Vascular Technology Professional Performance Guidelines

Native Arterio-Venous Fistula 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 sonographer and other interested parties. This guideline maybe used in part or in its entirety with suitable additions made by local policy implementors. 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 function of arterio-venous fistulae (AVF) for haemodialysis. This guide can be used in conjunction with local protocols agreed between sonography and renal and/or vascular departments.

Common Indications

Common indications for performing this examination include:

- post-op. surveillance
- ?failing AVF (e.g. pulsatile flow, low arterial volume, high venous pressure)
- difficulty accessing for dialysis
- suspected steal syndrome
- arm swelling
- ?aneurysm or false aneurysm
- post intervention (e.g. angioplasty.)

Contraindications and Limitations

Contraindications or limits for AVF examination 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.

Equipment

Duplex Doppler ultrasound machine with imaging frequencies of 3.5MHz and greater, with both linear and curvilinear transducers available. Doppler frequencies of at least 5.0MHz should be available, with colour Doppler capability.

Compliance with the Medical Devices Directive is necessary. Electrical safety testing is required annually, with regular maintenance and quality assurance testing to specified level by qualified personnel. Review of in-service equipment should typically be undertaken four to six years after installation[1].

The examination couch should be height adjustable and preferably electrical. The CVS's chair should provide good lumbar support, be height adjustable and allow for the CVS to move close to the examination couch[2 3].

The examination room should be temperature controlled with adjustable lighting suitable for the examination[2]. Suitable cleaning materials should be available and used in line with manufactures' guidelines[2].

Explanation of Examination and Patient History

The CVS undertaking the examination should:

- introduce themselves
- confirm the patient's identity (e.g. full name and date of birth)
- give an explanation of the procedure and it's duration – consideration should be made to the age and mental status of the patient
- obtain verbal consent for the examination
- obtain a relevant medical history from the patient and/or notes, including;
    - Presence of risk factors
        - impaired fistula function
        - difficulty accessing for dialysis
        - hypotension
        - aneurysm
        - bleeding
        - suspected steal syndrome
        - intervention or surgery to the limb
        - thrombosis
    - results of other relevant diagnostic tests and previous vascular studies
- complete a limited physical examination, observing the presence of any signs, previous surgery or vascular injury
- verify the requested procedure correlates with the patient's clinical requirements

Examination

The patient is asked to remove their clothing to expose the upper limb. The patient is examined in the supine position, head and shoulders can be raised. The limb to be examined may be abducted to nearly 90 degrees and the arm rested on the CVS's lap/pillow. To avoid stretching, the examination couch may be rotated to allow easy access to either side of the body.

Due to intimate nature of the examination it may be necessary to offer a chaperone[4]

During the examination, monitor the patient's mental and physical status and modify the examination accordingly.

When possible, it is best to assess fistulae before dialysis. Examine the entire fistula circuit, from arterial inflow to distal venous outflow. Pay particular attention to the anastomosis, peri-anastomotic region, and the region for dialysis access, any areas of aliasing, and the outflow vessels.

The following vessels may be assessed:

- brachiocephalic vein
- internal jugular vein
- subclavian vein
- axillary vein
- brachial veins
- cephalic vein
- basilic vein

and

- subclavian artery
- axillary artery
- brachial artery
- radial artery
- ulnar artery.

The following imaging modes should be used to evaluate the upper limb veins:

- B-mode
    - ascertain anatomy, assess aneurysms, peri-fistula fluid (e.g. pseudoaneurysms, seroma), prominent branches and stenoses, and abnormal vessel contents
    - measure aneurysms 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)
    - fistula depth may also be measured
- Colour and Spectral Doppler
    - determine presence/absence of flow and its direction throughout the fistula circuit, distal to the fistula and in any prominent branches
    - quantify volume flow rates
    - identify abnormal flow patterns and quantify stenoses
    - assess pseudoaneurysms.

Additional Information

Volume Flow Rates (VFR)

Normally, high velocity flow and low resistant waveforms are encountered in the 'feeding' artery and fistula. Flow may settle to a more typical venous pattern in the deep venous outflow distal to the fistula.

For adequate dialysis, VFR in the fistula should measure at least 300 to 400ml/min[5], and ideally be 600mL/min[6 7]. If less than 300 to 400mL/min, the fistula may not be maturing or obstruction may be present[5].

VFRs can be assessed in the feeding artery and in the fistula just distal to the access site, and should also be estimated distal to any stenoses or prominent branches to determine their effect on flow. VFR can be assessed in these branches if they are thought to be shunting significant amounts of flow.

Image in longitudinal in B mode, ideally in a straight segment where there is a large calibre, no tortuosity and uniform, non turbulent flow. Then, using spectral Doppler, a waveform that typifies flow here is chosen for mean velocity calculations, and 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 is <60 degrees and vessel diameter callipers must 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. A velocity ratio of 2:1 (intra stenosis vs. pre stenosis velocity) indicates a 50% stenosis in a straight section of the inflow artery, the outflow veins, and in the fistula (but not at its anastomosis.)

Stenoses are more difficult to grade at the fistula anastomosis, where there is often acute angulation or disparity between inflow vessel and fistula calibres. Here, velocities often normally measure around 300 to 500cm/s and It is has been suggested a two to three fold increase in velocity indicates a 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[5]; 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 reduction in overall vessel calibre etc.

Steal syndrome

Steal syndrome is a diagnosed clinically, and ultrasound can provide haemodynamic evidence to support this[8] (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 distal to the anastomosis. VFR in the radial and ulnar arteries can be assessed. Photoplethysmography can aid in demonstrating reduced flow in fingers.

Reporting

The report is a record of observations and interpretations made during the duplex ultrasound examination. It should be written by the CVS undertaking the examination and viewed as integral to the whole examination[9].

The report should include:

- correct patient demographics; examination type and date; name and status of the CVS
- 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 +/- feeding 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[10].

Referral of urgent results should be made to the referring consultant and/or appropriate medical/surgical team as per local protocol, so treatment plans can be developed, enforced or expedited accordingly.

RESOURCES:

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

Society for Vascular Technology Physiological Measurement Service Specifications; Duplex Assessment and Surveillance of Arteriovenous (AV) Fistula (pre and post fistula formation) www.svtgbi.org.uk

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

REFERENCES:

[1] Standards for Ultrasound Equipment; Royal College of Radiologists, February 2005 www.rcr.ac.uk

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

[3] The Causes of Musculoskeletal Injury Amongst Sonographers in the UK; Society of Radiographers, June 2002 www.sor.org/learning/document-library

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

[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] Ferring M, Henderson J, Wilmink A, Smith S. Vascular ultrasound for the pre-operative evaluation prior to arteriovenous fistula formation for haemodialysis: review of the evidence. *Nephrology Dialysis Transplant* (2008) 23: 1809-1815

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

SVT Professional Standards Committee September 2013