THE SOCIETY FOR VASCULAR TECHNOLOGY OF GREAT BRITAIN AND IRELAND

Vascular Technology Professional Performance Guidelines

Native Arterio-Venous Fistula (AVF) Duplex Ultrasound Examination: Upper Limb

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[8]
- Duplex Ultrasound Assessment of Prosthetic Arterio-Venous Dialysis Grafts (AVG.)[9]

In addition, the SVU publication[1] provides detailed indications for fistula investigations. 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 AVF for haemodialysis (HD.) Flow characteristics prior to the fistula, within it and downstream from it are examined.

Common Indications

Common indications for performing this examination include:

- post-operative surveillance
- failing AVF (*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 AVF examinations include:

- wound dressings
- recent bleeding from the access site
- very aneurysmal or tortuous fistula
- 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 AVF. 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.[11]

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.[4]

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, but it is important to ensure veins are adequately filled. If an open wound is present, then 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 limb to be examined may be abducted to nearly 90 degrees and the arm rested on a lap or pillow. To avoid stretching, the examination couch may be rotated to allow easy access to either side of the body.

It is best to assess a fistula before dialysis. Examine the entire fistula circuit, from arterial inflow to distal venous outflow, paying particular attention to the anastomosis, peri-anastomotic region and the region for dialysis access. Due to the intimate nature of the examination it may be necessary to offer a chaperone.[2]

B-mode is used to ascertain anatomy, assess aneurysms, peri-fistula fluid, prominent branches and stenoses, and abnormal vessel contents. Aneurysms should be measured in transverse, 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) and a fistula's depth may also be measured.

Colour and pulsed Doppler are used to investigate the inflow artery, anastomoses, fistula 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 60° or less when recording velocity measurements. An estimate of volume flow within the supplying artery or within the fistula itself may be useful, but it should be noted that volume flow estimates are prone to large margins of error. It is likely the colour flow scale will need to be set high. Flow in the arteries beyond the anastomosis should be assessed if there are clinical indications of steal.[7]

Volume Flow Rates (VFR)

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

For adequate dialysis, the fistula should ideally measure >0.5cm dia., with an estimated VFR of at least 600mL/min.[6,7] When less than 300 to 400mL/min, a fistula may not be maturing or obstruction may be present.[5] 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, in the fistula just downstream from any access site, downstream to any stenoses, or in prominent branches 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 velocity calculations. Doppler gain is adjusted to minimise spectral broadening Mean velocity is calculated over at least three cardiac cycles.[7] It is essential the Doppler gate traverses the area of flow, Doppler angle measures <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.[7]

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 a stenosis. There should be no focal increase in PSV within the fistula (though velocities are commonly raised at a fistula's anastomosis.) The inflow artery and fistula should exhibit low resistance, pulsed Doppler waveforms.

A velocity ratio of 2:1 (intra stenosis vs. pre stenosis velocity) indicates a 50% stenosis in a straight section of the supplying artery, the outflow veins, and in the fistula 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 typically measure around 300 to 500cm/s and It is has been suggested a two to three fold increase in velocity indicates a significant stenosis,[5] with a >3:1 ratio indicating a >50% stenosis.[7] However, large changes in vessel calibre and angle, with corresponding flow changes, are common and may have subclinical significance;[7] general and local flow data and clinical presentation must be matched to give an overall picture of fistula 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.*

Steal syndrome

Steal syndrome is diagnosed clinically, and ultrasound can provide haemodynamic evidence to support this[6] (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 and flow direction in the arteries perfusing the limb distal to the anastomosis. VFR in the radial and ulnar arteries can be assessed. Photoplethysmography can aid in demonstrating reduced flow in digits.

Reporting

General fistula calibre as well as location and extent of narrowing or dilation should be recorded. If the fistula appears narrowed, 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 volume flow (and where it was recorded), size and location of any significant branches and any variation from typical fistula pattern should also be noted.

Other than the details stated in the SVT Vascular Service Specification X, the report should include:

- correct side 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 +/- supplying artery VFR, degree of any stenosis, occluded segments, flow direction and quality
- the position of any prominent tributaries diverting flow from the fistula
- 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.[3]

REFERENCES:

[1] SVU Professional performance guidelines Vascular Technology. Evaluation for Dialysis Access 2012. http://www.svunet.org/practicemanagementmain/professionalperformanceguidelines

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

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

[4] Guidelines for Professional Working Standards Ultrasound Practice; United Kingdom Association of Sonographers (UKAS) October 2008 www.sor.org/learning/document-library

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

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

[7] 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

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

[9] Duplex Ultrasound Assessment of Prosthetic Arterio-Venous Dialysis Grafts (AVG.) www.svtgbi.org.uk

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

[11] 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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