

The Significance of Inflow Artery and Tourniquet Derived Cephalic Vein Diameters on Predicting Successful Use and Patency of Arteriovenous Fistulas for Haemodialysis

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WHAT THIS PAPER ADDS

In patients undergoing radiocephalic arteriovenous fistulas, a tourniquet derived cephalic vein diameter <4.3 mm (lower three quartiles) was the single independent predictor of inferior secondary and functional secondary patency. In patients undergoing brachiocephalic arteriovenous fistulas, functionality and patency rates were all inferior in the presence of a small brachial artery (≤ 4.1 mm, lowest quartile), indicating that an alternative access site might be preferable.

Objective: To investigate the significance of inflow artery and cephalic vein diameters on predicting patency of radiocephalic and brachiocephalic arteriovenous fistulas (AVFs).

Design: Single centre study with retrospective analysis of prospectively collected data between November 2010 and July 2015.

Methods: A detailed history and physical examination was undertaken, including age, gender, history and duration of haemodialysis, cause of chronic kidney disease, and the presence of comorbidities/risk factors. Pre-operative arterial and venous upper extremity mapping was performed and inner vessel diameter was recorded, using a tourniquet for the veins. Outcome measures included AVF use (functionality), primary, primary assisted, secondary, and functional secondary patency.

Results: One hundred and thirty five AVFs (57 and 78 radiocephalic and brachiocephalic AVFs, respectively) were constructed and followed up for 5 years. A cephalic vein diameter <4.3 mm (lower three quartiles) was the single independent predictor of inferior secondary and also functional secondary patency of radiocephalic AVFs ($p = .02$, HR 11.2, 95% CI 1.44–90.9). A brachial artery diameter ≤ 4.1 mm (lowest quartile) was an independent predictor of AVF functionality (57% vs. 83% for larger arteries, $p = .017$), and inferior primary, primary assisted, secondary, and functional secondary patency of brachiocephalic AVFs (primary assisted patency 21.9% vs. 55.9% at 3 years, $p = .001$ /log-rank test, HR 3.1, $p = .002$ /Cox regression). The presence of lower extremity PAD or use of dual antithrombotics was also independently associated with an inferior secondary patency. The number of risk factors (brachial artery diameter ≤ 4.1 mm, PAD, and use of dual antithrombotics) demonstrated risk stratification capabilities for functional secondary patency.

Conclusions: Among patients undergoing radiocephalic AVFs, a tourniquet derived cephalic vein diameter <4.3 mm was the single independent predictor of inferior secondary and functional secondary patency. Among patients undergoing brachiocephalic AVFs, all patency rates were inferior in the presence of a brachial artery diameter ≤ 4.1 mm and secondary patency was inferior in the presence of multiple risk factors.

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INTRODUCTION

Arteriovenous fistulas (AVFs) are the first line option for haemodialysis according to recommendations^{1,2}; however, it is increasingly recognised that attempts to create an AVF should not be made at all costs, particularly in patients already on haemodialysis.³ Vein mapping has an established role in pre-operative assessment. Vein diameter is mostly used as a predictor of success, with a cephalic vein diameter >4 mm being a predictor of successful AVF function.^{4,5}

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Additionally, brachio basilic or brachio cephalic AVFs made with larger veins have better long-term patency rates, compared with those of smaller veins,⁶ the latter being typically excluded if too small (e.g. <2.5 mm).

Nevertheless, the evidence for the importance of the radial or brachial inflow artery diameter for radiocephalic and brachiocephalic AVFs, respectively, is conflicting, limited, and not put into clinical context.^{4,5,7–16} As a result, generally accepted minimum arterial diameters useful in clinical practice have not been provided and a possible effect of brachial artery diameters on long-term patency has not been investigated. For radiocephalic AVFs, several studies have demonstrated poor functionality rates with a radial artery smaller than 1.5–2.3 mm,^{8,10,11,13} and a cephalic vein smaller than 1.6–2.7 mm,^{7,10,11,13,16} but others have failed to confirm the above associations for arterial^{7,9,16} and venous diameters.^{7,9} One study showed an association between radial artery diameter and primary patency.⁷ For brachiocephalic AVFs, two studies have demonstrated that pre-operative brachial artery diameters were significantly smaller for upper arm fistulas that failed to become functional, compared with those that became functional^{5,14}; however, a third study failed to confirm these findings.¹⁶ Additionally, a minimum suggested diameter useful in clinical practice was not provided and a possible effect of brachial artery diameter on long-term patency was not investigated. Vein diameter has been shown to be a predictor of success, with a cephalic vein diameter exceeding 4 mm being a predictor of functionality.^{4,5}

Tourniquet use increases the number of patients eligible for forearm fistulas without decreasing the functionality rate, as veins that appear small in diameter because of possible spasm are not excluded if dilated with a tourniquet.¹⁷ Because vein diameter is not universally measured with a tourniquet, there is a lack of information for the results of this improved technique.

The aim of the present study was to investigate the relative role of the diameter of the inflow artery and cephalic vein using a tourniquet, on AVF functionality and patency results, in an effort to better define minimum arterial and venous diameters used during pre-operative work-up and improve patient selection.

PATIENTS AND METHODS

Consecutive patients who attended a Vascular Access Outpatient Clinic and had a primary radiocephalic or brachiocephalic AVF performed between November 2010 and July 2015 were prospectively evaluated and retrospectively analysed. Patients undergoing redo AVF surgery, brachio basilic AVFs, or brachio median antebrachial vein AVFs were excluded.

Pre-operative clinical assessment

A detailed history and physical examination was initially undertaken, including age, gender, history, duration of haemodialysis, cause of chronic kidney disease, and the presence of comorbidities/risk factors. The latter included diabetes mellitus (defined as use of insulin or oral

hypoglycemic agents), hypertension (systolic blood pressure >140 mmHg, diastolic blood pressure >90 mmHg, or use of anti-hypertensives), and dyslipidaemia (defined as use of anti-lipidaemic agents, e.g. statins, ezetimibe, etc). Also included were coronary artery disease, defined as history of angina, myocardial infarction, or coronary intervention, including angioplasty and/or bypass grafting, and peripheral arterial disease (PAD), defined as history of intermittent claudication, critical limb ischaemia, or revascularisation of the lower limbs. These clinical characteristics were collected to be used as potential cofounders and to adjust the results of multivariate analysis.

Pre-operative vessel mapping

Pre-operative arterial and venous mapping was performed, as previously described.¹⁸ Venous diameters were assessed with a phlebotomy tourniquet, that is a stretchable webbed 1 inch band with a buckle closure, sequentially applied to the proximal forearm, distal, and proximal arm.¹⁷ Duplex ultrasound was performed with a Mylab50xvision scanner (Esaote S.p.A., Genova, Italy). Radial and brachial artery inner diameters were routinely assessed at the level of intended anastomosis construction, noting the presence of atherosclerotic plaques, arterial calcification, and high bifurcation of the brachial artery. Velocity and waveform spectral analysis was performed. The minimum inner diameter of the cephalic and basilic veins was determined along their course after a 1 min tourniquet application; the depth of the cephalic vein along its path was also noted, with emphasis on identifying a section of sufficient length to allow future AVF use. This information was taken into account when assessing the possibility of cephalic vein elevation as a subsequent procedure to improve functionality. The axillary arteries and veins were also interrogated. Ultrasound commenced on the non-dominant arm and the assessment was selectively repeated on the contralateral arm as required. The minimum vessel diameter used to construct an AVF was 2 mm for the radial artery and 3 mm for the cephalic vein at the wrist and elbow levels respectively, with no minimum diameter exclusion for the brachial artery. Additional exclusion criteria included sites with heavy arterial calcification or a high brachial artery bifurcation.

Surgical technique

All procedures were performed under local anaesthesia with lidocaine solution 1%, preferably on an outpatient setting and using magnifying glasses (loupes). Cephalic vein flushing with 2500 IU heparin provided anticoagulation and simultaneous gentle dilatation. Cephalic vein transposition and use of mid to distal forearm cephalic vein, as dictated by pre-operative vessel mapping, was performed selectively. Brachiocephalic AVFs were performed through a transverse antecubital fossa incision. Arteriotomy length was restricted to 7–8 mm for brachiocephalic AVFs, while this was liberally extended to 10–15 mm for radiocephalic AVFs. All anastomoses were made with 7–

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