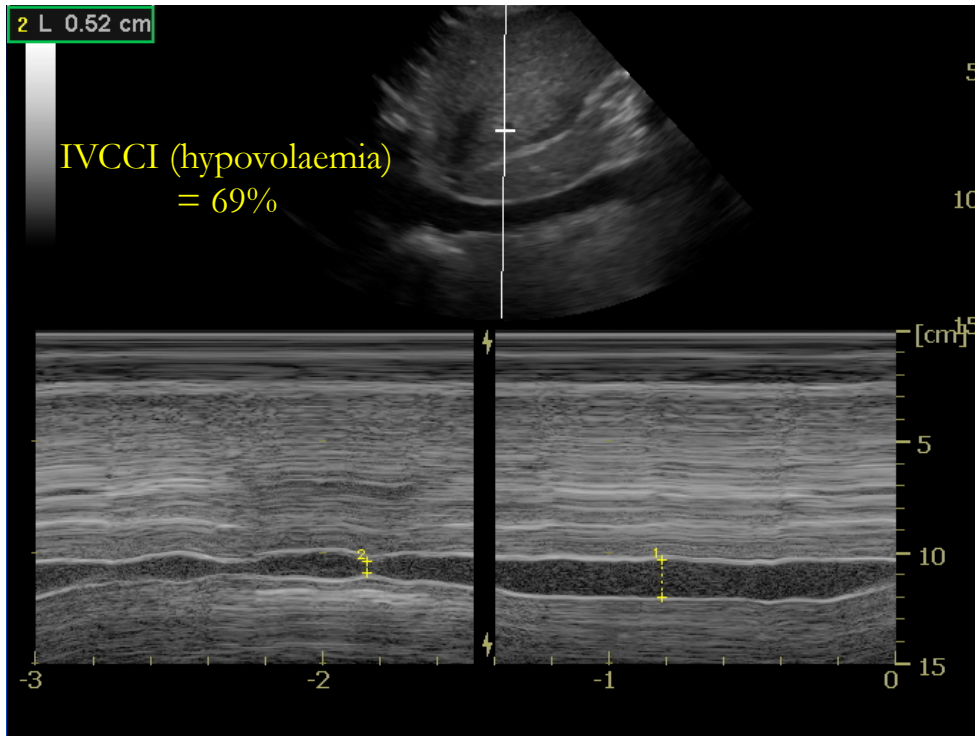
5 parameters to think about

1. **IVCD**
2. **IVCCI**
3. **IVC Shape**
4. **IVC Response to sniff test**

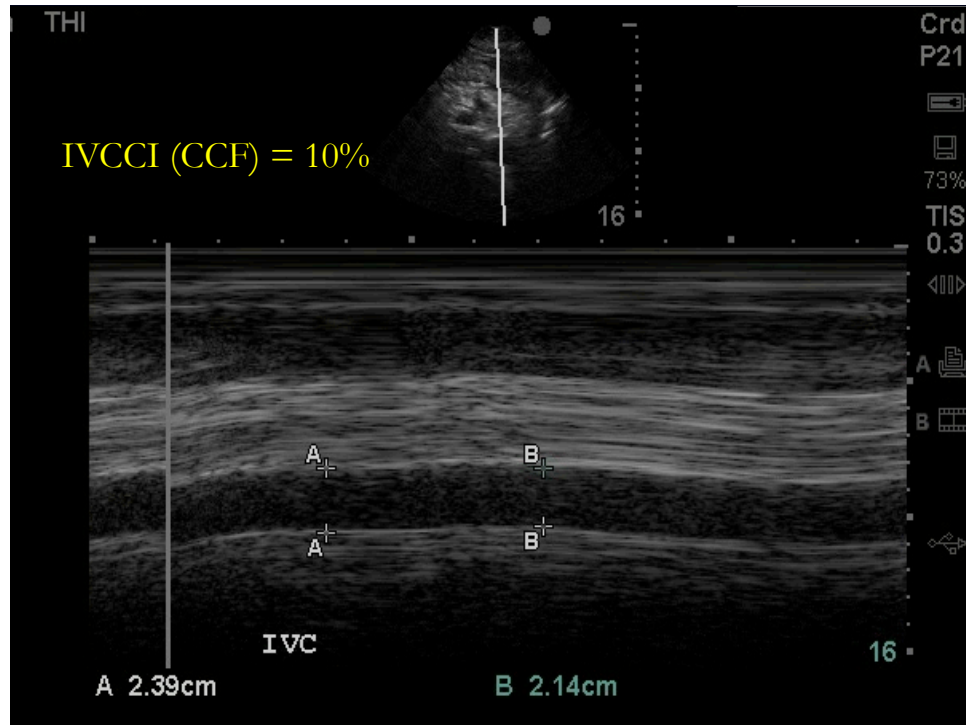
- **Maximum IVC diameter (IVCD):** this is probably the least reliable guide to fluid status. Why? Because IVCD depends on:
 - The patient (large or small?)
 - Athletes (larger IVCD)
 - The site measured: narrows as it descends
 - Body position (supine v semirecumbent v R/L decubitus)
 - Positive pressure ventilation (absolute IVCD increases)
 - Downstream obstruction (e.g. PE): IVCD increases
- **IVC collapsibility index (IVCCI) = $(\text{max} - \text{min})/\text{max} \times 100$:** this is a bit more useful, but IVC collapsibility index (IVCCI) changes with:
 - The site measured: e.g. measuring near the RA \neq measuring below hepatic veins
 - **Type** of respiration (diaphragmatic breathing = trend to greater collapse IVCCI 0.8, vs quiet resps IVCCI 0.57) (Kimura et al: 19 healthy volunteers)
 - Positive pressure ventilation: IVCCI is reversed
 - Downstream obstruction (e.g. PE): IVCCI decreases

Top tip: in ventilated patients, things are different.

- *The absolute IVCD is greater*
- *The IVC gets bigger on inspiration & smaller on expiration (i.e. things are 'the wrong way round')*
- **Shape (fat or flat?):** this is much more useful. Everyone agrees that the IVC is most useful at extremes... like many other tests.



M-mode image. Flat, collapsing IVC. IVCCI 69%, hypovolaemia



M-mode image. Fat IVC. IVCCI 69%, CCF

- **Response to ‘sniff test’:** although this is said to be useful, I don’t find it too valuable for the following reasons:⁴

- With a big sniff, the IVC often disappears out of view
- If you're critically ill, you're probably already breathing pretty hard (eg acidosis) or can't really follow commands anyway

Some numbers to think about in shocked patients

	IVCD	IVCCI	Correlation
Spontaneously breathing	<0.9cm	>50%	<i>Probably</i> fluid responsive
	>2cm	<15%	<i>Probably not</i> fluid responsive
	Anything in between		No-one's sure
Ventilated	<1.2cm	>18%	<i>Probably</i> fluid responsive
	>2.5cm	<10%	<i>Probably not</i> fluid responsive... or PE/PTX/ tamponade or other diseases that raise the CVP

But no-one's too sure!
TOP TIP: Stick to the extremes.

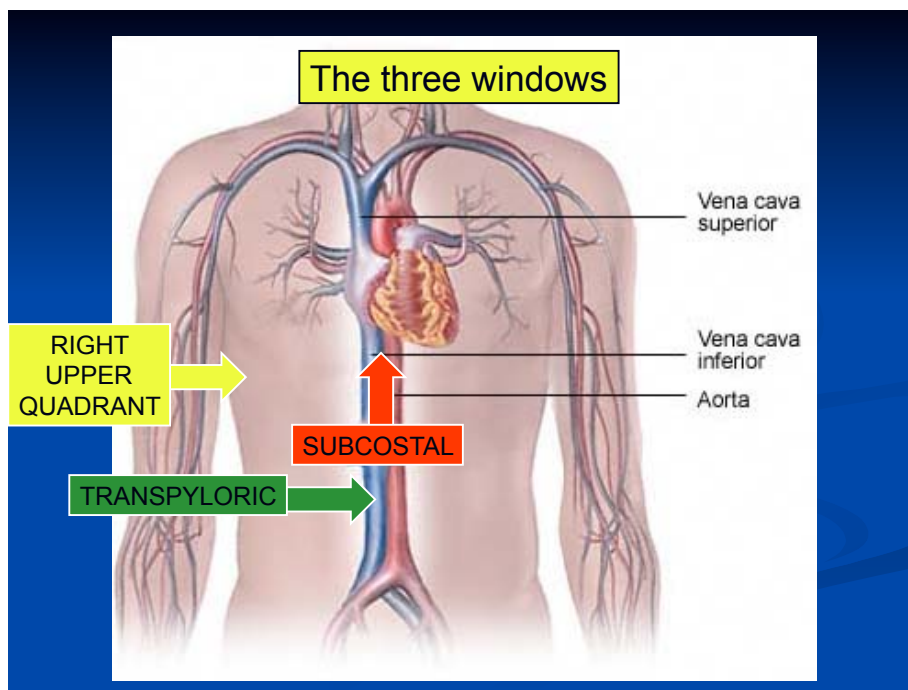
In a shocked patient:

*Big IVC, diameter not varying much: CVP is high / patient is **unlikely** to be fluid responsive.*

*Small IVC & CVP changing its shape: CVP is low / patient is **likely** to be fluid responsive.*

How to scan the IVC

- Patient position: well, that depends on the patient. Although it's easier to scan them supine (and a good idea to lie them down if shocked) they may be sitting up / semi-recumbent if breathless.
- Probe: either the sector (cardiac) or curved probe is fine. Abdo preset is probably better than the cardiac preset, but there's not much difference.
- Anywhere you can find the IVC, scan it. it can be surprisingly tricky in some patients.
- Generally three windows are used:
 - the subcostal is preferred by echocardiographers
 - the transpyloric / epigastric window (traditionally used for AAA scanning) is not bad either
 - Scanning through the liver (e.g. from the right upper quadrant) is great, but there's anecdotal evidence that this can make the IVC look 'fuller' than it really is, when using the long axis.



- If you can, scan the IVC in two planes to get a better 'feel' for it: both long axis and transverse
- And of course, differentiate between the aorta and IVC as described in the section on AAA scanning.
- M-mode is not as great as it looks. Unless the M-mode line lies along the true transverse diameter of the IVC, it will overestimate the IVCD and may underestimate the IVCCI, leading to a conclusion that the IVC is 'fuller' than you think!

Top tips when scanning the IVC:

- 1. The IVC collapses non-uniformly, in other words the numbers you come up with (IVCD, IVCCI) will depend on where you put the calipers! So that's why you should avoid trying to be too precise.*
- 2. If using the RUQ window, try and avoid using the long axis. Transverse view will be more accurate.*
- 3. Avoid M-mode when starting out: it's too easy to stuff up.*



Figure. Scanning the IVC from the subcostal window, curved probe

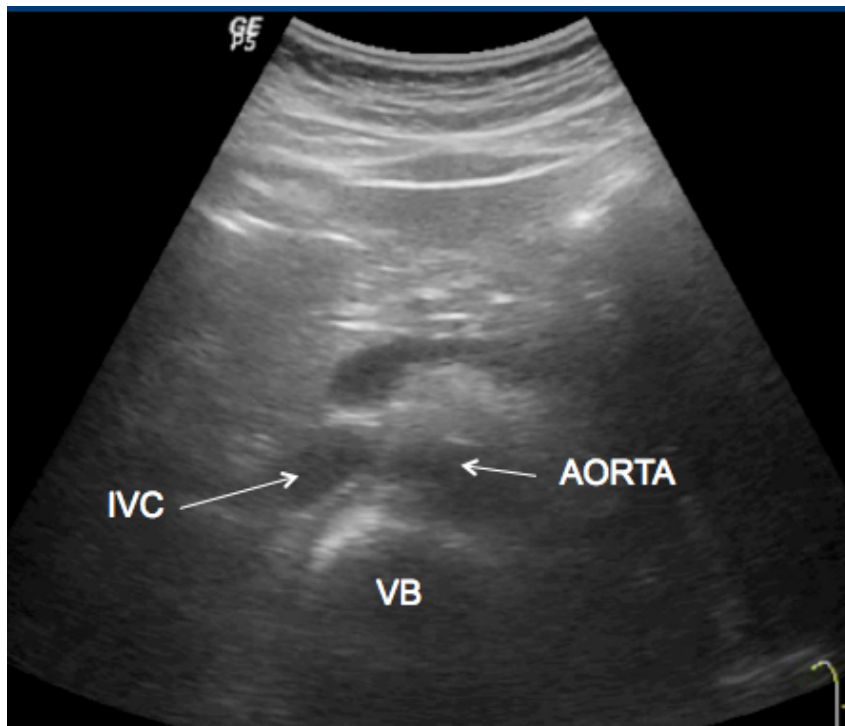


figure. Transverse subcostal image IVC, curved probe



Figure. Scanning the IVC from the transpyloric window, curved probe

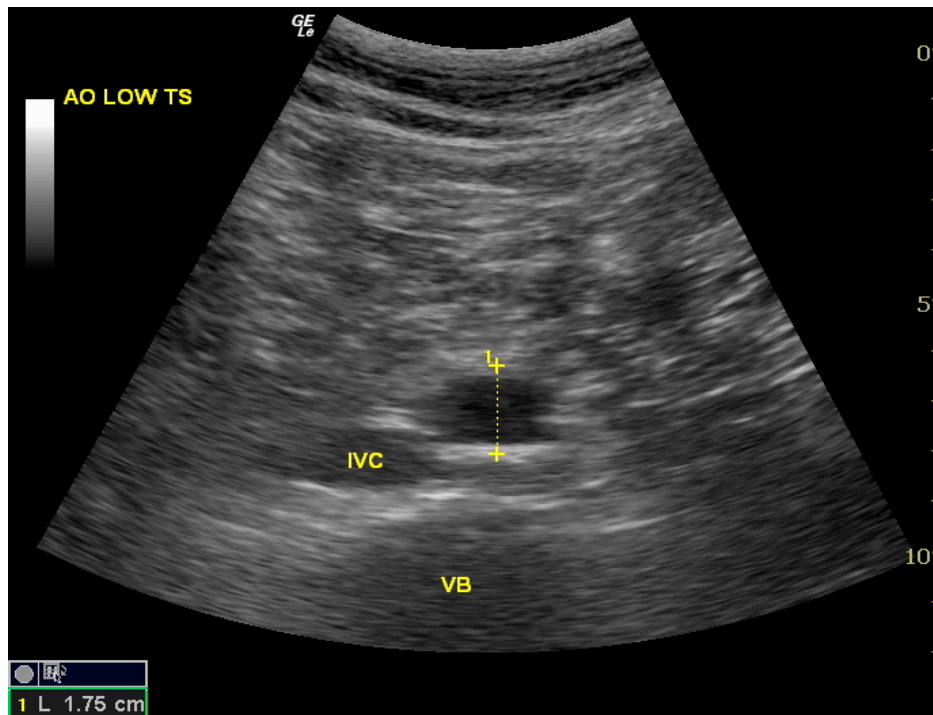


figure. Transverse transpyloric image IVC, curved probe

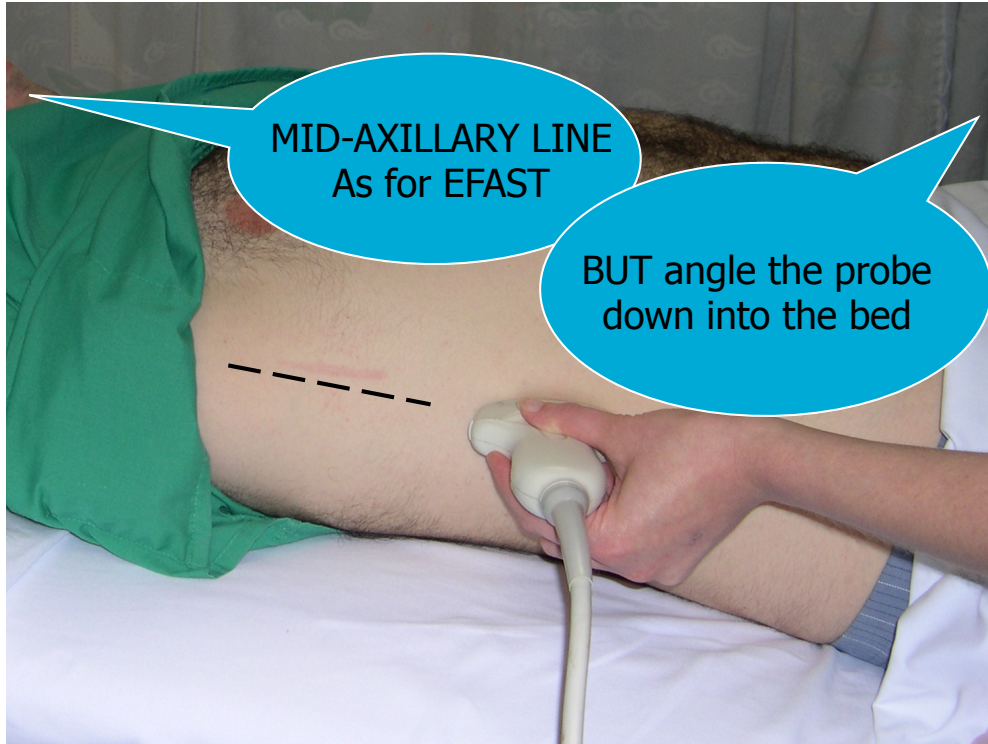


Figure. Scanning the IVC from the RUQ window, curved probe

A WORD OF WARNING ABOUT USING THE RUQ APPROACH:

Like all vessels, the IVC is most accurately measured in its transverse plane. This doesn't matter so much for the subcostal & transpyloric approaches, BUT it becomes a problem if you are using the RUQ approach.

Look carefully at the maximum and minimum IVC diameters measured below from the RUQ in the same healthy volunteer. In the first set of images (longitudinal), the IVC doesn't seem to collapse much at all: it looks 'full'.

In the second set of images (transverse), you can see that the IVC collapses in the AP plane rather than the transverse plane.

What's going on here? Well, in the supine patient the IVC's phasic variation (its collapse with inspiration) occurs mainly in the AP plane. It doesn't collapse much at all in the transverse plane.

But the transverse plane is the one that the probe 'looks along' from the RUQ!

In other words, if you are scanning from the RUQ try and avoid using the longitudinal approach. It will overestimate the patient's volume status and make you think they are 'full' when they're not.

(But you can trust it if it collapses in this view.)

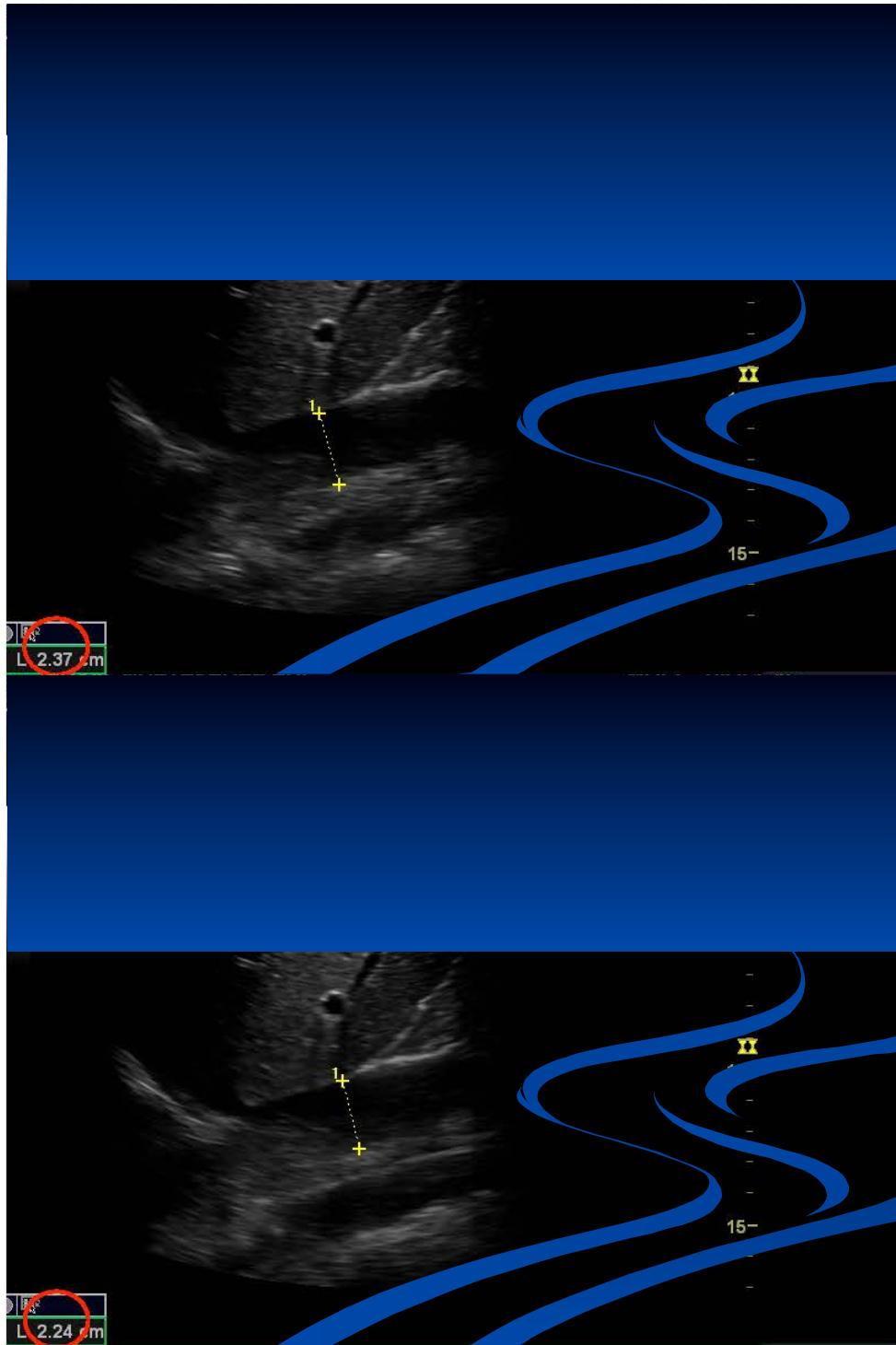


Figure. Maximum (2.37cm) and minimum (2.24cm) IVC diameters obtained in long axis in a healthy volunteer, curved probe. The IVCCI appears to be $(2.37 - 2.24)/2.37 \times 100 = 5.5\%$

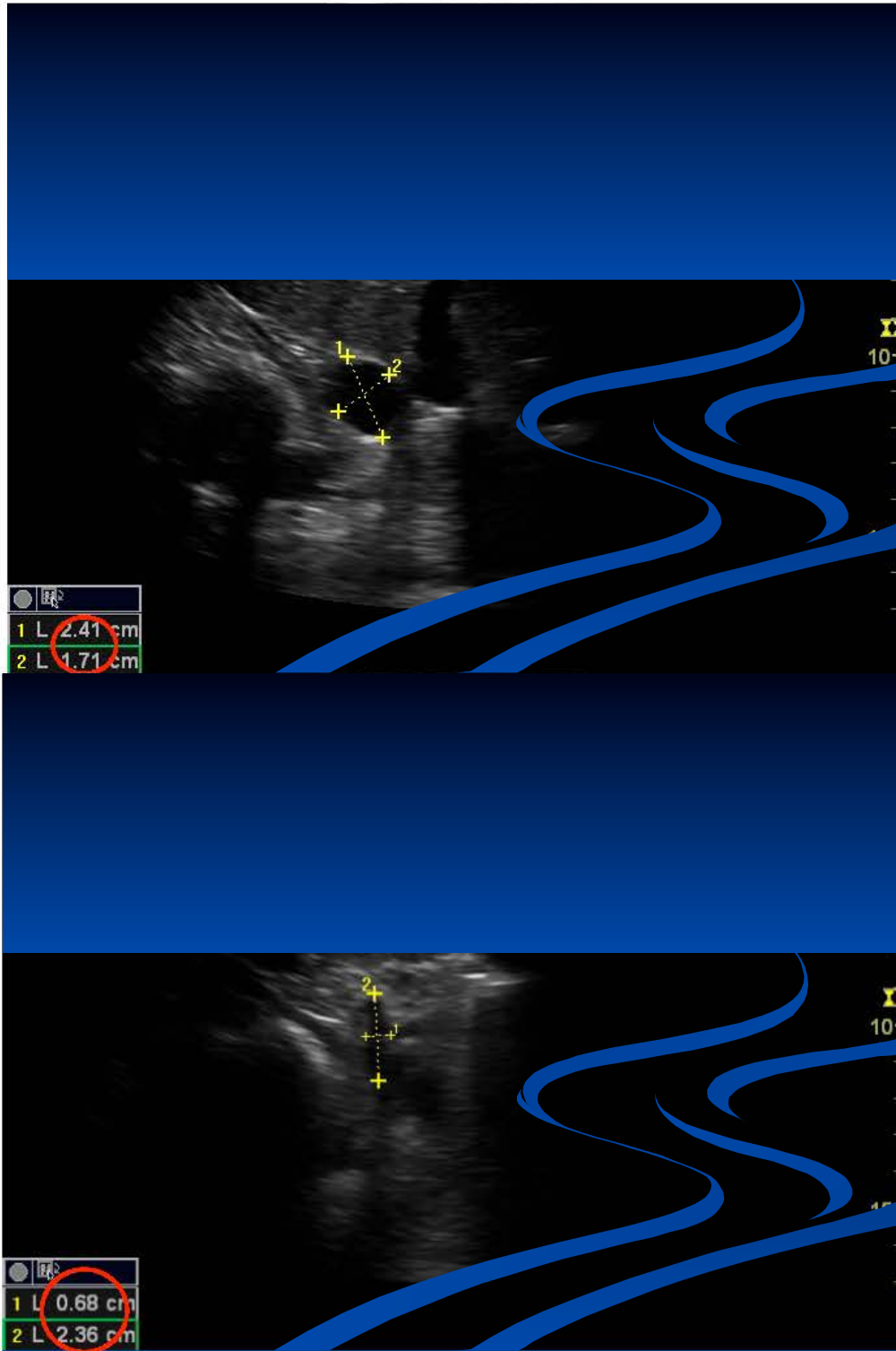


Figure. In the same healthy volunteer as above, the probe is now rotated to provide a transverse image of the IVC. In the AP diameter (which appears horizontal because we're scanning from the right), maximum diameter is now 1.71cm and minimum is 0.68cm. The true IVCCI is $(1.71 - 0.68)/1.71 \times 100 = 60\%$

WHERE SHOULD I PUT THE CALIPERS?

Short answer: no-one knows.

- A favourite spot is just at/below the IVC confluence with the hepatic veins.
- And it's probably best to avoid the spot where the IVC dives through the right atrium, because that might 'artificially hold open' the IVC.

Long answer:

- The IVC collapses non-uniformly, and no-one has really studied which spot most accurately reflects RA pressure/CVP.
- In 2010, a study by Wallace et al found that IVCCI measured above hepatic confluence did not correlate with IVCCI measured at other sites. Wallace's conclusion was that '*Clinicians should avoid measuring IVCCI at the junction of the right atrium and IVC*'. **But there was no gold standard in that study.** So how did Wallace know which site was the right one? Answer: Wallace didn't.

Wallace et al, 2010

Site	IVCCI
At level of diaphragm	20% (+/-16%)
At hepatic vein inlet	30% (+/-21%)
At left renal vein	35% (+/-22%)

In supine healthy volunteers

- And it gets harder, the more you look at the scientific studies:
 - The ASE recommends measuring 1-2cm from RA
 - Yanagawa found a correlation (IVCD & RAP) just below diaphragm
 - Charron found a correlation (IVCD & RAP) measured <2cm from RA
 - Blehar found a correlation (IVCCI & clinical diagnosis CCF) measured just distal to hepatic veins
 - Corl found **no** correlation (IVCI & CO) measured 3cm distal to the RA
- **So we don't even know where best to measure the IVC.**
 - Should we avoid measuring above the hepatic confluence? (Does the diaphragm hold it open?)
 - Should we insist on it? (Is the IVC more sensitive to intra-abdominal pressure and probe pressure as you go down the diaphragm?)

No-one knows where best to measure the IVC.

- *Most of us tend to measure the IVC:*
 - *In the subxiphoid window*
 - *In long axis (sagittal)*
 - *Roughly at the hepatic vein confluence*
- *And that's where most of the studies have looked.*
- *It's probably best to avoid:*
 - *The spot where the IVC dives through the right atrium, because that might 'artificially hold open' the IVC.*
 - *Too far down toward the umbilicus, because the IVC probably is more prone to fluctuations in probe pressure at this point. (The liver seems to 'shield' against this, higher up.)*

WHAT ABOUT M-MODE?

M-mode scanning can be used to capture maximum and minimum diameters on a single image. Sounds great, right? BUT unless you're careful, the M-mode line (white line which appears over the B-mode images below) might not be perpendicular to the IVC.

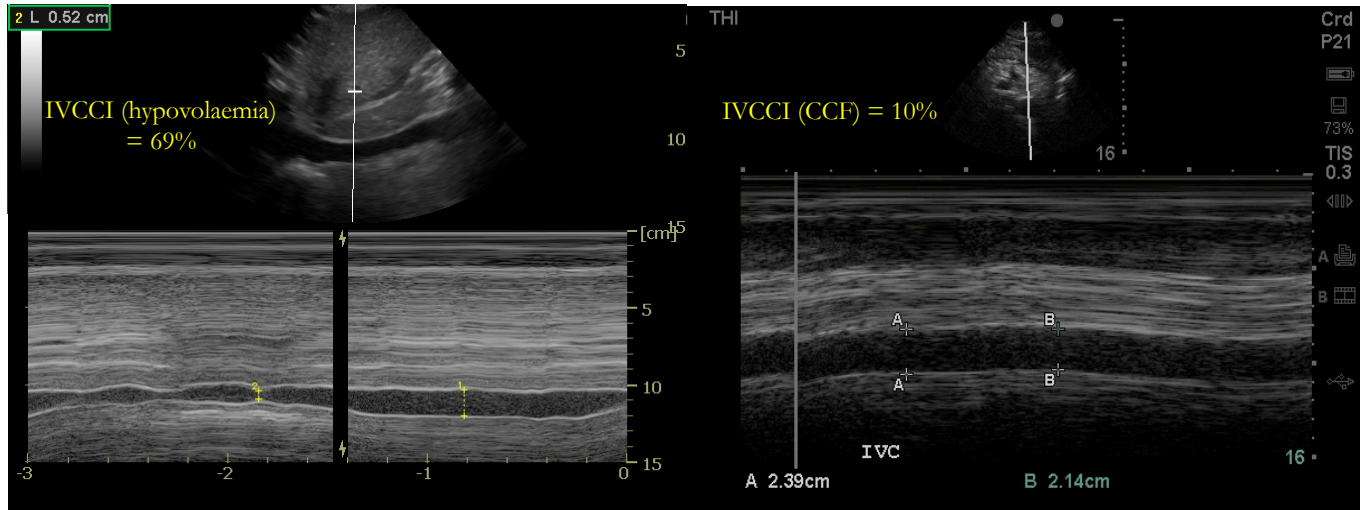
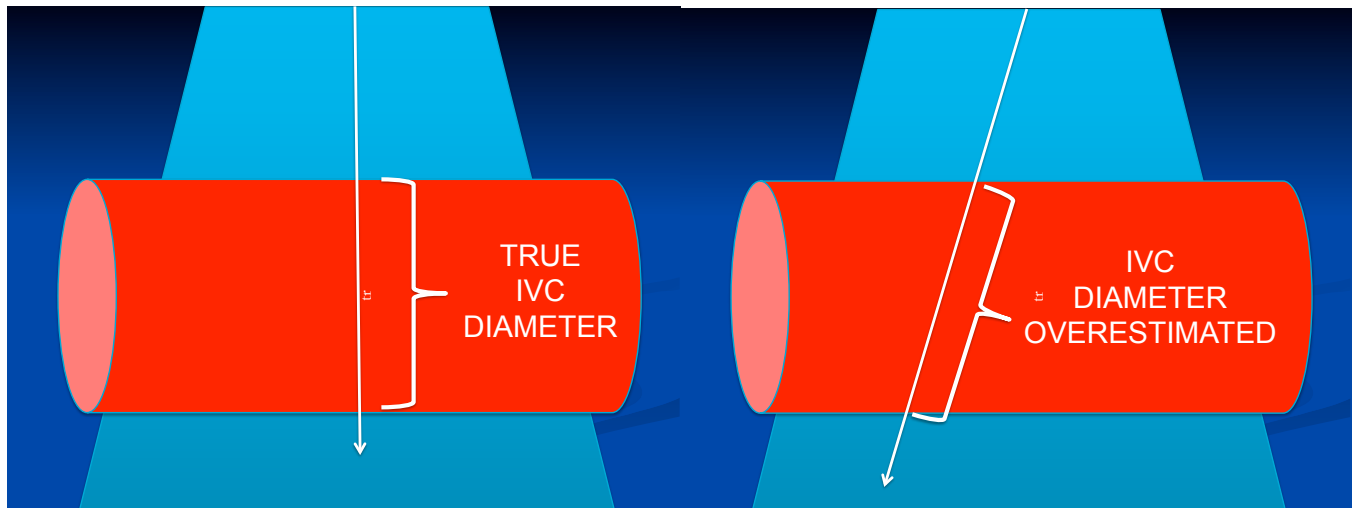


figure. empty IVC (IVCCI 69%) and full IVC (IVCCI 69%)

And if it cuts the IVC at an angle as in the 2nd schematic below, then it will overestimate the IVC diameter and underestimate the IVC collapsibility index. In other words, it will make the IVC appear 'fuller' than it really is.



TOP TIP:

Leave M-mode alone, at least when starting out.

Handy hints and pitfalls

Using the IVC to indicate fluid status is most useful at extremes.

If it's really skinny & collapsing, or if it's really fat and non-collapsing, you can probably trust it.

Beware the 'falsely dry' IVC:

- Excess probe pressure while scanning
- High intra-abdominal pressure (eg abdominal compartment syndrome)

And remember that a big IVC occurs in many conditions:

- intravascular overload
- right heart failure
- any acute or chronic cause of cor pulmonale, e.g:
 - massive PE
 - COPD
 - pulmonary hypertension
- any distal ['downstream'] obstruction to flow: massive PE, tamponade, tension PTX

If the IVC is also difficult to compress by direct pressure with the US probe, then distal obstruction is more likely eg:

- massive PE
- tension pneumothorax cardiac tamponade

Remember how dependent the IVC is on **patient position** [this is why we lie shocked pregnant patients on their left]. So beware of over-interpretation of your findings!

Keep repeating the scan during ongoing resuscitation: trends are more important than single readings.

Finally, clinical context is everything. For example, a dilated IVC is less meaningful in a patient with chronic right heart failure.

Treat the patient, not the scan.

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