

Arterial and Venous Evaluation for Predicting Arteriovenous Fistula Functionality

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Abstract

Background

Arteriovenous fistula (AVF) is the preferred form of permanent vascular access for most patients requiring maintenance haemodialysis because of its favourable long-term outcomes and lower infectious complications compared with central venous catheters [1,2]. However, failure of AVF maturation remains a significant clinical problem. Preoperative assessment of arterial and venous anatomy may help identify suitable vessels, guide access-site selection and improve the likelihood of successful fistula maturation [3-5].

Aim

To evaluate the role of preoperative arterial and venous diameter assessment in predicting AVF maturation and functionality.

Methods

A prospective cohort study was conducted among 50 patients with end-stage renal disease or advanced chronic kidney disease planned for first-time AVF creation. Patients aged 25–75 years were included. Patients with previous access failure, central venous stenosis, severe arterial calcification or venous thrombosis were excluded. Preoperative arterial and venous diameters were documented and correlated with AVF maturation. Radiocephalic (RC) and brachiocephalic (BC) AVFs were compared.

Results

The study included 50 patients, comprising 30 males (60%) and 20 females (40%), with a mean age of 55.2 ± 12.1 years. Twenty-one patients (42%) underwent RC AVF creation and 29 (58%) underwent BC AVF creation. Mean arterial diameter was 2.6 ± 0.4 mm and mean venous diameter was 2.5 ± 0.4 mm. Maturation success was 23% among patients with an arterial diameter of 1.5–2.0 mm compared with 68% among those with an arterial diameter >2.0 mm. The reported maturation rate was 66.7% for RC AVFs and 82.8% for BC AVFs, with a reported p value of 0.04.

Conclusion

Preoperative vascular assessment appears useful in predicting AVF maturation. Larger arterial calibre was associated with improved maturation, and BC AVFs demonstrated a higher reported maturation rate than RC AVFs. An arterial and venous diameter of approximately 2.0 mm or greater may be considered desirable during access planning, while access selection should remain individualized according to vessel characteristics and patient factors.

Keywords: arteriovenous fistula; haemodialysis; vascular access; radiocephalic fistula; brachiocephalic fistula; arterial diameter; venous diameter; maturation.

Introduction

Vascular access is an essential component of long-term haemodialysis care. Among available vascular access options, autogenous AVF is generally preferred because it provides durable access and is associated with fewer infectious complications and lower long-term access-related morbidity compared with central venous catheters [1,2].

Despite these advantages, AVF maturation failure remains an important challenge. A fistula that fails to mature adequately may result in prolonged catheter dependence, additional procedures, delayed initiation of dialysis through the fistula and increased healthcare utilization [3,4].

Successful maturation depends on several anatomical and physiological factors. These include arterial inflow, arterial diameter, venous diameter, venous quality, vessel distensibility, blood flow and the presence of comorbidities such as diabetes mellitus and peripheral arterial disease [5-8].

Preoperative duplex ultrasonography allows assessment of the arterial and venous systems before surgery. Measurement of vessel diameter can help identify vessels that are more likely to support successful fistula creation and maturation [5,6]. Previous studies have demonstrated an association between radial artery and cephalic vein diameter and the outcome of radiocephalic AVFs [7-9].

The choice between radiocephalic and brachiocephalic access is also clinically important. Radiocephalic AVF is generally favoured as a distal access option when anatomically feasible because it preserves more proximal sites for future access creation. However, brachiocephalic AVF may have a higher maturation rate in selected patients because of the larger calibre of the brachial artery and upper-arm veins [1,2,10].

Recent evidence continues to support the importance of vessel characteristics in AVF outcomes, although maturation is multifactorial and vessel diameter alone does not determine success [11,12]. KDOQI recommends that access selection should take into account vessel characteristics, patient comorbidities, health circumstances and patient preference rather than applying a single universal anatomical threshold [2].

The present study was undertaken to evaluate preoperative arterial and venous diameters as predictors of AVF maturation and to compare maturation outcomes between RC and BC AVFs.

Aim

To evaluate the role of preoperative arterial and venous diameter assessment in predicting arteriovenous fistula maturation and functionality.

Objectives

1. To determine the preoperative arterial diameter in patients undergoing first-time AVF creation.
2. To determine the preoperative venous diameter in patients undergoing first-time AVF creation.
3. To evaluate the relationship between arterial diameter and AVF maturation.
4. To evaluate the relationship between venous diameter and AVF maturation.
5. To compare maturation rates between radiocephalic and brachiocephalic AVFs.
6. To identify clinically useful vessel-diameter thresholds associated with successful AVF maturation.

Materials And Methods

Study design

A prospective cohort study was conducted among patients with ESRD or advanced CKD planned for creation of a first-time autogenous AVF.

Study setting

The study was conducted in the Department of Vascular Surgery at the study institution.

Study population

Patients with ESRD or advanced CKD who were planned for first-time AVF creation were evaluated.

A total of 50 patients were included. The supplied study data reported 30 males and 20 females, with a mean age of 55.2 ± 12.1 years.

Inclusion criteria

Patients fulfilling the following criteria were included:

- Age 25–75 years.
- ESRD or advanced CKD requiring haemodialysis vascular access.
- Planned first-time AVF creation.
- Adequate clinical condition to undergo AVF creation.
- Availability of preoperative vascular assessment.

Exclusion criteria

Patients were excluded if they had:

- Previous vascular access failure.
- Central venous stenosis.
- Severe arterial calcification.
- Venous thrombosis.
- Previous vascular access at the intended site.

These criteria correspond to the criteria reported in the supplied study data.

Preoperative vascular assessment

Preoperative assessment included evaluation of arterial and venous vessel calibre. Arterial and venous diameters were documented before AVF creation and subsequently correlated with maturation outcomes.

AVF classification

Patients were categorized according to the type of AVF created:

- Radiocephalic AVF
- Brachiocephalic AVF

The study included 21 RC AVFs and 29 BC AVFs.

Primary outcome

The primary outcome was successful AVF maturation/functionality.

Secondary outcomes

Secondary outcomes included:

- Association between arterial diameter and maturation.
- Association between venous diameter and maturation.
- Comparison of maturation between RC and BC AVFs.

Statistical analysis

Continuous variables were summarized using mean and standard deviation. Categorical variables were expressed as frequencies and percentages.

The supplied study reported a p value of 0.04 for the comparison of RC and BC maturation. Because the underlying statistical output/test was not included in the supplied source, the manuscript reports this as the reported p value rather than assigning a statistical test retrospectively.

A p value <0.05 was considered statistically significant.

Results

Demographic characteristics

Fifty patients were included in the study. There were 30 males (60%) and 20 females (40%). The mean age was 55.2 ± 12.1 years.

Table 1. Baseline demographic characteristics

Characteristic	Value
Total patients	50
Male	30 (60%)
Female	20 (40%)
Mean age	55.2 ± 12.1 years

Distribution of AVF type

Of the 50 patients, 21 (42%) underwent radiocephalic AVF creation, while 29 (58%) underwent brachiocephalic AVF creation.

Table 2. Distribution according to AVF type

AVF type	Number	Percentage
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Radiocephalic	21	42.00%
Brachiocephalic	29	58.00%
Total	50	100%

Preoperative arterial and venous diameters

The mean arterial diameter was 2.6 ± 0.4 mm and the mean venous diameter was 2.5 ± 0.4 mm.

Table 3. Preoperative vascular measurements

Parameter	Mean $\pm$ SD
Arterial diameter	2.6 ± 0.4 mm
Venous diameter	2.5 ± 0.4 mm

Arterial Diameter and AVF Maturation

A marked difference in maturation was reported according to arterial diameter.

Patients with an arterial diameter of 1.5–2.0 mm had a maturation success rate of 23%, whereas those with arterial diameter >2.0 mm had a maturation success rate of 68%.

Table 4. Association between arterial diameter and maturation

Arterial diameter	Maturation success
1.5–2.0 mm	23%
>2.0 mm	68%

There was a substantially higher maturation rate among patients with arterial diameter >2.0 mm. The difference in reported success rates was approximately 45 percentage points, suggesting that arterial calibre may be an important predictor of successful AVF maturation.

Radiocephalic versus Brachiocephalic AVF

The study reported maturation rates of 66.7% for RC AVFs and 82.8% for BC AVFs, with a reported p value of 0.04.

Table 5. Comparison of radiocephalic and brachiocephalic AVF maturation

Parameter	Radiocephalic AVF	Brachiocephalic AVF
Number of patients	21	29
Percentage of total	42.00%	58.00%
Reported maturation rate	66.70%	82.80%
Approximate mature AVFs*	14	24
Approximate non-mature AVFs*	7	5

Reported p value	0.04	
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Brachiocephalic AVFs had a reported maturation rate of 82.8%, compared with 66.7% for radiocephalic AVFs. Thus, the absolute difference in reported maturation was approximately **16.1 percentage points** in favour of BC AVF.

Discussion

The present prospective cohort study evaluated the association between preoperative vascular dimensions and AVF maturation in 50 patients undergoing first-time AVF creation. The principal findings were that larger arterial diameter was associated with better maturation and that brachiocephalic AVFs demonstrated a higher reported maturation rate than radiocephalic AVFs.

The importance of preoperative vascular assessment has been recognized in contemporary vascular-access practice. KDOQI recommends individualized selection of vascular access based on vessel characteristics, patient comorbidities, health circumstances and patient preference [2].

In the present study, the mean arterial diameter was 2.6 ± 0.4 mm and mean venous diameter was 2.5 ± 0.4 mm. The study also demonstrated a substantial difference in maturation according to arterial diameter. Patients with arterial diameters >2.0 mm had a reported maturation success of 68%, compared with 23% among those with arterial diameters of 1.5–2.0 mm.

The association between arterial calibre and AVF maturation has biological plausibility. Creation of an AVF results in increased blood flow through the feeding artery and venous outflow tract. Adequate arterial inflow is necessary to support the haemodynamic changes and vascular remodelling required for successful maturation [5,6].

Previous clinical studies have also demonstrated relationships between preoperative vessel measurements and AVF outcomes. In one study, larger vessel diameters were associated with improved maturation, although the relationship was influenced by fistula type and patient characteristics.

Venous diameter is similarly important because the venous segment must accommodate increased blood flow and undergo enlargement before it becomes suitable for repeated cannulation. A study of radiocephalic AVFs reported that a minimum cephalic vein diameter >2 mm independently predicted maturation, with an odds ratio of 3.672 (95% CI 1.394–9.673; $p=0.008$) [9].

A recent meta-analysis involving 4610 patients further evaluated the relationship between radial artery and cephalic vein diameter and functional maturation of radiocephalic AVFs. The findings reinforce the relevance of preoperative vessel calibre while also highlighting the multifactorial nature of AVF outcomes.

Radiocephalic versus brachiocephalic AVF

An important finding of the present study was the higher reported maturation rate of BC AVFs compared with RC AVFs. RC AVFs accounted for 21 cases, with a reported maturation rate of 66.7%, whereas BC AVFs accounted for 29 cases, with a maturation rate of 82.8%. The reported p value was 0.04.

The approximately 16.1-percentage-point difference in maturation may reflect the larger calibre and greater blood-flow capacity of upper-arm vessels. However, the choice of BC AVF should not be based solely on its potentially higher maturation rate.

Radiocephalic AVF remains an important distal access option because successful distal access preserves more proximal sites for future access creation. Consequently, the preferred access should be selected according to the patient's individual vascular anatomy and long-term vascular-access plan [1,2]. KDOQI specifically emphasizes individualized access planning rather than a one-size-fits-all approach.

Interestingly, published studies do not uniformly demonstrate a statistically significant difference between RC and BC AVF maturation. One cohort reported maturation rates of 68.1% for RC and 83.8% for BC AVFs, but the difference was not statistically significant ($p=0.15$) [13]. This illustrates why the reported $p=0.04$ in the present study should be interpreted in the context of the study's sample size and methodology rather than being generalized to all patient populations.

Recent evidence also emphasizes that AVF maturation is affected by factors beyond absolute vessel diameter, including vein distensibility, previous access, anastomotic configuration and patient characteristics [11,12,14]. A 2025 study of patients undergoing radiocephalic or brachiocephalic fistula creation found no significant difference

in cumulative maturation between the two fistula types, further demonstrating the heterogeneous nature of AVF outcomes.

Therefore, the current study supports preoperative vascular mapping as an important component of AVF planning but does not suggest that arterial or venous diameter should be used as an isolated criterion.

Clinical Implications

The findings have several practical implications.

First, preoperative vascular mapping should be considered before first-time AVF creation because it allows identification of suitable arterial and venous segments.

Second, an arterial diameter >2.0 mm was associated with substantially better maturation in the present cohort.

Third, a venous diameter of approximately 2.0 mm or greater may be considered a useful anatomical parameter, particularly when planning radiocephalic access. Published evidence similarly supports the importance of cephalic vein calibre in RC AVF maturation [9,11].

Fourth, although BC AVF showed a higher maturation rate in the present cohort, distal RC access should remain strongly considered when anatomically appropriate because it preserves future access options.

Limitations

The present study has several limitations. The sample size was relatively small, with only 50 patients, which limits the statistical power of the study and reduces the generalizability of the findings. The study population also represents a single cohort, and therefore the results may not be directly applicable to all haemodialysis populations. The study also does not provide detailed information regarding potentially important confounding variables such as diabetes mellitus, hypertension, smoking, peripheral arterial disease, body mass index, vessel depth, vein distensibility, arterial flow characteristics and surgical technique. These factors may independently influence AVF maturation.

Conclusion

Preoperative arterial and venous evaluation is an important component of AVF planning in patients requiring haemodialysis.

In this cohort of 50 patients, larger arterial diameter was associated with substantially better reported maturation. Patients with arterial diameter >2.0 mm had a reported maturation success of 68%, compared with 23% among patients with arterial diameter of 1.5–2.0 mm.

Brachiocephalic AVFs demonstrated a higher reported maturation rate than radiocephalic AVFs (82.8% vs 66.7%), corresponding to an absolute difference of approximately 16.1 percentage points. The study reports this difference as statistically significant ($p=0.04$).

These findings support systematic preoperative vascular mapping before AVF creation. However, AVF selection should be individualized according to arterial and venous anatomy, patient comorbidities, access history and the patient's long-term vascular-access plan [1,2].

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