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Navigating Success and Challenges in Arteriovenous Fistulain Pediatrics: A Retrospective Observational Study

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ABSTRACT

Background and Aim: Arteriovenous fistula (AVF) is an essential surgery for young patients who need long-term access to hemodialysis (HD). Despite the widespread use of AVFs in adult populations, there is a lack of research on their utilization and outcomes in pediatric patients. The purpose of this study was to assess the outcomes of AVF development in children, including the factors that affect success rates, complications, and long-term outcomes.

Methods: This study was a retrospective cohort of patients with end-stage renal disease (ESRD) who were aged under 18 years old and underwent an AVF surgery at our center between December 2021 and January 2023. We collected demographic data from patients and follow-up data at 1 week, 6 weeks, 6 months, 12 months, and 18 months. Details, such as the type of access, its anatomical location, and complications, were also documented.

Results: During the study period, a total of 47 AVFs were created. We created brachiocephalic AVF in 63.83% of cases (n=30), radiocephalic AVF in 14.89% (n=07), and brachiobasilic transposition in 21.28% (n=10). The overall primary patency rate at 12 months was 78.72%. The median survival of the brachiocephalic fistula was much greater than that of the radiocephalic and brachiobasilic fistulas (BBF). The primary patency rates at 1 week, 6 weeks, 6 months, 12 months, and 18 months were 87.23%, 85.11%, 82.97% and 74.47%, and 66%, respectively.

Conclusion: AVF provides effective long-term HD access in the pediatric population with ESRD. Thromosis was identified as the main cause of failure, underscoring the importance of proactive monitoring and interventions to improve outcomes.

Keywords: Arteriovenous fistula (AVF), Pediatric, End-stage renal disease

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Introduction

Kidney transplantation is the most frequently used treatment for end-stage renal disease (ESRD) in the pediatric population, with the highest five-year survival rate among all therapeutic options for ESRD, such as peritoneal dialysis (PD) and hemodialysis (HD). However, there is a shortage of available organs, leading to a situation where many pediatric patients must wait several years before receiving a transplant [1, 2]. HD serves as a stopgap measure until an organ is assigned in the meantime [3]. India adds about 2.2 lakh new patients with ESRD annually, increasing the demand for 3.4 crore dialysis sessions. Toward this end, the Ministry of Health and Family Welfare (MOHFW) launched the Pradhan Mantri National Dialysis Program [4]. When selecting vascular access for pediatric patients undergoing HD, several aspects need to be considered.

Patients who experience an unanticipated commencement of dialysis and choose to undergo HD for kidney replacement therapy (KRT) will require a central venous catheter (CVC), regardless of their age, body size, venous structure, or other medical conditions. Patients with small or diminutive veins that are not appropriate for an arteriovenous fistula (AVF) or arteriovenous graft (AVG) may need to have a CVC placed. However, it is important to view this as a temporary or intermediate solution until the vessels reach a sufficient size. In this context, there are no specific limits on weight or vessel diameter [5, 6]. Worldwide research has proven the superiority of AVF over CVC and AVG, even in pediatric cases [6-10]. In pediatric patients, parental willingness and the maturation of AVF are important factors to consider. It may take up to 6 months for an AVF to mature. Generally, parents prefer not to have their children cannulated frequently. In a study by Brittinger et al. almost 80% reported no or mild difficulty [10].

A proactive strategy for managing pediatric patients with chronic kidney disease (CKD) and declining estimated glomerular filtration rate (eGFR) is crucial to prevent the need for CVC placement when initiating HD. This article aims to motivate nephrologists to prioritize the creation of AVFs for long-term pediatric HD patients who are not suitable for preemptive transplantation or PD therapy. The objective of our study was to explore the outcomes and challenges related to AVFs within the pediatric population in India.

Materials and Methods

This study was a retrospective cohort of patients with ESRD who were under 18 years old and underwent AVF surgery at our center between December 2021 and January 2023.

All patients were evaluated a nephrologist and a surgeon. Preoperative ultrasound and Doppler imaging were performed on selected patients. If a radial AVF was not feasible, a brachial AVF was performed instead. We did not conduct brachiobasilic fistula (BBF) in the same session if brachiocephalic AVF was not possible. We created a fistula by performing anastomosis between the artery and the vein using loupe magnification (3.5x).

We gathered demographic data from patients and collected follow-up data at 1 week, 3 months, 6 months, and 12 months. Details, such as the type of access, its anatomical location, and any complications, were also documented. In case of access thrombosis, an interventional radiologist was consulted.

We entered the data into an Excel sheet and analyzed it using MS Excel software, version 2016. Primary patency was defined as the period during which the fistula was mature and functioning effectively without requiring any additional interventions. Secondary (cumulative) patency was defined as the total duration for which the fistula remained usable for dialysis.

Results

During the study period, a total of 47 AVFs were created. The mean age of the patients was 12.9 years. Pearson correlation analysis between age and complication rates showed no significant difference. The overall primary patency rate at 12 months was 74.46%. Linear-by-Linear Association test in the chi-square test (P=0.002) indicated a significant trend in success rates over time, although there is a downward trend, suggesting that long-term monitoring and intervention in the form of fistuloplasty or thrombolysis may be required.

The median survival of the BC fistula was significantly greater than that of the RC and BB fistulas. In our study, thrombosis was the main cause of AVF loss, accounting for 67% of cases, while non-thrombotic complications caused one fistula to fail. A cannulation injury led to two losses. Two fistulas with a vessel diameter of less than 1.6 mm failed to mature. A chi-square test was applied to examine the statistical significance between the type of fistula surgery and complications (P=0.52), suggesting

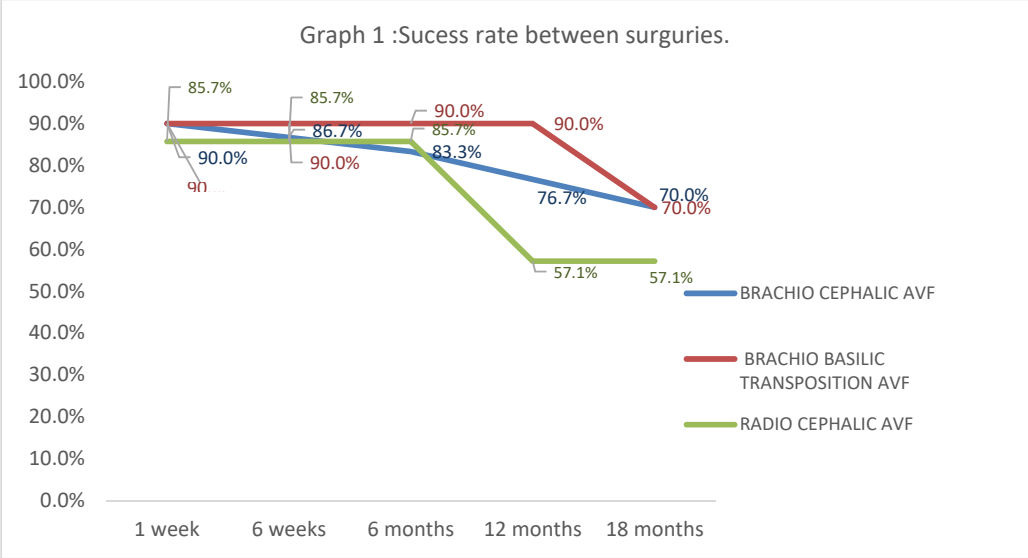

Figure 1. success rate between surgeries and omit it from the top of the graph

that there is no significant difference in complications among the surgical groups.

There was a statistically significant difference between the use of a surgical loop and primary patency (P=0.001; chi-square test), indicating that the use of a surgical loop is highly recommended. All BBT patients had a history of previous access; however, this did not significantly impact the success rate. Hypertension did not play a significant role (P=0.28) in the success of fistula surgery (Figure 1).

Discussion

According to the 2019 KDOQI guidelines, the preferred locations for creating an AVF, ranked from most to least desirable, are the brachiocephalic (elbow), radiocephalic (wrist), and brachiobasilic (arm) sites [11]. In the Western world, research shows that the long-term survival rates for children needing renal replacement therapy are significant at both the 10-year and 20-year marks [12, 13]. Additionally, weight and AVF location do not show a significant correlation with primary or secondary patency [14, 15]. Furthermore, the site of vascular access is predictive of secondary failure, with radial sites exhibiting the lowest risk of secondary failure compared to brachial and femoral sites [15]. Some studies have indicated that the first cannulation after AVF creation should occur at least 30 days later; however, waiting longer than 45 days does not provide additional benefits [16, 17]. Regarding the timing of AVF creation in ESRD patients, the ESPN dialysis working group suggested that an AVF should be created at least 3 months before its anticipated use [16].

In a study by Borzych-Duzalka et al. [16] the overall primary patency rates at 1, 3, 6, 12, 18, and 24 months were 100%, 91%, 86%, 76%, 55%, and 44%, respectively, while secondary patency rates at the same time points were 100%, 99%, 95%, 85%, and 77%, respectively. 16 Gradman et al. reported primary patency rates of 100% and 96% at 1 and 2 years, respectively, with a secondary patency rate of 100% at two years [18]. The largest published series reporting long-term patency, conducted by Bourquelot et al. found that the primary patency was 85% for radiocephalic AVFs, 72% for brachiobasilic AVFs, and 47% for brachiocephalic AVFs [19]. Our results are comparable to the published data on the pediatric population [16, 18, 19]. Overall, our findings align with the available literature.

Sheth et al. [6] reported that 3 out of 24 AVFs in pediatric patients developed stenosis, resulting in an incidence rate of 0.33 per 12 access months. Additionally, thrombi formed in 8 out of 24 AVFs, with an incidence of thrombosis at 0.78 per 12 access months. The IPHN identified thrombosis as the leading cause of AVF dysfunction. Our study yielded similar findings [16]. Onder et al. [15] found that AVF stenosis was the most common complication (31%), followed by thrombosis (16%), [20] which is consistent with our study. After surgery, we did not use any antiplatelet agents. However, the ESPN clinical practice recommendations advise administering antiplatelet agents (such as aspirin, ticlopidine,

or clopidogrel) during the initial months following AVF creation to help reduce the risk of thrombosis (grade 2D recommendation). To prevent early thrombosis during the perioperative period of AVF formation, it is essential to ensure adequate intravascular volume. This can be achieved by reducing ultrafiltration for several HD sessions right after AVF creation and allowing for some degree of hypertension. Adjusting antihypertensive treatment during this early post-operative period is also worth considering [17]. According to the USRDS database, only 5% of pediatric patients dialyzed via an AVF developed an access infection after 6 months of receiving HD. Steal syndrome is a possible complication of AVFs, but it is rarely seen in children [21]. In our study, two fistulas failed to mature. Various studies have found that to achieve assisted maturation, angioplasty may be required in 17–28% of AVFs in children [22-24].

The limitations of our study are that it is single-center and retrospective in nature. There is limited data on AVF outcomes in pediatric populations, and standardized protocols and guidelines are needed.

Conclusion

This retrospective study revealed that AVFs provide effective long-term HD access in the pediatric population with ESRD. Thrombosis was identified as the main cause of failure, underscoring the importance of proactive monitoring and intervention to improve outcomes. Given the growing incidence of pediatric ESRD in India and the limited availability of donor organs, establishing standardized protocols for AVF creation and management is essential. Further multi-center studies are warranted to validate our findings and develop comprehensive guidelines to optimize AVF outcomes in the pediatric population.

Recommendations: More frequent monitoring after 6 months is recommended to address complications early. Preventive measures should be considered for thrombosis, especially in BC access types. The use of surgical loops, where feasible, should be encouraged to improve success rates.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Institute Of Kidney Diseases & Research Centre, Ahmedabad, India (Code: Guts/ec-09/uro-25).

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Authors' contributions

Conceptualization, Manharsinh Rajput and Subho Banerjee; Methodology, software, validation, formal analysis, investigation, resources,data collection, writing of the original draft, review, editing, visualization, supervision, project administration: Manharsinh Rajput.

Conflict of interest

The authors declared no conflicts of interest.

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