

The Impact of Patient Demographics, Anatomy, Comorbidities, and Peri-operative Planning on the Primary Functional Maturation of Autogenous Radiocephalic Arteriovenous Fistula

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WHAT THIS PAPER ADDS

The largest prospective cohort study on radiocephalic arteriovenous fistulae (RCAVF) reveals that among all variables, the anatomical factors of cephalic vein and radial artery diameter are independently associated with the primary functional maturation of RCAVF.

Objectives: The aim of this study was to evaluate the collective and/or independent impact of patient demographics, comorbidities, anatomical factors, and peri-operative parameters on the primary functional maturation of RCAVFs. This study also aimed to identify the range and best cut off value for each variable and evaluate the likelihood, significance and percentage of primary functional maturation of RCAVFs.

Methods: This was a prospective consecutive single centre cohort study over a 4 year period; it was conducted on patients with the intention-to-treat using a radiocephalic arteriovenous fistula (RCAVF) (Brescia–Cimino). During this period 548 vascular access procedures, inclusive of RCAVF, were performed. Variables included patient demographics (age, gender), anatomical variance (cephalic vein, radial artery diameter, laterality), comorbidities (diabetes mellitus, ischaemic heart disease, congestive cardiac failure, hypertension), aetiology of renal failure, and anaesthesia type (local versus general anaesthesia).

Results: Of the total, 324 patients, cephalic vein diameter > 1.5 mm (OR 4.57, 95% CI, 2.42–8.63, $p < .001$) (non-augmented) and radial artery diameter > 1.6 mm (OR 12.26, 95% CI, 6.27–23.97, $p < .001$) were found to be independently associated with the primary functional maturation of 86% in the RCAVF formation.

Conclusion: Of all the variables, cephalic vein and radial artery diameter are independently associated with the primary functional maturation of RCAVFs.

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INTRODUCTION

The incidence of end stage renal disease (ESRD) in the UK is estimated at 498 per million and over a fifth progress to dialysis each year.¹ Over the next decade, this figure is estimated to double because of an ageing population and changing demographics.² The Brescia–Cimino arteriovenous fistula is the gold standard primary vascular access for dialysis-dependent patients,³ although failure of functional maturation (FM) remains a major obstacle. Its incidence is reported as ranging from 9% to 70% across various centres.⁴ Failure demands further interventions (radiological and

surgical) to gain a functional fistula but, despite various efforts, a substantial proportion do not prevail. This results in significant reliance on temporary dialysis, use of bridging catheters, use of prosthetic conduits, possible central venous stenosis, and an overall increase in cost and utilisation of health resources (surgeon, anaesthetics, theatre resources, nursing, dialysis unit, renal physicians, equipment, admission). Furthermore, repeated intervention may result in patient refusal for further intervention and mortality.⁵

To date, various studies have assessed the impact of different variables on the FM of radiocephalic arteriovenous fistulas (RCAVFs).^{6,7} These include patient comorbidities and demographics; anatomical variance; operator experience and peri-operative factors. However, these studies are a mixed picture (i.e., not limited to RCAVFs), small in size, and confined to a few predictors at a time. The evidence derived from these articles is not consistent, does not

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provide a solid platform for the planning of RCAVF formation, and does not assist in the process of informed consent (percentage likelihood of success and/or failure). Furthermore, recent evidence has highlighted a failure of the literature to identify factors associated with maturation.⁸ A recent systematic review suggested⁹ cephalic vein and radial artery diameter remain the only predictors of success as the impact of comorbidities such as diabetes have already taken their toll on the vessels once assessed pre-operatively. Therefore, the primary aim of this study was to evaluate the collated impact of comorbidities, anatomical factors, patient demographics, and peri-operative parameters on the primary FM of RCAVFs. The secondary aim focused on a stepwise analysis of variables to identify the range and best cutoff value for each variable with their respective impact on the FM. The final part evaluated the significance and percentage of FM obtained through the secondary aim.

MATERIAL AND METHODS

A prospective consecutive cohort study with the intention-to-treat 335 patients undergoing only Brescia—Cimino arteriovenous fistula (RCAVF) at the Mid Essex Hospital Services NHS Trust with an estimated population coverage of 380,000 from May 1, 2012, to May 1, 2016, was conducted. Variables included patient demographics (age, gender), anatomical variance (cephalic vein, radial artery diameter, laterality), comorbidities (diabetes mellitus [DM], ischaemic heart disease [IHD], congestive cardiac failure [CHF], hypertension [HTN]), aetiology of renal failure, and anaesthesia type (local vs. general). Follow-up was set at 1, 4 and 6 weeks from the time of creation depending on the status of the fistula. If failure was noted, this was considered to be a primary FM failure. The results of this study do not include any maturation that was gained through assisted means ($n = 38$) beyond 6 weeks. Following primary FM, patients were regularly followed up in the same unit as access provision is coupled with haemodialysis in the same hospital and department.

Planning

All patients underwent a full pre-operative consultation with a vascular access consultant and specialist dialysis nurse at the unit. This included full clinical examinations for the presence of a vein and artery (Allen's test) and pre-operative (within 1–2 weeks of operation) arterial and venous duplex examination by a senior vascular scientist. During this period 548 vascular access procedures, inclusive of the RCAVF, were performed. All patients were on a fistula first protocol and all patients had no other access provision. The permission to access the renal registry data was granted through clinical audit number CA13-225.

Standards and definitions

To avoid heterogeneity and to create a uniform approach and clinical applicability to wider practice, all assessment

techniques, standards, and definitions were defined as follows:

1. The cephalic vein was considered suitable if the tap test was positive and the vein was continuous to the cubital fossa and/or cephalic vein of arm directly or indirectly with a consistent diameter and/or more throughout.
2. The radial artery was used and assessed further with ultrasound only if Allen's test was normal (positive) indicating adequate blood supply to the ulnar artery.
3. Comorbidities were categorized and defined in accordance with definitions provided by World Health Organization (WHO).¹⁰
4. Pre-operative duplex of cephalic vein and radial artery assessed the internal diameter of both vessels with a 5–7 MHz linear transducer MHz with arm position fully rested at 45–60°. The radial artery was also assessed for haemodynamic studies (flow and stenosis) with vein in a non-augmented state in similar format.⁸
5. Definition of FM was set against the "Rule of 6s" assessed clinically and with duplex ultrasonography at 6 weeks after RCAVF formation, with a depth of not more than 0.5 to 0.6 cm from skin and diameter (main body of fistula) of 6 mm with a flow rate of 600 ml/minute and length of 5–6 cm for successful two-needle dialysis.¹¹
6. The presence of intra-operative thrill and/or pulse had to be confirmed by two surgeons (surgeon and senior assistant) beyond the point of anastomosis.
7. All fistulas were created by a consultant and/or senior surgeon with end (cephalic vein) to side (radial artery) anastomosis using 2.5× magnifying lenses with 6/0 monofilament polypropylene continuous suture from heel to toe with parachute technique. The local anaesthesia used was 2% lignocaine with adrenaline. The local anaesthesia was given on a pre-operative marked site (skin incision) to avoid damaging the cephalic vein during its infiltration.

Statistical analysis

Continuous variables were reported as medians with their corresponding interquartile range (IQR). The best cutoff diameter for the cephalic vein and radial artery was estimated with receiver operating characteristic curve analysis and obtained from the corresponding points of the curve; values with an optimum combination of sensitivity and specificity were considered to be the best diameter cutoff points for each variable. Chi-square analyses were used to determine difference between groups. For regression analyses, variables were initially tested at the univariate level to determine factors associated with the outcome (maturation). Those variables that were significant ($p < .05$) were entered into a multivariate regression model. In multivariate analyses, variables that were significant were deemed to be independently associated with fistula maturation. Associations were reported as odds ratios (OR) with the accompanying measure of uncertainty (95% CI) as well as

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