

Standard Operating Procedure (SOP)

Lower Limb Arterial Duplex Examination

SETTING	Gloucestershire Hospitals NHS Foundation Trust
FOR STAFF	Vascular Laboratory
PATIENTS	Patients referred for lower limb arterial duplex examination

PURPOSE

Lower limb arterial duplex is carried out to assess for stenotic, occlusive, or aneurysmal disease of the lower-limb arteries.

COMMON INDICATIONS

Common indications for performance of this examination include, but are not limited to:

- Claudication
- Rest pain
- Acute/Chronic limb threatening ischaemia
- Ulceration/tissue loss/gangrene
- Reduced ABPI
- Post-surgical intervention (i.e. stent, graft, or angioplasty)
- Suspected aneurysmal disease
- Lower extremity permanent dialysis vascular access
- Suspected popliteal artery entrapment syndrome

CONTRAINDICATIONS AND LIMITATIONS

Contraindications and limitations may include the following:

- Recent surgical intervention
- Ulceration, open wounds, bandaging or casts
- Vascular access lines and catheters
- Extensive calcific disease
- Patients unable to cooperate or those with involuntary movements
- Bedside interventions with limited light adjustment
- Patients with impaired mobility

PATIENT PREPARATION

Prior to beginning the exam, the examiner should:

- Introduce themselves, explain why the examination is being performed and indicate how much time the examination will take. Be aware of special circumstances such as the need for an interpreter or chaperone.
- Correctly identify the patient according to the relevant trust policies and procedures.
- Explain the procedure, taking into consideration the age and mental status of the patient and ensuring that the necessity for each portion of the evaluation is understood.
- Respond to questions and concerns about any aspect of the evaluation.

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- Refer specific diagnostic, treatment or prognosis questions to the patient's referring clinician.
- Verbal consent is suitable for this examination. Additional consent is required if the scan is being performed for teaching or research purposes.

PATIENT ASSESSMENT AND PHYSICAL EXAMINATION

Patient assessment must be performed prior to imaging. This includes assessment of the patient's ability to tolerate the examination or any contraindications to the procedure. A medical history relevant to pathology should be taken prior to the scan. This should include presenting symptoms, their timescales and frequency, and presence of risk factors. Verify that the requested procedure correlates with the patient's clinical presentation. Perform a limited or focused physical exam, including observation and localisation of any signs or symptoms of lower limb ischaemia. All consultations must be made and documented in accordance with the relevant Trust policies, for example promoting dignity and respect, maintaining patient confidentiality.

PATIENT POSITIONING

The patient should be positioned on the examination couch in a manner commensurate with the procedure being undertaken. The patient is usually scanned in a supine position with the head supported by a pillow. Ask patient to remove clothing and jewellery appropriate to the procedure, assisting if necessary. Throughout the procedure the patient's privacy, dignity and security should be observed. Examiner should be as close to the examined extremity as possible to allow for ergonomically sound scanning.

EQUIPMENT

The examination is performed using an appropriate transducer for the vessel being examined. The ultrasound machine should be regularly safety checked and maintained according to local Quality Assurance protocols.

To ensure best recommended practice to reduce the risk of musculo-skeletal disorders, the examination couch should be height adjustable and the examiner's chair, if required, should be height adjustable and designed to promote best ergonomic positioning.

The examination room should be temperature-controlled with adjustable lighting suitable for examination.

Cleaning materials should be available in line with local and manufacturer's guidelines.

EXAMINATION PROTOCOL

The examination may be unilateral or bilateral dependent upon clinical symptoms.

The vascular optimised preset is selected at the start of the examination. The patient name/operator ID should be entered for image capture either manually or selected from the daily worklist.

The following techniques should be used to evaluate the lower limb arterial system:

- B-mode to image the artery and assess for aneurysmal dilation and vessel contents e.g. atheromatous plaque
- Colour Doppler to assess for presence/absence of flow and aid the position of spectral Doppler when quantifying stenoses
- Spectral Doppler to determine direction of flow, blood flow velocities, waveform pattern and absence of flow

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Throughout the duplex scan the machine controls (e.g. scale, gain, angle, depth, gate etc.) should be adjusted to optimise the image/colour filling/spectral trace.

Care should be taken to ensure the Doppler angle is $\leq 60^\circ$ and the Doppler cursor is angled in the direction of flow.

Evaluation of the following arteries should be performed:

- Common femoral artery (CFA)
- Proximal profunda femoris artery (PFA)
- Superficial femoral artery (SFA)
- Popliteal artery (PopA)
- Tibio-peroneal trunk (TPT)
- Posterior tibial artery (PTA)
- Peroneal artery (PerA)
- Anterior tibial artery (ATA)

If spectral analysis of the CFA demonstrates an abnormal waveform (i.e. tardus-parvus) or prolonged acceleration time indicative of significant proximal disease, the aorto-iliac arterial segment and contralateral CFA should be examined.

Each artery is examined at regular intervals along its length, particularly at areas of turbulence or colour aliasing. Any significant changes in calibre should be quantified and documented.

In the presence of moderate $<50\%$ stenosis in CFA, plaque characteristics, diameter reduction ($<50\%$) and patent residual vessel lumen measured in transverse view should be noted on the report to facilitate access for endovascular interventions.

In the presence of disease, both B-mode assessment and peak systolic velocity (PSV) measurements are used to grade the degree of stenosis. The main PSV criterion used to grade the degree of stenosis in the artery is the ratio between the velocity at the site of the stenosis and pre-stenotic velocity in a normal vessel segment immediately proximal to the stenosis. Care should be taken for stenosis assessment at the origin of the vessel, bifurcations and in the presence of stents to account for associated calibre change and change in flow dynamics when grading stenoses. As such, B-mode to assess visual degree of narrowing and colour Doppler to assess Doppler spectrum changes should be utilised in tandem with velocity ratios in order to grade stenosis.

Criteria for the estimation of stenosis severity

Diameter reduction	Velocity ratio
$<50\%$	<2
50-70%	2-3.3
70-99%	≥ 3.4
Near-occlusion	High, low – string flow
Occluded	No flow

The length of occlusive disease and the presence of a flush occlusion should be recorded to aid appropriate treatment. In non-flush occlusions, the length of patent vessel proximal to the occlusion should be recorded.

If stenosis is located at the vessel origin it should also be noted on the report.

Any significant increases in vessel diameter should be measured perpendicular to the centreline of the vessel with callipers placed at leading edge-to-leading edge of the vessel wall considering, compared to a normal adjacent vessel segment, a less than 1.5-fold increase as

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ectatic and an equal or greater than 1.5-fold increase as aneurysmal. In the presence of femoral or popliteal aneurysm, calf runoff arteries should be examined.

The presence and patency of stents and grafts should be noted and assessed according to the relevant SOP. If the stent is under individual surveillance programme and there has been no significant change in the stent appearance on the interval surveillance scan, examination of calf runoff arteries is unlikely to be required unless it has specifically been requested or patient presentation indicated significant deterioration of foot supply since the most recent surveillance scan.

Particular attention should be paid to surgical sites for the presence of pseudoaneurysm. The length, depth, and width should be measured and a spectral waveform should be obtained at the neck. The length and width of the pseudoaneurysm neck should be recorded. In the presence of true aneurysm, thrombus burden should be described and patent residual vessel lumen diameter measured.

FOLLOW UP

Please refer to the Vascular Laboratory Surveillance Protocols standard operating procedures.

REPORTING

The report should include patient demographics, date of examination, examination type and status of vascular scientist. Any other considerations regarding trust policies including but not limited to consent and chaperone should be documented.

If necessary, a pictorial report with written conclusions should be provided alongside appropriate ultrasound images.

As a minimum, the report should include:

- Arteries assessed and general comments on vessel status (i.e. small calibre, calcified, ectatic, diffuse disease)
- PSV and flow pattern in CFA and calf runoff arteries (i.e. triphasic/biphasic/monophasic)
- Comments on the presence/absence of flow
- Anatomical position of any occlusions, stenoses or aneurysms indicating the degree of stenosis
- Diameter measurements where appropriate
- Any limitations to the examination, non-visualised segments, and suboptimal imaging
- Follow-up duration (in the case of surveillance)

IMAGE STORAGE

Images form a part of the patient record and may be used as evidence in relation to the management of patient care. Images should be as clear as possible for the purposes of demonstrating the appropriate pathology, including measurements where necessary, and provide sufficient information to support the written report. Images should include patient identification, date and time of examination and hospital/department information. Images should be clearly and appropriately labelled according to the side examined, vessel segment and the anatomical position and length of any stenosis/occlusion if present.

As a minimum, the following images should be archived in the longitudinal plane using colour and spectral Doppler:

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- CFA at the groin
 - If the CFA is diseased to a less than 50% diameter reduction, the narrowest point should be imaged in the transverse plane and a diameter reduction should be measured
- PFA origin
- SFA (proximal, mid and distal segments)
- PopA above-knee and below-knee segments
- TPT
- ATA, PTA, and Pero A proximal and distal segments

In addition, using colour and spectral Doppler pre-stenotic and the highest at the site of the stenosis velocities measurements should be recorded and stored for any haemodynamically significant stenosis.

POST-PROCEDURE

The result of the scan is explained to the patient. The patient is informed that the result will be communicated to the referrer who will arrange appropriate follow up.

In case of urgent findings such as acute limb ischaemia or pseudoaneurysm, the vascular on call team should be contacted before the patient leaves the department. The referring clinician should be informed of any non-urgent but actionable findings.

REFERENCES

1. IPEM/SVT Vascular Laboratory Practice, Part 3
2. Phillips, G., 2000. Review of Arterial Vascular Ultrasound. World Journal of Surgery, 24(2), pp.232-240.
3. Ranke, C., Creutzig, A. and Alexander, K., 1992. Duplex scanning of the peripheral arteries: Correlation of the peak velocity ratio with angiographic diameter reduction. Ultrasound in Medicine & Biology, 18(5), pp.433-440.
4. Svtgbi.org.uk. 2021. Vascular Technology Professional Performance Guidelines. Arterial Duplex Ultrasound Examination. [online] Available at: <https://www.svtgbi.org.uk/media/resources/Arterial_PPG_-_29.03.21.pdf> [Accessed 9 July 2021].

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