


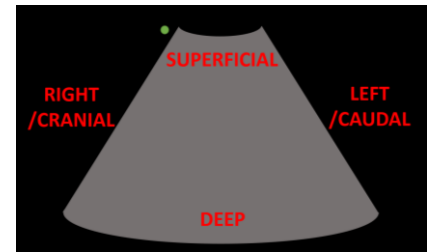
Setting up and adjusting the machine - PPPDFG

Patient <small>Press 'patient' button</small>	<ul style="list-style-type: none"> Press 'patient' button and enter patient details
Probe <small>Select probe (most machines will have three probes)</small>	 <ul style="list-style-type: none"> Linear (high frequency 7-15MHz & high resolution but superficial depth 1-6cm) – for vascular imaging/access, nerve blocks, small parts (e.g. MSK, testes), superficial lung Curvilinear (low frequency 2-5MHz & low resolution but greater depth 10-20cm) – for abdominal/pelvic/obstetric imaging, deep lung Phased/Cardiac (lowest frequency 1-3MHz and lowest resolution but greatest depth and good Doppler) – for echocardiography
Pre-set <small>Press 'pre-set' button to select one</small>	<ul style="list-style-type: none"> On some machines you can pre-set the type of scan you are going to do and the machine will change to the optimum settings for that scan (e.g. abdominal, MSK, O&G, paediatric, small parts, vascular) Only appropriate pre-sets for the probe you have selected will be available
Depth <small>Toggle depth knob or ↑/↓ buttons</small>	<ul style="list-style-type: none"> Start at high-depth to orientate and work more superficial to bring the object of interest into the middle of the screen Depth measurements in cm are shown on the side of the screen
Frequency <small>Toggle frequency knob or ↑/↓ buttons if required</small>	<ul style="list-style-type: none"> Frequency = quality but at the expense of depth i.e. High frequency = high quality but poor depth Low frequency = low quality (i.e. grainy) but greater depth The frequency range is determined by the probe and the machine will automatically select the mid-frequency for the probe (or optimum for the pre-set scan) you select, so you generally don't need to worry about changing it If you do adjust it, aim to use the highest frequency that will allow you to see reasonably at the required depth Note some machines will just have three modes of frequency: 'resolution' (high frequency), 'general' (medium frequency) and 'penetration' (low frequency)
Gain <small>Toggle gain knob or ↑/↓ buttons</small>	<ul style="list-style-type: none"> Gain = brightness Toggle so that fluid is black, soft tissues are mid-grey and some bits of the image are white Some machines will have different gain knobs/buttons for 'near', 'middle' and 'far' so you can change the brightness of different parts of the image



Orientation

- Positioning
 - Procedural ultrasound: line up everything in a row 1. You, 2. Probe and patient, 3. Screen
 - Abdominal ultrasound: traditionally scan standing on the patient's right side (like you would examine them) while looking towards the screen, which should be at the head of their bed
- Markers
 - The probe marker (a dot on the probe) should be orientated towards the **patient's right side** (transverse) or their head (longitudinal)
 - This probe marker corresponds a screen marker on **the left of the screen**
 - The probe marker should be on the same side as the screen marker when scanning in transverse orientation (you can touch the edge of the probe to orient yourself)
 - EXCEPTION = CARDIAC PROBE: the cardiac probe marker should be on the patient's left side and the screen marker is on the right side of the screen (the screen marker changes sides when you select the cardiac probe)
- Image screen orientation
 - Transverse probe position: like CT and MRI imaging, axial slices of the patient are shown as if you are looking towards the patients head from the foot of the bed while they are lying supine (i.e. their left is on your right and vice versa)
 - Longitudinal probe position: sagittal/coronal slices of the patient are shown with the left of the screen (with screen marker) displaying more cranial tissues
- Depth
 - The top of the screen (apex of a curvilinear image) is superficial and the bottom of the screen (wide base of a curvilinear image) is deep



Using the probe

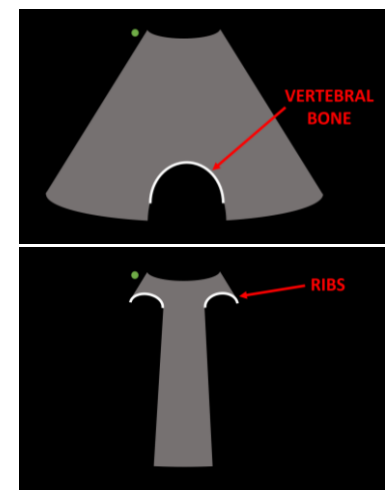
- Hold the probe with the thumb and three fingers and rest the little finger and ulnar border of the arm on the patient to stabilise
- Start off using big, bold movements to find what you're looking for
 - Transverse slide: with the probe in transverse orientation, slide it down/across
 - Longitudinal slide: with the probe in longitudinal orientation, slide it down/across
- When you've found it, keeping the foot print of the probe in the same place, use small fine movements to adjust image angle
 - Fan: angle probe slightly side to side along the big axis
 - Tilt: angle probe slightly side to side along the small axis
 - Rotate: from transverse to longitudinal and vice versa, keeping what you're looking at in the middle of the screen
- Exploring the organ – must scan in two planes
 - View the organ by fanning through it in transverse and longitudinal planes

Tips for getting the best images

- Use lots of gel
- Press hard
- Use a darkened room
- Ensure the probe is perpendicular to the skin (less energy lost)
- If there is bowel gas getting in the way, press hard to try and move it

Viewing the image

- Colours
 - Black – fluid (including blood, urine etc)
 - Grey – tissue
 - White – bone (but USS cannot penetrate bone, so it appears as a bright-white, fine, single line with everything below it black)
- Air distorts the whole image below and is the enemy!
- Be aware of artefacts (acoustic shadows behind hypoechoic objects; acoustic enhancement behind hyperechoic objects; reverberation behind strong reflecting surface; mirror images)



Saving and measuring

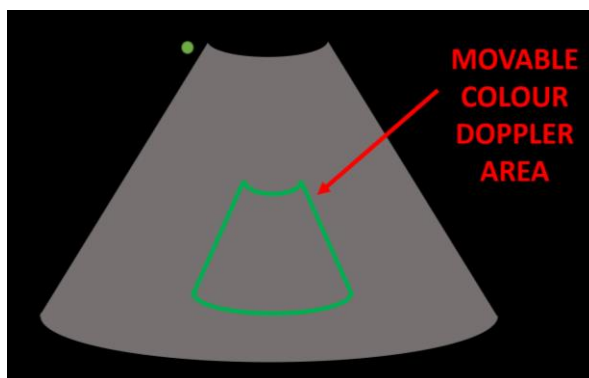
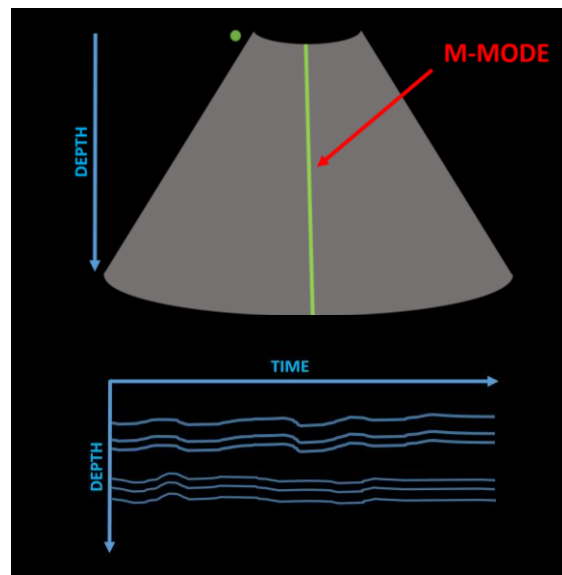
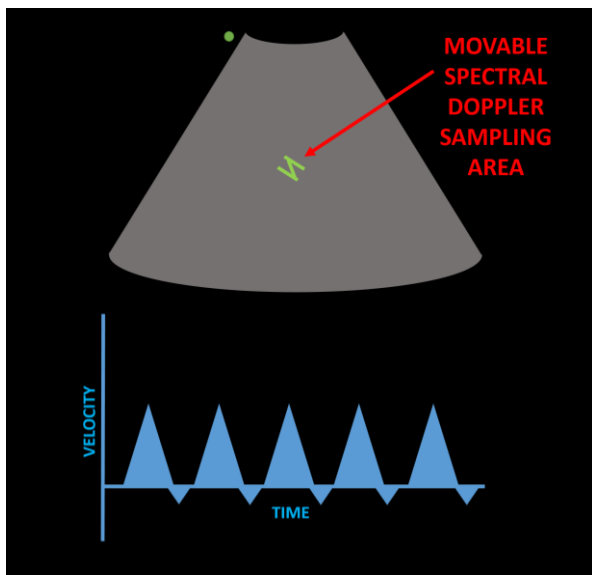
- Press 'freeze'
- To save an image
 - Press 'save'
 - Press 'text' and label the organ/view (e.g. distal aorta) and the probe orientation (LS = longitudinal; TS = transverse; LX = long axis; SX = short axis)
 - You should save images for all scans to prove what you have seen

- At the end of the scan, when you press 'end scan' the saved images will be stored and can be exported
- To measure something
 - Press 'caliper'
 - An X will appear on the screen – move this to one end of the object you want to measure and press 'select'
 - A second X will then appear on the screen – move this to the other end of the object and press 'select' again
 - The distance between will be shown on the screen
- Press 'B-mode' or '2D' to return to scanning

Scan modes

- 'B-mode' or '2D' (brightness) = standard 2D pixel mode described above
- 'M-mode' (motion) = displays the motion along a single line of the ultrasound screen with time, displayed in a wave-like pattern on a graph
 - Commonly used in echocardiography to assess valve movement
 - The line can be moved with the machine arrows/touch screen
 - The depth on the graph corresponds to the B-mode image depth
- D-mode (Doppler) = measures blood flow
 - Spectral/pulse-wave Doppler ('Doppler') – sound and graph produced from echos from moving red blood cells at a selected point of a B-mode image (usually used to confirm a vessel is an artery/vein)
 - Colour Doppler ('Colour') – adds colour to selected area of a B-mode image (red = blood flow towards probe; blue = blood flow away from probe)
 - Power Doppler ('Power') – adds colour to selected area of a B-mode image (any flow appears red/orange, whatever the direction; colour intensity is proportional to strength of Doppler signal) – *more sensitive and less interference but can't tell direction*

The Doppler selection area can be moved with the machine arrows/touch screen



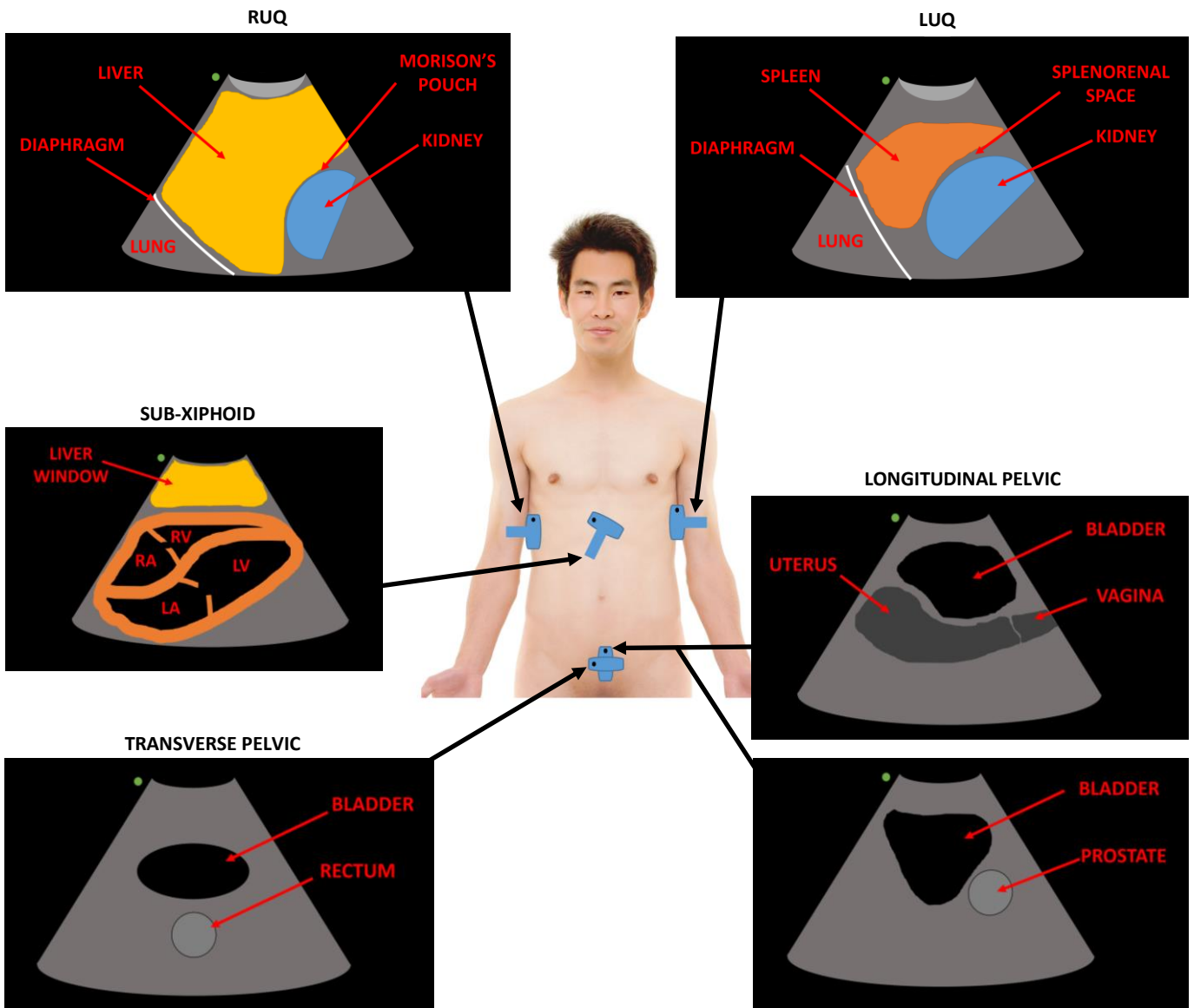
Bedside Ultrasound Scans

FAST scan

Curvilinear probe (~15-20cm depth)

4 views to look for free fluid in dependant areas after blunt or penetrating torso trauma:

1. **RUQ (MORISON'S pouch)** – coronal plane in right mid-axillary line (between 11th/12th ribs)
 - Most dependant part of the upper peritoneal cavity
 - Look for free fluid (a black stripe) between the liver and kidney
 - For this view, use you right fingers underneath the probe, right thumb above and rest your radial forearm border on the patient to stabilise
 - For the RUQ and LUQ views, the rib shadows often get in the way, so try tilting the cranial end of the probe slightly posteriorly to align the probe with the intercostal space
2. **LUQ (splenorenal space)** – coronal plane in left posterior-axillary line (between 10th/11th ribs)
 - Similar position to the RUQ but half a probe length more superiorly and further posteriorly (because the left kidney is further superior and posterior than the right as the liver is not displacing it)
 - Look for free fluid between the kidney and spleen
 - Blood also commonly collects above spleen
3. **Pelvic** – transverse then longitudinal plane 4cm superior to symphysis pubis (with the probe angled inferiorly)
 - Most dependant part of the lower peritoneal cavity
 - Look for free fluid outside bladder (around bladder, rectum and retrovesical pouch/Pouch of Douglas)
4. **Sub-xiphoid** – transverse plane in sub-xiphoid region (aimed towards heart)
 - Press probe hard into the sub-xiphoid region aimed extremely superiorly and slightly to the patient's left side
 - Look for pericardial effusion



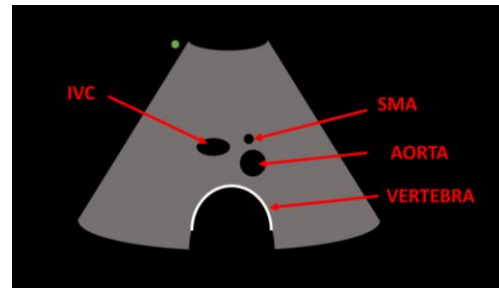
AAA scan

Curvilinear probe (~10-20cm depth)

- Start superiorly in the epigastrium in transverse plane
- Identify the anterior bright-white line of the vertebra posteriorly
- Identify aorta anteriorly and to the left lateral side of the vertebra
- Differentiate between the aorta and IVC
 - Aorta: left, thick wall, non-compressible, pulsatile, arterial waveform on spectral Doppler, anterior vessel branches
 - IVC: right, thin wall, collapsible, transmitted pulsations, no anterior vessel branches

If there is any bowel gas, try pressing hard to move it

- Transverse view
 - Assess along the whole length of the aorta in transverse section
 - Look for aneurysms (>3cm is abnormal), atheroma and ectasia
 - Measure aortic wall (outer intima to outer intima) of the widest part in A-P (including any thrombus)
- Longitudinal view
 - Assess along the length of the aorta in longitudinal section



Lung scan

Linear probe (~5cm depth)

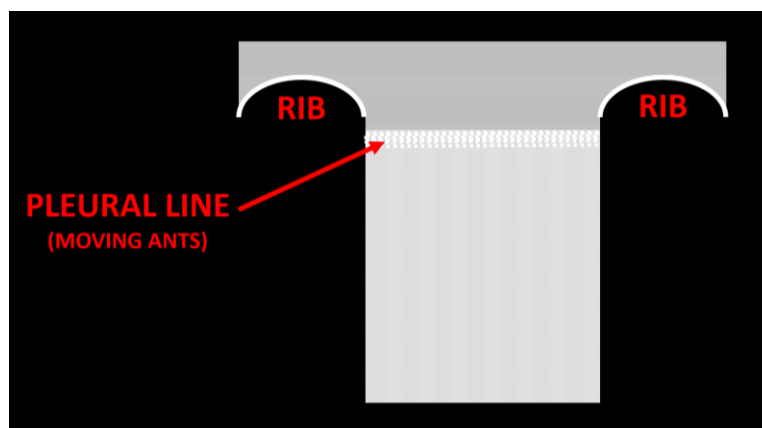
Uses artefacts to look for pneumothorax or pulmonary oedema

Pneumothorax

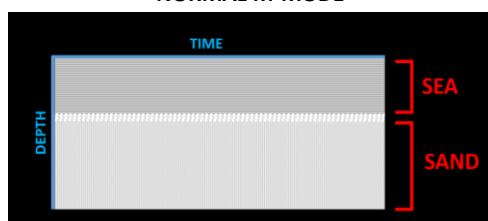
- Position probe in longitudinal plane between 2nd/3rd or 3rd/4th ribs anteriorly
- Look for the pleura deep to the intercostal muscles and ribs
- **2D:** you should see a horizontal white line which looks as if ants are crawling in it (this is the two pleura rubbing against each other) – this is absent in a pneumothorax
- **M-mode:** next use M-mode to look inbetween the rib shadows; the pattern made should look like sea at the top of the image and sand at the bottom of the image – in pneumothorax, the whole image looks like sea
- Ultrasound can say if there is or is not a pneumothorax but cannot tell anything about the size

Pulmonary oedema

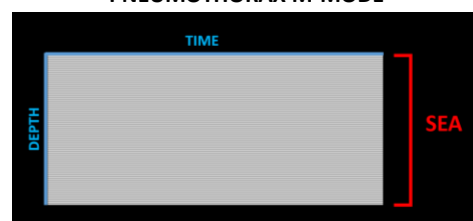
- With probe in same position in 2D mode, look for B-lines (vertical black lines from pleura to bottom of screen)
- Intensity and quantity of B-lines is proportional to extent of pulmonary oedema



NORMAL M-MODE



PNEUMOTHORAX M-MODE

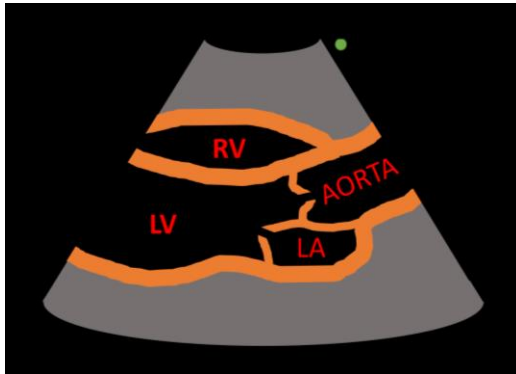


Cardiac scan

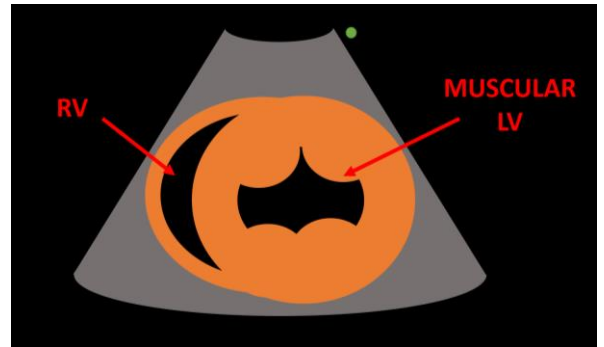
Phased probe (~20cm depth) – remember the probe and screen markers are on opposite sides to the other probes

4 major views:

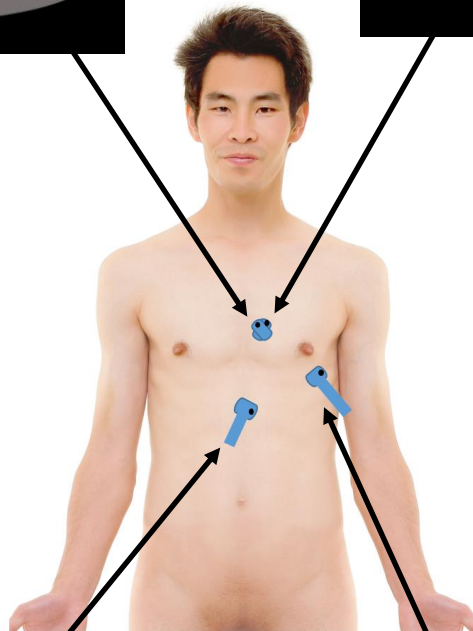
- **Parasternal long axis:** probe just to the left of the sternum (~3rd/4th intercostal space) with the probe marker pointing to the patient's right shoulder
- **Parasternal short axis:** same but rotate so probe marker is pointing to the patient's left shoulder. Fan probe up/down to get 3 sagittal slices
 1. Aortic valve
 2. Mitral valve
 3. Papillary muscle
- **Apical:** probe at cardiac apex
- **Subcostal:** press transverse probe hard into the sub-xiphoid region aimed extremely superiorly and slightly to the patient's left side



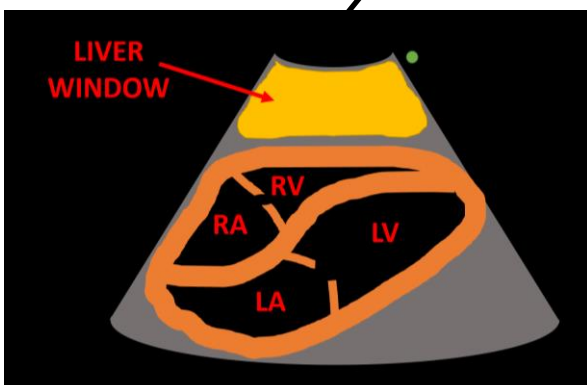
PARASTERNAL LONG AXIS



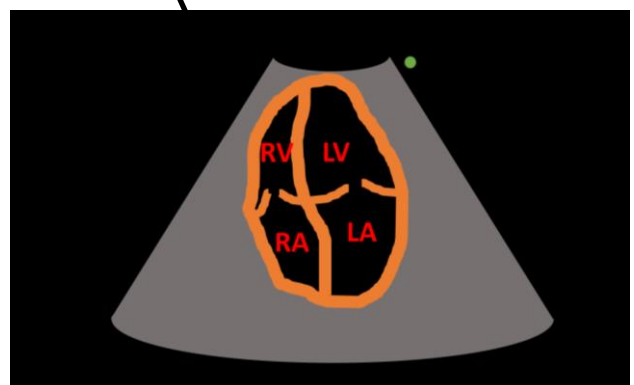
PARASTERNAL SHORT AXIS



SUBCOSTAL



APICAL



IVC scan

Curvilinear probe (~10-20cm depth)

- Start superiorly in the epigastrium in transverse plane
 - Identify the anterior bright-white line of the vertebra posteriorly
 - Identify aorta anteriorly and to the left-lateral side of the vertebra
 - Now find the IVC to the right of the aorta
 - Differentiate between the aorta and IVC
 - Aorta: left, thick wall, non-compressible, pulsatile, arterial waveform on spectral Doppler, anterior vessel branches
 - IVC: right, thin wall, collapsible, transmitted pulsations, no anterior vessel branches
- If there is any bowel gas, try pressing hard to move it*
- Longitudinal view
 - Look at the patency of the IVC
 - Flat (ribbon shaped) = hypovolaemia, shock
 - Normal (kissing contact of walls during inspiration)
 - Distended >2cm (sausage shaped) = right heart strain (PE, tamponade, right heart failure)
 - Compressibility index = max diameter in expiration – max diameter in inspiration
 - This estimates central venous pressure
 - You can use M-mode to help calculate it

Peri-arrest shock scan

A composite of all of the above scans

FLAPMI

- Free fluid (abdominal FAST scan, pleural)
- Lung (pneumothorax)
- Aorta (AAA)
- Pericardium (effusion, haemopericardium, tamponade)
- Myocardium (chamber size, contractility)
- IVC (collapsibility, engorged)

In cardiac arrest, the parasternal long axis cardiac view can be performed during a pulse check to look for tamponade and heart contractility

Vascular access

Linear probe (~3-5cm depth)

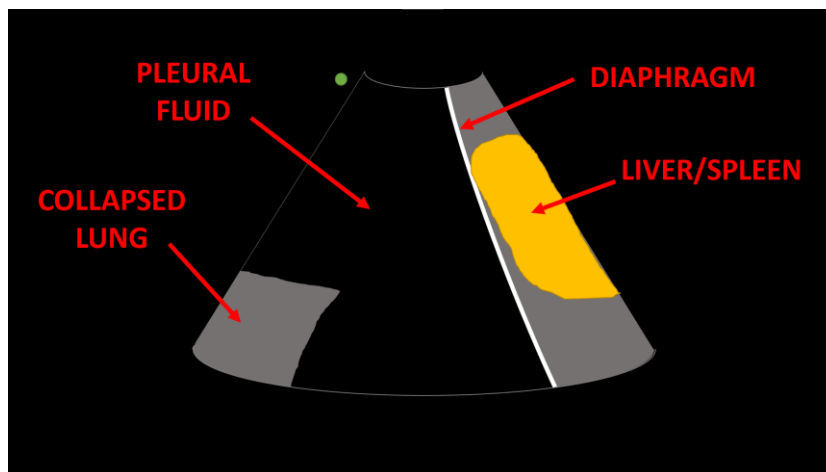
Can be used for central lines (internal jugular/femoral) or peripheral lines

- Need sterile probe cover and sterile gel for central line
- Can be done with 1 person (probe in one hand, cannula in other) or 2 people (one to hold probe, other to insert line)
- Approaches
 - Transverse – view of vein and all surrounding structures but difficult to see needle (tip will appear as bright dot when in view and can't be visualised all the way but you can see soft tissue movement by pressing the needle ('tenting the tissue'))
 - Longitudinal – more technically challenging due to narrow beam width, but can see whole needle on the screen
- Identifying vessels
 - Appear as black dots in a transverse view
 - Longitudinal view can be used to assess vessel orientation and length
 - Colour Doppler may be used to help identify vessels
 - Artery vs vein
 - Arteries: pulsate, non-compressible
 - Veins: non-pulsatile, compressible
- Technique
 - Transverse view:
 - Ensure the vein is directly in the middle of the screen so you know where to aim for with the needle
 - Needle should be inserted at 45° and the insertion point is the same distance distal to the centre of the probe as the depth of the vein
 - You can move or tilt the probe to follow the needle tip
 - Flatten the needle once you are in the vein and advance the cannula/wire
 - Longitudinal view:
 - Insertion point is as close to the probe as possible
 - A more superficial angle can be used
 - Keep the needle exactly in line with the middle of the longitudinal probe and you can follow it down on the screen

Pleural drainage

Linear or curvilinear probe (~10-15cm depth)

- Position patient sat on side of bed with arm crossed leaning on table
- Scan inbetween the ribs (as USS can't see through bone)
- Use a longitudinal probe orientation and identify the liver/spleen, heart (if left side), diaphragm, collapsed floating lung and pleural fluid
- Look for the 'Quad sign' – a quad image between the ribs shadow superiorly and inferiorly, the pleural line superficially and the lung line deeply
- Mark insertion point
 - Ensure it is well away from heart
 - A large pocket of fluid
 - Beware of loculations in pleural fluid
- Ideally perform procedure under direct ultrasound visualisation; however, if using an X-marks the spot approach, ensure the position of the patient does not change
- See [pleural aspiration](#) and [pleural drain](#) for procedural guidance



3-point DVT scan

Linear probe (5cm depth)

- Position patient lying supine with their hip externally rotated and knee flexed (**common & superficial femoral veins**)
 - Start in the groin and identify the femoral artery (lateral) and vein (medial) – the vein should be collapsible and non-pulsatile
 - Follow the common femoral vein and then superficial femoral vein down
 - Check the compressibility of the vein by pressing down with the probe every couple centimetres
 - You will not be able to follow the vein further when it enters the abductor canal
- Ask the patient to lie on their front with their legs straight (**popliteal vein**)
 - Starting distally in the popliteal fossa, find the popliteal artery (deep) and vein (superficial)
 - Follow the popliteal vein up
 - Check the compressibility of the vein by pressing down with the probe every couple centimetres
 - You will not be able to follow the vein further when it enters the abductor canal ~5cm superior to the popliteal fossa

Other scan uses

- Foreign bodies
 - Can see wood, plastic, graphite
 - May be identified by artefacts (shadowing, comet tails, reverberation, halo-oedema)
 - View them in 2 planes
 - You can insert needles in 2 planes to mark their position for removal
- Abscess characterisation and drainage
- Look for gallstones
 - Probe in longitudinal plane, in the right side of the patient's epigastrium
 - Identify the hyperechoic gallbladder and look for stones, sludge, oedema of the wall (cholecystitis) and measure wall thickness
- Look for hydronephrosis
 - Use the RUQ and LUQ views described in the FAST scan above
 - Measure the size of the kidneys (normal length 10-12cm) and look for hydronephrosis