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Diameter Criteria Have Limited Value for Prediction of Functional Dialysis Use of Arteriovenous Fistulas

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WHAT THIS PAPER ADDS

Diameter measurements are poor predictors of functional dialysis use of arteriovenous fistulas. Arterial diameters have limited value predicting dialysis use in forearm fistulas, while elbow vein diameter has some value predicting dialysis use in upper arm fistulas. A diameter of 2 mm at the wrist for arteries and veins is a reasonable guide to proceed with a forearm fistula but should not automatically preclude fistula formation in patients with good smaller vessels. A cut off point of 3 mm for brachial artery in the elbow should not be used to exclude creation of a brachiocephalic fistula.

Objective: To determine the value of diameter measurements for prediction of functional dialysis use (FDU) of arteriovenous fistulas (AVF).

Methods: Review of access operations and dialysis databases from January 1, 2007 to August 1, 2015. Follow up until July 1, 2016. FDU defined as six consecutive dialysis sessions with two needles on the AVF. Artery and vein diameters measured by portable ultrasound in access clinic. Contribution of diameter to predict FDU assessed with logistic regression. Diagnostic accuracy assessed by sensitivity, specificity, positive and negative predictive values (PPV and NPV).

Results: 803 AVF operations were analysed: 507 (63%) radiocephalic fistulas (RCAVF), 237 (30%) brachiocephalic fistulas (BCAVF), and 59 (7%) brachiobasilic fistulas (BBAVF). Women had lower FDU in RCAVF (0.65, 95% CI 0.58—0.72 vs. 0.86, 95% CI 0.81—0.89; $p < .0001$), but not in BCAVF (0.83, 95% CI 0.75—0.89 vs. 0.81, 95% CI 0.73—0.88; $p = .75$). Female gender was an independent negative predictor of FDU in RCAVF (OR 0.31; 95% CI 0.20—0.49). Vascular kidney disease was an independent negative predictor for FDU in RCAVF (OR 0.33; 95% CI 0.17—0.64) and BCAVF (OR 0.22; 95% CI 0.09—0.57) in multivariable analysis. Artery and vein diameter did not improve the model for RCAVF. Vein diameter as categorical variable improved the model for BCAVF. Diameter cut off of radial artery $\geq$ 2 mm has 96% sensitivity, 86% PPV, 9% specificity, and 29% NPV in men. Radial artery diameter $\geq$2 mm had 96% sensitivity, 67% PPV but 13% specificity and 62% NPV in women.

Conclusions: Diameter is a poor predictor of FDU of AVF. Arterial diameter measurements add no diagnostic value for BCAVF. Poor specificity suggests a diameter under 2 mm at the wrist should not preclude AVF formation. Vascular kidney disease is an independent negative predictor for FDU in all AVF.

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INTRODUCTION

An autologous arteriovenous fistula (AVF) is the access of choice for haemodialysis patients,[1—3] yet primary failure (PF) rates remain around 23%.[4] There is good evidence that pre-operative evaluation with duplex ultrasound (DUS) improves outcomes of fistula surgery.[5—8] The most commonly used parameters to measure are vessel diameters. Debate continues about vessel size criteria,[7,9—12] and most of this has centred on forearm AVF. Earlier studies advocated a minimum radial artery diameter of 1.5 mm,[9,10] but recent studies recommend a minimum radial artery diameter of 2 mm,[7,13] although a paper in 2013 suggested 1.6 mm as the cutoff point.[14] Recommended minimal cephalic vein (CV) internal diameters associated with forearm AVF outcomes vary from 1.6 to 2.6 mm.[9,15,16] There are no diameter recommendations for the brachial artery.[8]

Multiple factors influence PF. Gender is important: several studies reported higher PF in women, which persists after the use of pre-operative vein mapping.[17—20] Vessel quality is likely to be important but is harder to measure.[8,14,21]

This study aimed at assessing the value of diameter criteria to predict FDU of autogenous AVF in a large cohort

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of AVF operations by estimating the contribution of diameter to the prediction of FDU, by assessing discriminatory accuracy and predictive values of pre-operative diameter measurements and by comparing pre- and post-ultrasound assessment probabilities of FDU.[22]

METHODS

This was a retrospective analysis of two prospectively maintained databases of all vascular access operations and all dialysis sessions (Proton, a bespoke UK renal database)[23] in the authors' Hospital Trust, which includes three hospitals, four satellite dialysis units, and a home haemodialysis programme serving an average prevalent dialysis population of 475 patients. The pre-ultrasound assessment period was from December 1, 2002 when the access database was started. The main study period was from January 1, 2007, when routine ultrasound assessments were started for planning of vascular access, until August 1, 2015. Follow up was until July 1, 2016. All operations were corroborated with the electronic patient records. First, sixth consecutive, and last cannulation dates were obtained from the renal database. If required, additional information was sought from the home dialysis team, the vascular access nurses, or the dialysis units.

Functional dialysis use (FDU) was defined as six consecutive dialysis sessions with two needles on the AVF.[24,25] Primary failure (PF) was defined as failure to achieve six consecutive successful two needle cannulations of the AVF. This included failure to mature. Diabetes was coded according to the dialysis database and the electronic patient records. Cause of chronic kidney disease (CKD) was coded as diabetic, vascular CKD (defined as hypertensive or reno-vascular CKD), polycystic kidney disease, autoimmune CKD (glomerulonephritis, vasculitis, anti-glomerular basement membrane disease, IgA nephropathy, etc.), post-renal CKD (urological causes), and other or unknown as per nephrology records. AVF survival was defined as cumulative survival[26] from the operation date to the last needling date before the AVF was abandoned for a new form of access. This is identical to secondary patency in the ESVS guidelines.[1] A surgical revision was not coded as a new AVF if the patient continued to dialyse on the same AVF within three dialysis sessions. An elbow AVF above a previous forearm AVF was always coded as a new AVF and the forearm AVF as failed. Revisions of pre-dialysis AVF were coded as PF if a new AVF was created but as FDU if the AVF was patent and the patient went on to have six consecutive dialysis sessions on the same AVF.

Radiocephalic AVF (RCAVF) and brachiocephalic AVF (BCAVF) were analysed separately. Brachiobasilic AVF (BBAVF) was excluded because the transposition and the haemodynamic effects of general anaesthesia may confound associations between diameter and FDU.[27,28]

Access planning protocol

All assessments were done in a vascular access clinic. The authors' standardised assessment protocol has been described previously.[6,8,24] Pulses at elbows and wrists, and the superficial veins in the forearm and upper arm (with tourniquet) were assessed clinically by one of three vascular surgeons or a vascular access nurse specialist. This was followed by ultrasound examination by the same assessor in the same clinic. Patients were scanned with a portable ultrasound scanner (SonoSite MicroMaxx, SonoSite, USA) with a 5—10 MHz linear probe. The arterial scan followed the arteries from brachial artery in the elbow to radial artery at the wrist in B-mode. Internal diameters were measured of the radial artery at the wrist and the distal forearm and of the brachial artery at the elbow. The recommended minimum arterial diameters suitable for AVF formation were 2 mm in the forearm and 3 mm in the upper arm.[1,3,29] Spectral duplex ultrasound waveforms were recorded in the brachial artery at the elbow, in the radial artery at the wrist or in the distal forearm if that site was chosen for the anastomosis. The spectral Doppler waveform was considered adequate if triphasic or biphasic in antegrade direction, but inadequate if retrograde, damped, or absent.[30] The ulnar artery was assessed in the distal forearm. Complete or near occlusion of the ulnar artery was a relative contraindication to access formation in that arm.

Based on the literature the vein was examined with tourniquet.[8] The superficial veins were followed in cross section with B-mode from wrist to mid-upper arm, with intermittent vein compression. The cephalic vein was scanned from wrist to mid-upper arm. The basilic vein was scanned from the elbow level to its drainage into the deep brachial veins, and in the forearm, if the cephalic vein was unsuitable.[31] Internal diameters and vein depth were measured at the wrist, the distal forearm, and at the level of the elbow and in the upper arm. Eight surgeons, including supervised trainees, performed the operations, with the vast majority done by three access surgeons. Diameter categories were decided before analysis by the authors, based on existing guidelines[3] and variance of vessel diameters.

Measurement variability

Intra-and inter-observer agreement was studied in 21 patients in 2006. Each patient had two consecutive scans by the same examiner within 30 min of each other and two scans by a second examiner a few days later. For the measurement variability scans only, all scans were performed within the first hour of haemodialysis, to control for the effects of hydration on venous filling. A portable ultrasound scanner (SonoSite MicroMaxx) was used to assess internal arterial and venous diameters (with tourniquet) on one arm. Observers were also asked to predict the likely outcome if a RCAVF were to be made in that arm, based on the ultrasound assessment. Intra-observer measurement error and repeatability were calculated according to Bland and Altman.[32] The inter-observer coefficient of variation and agreement on predicted fistula outcome was calculated using the Kappa statistic.

Statistical analysis

Comparisons of categorical data were made using chi-square tests. Continuous variables were analysed with a

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