

**Vascular Technology Professional Performance Guidelines**

**Duplex Ultrasound Examination Post- creation of Dialysis Arterio-Venous Fistulas (AVF) and Arterio-Venous Grafts (AVG)**

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Suggestions for improvement of this guideline are welcome and should be sent to the Chair of the PSC

see www.svtgbi.org.uk for current Chair details.

**Introduction**

This guideline was prepared by the Professional Standards Committee (PSC) of the Society for Vascular Technology (SVT) as a template to aid the clinical vascular scientist / vascular sonographer and other interested parties. It can be used in conjunction with local protocols agreed with Renal and/or Vascular departments. It may be used in part or in its entirety with suitable additions made by local policy implementors, and should be read in combination with the following SVT guideline when setting up a fistula ultrasound assessment service:

* Vascular Ultrasound Service Specifications1

In addition, the SVU publications 2 3 4 provide further detailed guidance in relation to assessment post creation of fistulas.

Suggestions for improving this guideline are welcome and should be sent to the Chair of the PSC; see [www.svtgbi.org.uk](http://www.svtgbi.org.uk) for current Chair details.

**Purpose**

Access to the vascular system is essential in patients with renal failure, in whom haemodialysis (HD) is required. The ideal form of access is a surgically created autogenous arterio-venous fistula (AVF), where an anastomosis is created between an artery and a vein. Sometimes a synthetic graft joins the artery and vein to create an arterio-venous dialysis graft (AVG).

This allows for high volumes of blood flow in an easily accessible vessel (vein or graft), which is ideal for the repeated needle punctures required to divert blood to a dialysis machine. The majority of AVFs and AVGs are created in the upper limb, however if all upper limb options are exhausted the thigh or abdomen may be utilised. The new AVF conduit takes time to “mature” as the “arterialised” draining vein enlarges in response to increased flow. Typically, this takes about two months.

Duplex ultrasound is used to assess the suitability of upper or lower limb arteries and veins prior to and post AVF or AVG formation for HD.

**Common Indications**

Common indications for performing these examinations include:

* failing AVF or AVG (*e.*g. low flow on transonic assessment or during dialysis)
* post-operative (*e.*g. angioplasty) surveillance
* difficulty accessing for dialysis/clotting of needles
* failure of fistula to mature
* prolonged bleeding post-dialysis
* suspected steal syndrome, arm swelling, or discomfort in the hand during or after dialysis
* shortness of breath which may indicate very high flow volumes
* suspected occlusion of fistula/graft
* suspected aneurysm or false aneurysm
* elevated venous pressures

**Contraindications and Limits**

These include:

* Obesity
* Dressings, open wounds etc.
* recent bleeding from the access site
* Patients who are unable to co-operate due to impaired cognition (e.g. dementia) or through involuntary movements
* Acoustic shadowing from calcified arteries
* Previous phlebitis/scarred veins
* Very tortuous or eroding fistula/graft
* limitations of accuracy and reliability for flow volume measurements due to inherent errors (see detailed information later in this document)

**Patient Pathways**

Post-access assessments are relevant to those patients who currently have an AVF or AVG for haemodialysis and may require regular surveillance. Assessments should ideally take the patients’ dialysis appointments into account and be scheduled to minimise the number of hospital visits.

Further detailed guidance is given in a report jointly produced by The Renal Association, The Vascular Society and The British Society of Interventional Radiology 5.

**Patient Referral**

For post-fistula assessments, the referral should include details of the fistula to be scanned and the nature of any concerns relating to its function. These are complex scans and having as much information as possible will aid the investigation.

The Society for Vascular Ultrasound (SVU) publications 2 3 4 provide further detailed information.

**Patient Preparation**

No specific preparation is required although access to the relevant limb will be required. The patient may sit or lie.

Ideally, post-fistula/graft scans should be performed prior to dialysis. If an open wound is present, sterile gel 6 and a probe cover should be used. Use of a clear dressing or sterile pad may be helpful.

Due to the intimate nature of the examination it may be necessary to offer a chaperone 7.

**Examination**

Post-Fistula (AVF) and Post-Graft (AVG) Assessment

The patient is asked to remove their clothing to expose the relevant limb(s) and be examined supine. Head and shoulders can be raised. Upper limbs to be examined may be abducted to nearly 90 degrees and rested on a lap or pillow and to avoid stretching, the examination couch may be rotated to allow easy access to either side of the body. The knee of the leg to be examined can be bent slightly and thigh abducted.

To minimise risk of infection it is advisable to assess a fistula/graft before dialysis. Examine the entire fistula/graft circuit, from arterial inflow to distal venous outflow, paying particular attention to the anastomoses, peri-anastomotic region and the region for dialysis access.

B-mode is used to ascertain anatomy, assess aneurysms, peri-fistula fluid, prominent branches and stenoses, and abnormal vessel contents. Aneurysms should be measured ideally in a longitudinal plane, outer wall to outer wall. Landing sites for needles can be assessed for accurate placement (where a tract is visible extending from skin to fistula/graft) and a fistula’s depth may also be measured.

Assessment of graft wall integrity should be made for prosthetic grafts.

Suspect a loss of graft wall integrity if a haematoma is present. Disruption to the graft wall, interstitial and peri-graft fluid are common indicators of graft infection.

Colour and pulsed Doppler are used to investigate the inflow artery, anastomoses, fistula/graft and outflow, including the presence or absence of flow, flow direction, prominent branches, volume flow rates, stenoses and pseudoaneurysms. Care should be taken to keep the Doppler angle to 60 degrees or less when recording velocity measurements. The extent, haemodynamic effect and nature of any lesion (eg. stenosis, valve cusp) should be recorded as well as its site. It is likely that the colour flow scale will need to be set high. An estimate of volume flow should be made within the supplying artery for AVF and from within the graft for AVGs, but it should be noted that volume flow estimates are prone to large margins of error. Flow in the arteries beyond the anastomosis should be assessed if there are clinical indications of steal 8.

Volume Flow Rate (VFR)

Typically, high velocity flow and low resistant waveforms are encountered in a fistula/graft and its supplying artery.

Fistula - For adequate dialysis, the fistula should ideally measure >0.5cm diameter, with an estimated VFR of at least 600ml/min 8 9. When less than 300 to 400ml/min, a fistula may not be maturing or obstruction may be present 15.

Graft - To maintain patency, VFRs in a graft should be higher than for native fistulae 8,9, possibly in excess of 800mL/min.9 A VFR of <500ml/min is considered abnormal,8 and < 600ml/min can indicate risk of thrombosis 10.

VFR may be considered pathologically high in a fistula/graft if exceeding around 2l/min in conjunction with symptoms (*e.g*. shortness of breath.)

VFR can be assessed in the supplying artery, in the fistula/graft just downstream from any access site, downstream to any stenoses, or in prominent branches to determine their effect on flow. However, caution should be applied when assessing flow volumes in veins due to the inherent inaccuracies because of their elliptical shape and helical flow patterns in non-straight segments making angle correction impossible.  Dialysis access flow should always be measured in the supplying (e.g. brachial) artery for AVF or in the graft for AVG.  Estimates of flow in veins may be useful for evaluating flow split into large branches.

Image in longitudinal in B mode, ideally in a uniform, large calibre segment where there is no turbulent flow.

Recommended methodology for VFR measurements

Using spectral Doppler and optimising the following controls to minimise errors, record a waveform that typifies flow:

* Depth - to ensure accurate diameter measurements, using the zoom function where appropriate.
* Doppler gain and wall filter - to minimise spectral broadening and ensure the displayed mean velocity is appropriate and consistent across the displayed waveforms.
* Doppler gate – it is essential that this traverses the area of flow to ensure an accurate estimation of mean velocity
* Doppler angle – should be <60 degrees
* Vessel diameter callipers – these should accurately match the vessel diameter and be placed at 90 degrees to the vessel walls.

The ultrasound machine calculates VFR using the following formulae:

* VFR (ml/min) = CSA x mean velocity x 60

Where:

* Cross Section Area (CSA, cm2) = diameter2 (cm) x π/4, assuming the vessel is circular
* Mean velocity (cm/s) - ensure callipers are optimised to enable calculation over at least three cardiac cycles

As there are inherent errors in measuring VFRs it is best to include at least three cardiac cycles to minimise these errors, stating an average of the measurements in the report 8 and rounding appropriately.

Flow characteristics and assessment of Stenosis

Doppler angles must be kept at or below 60 degrees. Areas of aliasing or reduction in calibre should be examined for presence of stenosis. There should be no focal increase in PSV within the fistula/graft (although velocities are commonly raised at an anastomosis.) The inflow artery and fistula/graft should exhibit low resistance, pulsed Doppler waveforms.

A velocity ratio of >2:1 (intra stenosis vs. pre stenosis velocity) suggests a >50% stenosis in a straight section of the supplying artery, the outflow veins, and in the fistula/graft itself. B-mode and colour appearances should be used in combination with velocity measurements for suspected areas of stenosis.

Stenoses are more difficult to grade at a fistula/graft’s anastomosis, where there is often acute angulation or disparity between inflow vessel and fistula calibres. Here, velocities typically measure around 300 to 500cm/s and it has been suggested a two-to-three-fold increase in velocity indicates a significant stenosis 10 11, with a >3:1 ratio indicating a >50% stenosis 8 . However, large changes in vessel calibre and angle with corresponding flow changes, are common and may have subclinical significance 8, General and local flow data and clinical presentation must be matched to give an overall picture of fistula/graft function.

The residual lumen calibre at a stenosis can be carefully measured in transverse, and it can be helpful to distinguish between haemodynamic stenoses caused by valves and those caused by intimal hyperplasia, thrombus or reduction in overall vessel calibre *etc*.

Assessment of AVF/AVG haemodynamics can be complex, it may therefore be useful to audit Duplex findings and compare with alternative imaging (e.g. fistulograms) to inform local protocol development.

Steal syndrome

Steal syndrome is diagnosed clinically, and ultrasound can provide haemodynamic evidence to support this 9. It is common for there to be non-pathologic retrograde flow in the brachial or radial artery distal to a fistula. Colour and spectral Doppler are used to assess waveforms, flow direction and the presence of haemodynamically significant disease in the arteries perfusing the limb distal to the anastomosis. VFR in the radial and ulnar arteries can be assessed and may be compared to those in the opposite “non-fistula/graft” limb. Photoplethysmography can aid in demonstrating reduced flow in digits. Assessment of distal arterial waveforms whilst the fistula is manually occluded can also be helpful.  Increased distal flow during fistula compression suggests the presence of steal, whereas little or no change suggests the absence of steal.

Ultrasound scanning is operator dependent and recorded images may not fully represent the entire examination. It is important to follow the sequence of events outlined in the protocol to avoid missing important information and images should be recorded in accordance with this locally agreed protocol. Any stored images should display patient information, examination date and the organisation or department. Further explanation and guidance is given in professional guidance documents 12 13 .

**Reporting**

For generic information regarding reports and their content, see the SVT Vascular Ultrasound Service Specification document 1.

The report should include:

* Correct patient demographics; examination type and date; name and status of the CVS
* Which limbs were examined
* The vessels assessed, their patency, calibre and depth, as appropriate
* Flow characteristics
* Any variation from the expected anatomy (e.g., presence of aneurysms, tortuosity)
* Anything limiting the examination
* Indication of the fistula/graft anatomy including inflow and outflow vessels
* Any variation from typical anatomy
* Flow directions including Volume Flows and an indication of where these have been assessed
* Presence and location of any stenosis/abnormality
* Position of any prominent tributaries diverting flow from a fistula
* Lack of integrity or features to suggest infection of a prosthetic graft
* A note of any arranged follow-up or referral as a result of the scan

There should be an appropriate number of annotated images representing the entire ultrasound examination, in accordance with local protocols and SVT Image Storage Guidelines 11.

**General Considerations**

Measurement technique should ensure accuracy is optimised as appropriate to the clinical scenario; this may require:

* Optimal adjustment to scale, gain and cursor placement for velocity measurements
* Selection of an appropriate probe including knowledge of probe resolution (axial/lateral) for linear measurements.
* Ensuring reported linear measurements are consistent with the level of accuracy/resolution possible, including the use of rounding where appropriate.
* Optimised technique for volume flow measurements, applying knowledge of all sources of error and ensuring reported measurements do not imply a level of accuracy which is not possible.

References

1  The Society for Vascular Technology of Great Britain & Ireland “Vascular Ultrasound Service Specifications” [www.svtgbi.org.uk](http://www.svtgbi.org.uk)

2 Society for Vascular Ultrasound Professional Performance Guideline “Evaluation of Hemodialysis Access” <https://www.svu.org/practice-resources/professional-performance-guidelines/>

3 Society for Vascular Ultrasound Professional Performance Guideline “Upper Extremity Vein Mapping for Creation of a Dialysis Access or Peripheral Vascular Bypass Graft” <https://www.svu.org/practice-resources/professional-performance-guidelines/>

4 Society for Vascular Ultrasound Professional Performance Guideline “Lower Extremity Vein Mapping” <https://www.svu.org/practice-resources/professional-performance-guidelines/>

5 The Organisation and Delivery of the Vascular Access Service for Maintenance Haemodialysis Patients (August 2006) Joint Working Party The Renal Association, Vascular Society Great Britain and Ireland, British Society of Interventional Radiology [http://www.renal.org/docs/default-source/what-we-do/HD\_Vascular\_Access\_Wroking\_Party \_Report\_2006](http://www.renal.org/docs/default-source/what-we-do/HD_Vascular_Access_Wroking_Party%20_Report_2006)

6 UK Health Security AgencyGuidance. (2021)Good Infection Control Practice: using ultrasound gel. <https://www.gov.uk/government/publications/ultrasound-gel-good-infection-prevention-practice>

7 Society for Vascular Technology Professional Standards Committee Chaperone Guidelines <https://www.svtgbi.org.uk/professional-issues/>

8 American Institute of Ultrasound in Medicine Practice Guidelines for the Performance of a Vascular Ultrasound Examination for Postoperative Assessment of Dialysis Access 2007 [www.aium.org](http://www.aium.org)

9 Cullen N, Powell S. Interpretation of duplex in Arteriovenous dialysis access: a review of pathologies. Ultrasound 2011; 19:76-84 <https://www.researchgate.net/signup.SignUp.html>

10 Freedman B, Deane C. Ultrasound in Haemodialysis Access. *Ultrasound* (2005) 13:2 86-92

11 Ragu A Reliability of ultrasound duplex for detection of haemodynamically significant stenosis in haemodialysis access. Ann vasc Dis 6 )1): 57-61 <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3635001/pdf/avd-06-057.pdf>

12 SVT Guidance on Image Storage and use, for the vascular ultrasound scans <http://www.svtgbi.org.uk/professional-issues/>

13 Guidelines for Professional Ultrasound Practice. The Society and College of Radiographers and the British Medical Ultrasound Society Dec 2019 <https://www.sor.org/getmedia/00882406-9321-4b7d-b565-47262c2467de/2020.1.19_scor_bmus_guidelines_-.pdf_2>