**6.Lower limb arterial duplex/graft surveillance/angioplasty(stent) surveillance –**

**a)Thigh arteries**

Probe types – 4-7 MHz linear array2,4,6.

Measurements – velocities in centimetres per second, diameter (anterior-posterior AP, medial-lateral ML) in centimetres, length of disease in centimetres1,2.

Patient lies supine1,7. Due to the intimate nature of the scan, a chaperone should be offered25.

The common femoral artery is visualised in the groin and followed proximal to the inguinal ligament1,2.

The common femoral artery is then traced distally to the bifurcation and the profunda femoris and superficial femoral arteries are identified. The superficial femoral is traced along its length and through the adductor canal, visualisation is improved by flexing the leg at the knee to a 45 degree angle and turning the knee outwards1,2,7.

Peak velocity readings and waveform shape and quality are recorded in the common femoral, at the profunda origin and at the superficial femoral origin, and at the proximal, mid and distal SFA2,8.

If an area of stenosis is identified a peak velocity reading is taken immediately proximal, within and immediately distal to the diseased section. The colourflow and Doppler assessments are used to decide whether the disease is a stenosis or complete occlusion. The disease length and the distance from the medial malleolus is recorded. Any collateral vessels are noted. It should be stated whether the disease appears acute or chronic. It should be made clear in the report whether the distal superficial femoral reforms a disease free segment above the knee7,8.

If there is a significant stenosis present, measure the maximum PSV through the stenosis (V2) and the PSV just proximal to the stenosis as a "normal" reference velocity (V1), to enable calculation of the velocity ratio V2/V1. Note that at the SFA and PFA origins it may not be possible to obtain a V1 measurement; the absolute PSV will then be used to grade the % stenosis. If within the SFA, mark the position and length of any significant stenosis with a single-use surgical marker pen and measure the distance to the medial malleolus3,5.

Also remember to scan contralateral CFA when performing lower limb arterial assessments. In addition to our standard protocol if a patient has an iliac occlusion/severe disease (CIA, EIA or both) please scan contralateral iliac system. This may save the patient coming to VSU twice and speeds up the whole patient management process9.

For assessment of the popliteal artery, the patient sits with legs dependent or lies flat with the leg slightly flexed at the knee and externally rotated1,2. Alternatively, having the patient lie on their side can allow a good view of the popliteal artery.

The popliteal artery is identified behind the knee and traced proximally ensuring that the full length of artery through the adductor canal is visualised and assessed2,5.

The first arterial branch of the trifurcation is the anterior tibial (may not be viewed). The tibio-peroneal trunk is traced into the upper calf until it bifurcates into the posterior tibial and peroneal arteries. Waveforms are recorded and the velocities are measured in the popliteal and at each of the run-off artery origins and in any area where a stenosis is identified2,11,12. The number of run-off vessels viewed should be documented (0-3).

Velocity ratios:

Comparing Peak Systolic Velocity (PSV) in reference segment proximal to lesion (V1) with maximum stenotic jet PSV (V2) gives a V2:V1 ratio (namely V2/V1) which can be used as follows1,2,10:

|  |  |
| --- | --- |
| Classification  (diameter reduction) | Velocity Ratio |
| 0-19% | <2.0 |
| 20-49% | 2.0 – 2.5 |
| 50-75% | 2.5 – 3.5 |
| >75% | >3.5 |

Absolute velocities:

For use when it is not possible to obtain a suitable reference V1:24

|  |  |  |
| --- | --- | --- |
| artery | mean PSV (cm/s) | SD (cm/s) |
| Aorta | 76 | 17 |
| CIA | 111 | 17 |
| EIA | 112 | 49 |
| CFA | 90 | 41 |
| SFA prox | 89 | 23 |
| SFA mid | 83 | 25 |
| SFA distal | 74 | 21 |
| Popliteal | 59 | 12 |

* The above table shows peak systolic velocities for normal legs.
* For a normal distribution, 99% of observations will fall within the range of the mean +/- 2 standard deviations.

Ankle brachial pressure indices are performed. (See Peripheral waveform assessment)

**b) Calf arteries** – Calf vessels should be scanned along their length26.

Probe types – 4-7 MHz linear array/ if needed – 2-5MHz curved array2,4

Measurements – velocities in centimetres per second, length of disease in centimetres1,5.

Patient lies supine or sits on the edge of the bed with their legs dependent (aids visualisation with severe disease, and allows venous filling which can be used to map the course of the arteries)2.

Posterior tibial artery is identified posterior to the medial malleolus and is traced proximally. The peroneal artery is visualised deep to the posterior tibial artery (both arteries can be assessed throughout the length of the calf). If unable to visualise peroneal artery with 4-7MHz – then you must try the 2-5 curved array, or attempt to view from an anterior approach2,12,13.

Anterior tibial artery is identified on the anterio-lateral aspect of the ankle (do not apply too much pressure as the artery may be occluded by the transducer). Anterior tibial is traced to the upper calf12,13.

Velocities and waveforms are recorded from all the calf arteries at the ankle and proximal calf and also at any site of stenosis.

In the presence of proximal disease, calf velocities can be unreliable and disease should be graded mild, moderate, severe or occluded1,8.

**c) Prosthetic grafts** (usually above knee femoro-popliteal, aorto-bifemoral grafts (ABG), fem-fem crossover).

Probe types – 2-5MHz curved array, 4-7MHz and 5-10 MHz linear array2,14.

Measurements – velocities in centimetres per second, diameter (anterior-posterior AP, medial-lateral ML) in centimetres, length of disease in centimetres1,2.

Similar scanning protocols as above, except only the segments just proximal, mid and distal to the grafts are assessed. Particular attention is paid to the proximal and distal anastomosis where waveform shapes and velocities are recorded. ABPI are taken to assess any disease progression in non-treated segments (patient has usually had a full assessment prior to surgery)16,17.

With fem-fem crossover grafts it is important to record the direction of flow through the graft1,2,18.

With ABG and fem-fem crossover grafts, the common femoral waveforms are recorded1,2,18.

Waveforms, peak velocities, ABPIs and any areas of re-stenosis/new disease are recorded17.

**d)Vein grafts** (usually below knee)

Probe types – 4-7MHz linear array2.

Measurements – velocities in centimetres per second, diameter (anterior-posterior AP, medial-lateral ML) in centimetres, length of disease in centimetres1,2.

Similar scanning protocol to above, except only the segments just proximal, mid and distal to the grafts are assessed. Care is taken to scan the length of the graft and velocities and waveforms are recorded at areas of stenosis (usually valve cusps). Waveforms, peak velocities, ABPI and any areas of re-stenosis/new disease are recorded. Avoid taking ABPI on fem-distal grafts as inflating the cuff leads to danger of occluding the graft2,19,20.

**If peak velocity is less than 45cm/s - graft is probably at risk of failure and this must be noted in the report2.**

**e)Stent/angioplasty assessment**

Probe types – 4-7 MHz linear array4,6.

Measurements – velocities in centimetres per second, diameter (anterior-posterior AP, medial-lateral ML) in centimetres, length of disease in centimetres1,2.

Similar scanning protocol to above. Care is taken particularly at the just proximal to, mid and just distal to the stent/angioplasty site. Waveforms, peak velocities, ABPIs and any areas of re-stenosis/new disease are recorded2,20.

**f)Pseudo-aneurysm diagnosis and compression.**

##### Probe types – 4-7MHz linear array4,6.

Measure site of the feeder jet from the femoral bifurcation – if jet lies at or within 1cm of the bifurcation the pseudo-aneurysm will be usually be suitable for compression. The size of the sac must be measured in LS and TS, this is particularly important if the management results in thrombin injection as the radiologist will judge how much to use based on the size of the sac.

Suitability for compression depends on the position and width of the jet: the wider the jet the less likely it is going to successfully compressed. If the pseudo-aneurysm lies directly above the jet it will make it difficult to compress, the deeper the aneurysm i.e. if it originates off the posterior wall again it will be difficult to compress1,2,21,22.

The dimensions of the pseudo-aneurysm must be recorded – length, AP and ML21.

If no colourflow is seen filling a pseudo-aneurysm but there is evidence of fresh haematoma the report should state “ no evidence of patent pseudo-aneurysm but areas of fresh haematoma noted, cannot exclude a thrombosed pseudo-aneurysm or slow bleed”.

If the pseudo-aneurysm is deemed to be suitable for compression then it is necessary to arrange for the patient to come down on their bed. The patient may require analgesics as the compression can cause significant discomfort – the SHO/HO needs to supply and if necessary administer the pain relief.

Using the L7-5 probe, the vascular scientist needs to apply pressure over the jet of the pseudo-aneurysm and should attempt to occlude it. The first compression should last 10 minutes and the circulation should be checked with a hand held Doppler at the ankle to ensure patency. After 10 minutes the pseudo-aneursym needs to be checked to see if it is thrombosed or partially thrombosed. If still patent further compressions of 10 minutes need to be performed, up to a maximum of three sessions. If after the third session the pseudo-aneurysm is still patent then the patient should referred to interventional radiologist for thrombin injection.

If the pseudo-aneurysm has thrombosed then we need to rescan the patient the next day to ensure it remains occluded2,22,23.

**REFERENCES:**

1. Thrush and Hartshorne. (2010). Vascular Ultrasound, How, Why and When. 3rd Edition.
2. Institute of Physics and Engineering in Medicine in association with The Society For Vascular Technology of GB & Ireland. (2001). Vascular Laboratory Practice Part VI, IPEM 1st Edition.
3. Zwiebel WJ, Pellerito JS. (2005) Introduction to vascular ultrasonography 5th edition. Elsevier Saunders, Philadelphia.
4. Philips. (2005). iu22 Ultrasound System. Getting Started handbook.
5. Hammets D. (2004). Vascular Technology. The Burwin Institute. USA.
6. Leiner T, Kessels A, Nelemans P, Vasbinder B, Haan M, Kitslaar P, Yiu K, Tordoir J, Engelshoven J. (2005) Peripheral Arterial Disease Comparison of Colour Duplex US and Contrast-enhanced MR Angiography for Diagnosis. Radiology; 235:699-708.
7. Eiberg J, Gronvall Rasmussen J, Hansen M, Schroder T. (2010). Duplex Ultrasound Scanning of Peripheral Arterial Disease of the Lower Limb. European Journal of Vascular Surgery. 40:507-512.
8. Geehard-Herman M, Gardin J, Jaff M, Mohler E, Roman M, Naqvi T. (2001). Guidelines for Non-invasive Vascular Laboratory Testing: A Report from the American Society of Echocardiography and the Society for Vascular Medicine and Biology. Vascular Medicine; 11:183-200.
9. Marks, N, Ascher E, Hingorani A. (2007). Treatment of Failing Lower Extremity Arterial Bypasses Under Ultrasound Guidance. Perspectives in Vascular Surgery and Endovascular Therapy;19;34-39.
10. Gerhard-Herman M. et al. (2006). Guidelines for noninvasive vascular laboratory testing: a report from the American Society of Echocardiography and the Society for Vascular Medicine and Biology.
11. Polak J. (1992). Peripheral Vascular Sonography. A Practical Guide.
12. William and Wilkins, Baltimore. Rossi F et al. (2006). Colour-flow Duplex Hemodynamic Assessment of Runoff in Ischaemic Lower Limb Revascularisation. The International Society for Vascular Surgery. Vascular; 14:149-155.
13. Szpinda M. (2005). Compensating Crural Anastomoses in Chronic Critical Limb Ischaemia. Via Medica; 64(1):17-21.
14. Schlager O. et al. (2007). Duplex Sonography Versus Angiography for Assessment of Femoropopliteal Arterial Disease in a ‘Real-World’ Setting. [J Endovasc Ther.](https://www.ncbi.nlm.nih.gov/pubmed/17696618) Aug;14(4):452-9.
15. Polak J. (2016). Institute for Advanced Medical Education. Evaluation of Lower Extremity Bypass Grafts. Published online at https://iame.com/online-courses/ultrasound-vascular/evaluation-of-lower-extremity-bypass-grafts
16. Moore J, Salles-Cunah S, Scissons R, Beebe H, Toledo. (2001). Diameter Comparison of Saphenous Vein Bypasses for Popliteal Aneurysm Versus Peripheral Arterial Occlusive Disease in Matched Subjects. Vascular Surgery;35(6):449-455.
17. Baril D, Marone L. (2012). Duplex Evaluation Following Femoropopliteal Angioplasty and Stenting: Criteria and Utility of Surveillance. [Vasc Endovascular Surg](https://www.ncbi.nlm.nih.gov/pubmed/22609972).  Jul;46(5):353-7.
18. Scissons R, (2002). Lower Extremity Duplex Graft Surveillance. Journal of Vascular Technology 200126(1)55-60.
19. Cassar N, Dunjic B, Cassar K. (2010). Implementation of a Graft Surveillance Programme for Infrainuginal Vascular Bypass Surgery. Malta Medical Journal; 22(3): 24-26.
20. Bandyk D, Chauvapun J. (2007). Duplex Ultrasound Surveillance Can Be Worthwhile After Arterial Intervention. Perspectives in Vascular Surgery and Endovascular Therapy; 19(4):354-359.
21. Luedde M, Krumsdorf U, Zehelein J, Ivandic B, Dengler T, Katus H, Tiefenbacher C. (2007). Treatment of Iatrogenic Femoral Pseudoaneurysm by Ultrasound-Guided Compression Therapy and Thrombin Injection. Angiology;58:435-439.
22. Yetkin U, Gurbuz A. (2003). Post-Traumatic Pseudoaneurysm of the Brachial Artery and Its Surgical Treatment. Texas Heart Institute Journal;30:293-297.
23. Latic A, Delibegovic, Pudic I, Samardzic, Radmilovic. (2011). Non-Invasive Ultrasound Guided Compression Repair of Post Puncture Femoral Pseudoaneurysm. Med Arth: 65(2):113-114.
24. Wright I, Buckenham T. (2003). Lower Limb Arterial Duplex Ultrasound Exam Protocol. Christchurch Public Hospital.
25. Society for Vascular Technology. (2012). Professional Standards Committee Chaperone Guidelines [www.svtgbi.org.uk](http://www.svtgbi.org.uk)
26. Society for Vascular Technology. (2015). Vascular Technology Professional Performance Guidelines. Lower Limb Arterial Duplex Ultrasound Examination. [www.svtgbi.org.uk/media/resources/LowerLimbArterialPSCFinalJuly2015edit.pdf](http://www.svtgbi.org.uk/media/resources/LowerLimbArterialPSCFinalJuly2015edit.pdf)