Deep Vein Thrombosis

Imaging of blood vessels is performed primarily for two reasons in the intensive care unit (ICU).
1. To detect deep vein thrombosis (DVT), commonly in the veins of the lower extremities.
2. To guide central venous and arterial cannulation.

DVT is not uncommon in the ICU and it may often not be clinically obvious. It is important to rapidly diagnose DVT, allowing for immediate treatment thus reducing the chances of progression to pulmonary embolism (which is associated with high mortality and morbidity). Sometimes detecting a DVT strengthens a difficult diagnosis of pulmonary embolism.

Ultrasound is quick, non-radiating and can be easily performed at the bedside. This examination has been adapted for use by the bedside in the ICU and is called the ‘Two region compression technique’.

Venous thrombosis can occur in the upper limbs and jugular veins too, but is most common in the lower limbs. Hence the focus is on the lower limbs. The same technique can however be used on upper limb and neck veins as well.

Rationale for the ‘Two region compression technique’

Radiologists traditionally examine the entire lower limb venous system by visualising it from the common femoral vein to the calf veins inch by inch. They also use Doppler to study the blood flow patterns in the veins. This takes a lot of time and needs more skill.

Two region compression technique

In the two region compression technique, only the common femoral vein at the groin and the popliteal vein in the popliteal fossa are evaluated by visualising and compressing the vein. Doppler is not used.

This basic technique achieves a sensitivity of 94% while simplifying and shortening the evaluation for a DVT. This is because it is very rare to have isolated thrombus in a segment of lower limb veins which does not include the groin or popliteal regions. This means that while the two region compression ultrasound is fairly good at picking up DVT, a formal radiology evaluation should be requested if the 2 region test is negative but clinical suspicion still very high.

Probe used

The high frequency linear array vascular probe with a frequency range of 7 to 12MHz (Fig.1) is used for DVT studies. A lower frequency probe such as a 5-10 Mhz microconvex probe (Fig. 2) may be required on overtly obese or edematous lower limbs. Availability of CFI (Colour flow imaging) and PWD (pulsed wave doppler) capabilities is not essential to this technique.

Patient and Probe positioning

The supine position with neutral positioning of the lower limb is adequate for imaging of the common femoral vein at the groin. The limb must be externally...
rotated and mildly flexed at the knee to allow imaging of the popliteal vein (Figure 3 and 4). The probe is placed transversely, i.e. the long axis of the probe foot is perpendicular to the long axis of the vessel being studied. No angulation of the probe is necessary.

Identifying the vein and artery

On the 2D image, the vein and artery appear as a hypo or anechoic lumen surrounded by an echogenic wall. The artery and the vein can be differentiated based on the following characteristics.

1. **Location** - for example, just below the inguinal ligament, the artery is normally placed lateral to the vein. Anatomical aberrations are possible, however and this is not to be depended on.

2. **Shape and pulsatility** - the artery is round while the vein is ovoid. The artery is pulsatile whereas the vein is usually not. The wall of the artery is double lined while the wall of the vein is a single layer.

3. **Compressibility** - On applying downward pressure vertically over the vessels, the muscular wall of the artery resists deformation and stays open, while a non-thrombosed vein gets compressed and the walls meet each other.

4. **Colour flow imaging** - Angulating the transducer slightly downwards and selecting the CFI brings up the colour box, which should be placed to cover both visualized vessels. The artery shows an intermittent pulsatile flow with colour aliasing, whereas the vein shows a gradually undulating continuous flow. Do not go by the colour of the flow (eg. Blue for vein, red for artery), as this can be changed by changing the direction of angulation of the probe.

5. **Pulsed wave Doppler (PWD)** - Selecting the PWD and placing the cursor at the centre of the vessel and obtaining a trace will show a steady gradually changing flow in the vein and sharply accelerating, pulsatile flow in the artery.

Locations studied

**Region 1: groin**
The common femoral vein is visualised just below the inguinal ligament. The artery is located lateral to the vein here (Fig. 5). On sliding the probe inferiorly, the saphenofemoral junction (Fig. 6) can be seen. Further down, the common femoral artery is seen bifurcating into two branches (Fig. 7). Compression is performed both above and below the saphenofemoral junction.

**Region 2: popliteal fossa**
The popliteal vein is identified. The popliteal artery and vein lie next to each other in the upper part of the Popliteal fossa (Fig. 8). In the lower half, the vein is more superficial and appears to be sitting above the
Fig. 6: Sapheno-femoral junction. SFA- Superficial femoral artery, LSV- Long saphenous vein, CFV- Common femoral vein

Fig. 7: SFA- Superficial femoral artery, PFA – Profunda femoris artery, FV – Femoral vein

Fig. 8: Popliteal artery and vein lying side by side

Fig. 9: PV-Popliteal vein lying superficial to the PA – Popliteal artery

popliteal artery (Fig. 9). If the trifurcation of the popliteal vein is seen or if any smaller vessels are seen around the two main ones, then the probe is probably too distal and needs to be moved up.

Compression is performed in the upper and lower halves of the popliteal fossa.

Care must be taken to not apply pressure on the probe when looking for the vein as it may become compressed leading to non-visualisation of the vein. Lymph nodes particularly at the groin sometimes can mimic the appearance of a vein. However, when the probe is slid up and down, the discontinuity of the lymph node gives it away.

LOOKING FOR THROMBOSIS

There are four components in the ultrasound examination of a vein when looking for DVT. These are described below.

1. Compressibility

Normally, the lumen of a vein (that is not thrombosed) will collapse on applying pressure with the probe. Once the vein is identified, downward pressure is applied to the ultrasound transducer until the vein collapses completely on the ultrasound screen. **If the vein is not collapsing, it indicates the possibility of thrombus within the lumen of the vein.** A partial thrombus will result in the vein being only partially compressible. The amount of pressure required to collapse the vein will differ from patient to patient, and with experience; the sonologist will be able to ascertain if enough pressure...
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has been applied. Care must be taken, because downward pressure at the wrong angle or down the wrong vector can greatly decrease the actual pressure felt by the vein and make it appear uncompressible. As the vein lumen disappears and the walls meet each other, pressure on the transducer is relaxed and the vein allowed to take its normal shape again.

Compressibility indicates a lack of thrombus in the vein at the location being compressed, and hence for a complete study, the entire vein will have to be sequentially compressed along its entire length. However, it is enough to limit oneself to performing this test at the two designated locations described above and use other techniques to assess the rest of the segments.

The examination usually stops with just the compressibility test alone. The next 2 sections using Doppler to look for phasicity and augmentation add very little to the diagnostic ability of ultrasound in DVT.

Fig. 10. Femoral vessels below saphenofemoral junction prior to compression. The 2 branches of the femoral artery are to the left and the femoral vein (FV) is to the right.

Fig. 11 Femoral vein (white arrow) below saphenofemoral junction completely compressed - no DVT

Fig. 12 Incompressible femoral vein (arrow) suggesting DVT

Fig, 13 Popliteal vessels in upper popliteal fossa prior to compression. The vein (arrow) is to the right.
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2. Phasicity
The probe is slightly angulated downwards and a Pulsed wave Doppler (PWD) cursor is placed in the centre of the lumen of the vein. A PWD tracing is then obtained and observed for any significant variation in the flow velocity (Fig.16). The tracing shows flows below the baseline, but this may change if the probe is angulated upwards. Two variations are normally noticed, cardiac and respiratory. Variations with respiration are the more marked of the two. In spontaneously breathing patients, there is an increase in flow with inspiration, while in mechanical ventilation, the reverse is true.

The absence of such variation suggests a thrombosis above that point in the vein being tested. For example, if an absence of phasicity was noticed in the common femoral vein, then an iliac or IVC thrombus should be suspected.

3. Augmentation of flow
With the PWD still in place in the vein lumen, a PWD trace is obtained and the calf muscles are gently squeezed. This normally results in a surge of blood flowing through the vein and a peaking of the flow velocity trace (Fig.17). If this response is absent, it suggests thrombosis between the point being studied and the calf veins. It is important that the squeezing of the calf is not done too close to the probe, as this may result in spiky noise artefacts on the PWD trace.

4. Direct visualization of thrombus
Usually DVT is not visible inside the veins, requiring us to prove its existence with compression. However, sometimes an older (>1 week) thrombus may be visible.

Fig. 14 The popliteal vein (arrow) completely compressed - no DVT

Fig. 15 Incompressible popliteal vein (arrow) suggesting DVT

Fig. 16 – Respiratory variation (arrow) in venous flow

Fig. 17- Augmentation of flow (arrow) on squeezing calf
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as a slightly echogenic mass seen inside the vein lumen (Fig. 18). It may be sessile, fixed to the wall or be floating in the flow tethered at one point to the wall. As a clot becomes chronic and gets organized, it becomes more firmly attached to the wall and appears more echogenic. The degree to which the lumen is obstructed is variable.

It is important not to do the compressibility and augmentation tests when a thrombus is visualized as it may result in its embolization.

Upper limb and Jugular thrombosis

While less common that the femoral veins, central line associated thrombosis of the brachial, subclavian and jugular veins are sometimes encountered. The principles of identifying the vein, compressibility, phasicity and direct visualization of thrombus can be applied to these veins as well.

Conclusion

In conclusion, using these techniques makes the ultrasound a very valuable addition to the clinical examination of a patient suspected to have DVT in the OPD, ward, emergency room or ICU. One can make a diagnosis of DVT or rule it out in a matter of minutes.