

IVC

'The pro-BNP of ultrasound'

Dr Justin Bowra
Critical Care Ultrasound Course

IVC

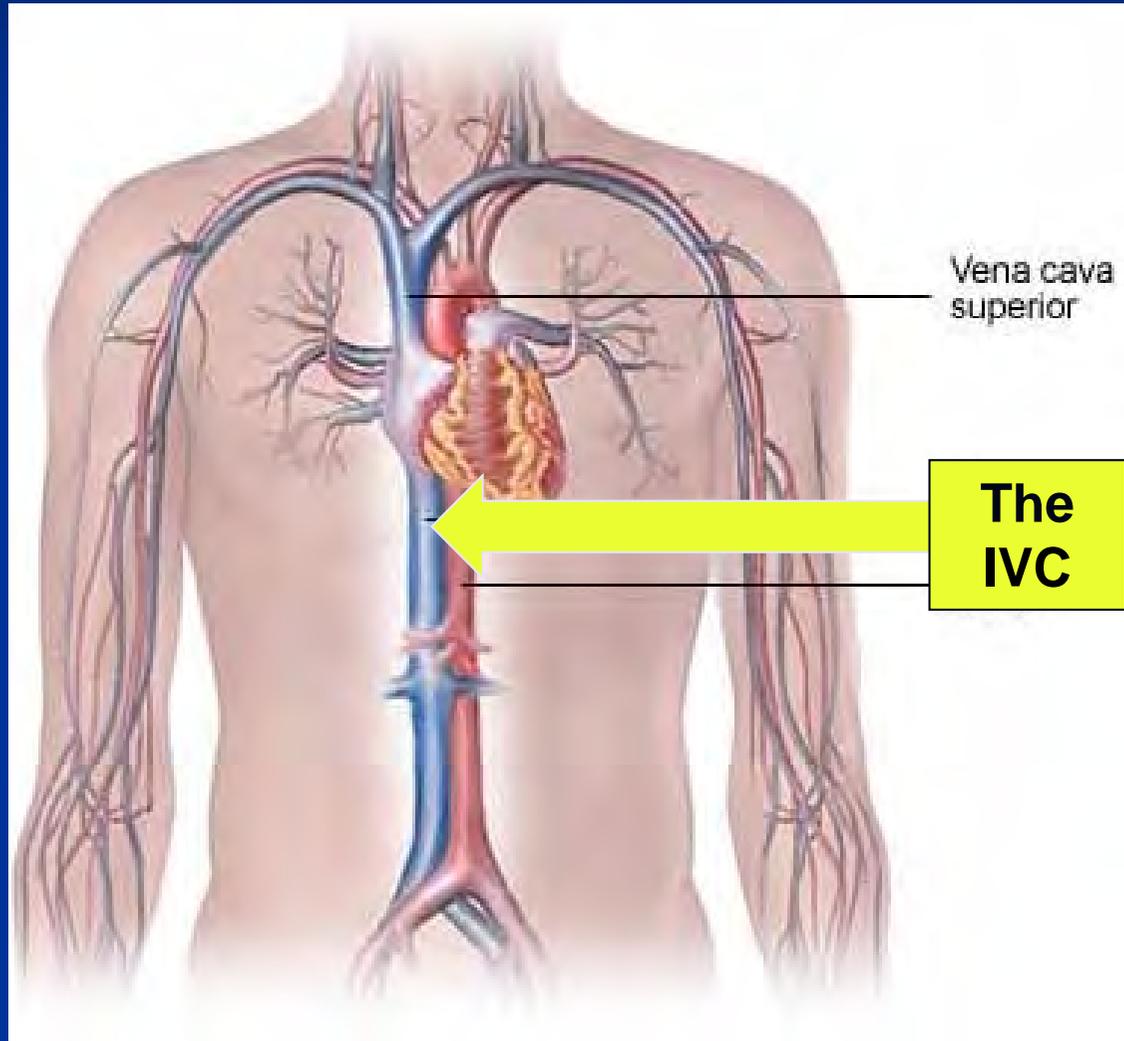
'More an art than a science'

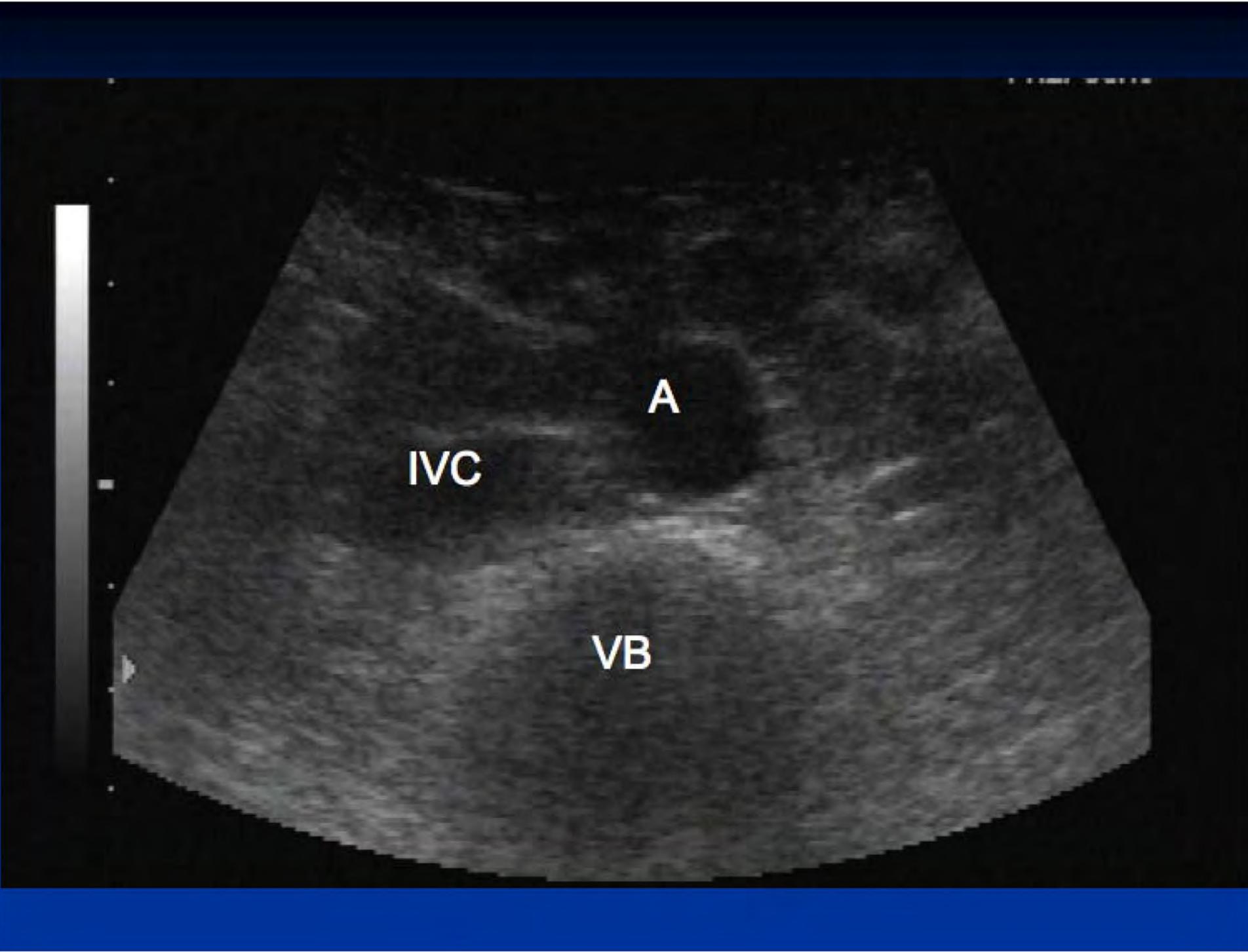
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IVC SUMMARY

- 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

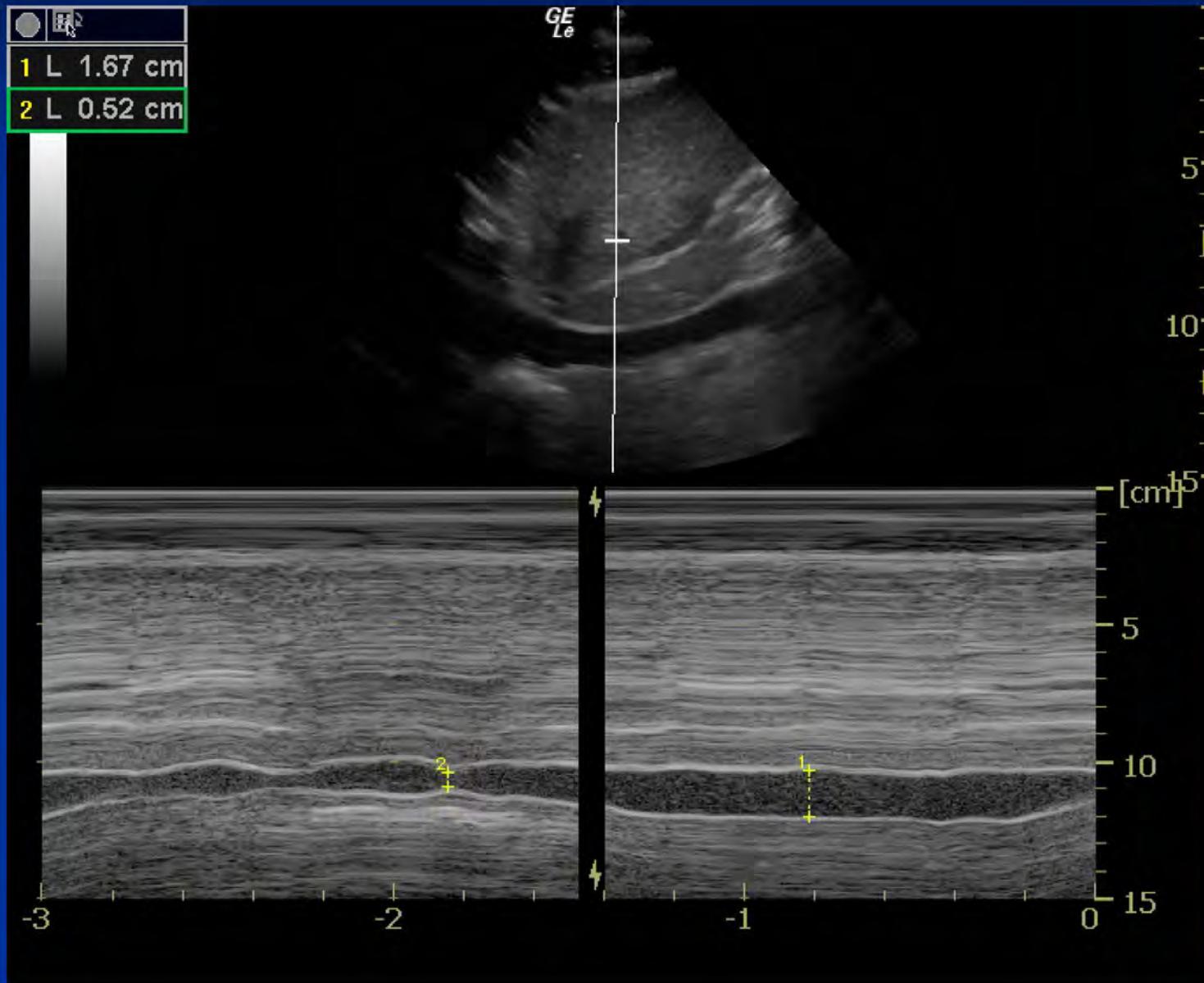
Shape (fat or flat?)

Maximum IVC diameter (IVCD)

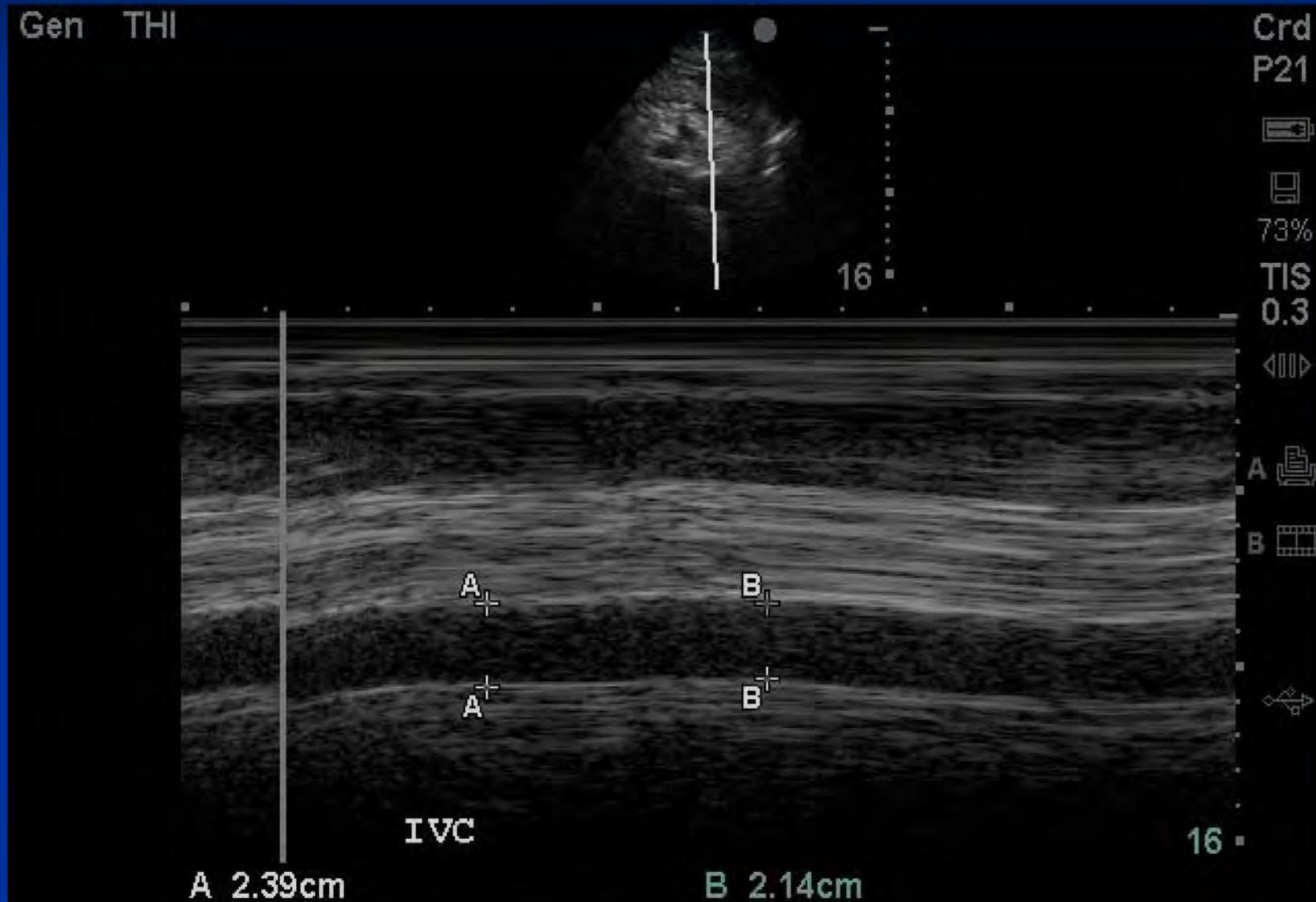
IVC collapsibility index (IVCCI) = $(\text{max} - \text{min}) / \text{max} \times 100$

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.

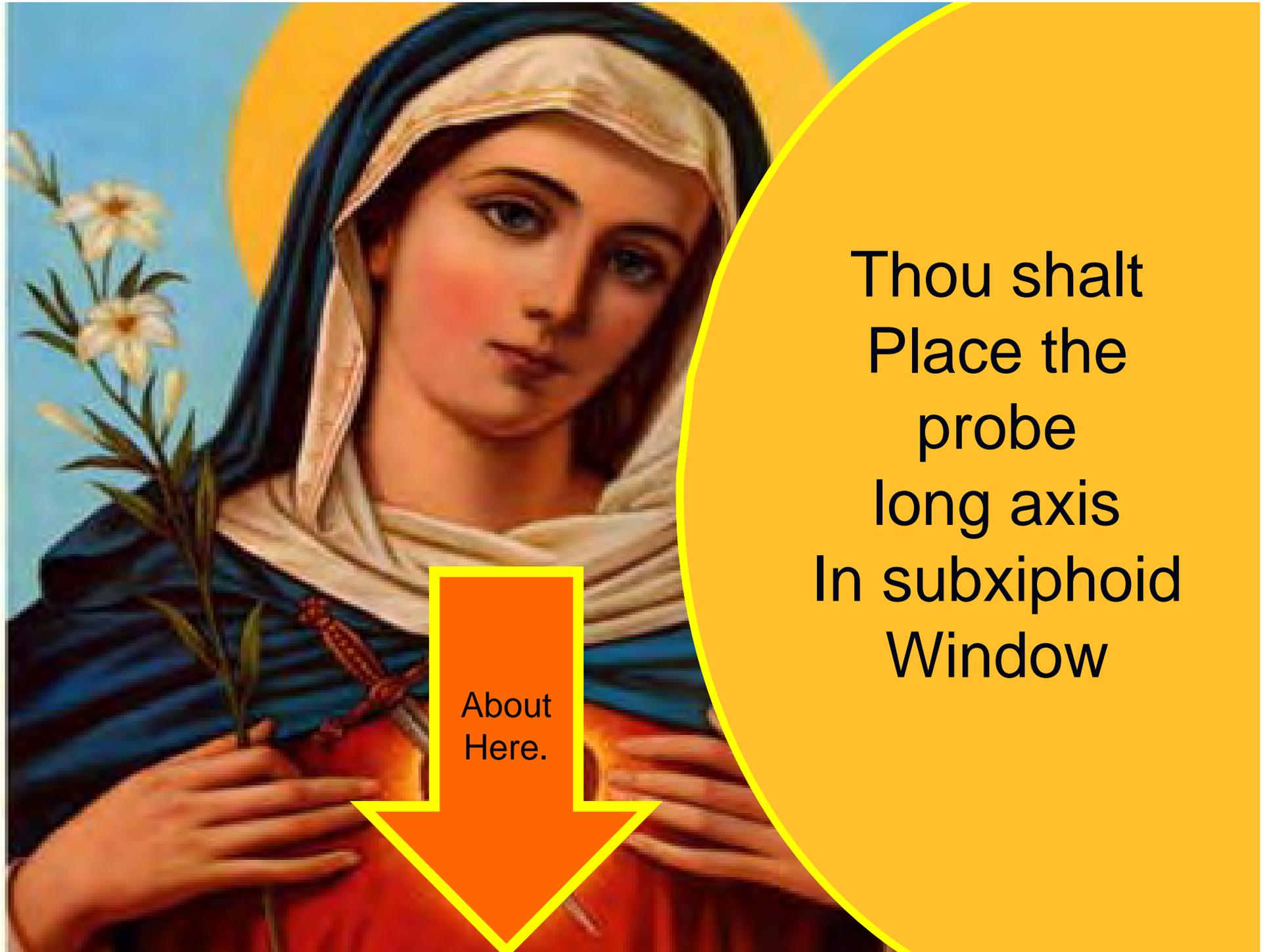
Curved or sector (cardiac) probably OK.

What preset?
No-one knows.

Abdo (FAST) probably beats cardiac preset.

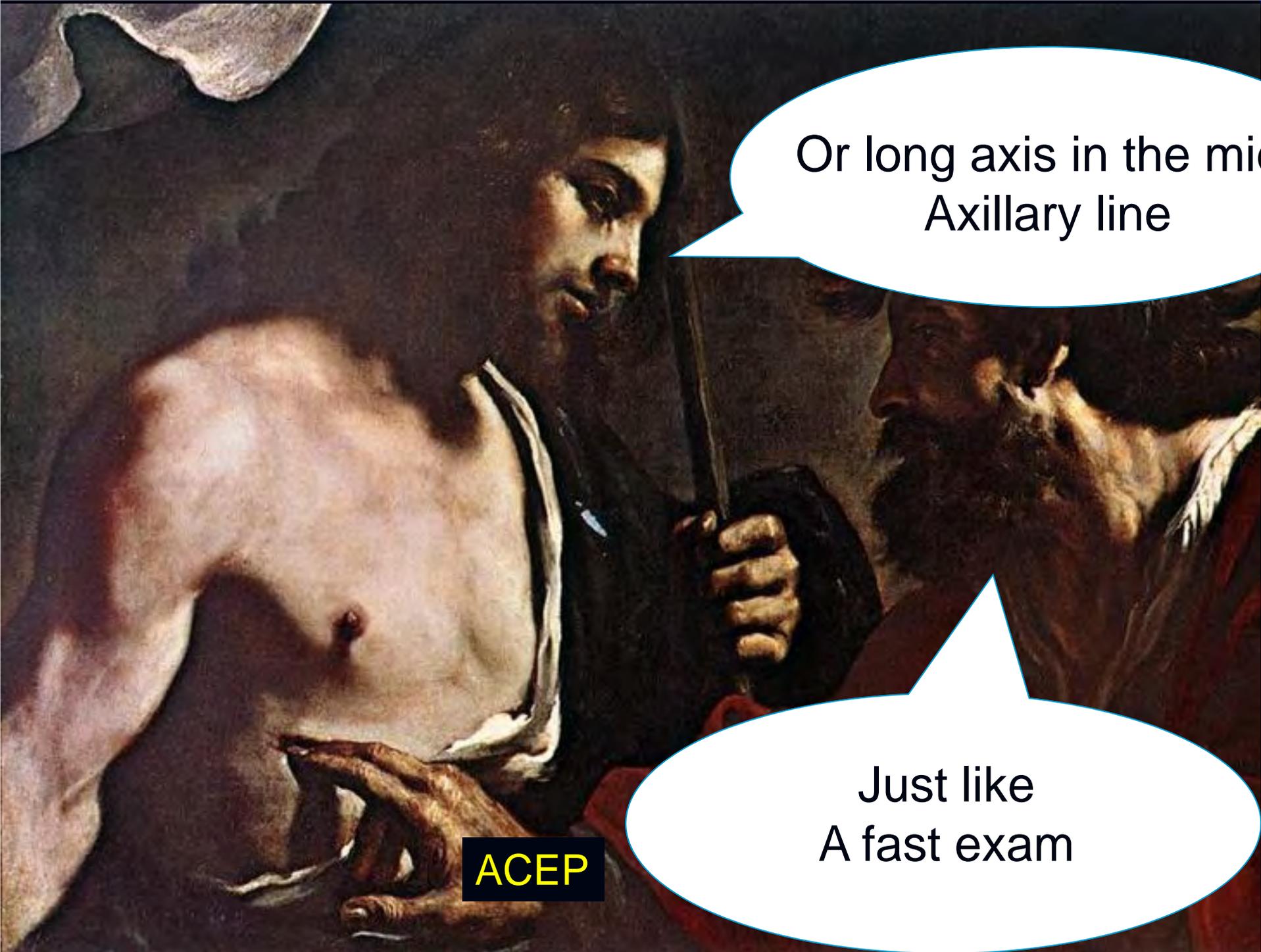
Where should we put the probe?

How should we align it?



About
Here.

Thou shalt
Place the
probe
long axis
In subxiphoid
Window



Or long axis in the mid
Axillary line

Just like
A fast exam

ACEP

Where should we put the probe?

How should we align it?

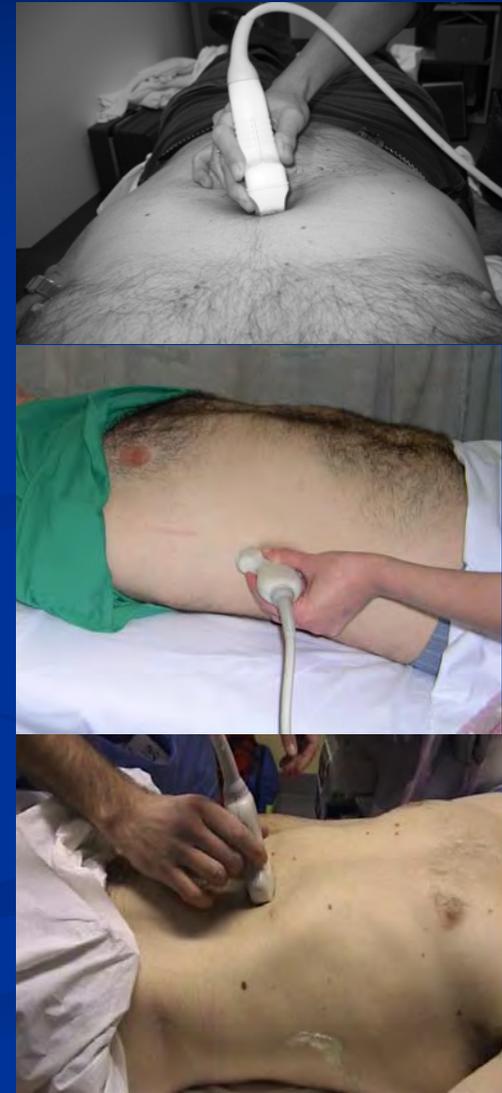
Where should we put the probe?

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



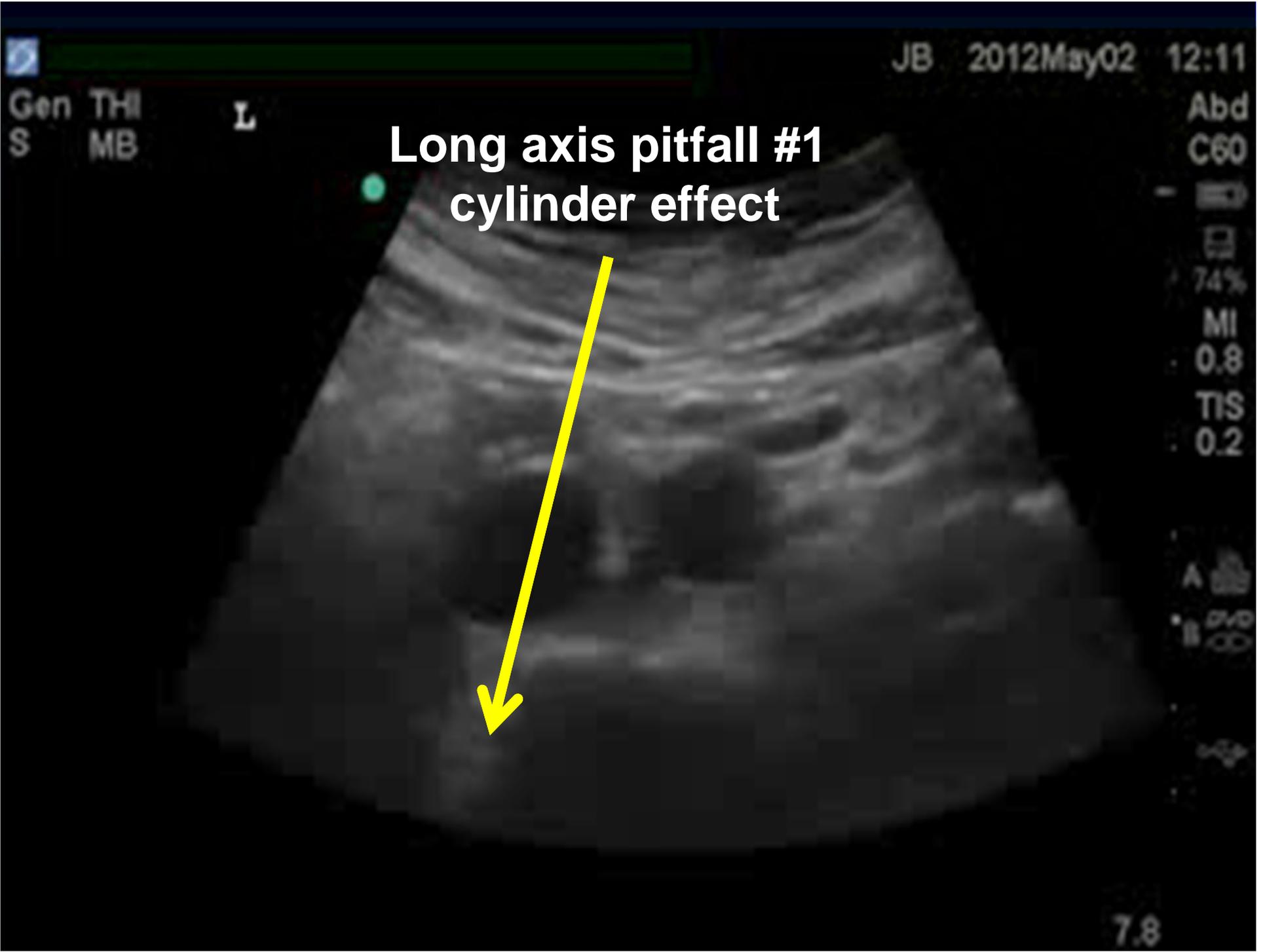
Gen THl
S MB

L

**Long axis pitfall #1
cylinder effect**

Abd
C60
74%
MI
0.8
TIS
0.2

A
B



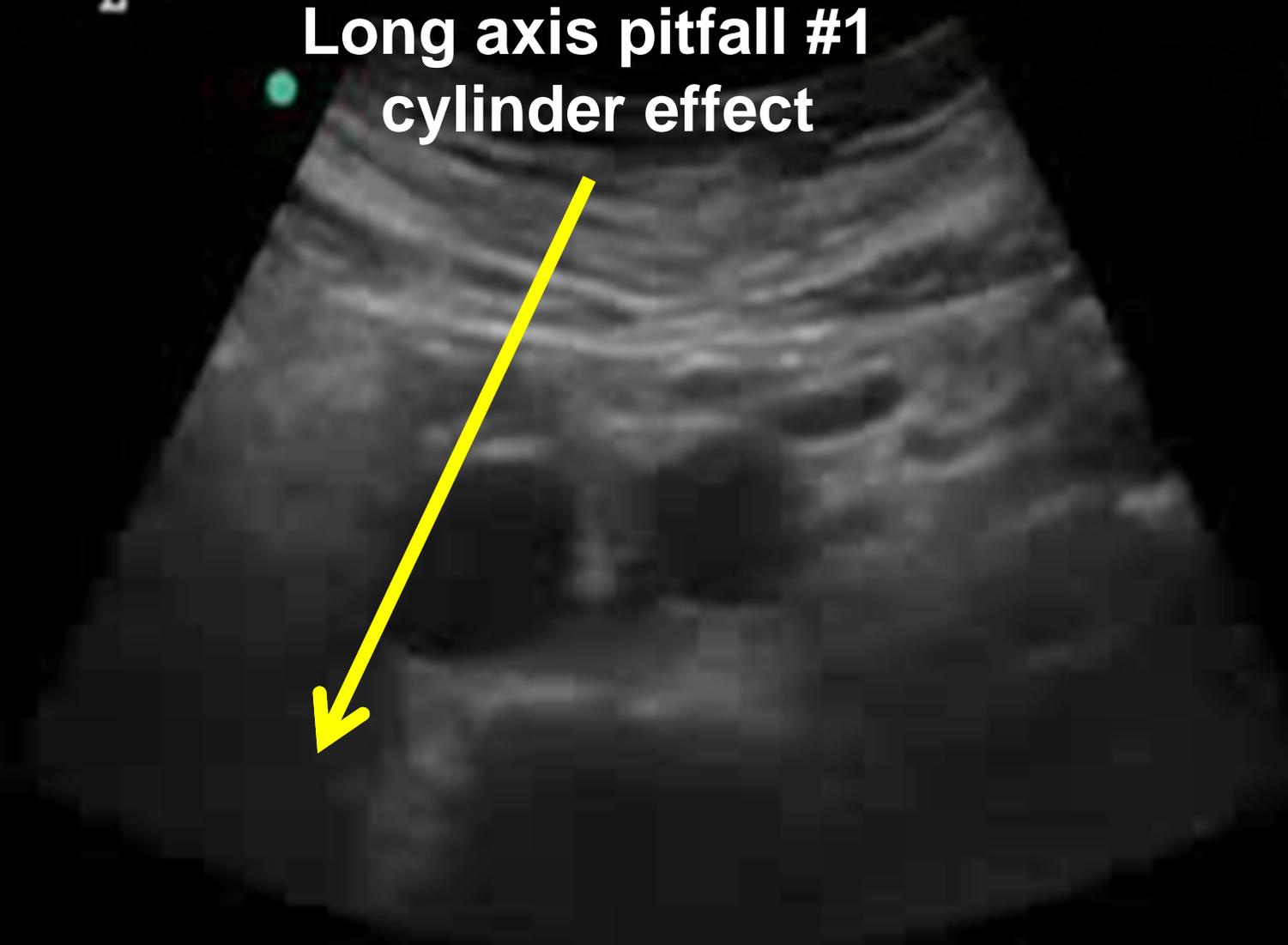
Gen THl
S MB

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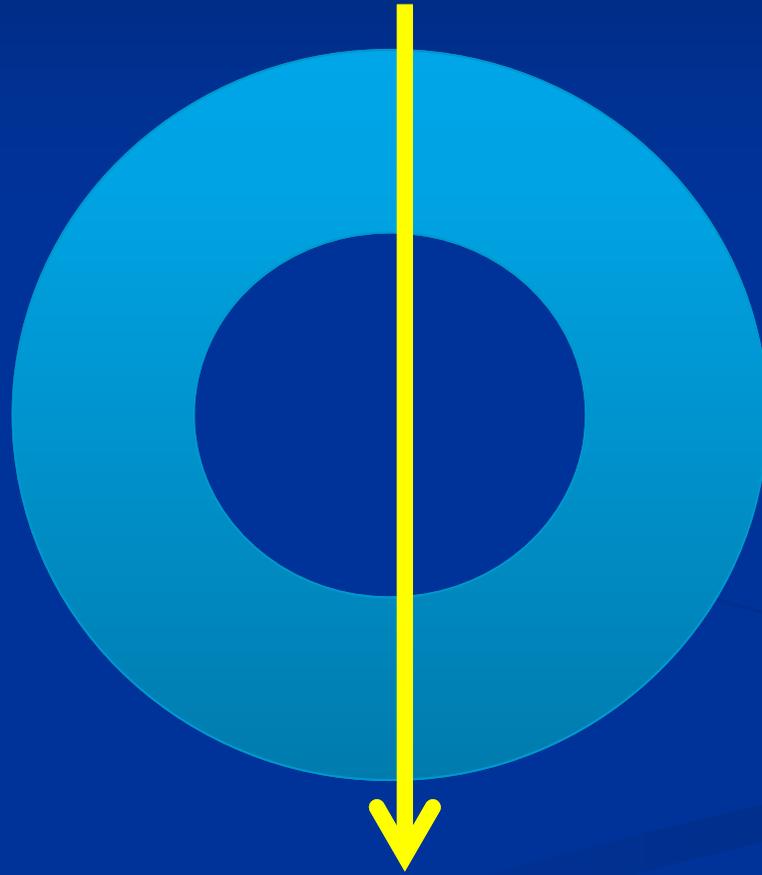
**Long axis pitfall #1
cylinder effect**

Abd
C60
74%
MI
0.8
TIS
0.2

A
B



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

GE
P5

Subxiphoid short axis

0

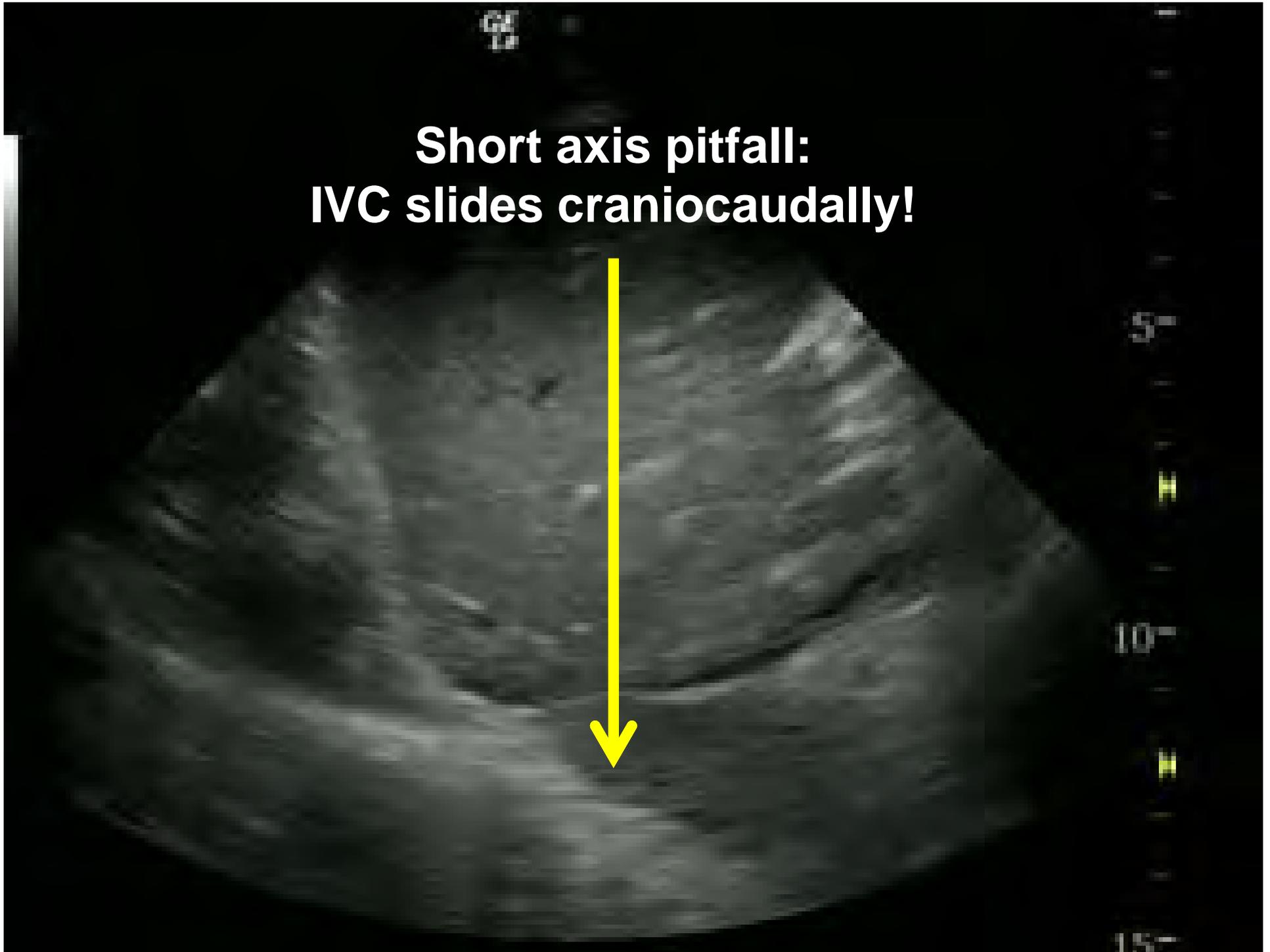
5

10

XX



**Short axis pitfall:
IVC slides craniocaudally!**



Midaxillary long axis: ACEP website recommends as an alternative.





B	CHI
0- Frq	5.0 MHz
- Gn	26
- E/A	2/2
- Map	H/O/O
- D	17.0 cm
- DR	69
- FR	28 Hz
- AO	100 %

5-



10-

15-

L 2.37 cm

GE
P5

B	CHI
0- Frq	5.0 MHz
Gn	26
- EIA	2/2
- Map	H10/0
D	17.0 cm
- DR	69
- FR	28 Hz
- AO	100 %

5-

10-

15-

20-

25-

30-

35-

40-

45-

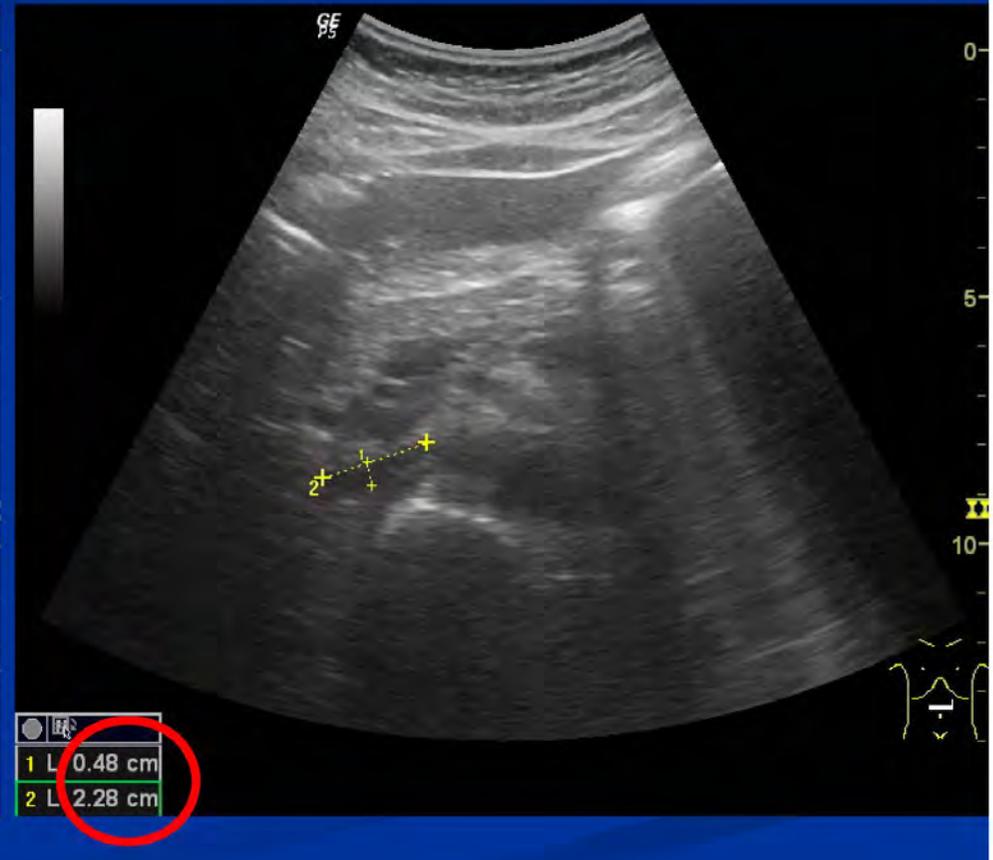
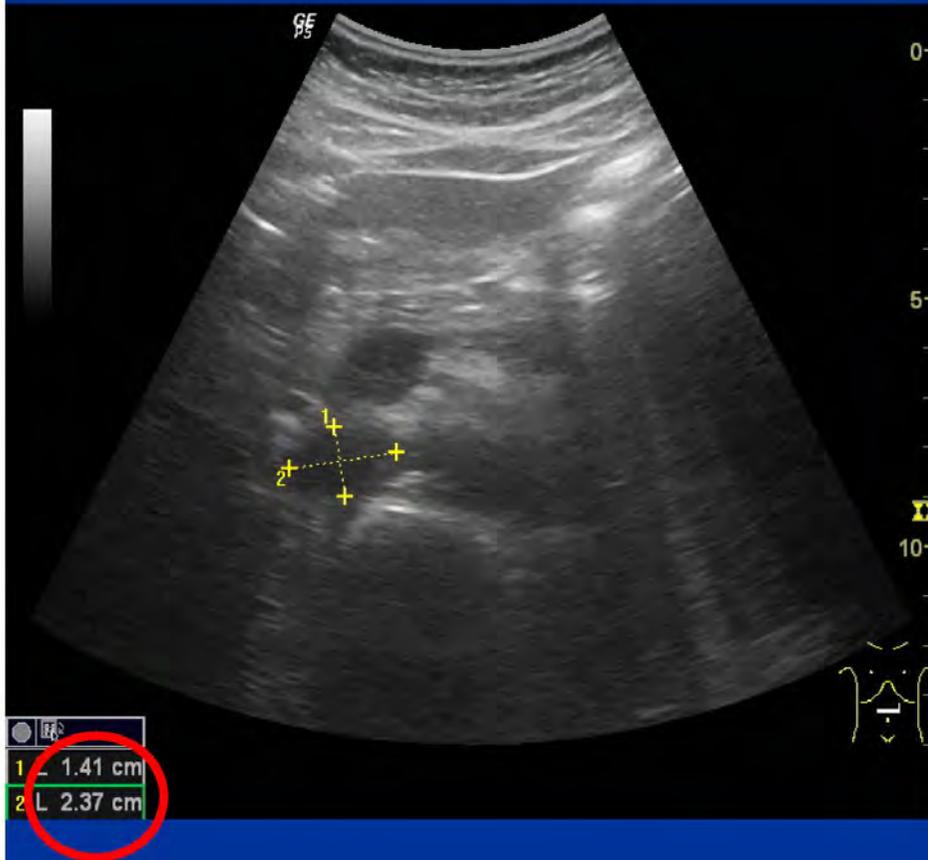
50-

1+

+

L 2.24 cm

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?

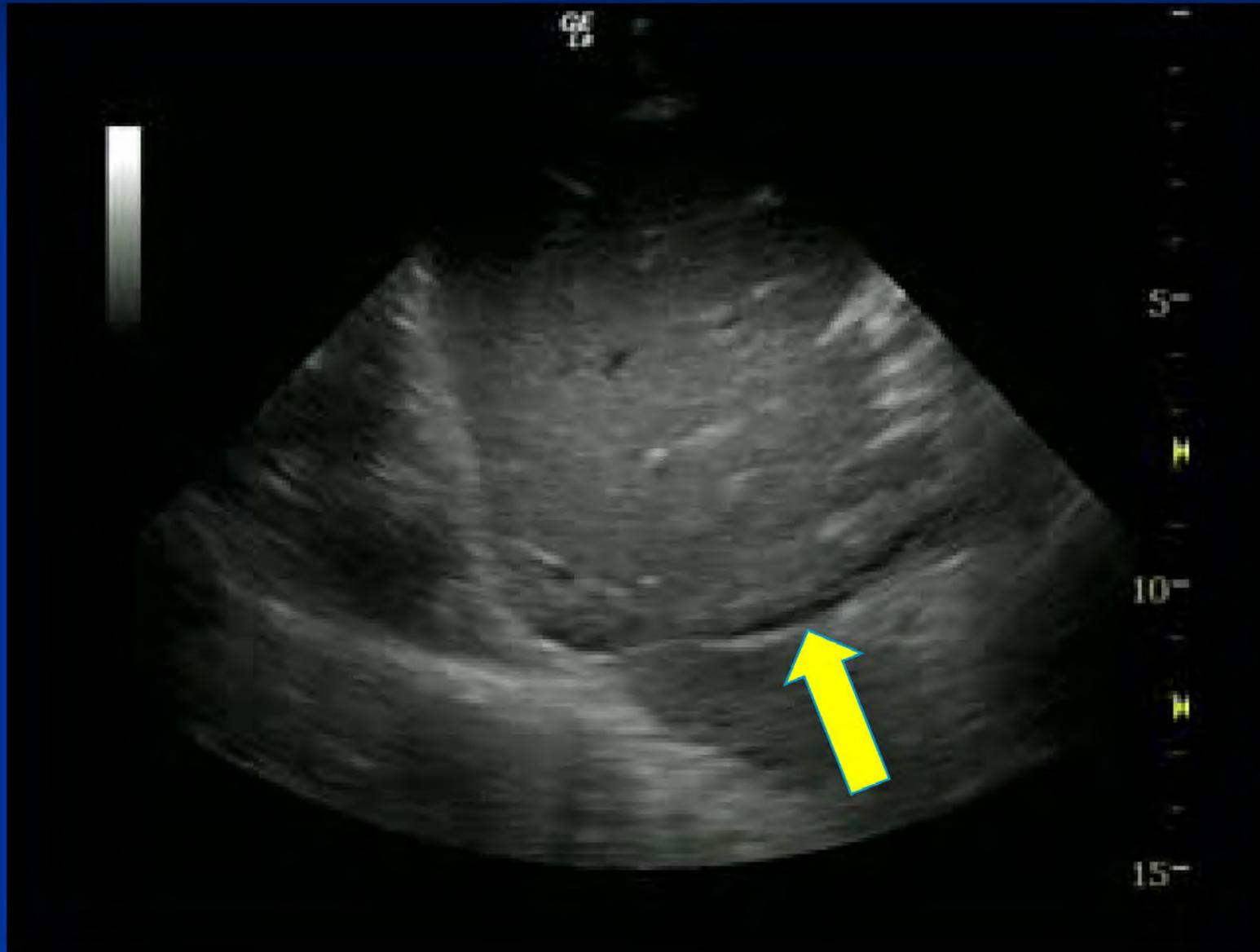


Thou shalt
Measure at the Hepatic vein
confluence

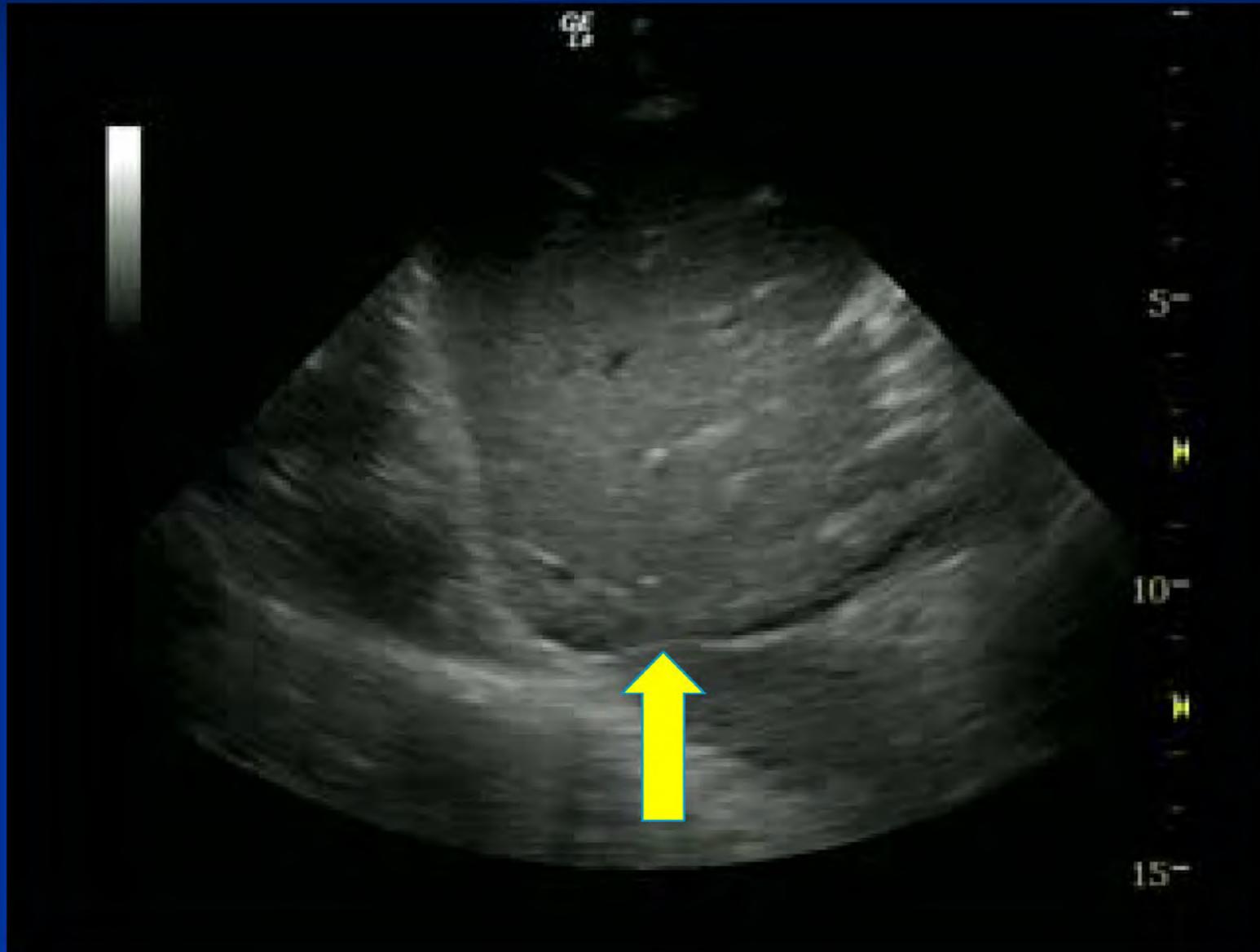
Where should we measure the IVC?

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.

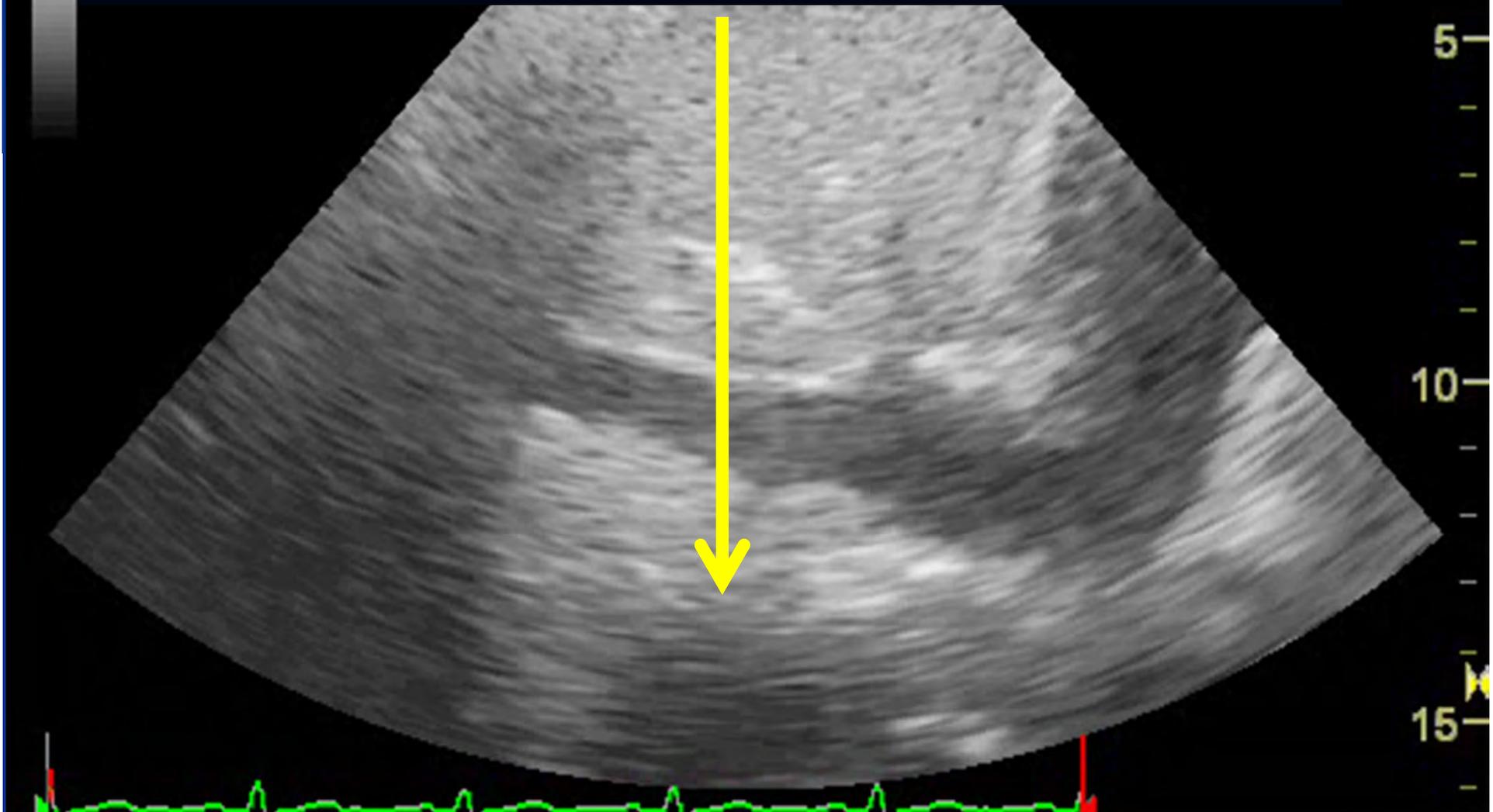
Many experts recommend it.

I like it.

But even experienced users can get the angles wrong...

GE

**M-mode pitfalls:
wrong angle, and IVC moves**

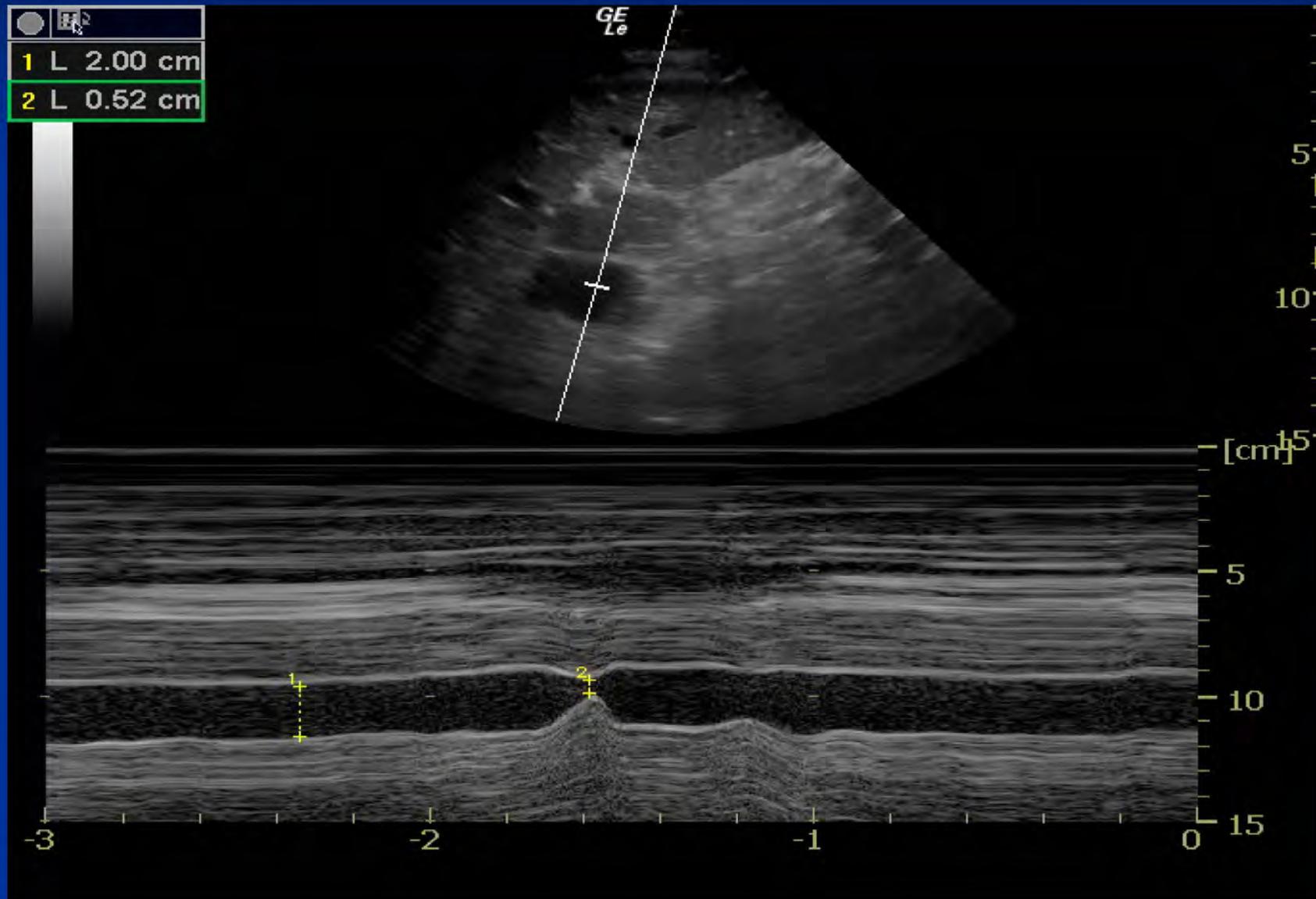


Top tip:

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.



IVC MYTHS

A pair of hands, palms up, holding a glowing white orb. The orb contains the text 'Myth 1: There's an ivc table You can use to predict fluid status'. The background is dark with a reddish glow.

Myth 1:
There's an ivc table
You can use
to predict
fluid status

ASE guidelines 2005

IVC diameter (cm)	IVCCI	Estimated RA pressure (mm Hg)
<1.7	>50%	0-5
>1.7	>50%	6-10
>1.7	<50%	11-15
'dilated'	none	>15

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).

ASE guidelines 2005

IVC diameter (cm)	IVCCI	Estimated pressure (mmHg)
<1.7	none	<6
>1.7	7-10	6-10
'dilated'	none	>15



A pair of hands is shown holding a glowing, spherical crystal ball. The hands are positioned on either side of the ball, with fingers slightly curled. The crystal ball is the central focus, emitting a bright, warm light that illuminates the hands and the surrounding area. The background is dark and textured, possibly a draped fabric. The text is centered within the crystal ball.

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.

A pair of hands, palms up, holding a glowing white orb. The background is dark with a reddish-orange glow. The text is centered on the orb.

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:
 - $IVCD < 0.9\text{cm}$, $IVCCI > 50\%$ (spontaneously breathing)
 - $IVCD < 1.2\text{cm}$, $IVCCI > 18\%$ (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: $IVCD > 2.5\text{cm}$, $IVCCI < 10\%$
- In spont breathing patients: $IVCCI < 15\%$
- Might be 'full tank'
- Might be RA pressure from other causes
 - Chronic cor pulmonale
 - Tricuspid disease
 - Obstruction (PE, PTX, tamponade)

A pair of hands is shown holding a glowing, spherical orb. The orb is bright white and contains text. The hands are positioned on either side of the orb, with fingers slightly curled. The background is dark and textured, possibly a fabric or a wall with some patterns. The lighting is warm, with a reddish-orange glow around the hands and the orb.

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?

In shocked patients:

	IVCD	IVCCI	Correlation
Spontaneously breathing	<0.9cm	>50%	<i>Probably empty / fluid responsive</i>
	?	<15%	<i>Probably full & unresponsive</i>
	Anything else		Dunno
Ventilated	<1.2cm	>18%	<i>Probably empty/ responsive</i>
	>2.5cm	<10%	<i>Probably full/ unresponsive</i>
		Or PE/ PTX/ tamponade	
		Or other stuff that raises CVP	

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)

Dr Adrian Goudie (for that IVC long axis image)

Drs Mike Blaivas, Matt Dawson, Cliff Reid & Scott Weingart
(for their advice & input)

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