CSVS

THE COLLEGE AND SOCIETY
FOR CLINICAL VASCULAR SCIENCE
Great Britain and Ireland

Vascular Science Guidelines

Duplex Ultrasound Examination Post-creation of Dialysis Arterio-Venous Fistula (AVF) and Arterio-Venous Graft (AVG)

Version 1.1

April 2026

PS-PG009

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1.1	Updated formatting and small content edits	Author: PSC Approval: CSVS Exec committee	April 2026

Purpose

This guideline was prepared by the Professional Standards Committee (PSC) of the College and Society for Clinical Vascular Science (CSVS) 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 CSVS guideline when setting up a fistula ultrasound assessment service:

- Vascular Ultrasound Service Specifications[1]

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.csvs.org.uk for current Chair details.

Introduction

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
- Palpable/pulsatile mass associated with the AVF or AVG
- 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

- follow up access revision

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)
- Recent dialysis affecting VF. An appropriate time interval for scanning post dialysis should be considered[5].

Patient Pathways

Post-access assessments are relevant to those patients who currently have an AVF or AVG for haemodialysis and may require 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 the UK Kidney Association Clinical Practice Guideline [6].

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. Sterile gel should be used for patients receiving dialysis or in receipt of a solid organ transplant[7], and a probe cover and disinfection of the probe to be used when there is potential contact with open wounds or fluids. 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 [8].

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 or sitting facing the examiner. 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 to the centre of the lumen 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 or pseudoaneurysm 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 direction and potentially volume in the arteries beyond the anastomosis should be assessed if there are clinical indications of steal [9].

Volume Flow Rate (VFR)

VFR should be assessed in the brachial artery (ideally including for radio-cephalic AVF). We recommend a minimum of three separate VF measurements are taken over at least three cardiac cycles. VFR can be measured in the outflow 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. It is not recommended to take volume flow within any aneurysmal segments of the fistula.
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.

Typically, high velocity flow and low resistant waveforms are encountered in a fistula/graft and its supplying artery. These volume flow rates are applicable to upper limb AVF/AVG, however services may wish to use similar VFRs for other anatomical AVF/AVGs.

Fistula - For adequate dialysis, the fistula should ideally measure >0.5cm diameter, with an estimated VFR of at least 600ml/min [9,10]. When <400ml/min, a fistula may not be maturing or obstruction may be present, although this is very site dependent (for example, this volume may be seen in a well-functioning radiocephalic fistula).

Graft - To maintain patency, VFRs in a graft should be higher than for native fistulae [9,10], possibly in excess of 800mL/min.[10] Risk of thrombosis increases with decreased VFRs, flows of <500-600ml/min are considered abnormal and indicate risk of thrombosis[9, 11]. Recommend local agreements with referring clinicians.

VFR may be considered pathologically high in a fistula/graft if exceeding around 2l/min in conjunction with symptoms (*e.g.* shortness of breath)[12].

Recommended methodology for VFR measurements

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

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 wall to wall to ensure an accurate estimation of mean velocity. Care should be taken not to sample velocities from adjacent vein.
- Doppler angle – should be ≤60 degrees, aligned to vessel walls.
- Vessel diameter callipers – these should accurately match the vessel diameter and be placed at 90 degrees to the inner 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, cm^2) = $diameter^2$ (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 due to operator dependency, it is best to include at least three cardiac cycles to minimise these errors, stating an average of the measurements in the report[9] 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 [11,13], with a >3:1 ratio indicating a >50% stenosis [9]. However, large changes in vessel calibre and angle with corresponding flow changes, are common and may have subclinical significance; 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 [10]. It is common for there to be non-pathologic retrograde flow in the radial artery distal to a fistula anastomosis. 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. High frequency ultrasound or 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. This should be performed / discussed with the referring clinical team due to clinical risks to the fistula.

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.
- 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 [14,15] .

Reporting

For generic information regarding reports and their content, see the CSVS 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 CSVS Image Storage Guidelines[13].

References

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5) Duplex ultrasound volumetric flow analysis before and after hemodialysis in patients with brachio-cephalic fistulae, Shakila Chowdhury 1, David Goss, Hiren Mistry, Matthew A Stephenson, Paul Seed, Colin Deane, Domenico Valenti. J Vasc Access, 2013 Oct-Dec;14(4):342-7., doi: 10.5301/jva.5000150. Date accessed 17/04/2026.
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7) UK Health Security Agency Guidance. (2021) Good Infection Control Practice: using ultrasound gel https://www.gov.uk/government/publications/ultrasound-gel-good-infection-prevention-practice
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10) 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
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