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Comparison of Radiocephalic and Brachiocephalic Arteriovenous Fistulas for Vascular Access in End-Stage Renal Disease Patients

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ABSTRACT

Background: Arteriovenous fistulas (AVFs) are the preferred vascular access for hemodialysis in end-stage renal disease (ESRD) patients. While radiocephalic (RC) and brachiocephalic (BC) AVFs are commonly used, their comparative efficacy remains debated. This study aimed to compare RC and BC AVFs outcomes in ESRD patients. ***Methods:*** A comparative observational study was conducted from January 2019 to December 2021, including 83 ESRD patients who underwent RC or BC AVF creation in the Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh. Demographic, clinical, and surgical data were collected. Outcomes included primary patency, maturation time, complication rates, and access usability for dialysis. Data were analyzed using SPSS version 23.0, with categorical variables compared via Chi-square tests and continuous variables via t-tests/Mann-Whitney U tests. ***Results:*** This prospective study compared outcomes between 45 radiocephalic (RC) and 38 brachiocephalic (BC) arteriovenous fistulas. BC fistulas demonstrated significantly better performance, with shorter mean maturation time (4.2 vs 6.5 weeks, $p<0.001$), higher 6-month primary patency (82.1% vs 65.3%), and lower thrombosis rates (10.5% vs 22.2%). However, BC fistulas had a 7.9% incidence of steal syndrome, while RC fistulas showed higher stenosis rates (28.9% vs 15.8%) and required more secondary interventions. ***Conclusion:*** BC fistulas provide superior outcomes but require monitoring for steal syndrome. RC fistulas remain important for access preservation despite higher failure rates. Individualized selection based on vascular anatomy and patient factors is crucial for optimal vascular access outcomes in hemodialysis patients.

Keywords: Arteriovenous fistula, Brachiocephalic, ESRD, Hemodialysis access, Radiocephalic.

INTRODUCTION

End-stage renal disease (ESRD) is a global health burden, with hemodialysis (HD) serving as a primary life-sustaining treatment for patients who are ineligible for transplantation [1]. Vascular access remains a critical determinant of HD efficacy, and arteriovenous fistulas (AVFs) are the gold standard due to their superior longevity and lower complication rates than grafts and catheters [2,3]. Among AVFs, the radiocephalic (RC) fistula—first described by Brescia and Cimino in 1966—and the brachiocephalic (BC) fistula are the most frequently utilized. However, the optimal choice between these access types remains controversial, with varying outcomes reported in contemporary literature [4,5]. The RC AVF, created at the wrist, is traditionally preferred as the first-line access due to its distal location, which preserves proximal sites for future access [6]. Despite this advantage, RC AVFs are associated with higher primary failure rates (20–40%) and longer maturation times, particularly in the elderly

patients or those with comorbidities such as diabetes and peripheral vascular disease [7,8]. In contrast, BC AVFs, constructed at the antecubital fossa, often exhibit better outcome and shorter maturation time due to larger vessel diameters and higher blood flow [9]. However, their proximal location may limit future access options and could theoretically increase cardiovascular strain due to higher flow volumes [10]. Recent studies highlight disparities in outcomes between RC and BC AVFs. A 2020 meta-analysis by Smith et al. [11] reported significantly better 1-year patency rates for BC AVFs (78% vs. 62%), while a multicenter cohort study by Lok et al. [12] emphasized the cost-effectiveness of RC AVFs despite higher early failure rates. Furthermore, demographic shifts toward older ESRD populations with increased cardiovascular risk factors necessitate reevaluating access selection criteria [13,14]. In our study, clinical observations suggest a trend toward BC AVF preference, but empirical data comparing outcomes with RC AVFs are lacking.

METHODOLOGY

This comparative observational study was conducted at Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh over two years from January 2019 to December 2021. The study included 83 adult patients with end-stage renal disease who were scheduled for their first arteriovenous fistula creation. Patients with previous vascular access procedures or severe comorbidities such as advanced heart failure were excluded from participation. Participants were divided into two groups based on clinical evaluation and surgeon's preference: 45 patients received radiocephalic fistulas while 38 underwent brachiocephalic fistula creation. Preoperative assessment included duplex ultrasound evaluation of vessel diameters and anatomy to guide surgical planning. All procedures utilized the end-to-side anastomosis technique performed by experienced Urologists. Patient demographics, including age, gender, and comorbidities such as diabetes and hypertension, were recorded. Postoperative monitoring involved weekly clinical evaluations until fistula maturation, followed by monthly assessments for a total follow-up period of 12 months. Primary outcomes measured included fistula patency duration, time to maturation (defined as the period until successful cannulation for hemodialysis), and incidence of complications such as thrombosis, infection, and steal syndrome. Ultrasound examinations were routinely performed to confirm patency and assess fistula characteristics. Statistical analysis was performed using SPSS version 23.0 software. Continuous variables such as maturation time were analyzed using independent t-tests or Mann-Whitney U tests as appropriate, while categorical variables, including complication rates, were compared using Chi-square or Fisher's exact tests. Patency rates were evaluated through Kaplan-Meier survival analysis with statistical significance set at $p<0.05$. All participants provided informed consent before their inclusion in the study.

RESULT

The study compared outcomes between 45 radiocephalic (RC) and 38 brachiocephalic (BC) arteriovenous fistulas in ESRD patients. Demographic analysis revealed comparable baseline characteristics between groups, with mean ages of 58.3±12.1 (RC) versus 61.2±10.8 years (BC). Diabetes prevalence was 42.2% in the RC and 47.4% in the BC groups. Vessel diameters measured preoperatively showed significantly larger cephalic veins in BC cases (3.1±0.5mm vs 2.4±0.6mm in RC, $p=0.002$). Primary patency rates at 6 months favored BC fistulas (82.1% vs 65.3%), maintaining superiority at 12 months (68.4% vs 51.1%). Maturation time was significantly shorter for BC fistulas (4.2±1.1 weeks) compared to RC (6.5±1.4 weeks, $p<0.001$). Early failure (<6 weeks) occurred in 8.9% of RC versus 2.6% of BC fistulas. Complication analysis demonstrated lower thrombosis rates in BC fistulas (10.5% vs 22.2%, $p=0.04$), while infection rates were similar (7.9% vs 11.1%). Steal syndrome occurred exclusively in BC fistulas (3 cases, 7.9%). Secondary interventions were required in 31.1% of RC versus 18.4% of BC fistulas. The study found significant improvements in hemodynamic parameters in the BC group compared to the RC over 12 months. At 3, 6, and 12 months, BC showed higher flow rates (1120±320 vs. 850±280 mL/min at 3 months, $p=0.008$; 1055±298 vs. 781±257 mL/min at 6 months, $p<0.001$; 991±279 vs. 698±227 mL/min at 12 months, $p<0.001$) and larger diameters (7.5±1.3 vs. 6.2±1.1 mm at 3 months, $p=0.003$; 6.8±1.1 vs. 5.6±0.9 mm at 6 months, $p<0.001$; 6.3±0.9 vs. 5.1±0.8 mm at 12 months, $p<0.001$). These differences were statistically significant at all time points. Ultrasound surveillance revealed more frequent stenosis development in RC fistulas (28.9% vs 15.8%). Functional dialysis adequacy (Kt/V) was comparable between groups at 6 months.

Table 1: Baseline patient characteristics

Characteristic	RC (n=45)	BC (n=38)	p-value
Age (years)	58.3±12.1	61.2±10.8	0.251
Male gender	28 (62.2%)	22 (57.9%)	0.687
Diabetes	19 (42.2%)	18 (47.4%)	0.637
Hypertension	39 (86.7%)	34 (89.5%)	0.692

Table 2: Preoperative vessel measurements

Parameter (mm)	RC	BC	p-value
Cephalic vein	2.4±0.6	3.1±0.5	0.002
Radial artery	2.1±0.4	-	-
Brachial artery	-	4.8±0.7	-

Table 3: Primary outcomes

Outcome	RC	BC	p-value
6-month patency	65.30%	82.10%	0.03
12-month patency	51.10%	68.40%	0.02
MT (weeks)	6.5±1.4	4.2±1.1	<0.001

MT: Maturation time

Table 4: Complication rates

Complication	RC	BC	p-value
Thrombosis	10 (22.2%)	4 (10.5%)	0.04
Infection	5 (11.1%)	3 (7.9%)	0.421
Steal syndrome	0 (0%)	3 (7.9%)	0.021

Table 5: Changes in hemodynamic parameters

Parameter	RC	BC	p-value
After 3 months			
Flow (mL/min)	850±280	1120±320	0.008
Diameter (mm)	6.2±1.1	7.5±1.3	0.003
After 6 months			
Flow (mL/min)	781±257	1055±298	<0.001
Diameter (mm)	5.6±0.9	6.8±1.1	<0.001
After 12 months			
Flow (mL/min)	698±227	991±279	<0.001
Diameter (mm)	5.1±0.8	6.3±0.9	<0.001

Table 6: Secondary interventions

Intervention	RC	BC	p-value
Angioplasty	9 (20.0%)	5 (13.2%)	0.041
SR	5 (11.1%)	2 (5.3%)	0.189
Total	14 (31.1%)	7 (18.4%)	0.039

SR: Surgical revision

DISCUSSION

The findings of this study demonstrate clear advantages of brachiocephalic arteriovenous fistulas over radiocephalic fistulas in end-stage renal disease patients. Our results show significantly better performance of BC fistulas in terms of maturation time, primary patency rates, and thrombosis incidence, while also highlighting important considerations for clinical practice. The 82.1% six-month patency rate observed in BC fistulas exceeds rates reported in several contemporary studies [15], suggesting that careful patient selection and surgical technique at our center may have contributed to these superior outcomes. The shorter maturation time of BC fistulas (4.2 weeks versus 6.5 weeks for RC fistulas) correlates strongly with the larger preoperative cephalic vein diameters measured in these patients, supporting current guidelines that emphasize the importance of vessel size assessment before access creation [16]. Several factors likely contribute to the better outcomes seen with BC fistulas. The larger vessel diameters in the upper arm not only facilitate surgical anastomosis but also lead to more favorable hemodynamic conditions. Our measurements showing higher flow volumes in BC fistulas (1120 mL/min versus 850 mL/min) align with computational modeling studies that demonstrate reduced turbulence and shear stress in larger-caliber vessels [17]. The lower thrombosis rates observed in BC fistulas (10.5% versus 22.2%) may reflect these more stable hemodynamic conditions, as well as potentially less neointimal hyperplasia development at the anastomotic site [18]. However, the occurrence of steal syndrome exclusively in BC fistulas (7.9% incidence) serves as an important reminder that these accesses require careful monitoring, particularly in patients with pre-

existing peripheral vascular disease [19]. The higher stenosis rates observed in RC fistulas (28.9% versus 15.8%) likely explain their greater need for secondary interventions. These findings are consistent with histological studies demonstrating that smaller vessels are more susceptible to turbulent flow-induced endothelial damage [20]. While RC fistulas remain valuable for preserving proximal access sites, our data suggest they may be less suitable for certain patient populations, particularly elderly individuals and those with diabetes, where we observed significantly higher failure rates. This observation supports the growing body of evidence suggesting that patient-specific factors should drive access selection rather than relying on rigid protocols [21]. These results have important implications for clinical practice. First, they support the preferential use of BC fistulas in appropriate candidates, particularly those with risk factors for RC fistula failure. Second, they reinforce the critical importance of preoperative vascular mapping to identify suitable vessels for access creation. Third, they highlight the need for different surveillance strategies for each access type, with particular attention to stenosis monitoring in RC fistulas and steal syndrome detection in BC fistulas. Future research should focus on optimizing techniques for both access types, including investigating new technologies like drug-coated balloons for stenosis treatment [22] and flow reduction techniques for high-flow fistulas [23]. Longer-term follow-up studies will be particularly valuable for understanding the lifetime performance of these vascular accesses in an increasing ESRD population [24].

Limitations:
This single-center study had a non-randomized design and relatively small sample size (n=83), which may limit generalizability. The 12-month follow-up period precludes assessment of long-term outcomes. Additionally, surgeon preference influenced access selection rather than standardized criteria, potentially introducing selection bias.

CONCLUSION
This study demonstrates that brachiocephalic arteriovenous fistulas offer superior outcomes compared to radiocephalic fistulas, with significantly shorter maturation times, higher patency rates, and lower thrombosis incidence. While BC fistulas showed better overall performance, the risk of steal syndrome requires careful patient selection. These findings support individualized vascular access planning based on patient anatomy and comorbidities, with BC fistulas being preferable for most patients when anatomically feasible. Preoperative vessel assessment remains crucial for optimal access outcomes in hemodialysis patients.

Recommendation:
Based on our findings, we recommend prioritizing brachiocephalic fistulas for suitable patients, especially elderly or diabetic cases. Preoperative vein mapping (≥2.5mm) is essential. Implement specific surveillance: monitor BC fistulas for steal syndrome and RC fistulas for stenosis. Individualized patient assessment should guide access selection over standardized protocols to optimize outcomes.

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