THE SOCIETY FOR VASCULAR TECHNOLOGY OF GREAT BRITAIN AND IRELAND

Vascular Technology Professional Performance Guidelines

Duplex Ultrasound Examination of Prosthetic Arterio-Venous Dialysis Grafts (AVG)

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 sonographers and other interested parties. It can be used in conjunction with local protocols agreed between sonography, 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 guidelines when setting up a fistula scanning service:

- Vascular Ultrasound Service Specifications[10]
- Duplex Ultrasound Examination Prior to Native Arterio-Venous Fistula (AVF) Formation: Upper Limb[11]
- Native Arterio-Venous Fistula Duplex Ultrasound Examination: Upper Limb.[12]

In addition, the SVU publication[13] provides detailed indications for investigating fistulas. Suggestions for improving this guideline are welcome, and should be sent to the Chair of the PSC; see www.svtgbi.org.uk for current Chair details.

Purpose

Duplex ultrasound is used to assess the anatomy, patency and function of AVGs (a type of fistula) for haemodialysis (HD.) Fistulas are placed in the arm or thigh, and either take the form of a straight vessel or loop. Flow characteristics are examined prior to the fistula, within and downstream from it.

Common Indications
Common indications for performing this examination include:

- post-operative surveillance
- failing AVG (*e.g.* low flow on transonic assessment or during dialysis)
- difficulty accessing for dialysis
- suspected steal syndrome
- arm swelling, or discomfort in the hand during or after dialysis
- ? aneurysm or false aneurysm
- post intervention (*e.g.* angioplasty)
- elevated venous pressures.

Contraindications and Limits
Contraindications or limits for AVG examinations include:

- wound dressings
- recent bleeding from the access site
- very tortuous or eroding graft
- patients unable to cooperate due to impaired cognition (e.g. dementia) or from involuntary movements.

Patient Pathway
These scans will apply to patients who already have an AVG. Investigations should 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.[14]

Patient Referral
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.

Patient Preparation
No specific preparation is required. Ideally these scans should be performed prior to dialysis. Access to the patient's limb will be required. The patient may sit or lie. If an open wound is present, a clear dressing or sterile pad may be required.

Examination
The patient is asked to remove their clothing to expose the upper limb and be examined supine. Head and shoulders can be raised. The arm to be examined may be abducted to nearly 90 degrees and rested on a lap or pillow. The knee of the leg to be examined can be bent slightly and thigh abducted. To avoid stretching, the examination couch may be rotated to allow easy access to either side of the body. Due to the intimate nature of the examination it may be appropriate to offer the presence of a chaperone.[2]

For general details on assessing artery and vein suitability for fistulae prior to surgery, please refer to the SVT Professional Performance Guideline.[11] There is little data in the literature specifying suitable artery and vein diameters for AVGs, but it has been stated a vein with a diameter of at least 4.0mm is required,[6, 7] and a minimum arterial diameter of 2.0mm.[7]

It is best to assess any fistula before dialysis. Examine the entire AVG circuit, from arterial inflow to distal venous outflow, attempting to image the subclavian and brachiocephalic veins in arms with grafts. Pay particular attention to the anastomoses (especially at the venous end of the graft), peri-anastomotic region, dialysis access sites, graft wall integrity and any areas of aliasing.

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

Colour and pulsed Doppler are used to investigate the inflow artery, anastomoses, the fistula itself, and outflow. Assess for the presence, absence and direction of flow, volume flow rates, stenoses and pseudoaneurysms. It is likely the colour flow sensitivity scale will need to be set high.

Care should be taken to keep the Doppler angle 60° or less when recording velocity measurements. An estimate of volume flow within the supplying artery or within the graft itself can be useful, but it should be noted volume flow estimates are prone to large margins of error. Flow in the arteries downstream from the anastomosis should be assessed if there are clinical indications of steal.[3]

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.

Volume Flow Rates (VFR)

Typically, high velocity flow and low resistant type waveforms are observed in a graft and its supplying artery. Waveforms may settle to a more typical venous pattern in the venous outflow downstream to the fistula.

To maintain patency, VFRs in a graft should be higher than for native fistulae,[4,5] possibly in excess of 800mL/min.[4] A VFR of <500mL/min is considered abnormal,[5] and ≤600mL/min can indicate risk of thrombosis.[3] VFR may be considered pathologically high if exceeding around 2L/min in conjunction with symptoms (*e.g.* shortness of breath.)

VFRs can be assessed in the supplying artery and in the graft just downstream from the access site, and should also be estimated downstream to any stenoses to determine their effect on flow.

Image in longitudinal in B mode, ideally in a uniform, large calibre segment where there is no turbulent flow. Using spectral Doppler, record a waveform that typifies flow here and displays mean velocities. Doppler gain must be adjusted to minimise spectral broadening. Mean velocity is calculated over at least three cardiac cycles to account for variation in flow characteristics.[5]

It is essential the Doppler gate traverses the area of flow, Doppler angles measure <60 degrees and vessel diameter callipers accurately match the vessel diameter (measured 90 degrees to vessel walls.) As there are inherent errors in measuring VFR, the average of at least three VFR values can be stated in the report.[5]

The ultrasound machine calculates VFR using the following formulae:

- Cross Section Area (CSA, cm^2) = $diameter^2$ (cm) x π/4, assuming the vessel is circular
- Mean velocity (cm/s) is calculated over at least three cardiac cycles
- VFR (mL/min) = CSA x mean velocity x 60.

Stenosis

Doppler angles must be kept below 60 degrees. Areas of aliasing or reduction in calibre should be examined for stenosis. A velocity ratio of 2:1 (intra stenosis ÷ pre stenosis velocity) indicates a 50% stenosis in a straight section of the supplying artery, the outflow veins, and in the graft itself (but not at its anastomosis.)

Stenoses are more difficult to grade at a fistula's anastomosis, where there is often acute angulation or disparity between inflow vessel and fistula calibres. Here, velocities often typically measure around 300 to 500cm/s, and It is has been suggested a two fold increase in velocity indicates at least a 50% stenosis,[9] and a two to three fold or greater ratio suggesting a more severe (>50%) stenosis.[3, 5, 8, 9]

However, large changes in vessel calibre and angle with corresponding flow changes are common and may have subclinical significance,[3] local and general flow data and clinical presentation must be accounted for to give an overall picture of fistula function. The residual lumen calibre at a stenosis can be carefully measured in transverse.

Steal syndrome

Steal syndrome is diagnosed clinically, and ultrasound can provide haemodynamic evidence to support this[4] (It is common for there to be non pathologic flow reversal in the brachial or radial artery distal to a fistula.)

Colour and spectral Doppler are used to assess waveforms and flow direction in the arteries perfusing the limb downstream to graft's anastomosis with an artery. VFR in the radial and ulnar arteries can be assessed, and photoplethysmography can aid in demonstrating flow in digits.

Reporting

General fistula condition (*e.g.* widely patent) as well as the location and extent of narrowing or dilation should be recorded. If the fistula appears narrow, the maximum PSV within the stenosis should be recorded and compared with the PSV within a normal section of the fistula. The presence and location of any thrombus, the estimated VFR (and where it was recorded) should be noted

Other than the details stated in the SVT Vascular Service Specification,[10] the report should include:

- correct side, location and which type of fistula is present
- any variation from the typical fistula anatomy
- which vessels were examined, their patency and general flow, fistula calibre and depth
- presence and location of any abnormality
- fistula and / or supplying artery VFR, degree of any stenosis, occluded segments, flow direction and quality
- anything limiting the examination
- a note of any follow up or referral as a result of the scan
- an appropriate number of annotated images representing the entire ultrasound examination, in accordance with local protocols and SVT Image Storage Guidelines.[1]

References

[1] Society for Vascular Technology Professional Standards Committee Image Storage Guideline April 2012 www.svtgbi.org.uk

[2] Society for Vascular Technology Professional Standards Committee Chaperone Guidelines April 2012 www.svtgbi.org.uk

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

[4] Cullen N, Powell S. Interpretation of duplex in Arteriovenous dialysis access: a review of pathologies. Ultrasound 2011; 19:76 - 84.

[5] American Institute of Ultrasound in Medicine Practice Guideline for the Performance of a Vascular Ultrasound Examination for Postoperative Assessment of Dialysis Access 2007 www.aium.org

[6] American Institute of Ultrasound in Medicine Practice Guideline for the Performance of Ultrasound Vascular Mapping for Preoperative Planning of Dialysis Access; 2011 www.aium.org

[7] Allon M, Robbil M.L. Increasing arteriovenous fistulas in haemodialysis patients: Problems and solutions; Kidney International, Vol. 62 (2002), pp 1109 – 1124

[8] Older RA *et al*. Haemodialysis access stenosis: early detection with colour Doppler. US Radiology 1998 Apr; 207(1):161-4.

[9] Robbin ML *et al*. Haemodialysis access graft stenosis: US detection. Radiology. 1998 Sep; 208 (3): 655-61.

[10] Vascular Ultrasound Service Specifications. www.svtgbi.org.uk

[11] Duplex Ultrasound Examination Prior to Native Arterio-Venous Fistula (AVF) Formation: Upper Limb. www.svtgbi.org.uk

[12] Native Arterio-Venous Fistula Duplex Ultrasound Examination: Upper Limb www.svtgbi.org.uk

[13] Society for Vascular Ultrasound; Vascular Technology Professional Performance Guidelines; Evaluation of Dialysis Access 2012 www.svunet.org

[14] 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_Working_Party_Report_2006.pdf?sfvrsn=0

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