**LOWER LIMB ARTERIAL IMAGING**

1. **SCOPE & OBJECTIVE**
   1. Arterial duplex ultrasound examination to assess for stenotic, occlusive or aneurysmal arterial disease in the major arteries of the lower extremity and abdomen.
   2. To provide operators with general instructions on how to undertake the investigation.
2. **Responsibility**
   1. The clinical scientist (or trainee clinical scientist) performing the scan is responsible for undertaking the procedure.
   2. The clinical scientist may alter procedure depending on individual patient and clinical information required.
   3. The chaperone/ clinical scientist (or trainee clinical scientist) is responsible for undertaking the patient identification.
3. **Imaging Procedure**
   1. Confirm patient identifiers (Name, DOB and Address) and introduce themselves. Explain the scan procedure and obtain informed consent ([trust consent policy](https://nhswales365.sharepoint.com/:b:/r/sites/CAV_Controlled%20Document%20Library/Shared%20Documents/Policies/Consent%20Policy%20final%20201119%20v2%20-%20Copy.pdf?csf=1&web=1&e=v6ubXr)). Obtain any relevant clinical history. Verify that the request correlates with patient’s clinical presentation.
   2. The protocol may be adjusted for a clinically focussed scan of a particular region, as per scan request.
   3. This is potentially an intimate procedure and if deemed so, then a chaperone can be present in the room at the time of the investigation. Ensure patient dignity is maintained throughout the examination.
   4. Ask the patient to lie on the bed supine for the abdominal and proximal leg investigation.
   5. Use sterile gel if required as per the sterile gel protocol.
   6. Select the correct patient on the ultrasound machine. Select the arterial pre-set and appropriate probe.
   7. The following techniques should be used to evaluate the lower arterial systems: B-mode should be used to assess for any aneurysmal dilatation and vessel contents e.g. atheroma, calcification, plaque or thrombus. Colour Doppler should be used to assess the presence or absence of flow and to detect stenoses. Spectral Doppler should be used to determine flow direction, to grade stenoses and to determine the arterial waveform (i.e. monophasic, biphasic, triphasic, hyperaemic – appendix 1) (1).
   8. Image common femoral artery (CFA) in longitudinal using B-mode, colour and spectral Doppler. Check patency of the artery and extent of any disease.
   9. Save an image of the CFA, including waveform and any other representative images, where possible.
   10. If the CFA waveform is triphasic continue to scan distally. If the CFA waveform is significantly modified or if aorto-iliac disease is suspected, then an aorto-iliac scan should be performed. This includes using colour and spectral Doppler to assess the aorta, common iliac artery (CIA), internal iliac artery (IIA) (where possible) and external iliac artery (EIA) for arterial disease.
   11. When scanned, and where possible, save a representative image of the aorta, CIA and EIA showing patency and waveform and any other representative images that may be appropriate. Make sure limitations are stated on the report if images aren’t saved.
   12. Image the profunda femoral artery (PFA) origin and check for patency and stenosis.
   13. Image the superficial femoral artery (SFA) in longitudinal (and transverse if necessary) using colour and spectral Doppler to determine patency and extent of disease.
   14. Examine the patency of the popliteal artery and the extent of disease using colour and spectral Doppler.
   15. A distal image of the SFA and popliteal artery showing patency and waveform should be saved as a minimum, where possible.
   16. Image the posterior tibial artery (PTA), anterior tibial artery (ATA) and peroneal artery (PER) in longitudinal and cross section if necessary, noting any disease present. The calf arteries can be challenging to view when calcified. Where possible, save a representative image of each tibial vessel showing patency and waveform as a minimum.
   17. If a stenosis is identified, then the following grading criteria should be used (table 1) (2):

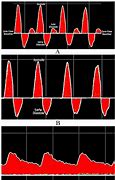
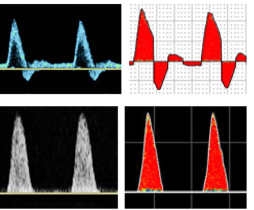
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| **PSV ratio** | **% Stenosis** |
| <2 | Not haemodynamically significant |
| >2 | 50-75% (Moderate) |
| >4 | >75% (Severe) |
| No colour flow | Complete Occlusion |

**Table 1 - Peripheral arterial stenosis grading criteria:** The grading criteria for stenoses is the ratio of *Velocity s* (stenosis) to *Velocity p* (pre), which is the peak systolic velocity ratio (PSVR). The highest velocity should be measured at the site of narrowing (Vs) and in a normal area just proximal to the narrowing (Vp). A ratio of greater than 2 is used to define a stenosis, causing a 50% reduction in diameter. A PSVR of >4 is generally defined as a >75% diameter reduction

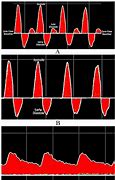
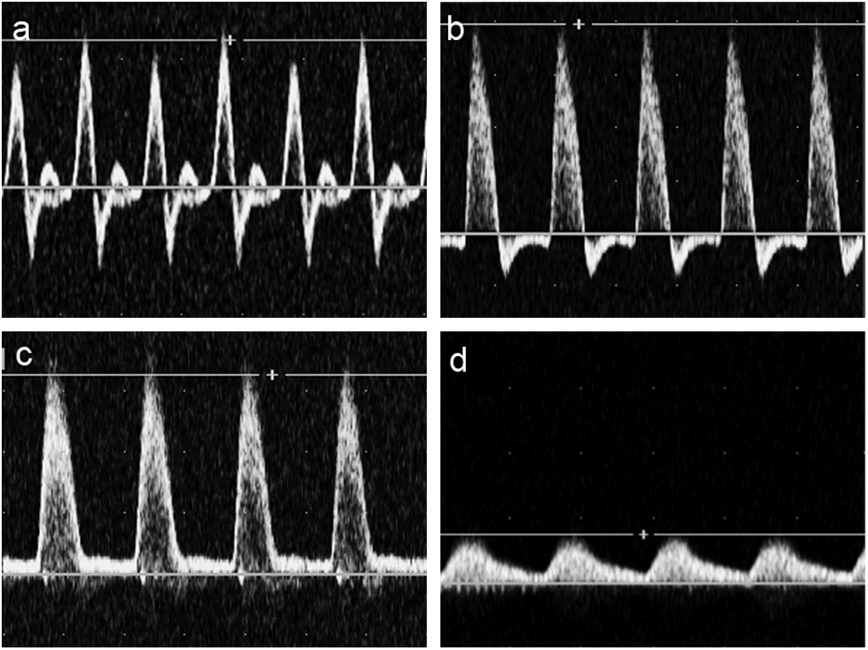
* 1. Triphasic and biphasic waveforms represent normal flow patterns and monophasic waveforms represent presence of disease. Hyperaemic multiphasic (above baseline) can indicate enhanced blood flow due to distal vessel dilation from ulceration/infection or distal occlusion.
  2. If a complete occlusion is suspected check for trickle flow. Reduce the colour scale or use power Doppler and/or superb microvascular imaging and/or spectral Doppler to confirm occlusion. Note the presence of collateral vessels and level of reconstitution.
  3. If an acute event is suspected (acute arterial embolus or thrombus present with possible arterial distension). Determine extent of the obstruction.
  4. For aneurysmal disease, if requested (or suspected) measure vessel diameter in transverse/longitudinal section. Note presence of aneurysm/ sites of ectasia on the report.
  5. At the end of the scan provide the patient with tissue to wipe any excess gel. Inform the patients of the results and let them know the report will be available for the referring doctor to access.

1. **Images and Reporting** 
   1. End the exam on the machine to send images to PACS
   2. This is a dynamic scan and any images saved are not representative of the full scan performed. All images that are saved should be used to evidence diagnosis and aid reporting. The images alone should not be used to retrospectively diagnose
   3. For scans performed under ergonomically challenging conditions or with time constraints such as portable scans on the ward or within clinics a reduced set of images may be saved
   4. Record the name of any chaperone present in comments box on RADIS
   5. Complete the exam in RADIS
   6. Report the scan on the “CWM” patient reporting system.
   7. For any urgent findings; including acutely ischemic limb or newly diagnosed above surgical threshold aneurysm bleep the on-call vascular registrar (5214).
2. **References** 
   1. Interpretation of peripheral arterial and venous Doppler waveforms: A consensus statement from the Society for Vascular Medicine and Society for Vascular Ultrasound; [Interpretation of peripheral arterial and venous Doppler waveforms: A consensus statement from the Society for Vascular Medicine and Society for Vascular Ultrasound - Esther SH Kim, Aditya M Sharma, Robert Scissons, David Dawson, Robert T Eberhardt, Marie Gerhard-Herman, Joseph P Hughes, Steve Knight, Ann Marie Kupinski, Guillaume Mahe, Marsha Neumyer, Patricia Poe, Rita Shugart, Paul Wennberg, David M Williams, R Eugene Zierler, 2020 (sagepub.com)](https://journals.sagepub.com/doi/10.1177/1358863X20937665?url_ver=Z39.88-2003&rfr_id=ori%3Arid%3Acrossref.org&rfr_dat=cr_pub++0pubmed&)
   2. SVT Professional Standards Committee April 2021. Arterial duplex ultrasound examination; [Arterial\_PPG\_-\_29.03.21.pdf (svtgbi.org.uk)](https://www.svtgbi.org.uk/media/resources/Arterial_PPG_-_29.03.21.pdf)
3. **Appendices**
   1. Appendix 1 – Waveform Examples

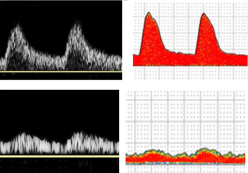
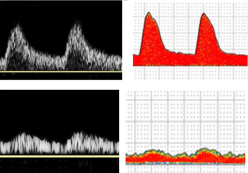
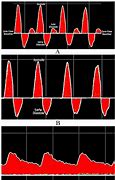
**TRIPHASIC:**



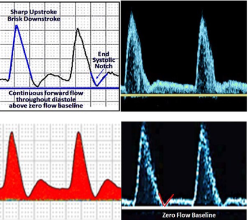
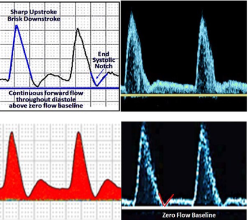
**BIPHASIC:**



**MONOPHASIC:**

**HYPERAEMIC:**



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| **Scan type Between July and September 24.** | **Report** |
| 31/07/2024- Bilateral arterial duplex | RIGHT: Irregular and calcified EIA. Poor views of the CIA due to body habitus and bowel gas.  LEFT: Irregular and calcified EIA. Poor views of the CIA due to body habitus and bowel gas.  US Doppler lower limb arteries Both  RIGHT: Heavily calcified CFA. Patent PFA origin. The SFA is heavily calcified with flow obscured throughout. Severe (>75%) stenosis seen mid-SFA (PSV 411 cm/s). Heavily calcified popliteal with damped monophasic flow. Very poor views of the run-off due to calcification ++. Some flow seen in the PER segmentally. Flow only seen in the proximal ATA.  LEFT: Heavily calcified CFA. Patent PFA origin. Patent SFA origin. The SFA then occludes for approx. 10 cm with refilling seen via collateral. Heavily calcified popliteal with damped monophasic flow  Very poor views of the run-off due to calcification ++. Flow only seen in the PER. |
| 31/07/2024- Graft duplex | US Graft surveillance  Ectatic distal aorta measuring 2.9 cm.  RIGHT: Patent graft limb with no obvious stenosis. Severe (>75%) stenosis in the CFA (PSV 36-150 cm/s). Moderate (50-75%) stenosis PFA origin. At least a moderate (50-75%) stenosis SFA origin.  LEFT: Patent graft limb some mild kinking proximal to CFA anastomosis. Mildly calcified CFA with triphasic flow. Patent PFA origin. At least a moderate (50-75%) stenosis SFA origin, extending into proximal SFA. |
| 01/08/2024-Graft duplex | LEFT: The FEM-BK POP and BK POP-PT grafts appear widely patent with good velocity triphasic flow throughout. Tri/Biphasic flow into the PTA. |
| 01/08/2024- Single leg arterial duplex | Unable to visualise the AA or proximal CIA due to bowel gas.  RIGHT: Patent EIA with monophasic flow. Poor colour filling in the distal CIA ? occluded.  US Doppler lower limb arteries Rt  RIGHT: Patent CFA and PFA origin with monophasic flow. The SFA occludes in the proximal thigh for approx. 10-15 cm with refilling seen distally. Patent popliteal artery with damped monophasic flow. Run-off only assessed in the proximal calf due to wounds. Patent ATA and PTA with very damped monophasic flow. Flow only seen segmentally in the PER. |
| 06/08/2024- Bilateral arterial duplex | RIGHT: Triphasic CFA waveform. Patent PFA origin. The SFA occludes approx. 10 cm from origin. Some refilling (2cm) seen mid-SFA. Collateral noted. Further 2 cm occlusion seen distal SFA with refilling seen via collateral of the above knee popliteal. Patent popliteal with damped monophasic flow.  Three vessel run-off seen from patent tibial peroneal trunk.  The posterior artery, peroneal artery and anterior tibial artery were mildly calcified but patent with monophasic flow  LEFT: Triphasic CFA waveform. Patent but heavily calcified PFA origin, possible moderate (50-75%) stenosis. Some mild atheroma and heavy calcification but no evidence of any significant femoral arterial disease. The SFA is heavily calcified proximally. Severe (>75%) seen mid-SFA for approx. 2cm. Patent distally.  The popliteal artery is patent, some enhanced velocities proximal popliteal suggesting possible 50-75% stenosis.  Three vessel run-off seen from patent tibial peroneal trunk.  The posterior artery and peroneal artery were mildly calcified but patent with monophasic flow. The anterior tibial artery was mildly calcified but patent with monophasic flow through the proximal and mid section. No flow seen distal ATA. |
| 06/08/2024- Iliac duplex | RIGHT: Poor views of the CIA due to bowel gas. Possible moderate (50-75%) stenosis proximal/mid CIA (PSV 41-113 cm/s). Calcified but patent EIA. |
| 07/08/2024- Single leg arterial duplex | RIGHT: Patent CFA with triphasic flow. Calcified PFA origin but <50%. The SFA is heavily calcified with a moderate (50-75%) stenosis seen mid-thigh level. Irregular and calcified popliteal with multiphasic flow. Unable to visualise the run-off due to overlying oedema. |
| 07/08/2024- Single leg arterial duplex. | RIGHT: Patent CFA and PFA origin with triphasic flow. The SFA is calcified with a moderate (50-75%) stenosis seen mid-SFA (PSV 124-252 cm/s). Patent distally and flow remains triphasic. Patent popliteal and TPT with hyperaemic multiphasic flow. The PER is patent throughout. Flow only seen in the proximal ATA. No flow seen in the PTA. |
| 28/08/2024- Single leg arterial duplex | RIGHT: The aorta appears occluded. No flow seen in the CIA. Patent EIA with monophasic flow. Patent CFA and PFA with monophasic flow. No obvious significant SFA disease however calcified throughout. Patent popliteal. Calcified three vessel run-off. |
| 28/08/2024- Single leg arterial duplex | RIGHT: The aorta appears occluded. No flow seen in the CIA. Patent EIA with monophasic flow. Patent CFA and PFA with monophasic flow. No obvious significant SFA disease however calcified throughout. Patent popliteal. Calcified three vessel run-off. |
| 28/08/2024- Focussed single segment duplex | Focussed assessment of the popliteal artery  RIGHT: Patent proximal and mid popliteal artery. No flow seen in the distal popliteal, likely chronically occluded - multiple collaterals noted. Patent ATA and PTA. No flow seen in the PERA, likely occluded. |
| 28/08/2024- Bilateral arterial duplex | RIGHT: Poor views of the CIA due to bowel gas. Patent EIA.. Occluded CFA. Large collaterals noted. Patent PFA origin. Heavily calcified SFA with multiple moderate (50-75%) stenosis proximally. Diffusely narrowed mid-distal SFA. Irregular and calcified popliteal artery. Heavily calcified run-off with poor views throughout. No flow seen in the ATA proximally. Patent PTA and PER at ankle with monophasic flow  LEFT: Large calcified plaque in the CFA causing enhanced velocities throughout however flow remains triphasic. Patent PFA origin. Heavily calcified SFA with moderate (50-75%) stenoses in the proximal and mid section. Patent distally. No flow seen in the proximal popliteal ? occluded ? heavily calcified. Patent distally. Heavily calcified run-off but where seen monophasic flow in the PTA, PER and ATA. |
| 30/08/2024- Single leg arterial duplex | LEFT: No haemodynamically significant arterial disease seen from groin to ankle, triphasic flow throughout. Patent ATA and PTA. No flow seen in the PER ? Occluded. |
| 30/08/2024- Single leg arterial duplex | RIGHT: Patent proximal CFA with multiphasic flow and collaterals noted. Large calcified plaque in the mid-distal CFA causing likely occlusion. Retrograde flow seen in the PFA refilling the SFA. Monophasic flow throughout the SFA and POP but no haemodynamically significant arterial disease. Mildly calcified three vessel run-off (PSV 10-30 cm/s). |
| 30/08/2024- Single leg arterial duplex | RIGHT: Patent CFA and PFA with triphasic flow. Mildly calcified SFA and POP with tri/biphasic flow and no haemodynamically significant arterial disease. Calcified three vessel run-off with triphasic flow at the ankle. |
| 11/09/2024- Single leg arterial duplex | RIGHT:  Patent EIA with triphasic flow.  Large calcified plaque in distal CFA causing a severe >75% stenosis. Patent PFA origin.  Turbulent flow seen at the SFA origin. Small calibre SFA throughout with severe >75% stenosis in the proximal SFA (PSV 34-500 cm/s), multiple moderate 50-75% in the mid SFA, very narrow channel of flow in the distal SFA with low monophasic flow.  Scan terminated early due to patient becoming acutely unwell. |
| 11/09/2024- Bilateral arterial duplex | RIGHT: Patent CFA and PFA origin with triphasic flow. Mildly calcified SFA which occludes distally for approx. 5 cm with refilling seen in the above knee-POPA. Multiple collaterals noted. Probable distal popliteal and TPT occlusion. Heavily calcified run-off. No flow seen in the PTA. Flow seen segmentally in the ATA and PER.  LEFT: Patent CFA with triphasic flow. Stenosed PFA origin. Acute on chronic occlusion of the SFA from origin with refilling seen in the POP. Heavily calcified run-off. Monophasic flow seen in the distal PERA only. Monophasic flow seen throughout the ATA. No flow seen in the PTA. |
| 11/09/2024-Single leg arterial duplex | LEFT: Irregular and calcified CIA. Approx. 3 cm severe (>75%) stenosis seen distal CIA/proximal EIA. Patent CFA. Small calibre but patent PFA. The SFA is calcified throughout with a moderate (50-75%) stenosis in the distal SFA. Irregular and calcified POP. Monophasic flow seen segmentally in the ATA, PER and PTA. |
| 12/09/2024- Bilateral arterial duplex | RIGHT: Patent aorta with low velocity monophasic flow (PSV 35 cm/s). The proximal CIA is at least moderately stenosed (PSV 278 cm/s). Patent EIA with monophasic flow.  LEFT: The CIA appears occluded. Low velocity "thready" flow seen in the distal EIA.  US Doppler lower limb arteries Both  RIGHT: Patent CFA and PFA origin with monophasic flow. No haemodynamically significant arterial disease seen throughout SFA and POP, monophasic throughout. Three vessel run-off with damped flow at the ankle.  LEFT: Patent CFA and PFA origin with monophasic flow. No haemodynamically significant arterial disease seen throughout SFA and POP, monophasic throughout. Three vessel run-off with damped flow at the ankle. |
| 13/09/2024- Single leg arterial duplex | LEFT: Patent CFA and PFA origin with triphasic flow. Calcified SFA and POP however flow remains triphasic with no haemodynamically significant arterial disease. Calcified three vessel run-off with hyperaemic multiphasic flow throughout (likely caused by enhanced blood flow due to distal wound). |
| 25/09/2024- Single leg arterial duplex | LEFT: Patent CFA with triphasic flow. Stenotic PFA origin (PSV 349 cm/s). Patent SFA with an approx. 1.3 cm severe (>75%) stenosis seen mid-SFA (PSV 664 cm/s). Severe (>75%) stenosis seen distal popliteal/TPT (PSV 44-182 cm/s). Three vessel run-off with monophasic flow at the ankle. |
| 25/09/2024- Single leg arterial | LEFT: Patent CFA with triphasic flow. Stenotic PFA origin (PSV 349 cm/s). Patent SFA with an approx. 1.3 cm severe (>75%) stenosis seen mid-SFA (PSV 664 cm/s). Severe (>75%) stenosis seen distal popliteal/TPT (PSV 44-182 cm/s). Three vessel run-off with monophasic flow at the ankle. |
| 26/09/2024- Bilateral arterial | RIGHT: Patent CFA and PFA origin with triphasic flow.  Patent SFA with triphasic flow throughout.  Patent popliteal and TPT  Three vessel run-off with triphasic flow at the ankle.  LEFT: Patent CFA and PFA origin with triphasic flow.  Patent SFA with triphasic flow throughout.  Patent popliteal and TPT  Three vessel run-off with triphasic flow at the ankle. |
| 26/09/2024- Bilateral arterial | RIGHT: Patent CFA and PFA origin with triphasic flow  Patent SFA with triphasic flow throughout and no haemodynamically significant arterial disease.  Patent popliteal and TPT.  Thee vessel run-off with triphasic flow at ankle.  LEFT: Patent CFA and PFA origin with triphasic flow  Patent SFA with triphasic flow throughout and no haemodynamically significant arterial disease.  Patent popliteal and TPT.  Thee vessel run-off with triphasic flow at ankle. |