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| **Title:** | Lower limb Arterial Duplex Ultrasound Protocol |
| **Protocol Number:** | 2.0 |
| **Version** | 4.0 |
| **Previous versions:** | V1.0 January 2008, V2.0 February 2015, V3.0 February 2016 V4.0 Feb 2018 |
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| **Position Held:** | Lead Clinical Vascular Scientist |
| 2.0 Examination overview **Intended Use:** | As a protocol to be followed by all Clinical Vascular Scientists employed by Vascular Solutions |
| **Related Policy’s:** | Infection prevention and control policy, Hand Hygiene policy. |
| **Last Review date:** | January 2019 |
| **Next Review Date:** | February 2020 |

# 1.0 Purpose

The purpose of this ultrasound protocol is to provide staff with a specific procedure to follow. This will ensure that every DVT ultrasound scan undertaken by a Clinical Vascular scientist employed by Vascular Solutions is complete and standardised.

# 2.0 Examination overview

Duplex ultrasound scanning is a specialist examination carried out by trained Clinical Vascular Scientist using B-mode ultrasound, Spectral Doppler and Colour flow Doppler. The examination of the lower limb peripheral arteries encompasses the abdominal Aorta and iliac arteries, the infra inguinal arteries and the tibial vessels to their terminal branches. This examination aims to determine the location and severity of vascular disease (atherosclerotic occlusive disease and aneurysmal disease) in the lower limb peripheral arteries.

# 3.0 Clinical Indications

* Intermittent Claudication
* Ischemic rest pain
* Gangrene
* Ulceration
* Post surgical intervention (Follow-up, surveillance scanning)
* Assessment for Aneurysm
* Assessment for pseudo aneurysm

**4.0 Contraindications and Limitations**

Contraindications for lower limb arterial duplex ultrasound assessment are unlikely; however, some limitations exist and may include the following:

* Obesity (limitations of access to the required areas due to size)
* Dressings for ulceration
* Cast’s
* Patients unable to co-operate due to reduced cognitive functions e.g. Alzheimers or dementia

# 5.0 Equipment

* High spec Ultrasound Machine with Vascular package
* Curvi-linear (ranging from as low as 3MHZ) and Linear probes (ranging from 4-9Mhz to as high as 15Mhz for very superficial arteries e.g. terminal branches of the Posterior tibial artery and anterior tibial artery)
* Electric Examination Couch (to prevent repetitive strain injuries by working at a level that is comfortable and maximises optimal imaging positions of each CVS)
* AC to allow for controlled temperature environment (temperature effects the vaso-tone of the distal arterioles)
* Adjustable lighting
* Consumables e.g. Gel, Gloves (Latex free only used), tissue paper, sanitizer for probes and equipment post examination (See infections Control policy)

# 6.0 Consent

No written consent is legally required prior to an ultrasound examination. However, all CVS **must** ensure that a full explanation of what the examination is for and what it will entails, prior to asking the patient for consent to perform the examination Please ensure consent is sought before asking the patient to undress or lie on the examination couch.

**7.0 Explanation of Exam, History taking**

* The CVS undertaking the examination should start by introducing themselves
* Confirm the patients name and date of birth. If the patient is unable to confirm for themselves, care should be taken checking the patients identity wrist tag and corresponding notes and department paperwork
* Explain the procedure and its duration – consideration should be made in respect to the patient’s age and mental status when giving explaining about the exam.
* Example; The examination uses ultrasound, which is a painless process without any use of needles. The area of the body to be examined will be covered with gel and a probe applied then moved over the skin to show images of inside. Explain to the patient that they will be required to lay flat or stand and give an approximate amount of time for the examination.
* The chaperone policy is clearly displayed in the department, and if necessary brought to the patient’s attention.
* Prior to entering the ultrasound room check the department’s records for any previous examinations performed.
* Read the clinical indications that are provided on the referral form, ask the patient further questions to assist with good history taking.
* Ensure the patients details are on the ultrasound worklist. Confirm name and DOB prior to selecting the patient from the worklist.

**8.0 Patient Preparation**

* The patient should lie in a comfortable supine position with the leg to be scanned slightly flexed at the knee and externally rotated ensuring they are comfortable and warm before beginning.
* The CVS should ensure they are in a comfortable, ergonomic position that is causing no strain on wrist, arms, neck or shoulders. As the examination can take up to an hour (bilateral examination’s) care should be taken to correct posture and positioning throughout the scan.

**9.0 Examination Protocol**

**Femoro-popliteal arterial scanning technique**

* Begin the exam using the linear probe (7-4MHz probe), starting at the inguinal ligament in cross section, identifying the Common femoral artery (CFA) Superficial Femoral artery (SFA) and Profunda Femoral artery (PFA).
* Triphasic waveforms with normal acceleration time detected in the CFA indicate low probability of significant proximal iliac disease, however, this does not rule out aneurysmal disease, for this reason all arterial scans must encompass the Aorto-iliac region and a maximum Ap size for the Abdominal Aorta recorded and reported.

***See Aorto-iliac arterial duplex scan)***

* The Femoral and popliteal arteries should be imaged in their entirety using Colour Flow Doppler in both cross sectional and longitudinal imaging planes for localisation of atherosclerotic occlusive disease and aneurysmal dilatation. The longitudinal plane is used during pulse wave Doppler for waveform analysis and recording Peak systolic velocity (PSV).
* PW Doppler should be used throughout the examination, routinely at the proximal, mid and distal segment in each artery, and/or at any site of visual flow disturbance or visible atherosclerotic plaque. **The waveform shape and PSV should be documented at each level**
* Arterial Waveforms are documented as triphasic, biphasic or monophasic. Noting any spectral broadening, loss of the reversal component, increase in end diastolic flow etc
* Peak Systolic Velocity is measured using the manual caliper and not the mean trace, it is then annotated and recorded as an image to be sent to PACS.
* **Any changes to the waveform from one arterial segment to the next should be described noted and the reason for the change identified.**
* Atherosclerotic plaque morphology should be described where possible using the following terminology, focal/diffuse/extensive, echogenic/echolucent/calcified,
* The amount of disease within the arterial segment binging examined can be described as an adjunct to aid the consultant and can be described as mild, moderate, focal or diffuse/ extensive disease

**10.0 Popliteal and run off vessels scanning technique**

* Place the probe behind the knee and obtain a longitudinal image of the popliteal artery. Proceed proximally, to ensure a good overlap is achieved with the SFA in the adductor canal.
* Continue the scan posteriorly moving distally to the trifurcation, assess the entire length of the tibio-peroneal trunk and the origins of the posterior tibial and peroneal arteries. The Anterior tibial artery origin can also be viewed from the posterior aspect of the knee. Doppler the origin of Anterior tibial artery, posterior tibial artery and peroneal artery.
* The posterior tibial artery and peroneal arteries should be imaged along their entire length starting from either the proximal calf or distal calf.
* Ask the patient to flex the knee more acutely, resting their heel on the examination couch, place the probe on the lateral aspect of the proximal lower leg, with the proximal edge hard up against the lateral head of the fibula the scan the entire length of the anterior tibia artery and its continuation into the foot as Dorsalis Pedis artery.
* The same criteria is used to grade stenosis in the tibial arteries as the femoral-popliteal segment. See below University of Washington criteria.

**11.0 Stenosis Criteria in the peripheral arteries**

* For calculation of degree of stenosis use V2/V1 ratio (See Table 1)

**V1** = Peak Systolic Velocity (PSV) recorded just proximal to the site of stenosis PSV in the disease free segment or the artery, where possible just proximal to the site of significant stenosis.

**V2** = Maximum PSV recorded at the site of maximal stenosis

**University of South Florida duplex Criteria for lower limb arterial occlusive disease**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| % Stenosis | Peak Systolic  Velocity (cm/sec) | End Diastolic Velocity (cm/sec) | Velocity Ratio | Distal arterial Waveforms |
| (1-19%) | <150 | <40 | <1.5 | Triphasic |
| 20-49% | 150-200 | <40 | 1.5-2.0 | Triphasic |
| 50-75% | 200-300 | <90 | **2.0 - 3.9** | Post stenotic turbulence distal to stenosis, monophasic distal waveform |
| >75% | >300 | >90 | **>4.0** | Damped distal waveforms and low PSV |

***Adapted from University of Washington Criteria Aburahma et al***

* + In cases of total occlusion, there should be a pre-occlusive thump (staccato waveform). No Doppler signal or colour flow is detected within the vessel lumen. The presence of exit collaterals and dampened distal waveforms, monophasic are predictive of total occlusion also.
  + The occlusion should be imaged in transverse orientation as well as longitudinal to confirm vessel occlusion and to measure the length of occlusion
  + The length of occlusion should be given in cm from the inguinal ligament or from the popliteal knee crease or a known anatomical location for reference.
  + Level of recanalization is very beneficial and should be commented on.

**12.0 Aorto-iliac Arterial Duplex Scan**

* A full scan of the aorto-iliac segment is recommended in all cases when peripheral vascular disease is suspected.
* Place the curvilinear C4-2 probe longitudinally over the inguinal ligament with the leading edge of the probe pointing towards the umbilics. Proceed proximally to the aorta.
* Peak systolic velocity (PSV) and waveform shape at the common femoral; distal mid and proximal external iliac; origin of internal iliac; proximal and distal common iliac.
* PSV at sites of visible disturbances to flow, calculation of PSV Ratio when stenosis encountered
* For the Abdominal Aorta In cross-section, measure the maximal external diameter of the aorta (outer-outer wall) in both anterior/posterior and transverse sections. Document the largest diameter obtained, Ap, Transverse, Trans diagonal
* If the patient is referred for screening/routine scanning of the abdominal aorta and one is diagnosed:
  + - * + Proceed to scanning the Femoral and Popliteal arteries bilaterally.
        + Perform ABPIs

**13.0 Stenosis Criteria in the aortoiliac segment**

Doppler velocity criteria used for Aortoiliac disease.

**De Smet et al 19965**

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| **50-70% DR stenosis**  **>50%** | **Vr >2.8** | **PSV >200cm/sec** |
| **>70% DR stenosis** | **Vr >5** | **EDV>40cm/sec** |
| **100% Occluded** | **No doppler signal or colour flow. Pre occlusive thump in proximal segment** | **Damped monophasic flow >=30cm/sec in CFA** |

PSV = Peak systolic Velocity, EDV= End diastolic velocity, DR diameter reduction

**14.0 Duplex monitored Endovascular stents**

**Stenosis Criteria**

* A PSV less than 180cm/sec and Vr across the treated segment of <2 is considered within normal limits.
* Document stenosis as >50% if ratio and velocities exceed the above criteria
* **If PSV >300cm/sec and Vr is >3.5 suggests a >75% stenosis**

**15.0 Aneurysms detected in the Femoro-popliteal segment**

* A true aneurysm is encased by the aortic wall and is defined as greater than or equal to 1.5 times the diameter of the more proximal vessel.
* A pseudoaneurysm is a tear through all the layers of the artery with persistent flow outside the vessel into a space contained by the surrounding tissue.
* A dissection is an intimal tear resulting in a false channel which generally occupies one-half of the artery and can compress the true lumen.

Measurements to be made in Femoral and popliteal aneurysms:

Outer to outer wall (AP) and transverse diameters as well as Inner to inner wall (AP) and the following observations documented:

1. Length of vessel involved in the aneurysmal dilatation
2. Amount of atherosclerotic plaque and/or thrombus within the aneurysm.
3. Shape of aneurysmal dilatation, fusiform or saccular
4. Any compression or occlusion (DVT) of the adjacent deep vein

***Of note:*** If the aneurysm is occluded, scan the run off vessels using adjusted PRF colour and PW doppler scales to detect low flow rates. If the run off vessels are also occluded with thrombus and the patient is experiencing rest pain escalate findings to the line manager and/or contact the referring consultant via bleep system.

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