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Original Article

Postoperative Outcomes of Arteriovenous Fistula Creation in Pediatric Hemodialysis Patients

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Background: Due to the limited availability of kidney transplants and the increasing number of patients on waiting lists, dialysis remains the primary treatment for children with end-stage renal disease. Vascular access, particularly arteriovenous fistula (AVF), is a key method for long-term hemodialysis, but it presents challenges in pediatric patients under 10 years old. This study aimed to evaluate the outcomes and complications of AVF creation in this age group.

Materials and Methods: This retrospective, cross-sectional study was conducted on 25 children with ESRD who underwent AVF creation between 2016 and 2020. Data collected included demographics, type of AVF created, and complications associated with the procedure. Descriptive statistical analysis was performed on the data.

Results: Among the 25 children, 9 (36%) experienced complications related to AVF. The most common complications were AVF immaturity (6 patients, 24%), thrombosis (2 patients, 8%), aneurysm (2 patients, 8%), hemorrhage (1 patient, 4%), and no infections at the surgical site. During follow-up, 4 patients (16%) received kidney transplants, and 5 patients (20%) required additional interventions to create new hemodialysis access.

***Conclusion*:** The results of this study show that complications related to AVF creation are more frequent in children under 10 compared to adults. Therefore, the use of alternative access methods, such as central venous catheters, to preserve the veins for future fistula creation and to avoid severe complications in children is recommended.

Keywords: Arteriovenous Fistula, Pediatric Hemodialysis, Complications

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Introduction

Chronic kidney disease (CKD) represents a significant global health challenge, affecting more than 13% of the global population. Approximately 80% of the CKD burden and its associated complications are concentrated in low- and middle-income countries (1). Although global estimates of CKD in children remain scarce, studies in Europe indicate that 11 to 12 pediatric cases per million individuals are diagnosed, often accompanied by significant cardiovascular complications (2).

The Iranian Pediatric Registry of Chronic Kidney Disease (IPRCKD) reports that 21.95 children per

million of the age-related population have suffered from CKD-related conditions between 1990 and 2009 (3). Growth retardation is a prominent and challenging complication in pediatric patients requiring dialysis, necessitating early and effective management (4). Dialysis serves as the primary renal replacement therapy (RRT) for children, as kidney transplants are considerably limited in availability (5). Furthermore, intensified dialysis can mitigate persistent growth failure in these patients (4).

Although kidney transplantation remains the preferred treatment modality (6), autologous arteriovenous fistulae (AVF) are widely regarded as the optimal choice for vascular access in patients with end-stage renal disease (ESRD) undergoing RRT. This approach is favored over prosthetic arteriovenous grafts (AVG) and central venous catheterization (CVC), due to its lower associated morbidity, mortality, and economic burden, while offering improved long-term survival (7). Consequently, international guidelines have strongly recommended AVF for vascular access in pediatric patients requiring hemodialysis (8), despite the time required for maturation (6).

Early studies, such as that by Wander et al., were among the first to explore AVF outcomes, emphasizing the importance of creating AVFs several months prior to initiating hemodialysis, as this approach significantly reduces the risks of infection, thrombosis, hemorrhage, and the need for surgical revision (9). A larger cohort study by Wartman et al. also evaluated the long-term patency and complication rates of AVF in pediatric patients aged 0 to 19 years, noting minimal complications and a long wait for kidney transplants, with 60% of patients unable to receive a kidney within one year of starting hemodialysis (10).

Based on these findings, they suggested that AVF should be prioritized for patients who are unlikely to receive a transplant in the near future. Unlike previous studies, which included pediatric patients across a wide age range, this study aims to focus specifically on children under 10 years of age. The objective is to assess the outcomes of AVF creation in this younger age group, using data from a referral hospital in Mashhad, Iran, over a five-year period.

Materials and methods

Study Design and Patient Recruitment

This retrospective cross-sectional study reviewed the medical records of pediatric patients under the age of 10 years with ESRD who were admitted to Alavi Hospital and other centers affiliated with Mashhad University of Medical Sciences in Mashhad, Iran, for AVF creation between 2016 and 2020. A convenience sampling method was used to include eligible cases in this study.

Data Collection

Demographic data, including age, sex, and the underlying cause of renal failure, were recorded at the time of arteriovenous fistula (AVF) creation. Additional data regarding the type of AVF constructed, as well as outcomes and complications—including thrombosis, ischaemia, aneurysm, haemorrhage, immaturity, infection, and venous hypertension—were collected during follow-up visits. These predefined variables were obtained through a comprehensive review of patients' medical records. In cases where follow-up information was incomplete, patients were contacted by telephone or invited to attend follow-up visits to complete their records.

Ethical Considerations

Ethical approval for this study was obtained from the Ethics Committee of Mashhad University of Medical Sciences (IR.MUMS.MEDICAL.REC. 1400. 804). The study was conducted in accordance with the Declaration of Helsinki, ensuring that ethical standards were maintained throughout the research process.

Statistical Analysis

Descriptive statistics were used to analyse the collected data. All analyses were performed using the Statistical Package for the Social Sciences (SPSS), version 24.

Results

The study involved 25 pediatric patients diagnosed with end-stage renal disease, with a mean age of 7.80 ± 1.73 years. Of these patients, 15 (60.0%) were male and 10 (40.0%) were female. Among these patients, 60% (15 patients) had ESRD, and 3 patients (12%) had polycystic kidney disease (PCKD). Other

diseases associated with kidney failure included nephrotic syndrome (N=2, 8%), vesicoureteral reflux (N=2, 8%), membranoproliferative glomerulonephritis (N=1, 4%), hyperoxaluria (N=1, 4%), and interstitial nephritis (N=1, 4%). The majority of the patients had left-sided arteriovenous fistulas (84%, 21 patients), with 13 (52.0%) having left radiocephalic access and 8 (32.0%) having left brachiocephalic access. A total of 2 patients (8.0%) had right radiocephalic AVF and 2 patients (8.0%) had right brachiocephalic AVF. Among the 25 children, 9 (36%) experienced complications related to AVF.

Complications observed included thrombosis in 2 patients (8.0%), aneurysm in 2 patients (8.0%), hemorrhage in 1 patient (4.0%), and immaturity in 6 patients (24.0%). No patients developed venous hypertension, steal syndrome, or surgical site infections. **(Figure 1)** Regarding secondary interventions, 5 patients (20.0%) required additional procedures to establish vascular access, including left radiocephalic AVF in 2 patients (40.0%), arteriovenous graft in 1 patient (20.0%), right central venous catheter in 1 patient (20.0%), and right femoral cuffed catheter in 1 patient (20.0%).

The complications observed in secondary interventions included thrombosis in 1 patient (20.0%) and immaturity in 3 patients (60.0%). No secondary interventions involved venous hypertension, steal syndrome, surgical site infections, aneurysm, or hemorrhage. Four patients (16%) received kidney transplants, and 16 other patients (64%) did not require additional interventions after the initial AVF access.

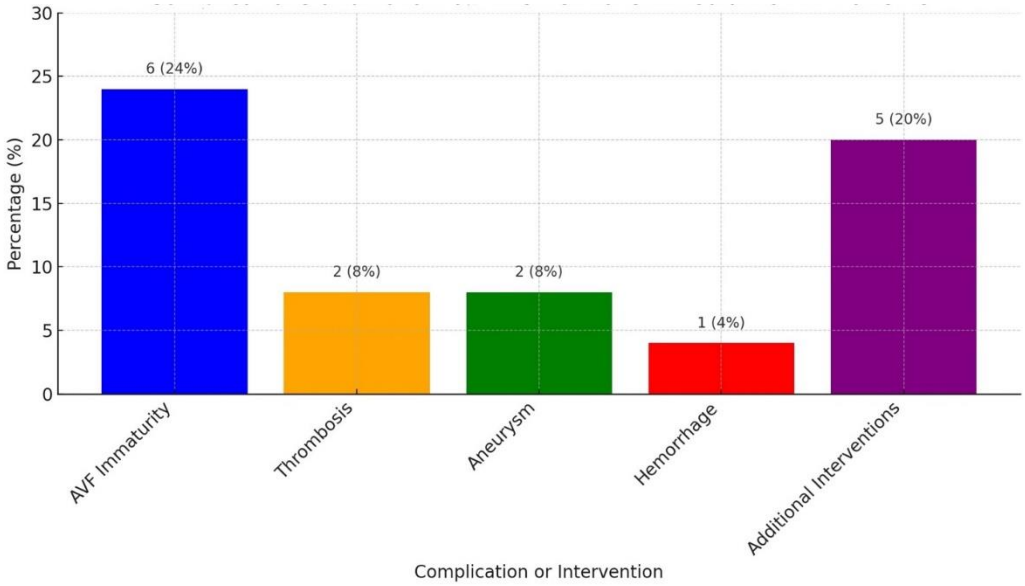

Fig 1. Complications and Follow-up Interventions in Pediatric AVF Patients

Discussion

Chronic kidney disease is characterized by the gradual decline of kidney function, eventually leading to kidney failure and the inability to maintain homeostasis (11). In children, the primary cause of CKD is often congenital (12). However, pediatric care is more expensive than that of adults on a case-by-case basis (11).

Establishing vascular access in children is a complex and uncommon procedure (13). While AVFs are preferred over CVCs due to their lower complication rates, they are used in only about 25% of pediatric patients. AVFs are considered the first-choice option for patients requiring long-term hemodialysis before kidney transplantation or for older children (14).

This study aimed to evaluate the postoperative outcomes of AVF creation in younger pediatric patients, specifically those under 11 years of age, with a focus on a cohort of Iranian children with ESRD. Our cross-sectional study revealed that 36% of patients who

had primary AVFs encountered complications. Notably, two-thirds of these complications were related to AVF immaturity. A retrospective analysis by Kim et al. on a sample of children and adolescents with a mean age of 15.7 years found primary AVF failure in 17.3% of patients (15).

The higher rate of immaturity observed in our cohort may be attributed to the younger age of the patients. This aligns with European consensus guidelines that recommend pediatric nephrologists avoid using AVFs in younger children (14). In the study by Kim et al., 82.7% of patients had a radiocephalic AVF, whereas 60% of our patients had primary vascular access. Their study, which followed patients for approximately 15 years, reported 20 kidney transplants (42.6%), while our 5-year analysis showed only 4 patients (16%) receiving transplants. Wartman et al. conducted a retrospective review of 93 patients under 20 years old to assess the long-term outcomes of AVFs for hemodialysis vascular access (16).

In their study, only 5% of the AVFs failed due to immaturity, a much lower rate than observed in our study, despite their longer follow-up period. Their study also demonstrated excellent long-term patency with minimal complications. However, their cohort included patients ranging from ages 3 to 19, with an average age of 14 years. The outcomes in their study are more applicable to older children, whereas our study focused on a younger cohort of ESRD patients, from infancy to age 11.

The most recent and methodologically similar study to ours was conducted by Şişli et al., involving 26 Turkish patients with a mean age of 13.2 years (IQR=11.9–15.6) (17). Over 80% of the AVFs created were radiocephalic, with the remainder at the brachial level, including brachiocephalic and brachiobasilic AVFs. As in our study, patients with radial AVFs were significantly younger. In their study, AVF failure occurred in 9 cases, mostly due to thrombosis in 7 patients, and 3 deaths were reported. Unlike the Wartman study, Şişli et al. concluded that the patency of AVFs was associated with patient weight, a finding that warrants further investigation.

The primary limitation of our study was the small sample size of pediatric patients. Additionally, the retrospective nature of the study limited our ability to gather more data during the intervention phase and post-operative follow-up. Therefore, we recommend prospective, long-term cohort studies to provide more accurate analyses, enabling a better understanding of the advantages and disadvantages of AVFs and other vascular access methods in different pediatric age groups. The impact of sexual hormones and sexual maturity could also be a valuable area of investigation.

Conclusion

In conclusion, our study found that complications related to arteriovenous fistulas were significantly more frequent in younger paediatric patients under the age of 10, particularly within a cohort from a developing country. Based on these findings, it is suggested that alternative methods, such as central venous catheterisation, be considered for this group until they become eligible for kidney transplantation with higher priority, given their expected longer survival prognosis. In settings with limited access to kidney transplantation facilities, central venous catheterisation may represent a practical interim option for younger patients until they mature into adolescence or beyond.

Declaration

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Conflict of Interest Statement

The authors have nothing to disclose.

Author Contributions

Conception and design: MMK, GK Analysis and interpretation: SMM, MMK, GK, FSK Data collection:

SMM, MMK, GK, JJS Writing the article: SMM, MMK, GH Critical revision of the article: MMK Final approval of the article: MMK Statistical analysis: FSK Obtained funding: MMK

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