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Mid-Term Outcome of Arteriovenous Fistula In Paediatric Patients With End-Stage Renal Disease: A Single Centre Experience

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ABSTRACT

The aim of the study was to evaluate the patency rates of arteriovenous fistula (AVF) in paediatric patients with end-stage renal disease (ESRD) in the mid-term.
The study was conducted retrospectively. The medical archive was searched between January 2015 and February 2018. A total of 26 patients comprised the study population.
The median age and weight of the patients at the time of AVF creation were 13.2 years (IQR = 11.9 – 15.6 years) and 41.5 kg (34.8 – 50.5 kg), respectively. Eight (69.2%) patents were male. The AVF created was radio-cephalic in 21 (80.8%) and brachial-level in five (19.2%) patients; brachio-cephalic in 3 and brachio-basilic in 2 patients. The patients with a radial-level AVF were younger ($p = 0.001$), and their body weights were lower ($p<0.001$). In patients with radio-cephalic AVF, analysis of age ($r_s = -0.48$, $p = 0.028$) and weight ($r_s = -0.56$, $p = 0.008$) revealed a negative correlation with duration of AVF maturation. The duration of follow-up was 21.2 months (IQR = 14.5 – 28.3 months). While the primary rates at 1 and 2 years were 92.3% and 84.6%, the secondary patency rates were 96.2% and 92.3%, respectively.
Our results showed that AVF is the most suitable and durable renal replacement therapy in patients with ESRD. The weight and level of AVF have a considerable influence on the duration of AVF maturation. In summary, AVF still remains the procedure of choice in regions where the paediatric kidney transplantation programmes are not completely set up that have resultant long transplantation waiting periods.

Key Words: Paediatrics, End-stage renal disease, Vascular surgical procedures, Arteriovenous fistula

Introduction

The creation of an arteriovenous fistula (AVF) for the paediatric population is encouraged based on the results of many studies that point to a variety of problems associated with the use of permanent dialysis catheters (PDC) for vascular access in paediatric patients with end-stage renal disease (ESRD) (1-4). In contrast, a PDC-first approach is utilised in some centres rather than fistula-first approach (5, 6). Comprising our initial experience of surgical AVF creation in paediatric patients, the aim of the current study was to evaluate the patency rates of AVF in the mid-term.

Material and Methods

Study Design and Patient Population: The ethical approval of the current retrospective study was obtained from the non-invasive clinical research committee at CENTRE on May 3, 2018 (Decision Nr: 2018/08). The medical archive was searched for patients who had received AVF. Patients who were younger than 18 years old and who had received the initial AVF surgery had been performed in our centre were included. A total of 26 patients were selected for the study population from a total of 148 patients who had received surgical AVF creation between January 2015 and February 2018 (Figure 1). The follow-up data was collected from the medical records including AVF patency assessed through Doppler ultrasonographic evaluation, issueless haemodialysis sessions and kidney transplantation. For patients whose medical records lacked the predetermined data, it was obtained through a phone call with the relatives. All patients lacking the predetermined data were excluded. Surgical

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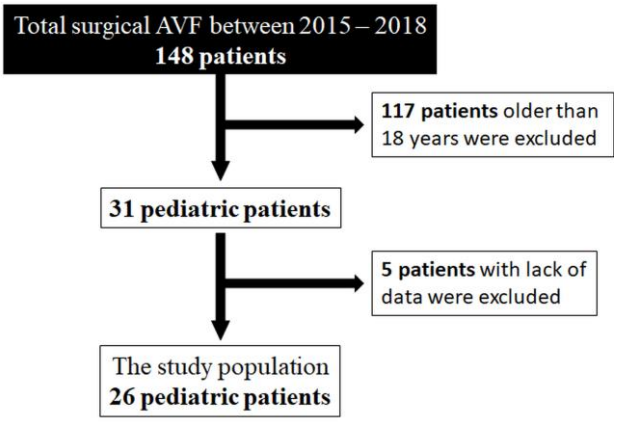

Fig. 1. Determination of the study population

AVF creation procedure: All surgical procedures were performed under a high-magnification surgical loupe. In general, according to the weight and the appropriateness of the vascular structures, while a distal radio-cephalic AVF was chosen in patients with higher weight, a proximal brachio-cephalic or brachio-basilic AVF was preferred in patients with a small body size. Preoperative mapping was also a determinant factor in selecting the AVF level. Under local anaesthesia and intravenous sedation, the radial artery or brachial artery was encircled. In radio-cephalic AVF, the cephalic vein was reached through the radial skin incision, encircled and freed from the surrounding structures 3-4 cm in the cephalad direction. In patients receiving brachial-basilic vein AVF, a basilic vein transposition was performed. In all AVF procedures, after the vein was cut followed by distal ligation, the proximal segment was dilated with inflation of saline, and an end-to-side anastomosis was performed using a polypropylene 8.0 suture.

Outcome Measure: Primary patency was defined as the interval from the time of AVF creation until any intervention performed to maintain or re-establish patency due to thrombosis. Secondary patency was defined as the interval from the time of AVF creation until AVF abandonment, thrombosis, or the time of patency including surgical or endovascular interventional manipulations with the aim of re-establishing functionality in a thrombosed AVF. An access was considered functional when it was able to deliver a flow rate of 350-400mL/min without access recirculation to maintain a treatment time of less than four hours.

Statistical Analysis: Statistical analyses were performed using a licensed Statistical Package for Social Sciences, version 19 (Kaysville, Utah, USA). The distribution of categorical variables was presented as frequency and percent. None of the continuous variables revealed a normal distribution, thus the median value [interquartile range (IQR) 25%–75%] was used. While two continuous variables were compared using Mann-Whitney U test, the categorical variables were compared using Fischer's exact test with continuity correction. The correlation between continuous variables was performed using the Spearman's rank correlation coefficient test. A Kaplan-Meier survival analysis was utilised for the primary and secondary patency rates.

Results

Twenty-six patients at the median age of 13.2 years (IQR=11.9–15.6 years) underwent surgical AVF creation. Eighteen (69.2%) patients were male. (Table 1) summarises the demographic and clinical characteristics along with the ESRD aetiologies. The initial renal replacement therapy (RRT) was commenced through peritoneal dialysis (PD) in 21 (80.8%) and PDC in five (19.2%) patients. In time, eight of 21 patients who received RRT through PD received PDC. The site and side of the PDC was the internal jugular vein in seven, the subclavian vein five and the femoral vein in one patient (12 right-sided and one left-sided). In total, two patients had a PDC that was placed on the same side of the AVF.

The AVF created was radio-cephalic in 21 (80.8%) and brachial level in five (19.2%) patients; brachio-cephalic in three and brachio-basilic in two patients. In subgroup comparative analysis (Table 2), the patients with radial level AVFs were considerably younger ($p=0.001$), their body weights were lower ($p<0.001$), and the time to maturation of the AVF was significantly longer ($p<0.001$). In correlation analysis, there was no correlation between the duration of AVF maturation with age ($r_s=0.19$, $p=0.361$) and weight ($r_s=0.13$, $p=0.515$) in the whole study population. On the other hand, in patients with radio-cephalic AVF, both the age ($r_s=-0.48$, $p=0.028$) and weight ($r_s=-0.56$, $p=0.008$) were found to be negatively correlated with the duration of AVF maturation. Additionally, in patients with brachial level AVF, only the weight ($r_s=-0.95$, $p=0.014$) was significantly correlated with the duration of AVF maturation (Figure 2).

The duration of follow-up was 21.2 months (IQR=14.5–28.3 months). During the follow-up period, AVF loss occurred in nine (34.6%) patients. The reason for AVF loss was thrombosis in seven, aneurysm formation in one and

Table 1. Demographic and clinical characteristics of the patients

Characteristics	n (%)
Age, years*	13.2 (11.9 – 15.6)
Male	18 (69.2)
Weight, kg*	41.5 (34.8 – 50.5)
Glomerular filtration rate, mL/min/1.73m2*	30 (20 – 36.3)
Underlying renal disease	
Focal / segmental glomerulosclerosis	7 (26.9)
Hemolytic uremic syndrome	4 (15.9)
Other glomerular diseases	3 (11.5)
Polycystic kidney disease	2 (7.7)
Obstructive uropathy	1 (3.8)
Hypoplastic kidneys	1 (3.8)
Initial renal replacement	
Peritoneal dialysis	21 (80.8)
Central venous catheter	5 (19.2)
Duration of maturation, months*	4.3 (3.2 – 4.9)

*Median (IQR 25%–75%)

Table 2. The subgroup comparative analysis of patients with radial and brachial level arteriovenous fistula

Characteristics	Radial AVF (n=21)	Brachial AVF (n=5)	p value
Age, years*	13.8 (12.7 – 15.8)	10.3 (9.6 – 10.7)	0.001a
Weight, kg*	43 (39.5 – 53)	30 (29 – 31)	<0.001a
Male	14 (66.7)	4 (80)	0.967b
Duration of maturation, months*	4.6 (4.2 – 5.0)	2.5 (1.7 – 2.9)	<0.001a

*indicates continuous variables, [a]Mann-Whitney U test, [b]Fischer's exact test

high-output leading to hand ischemia in one patient. The AVF thrombosis occurred in one patient during the in-hospital course. None of these patients received AVF closure. While thrombectomy was performed in patients with AVF thrombosis, aneurysm plication was performed in the patient with the AVF aneurysm. Additionally, distal ligation was performed in the patient with hand ischaemia.

The primary patency rates at 1 and 2 years were 92.3% and 84.6%, respectively. The secondary patency rates at 1 and 2 years were 96.2% and 92.3%, respectively. While the primary patency rate at the median follow-up period of 29.9 months (IQR=24.2–30.3 months) was 69.2%, the secondary patency rate at the median follow-up period of 31 months (IQR=27.3–39.5 months) was 65.4% (Figure 3). The AVF did not mature at all in three patients with radio-cephalic AVF. While four (15.4%) patients received kidney transplantation, three (11.5%) patients died; one due to acute respiratory distress syndrome, one due to intracranial haemorrhage and one due to endocarditis. The AVF occluded in patients with mortality a little while back.

Discussion

In paediatric ESRD patients with AVF, the long-term patency is excellent and is accompanied by low complication rates (1-3-7). The literature comprises a wide range of primary patency rates at different time points, that range from 51.4% – 83% at 2 years (1-3,4-8). These variable outcomes may be explained mainly by the existence of too many dependent factors, including body weight, utilisation of preoperative Doppler ultrasonographic mapping and utilisation of micro-vascular surgical techniques (1-3-7-9). With as low as a 57% primary patency rate at 1 year, around one quarter of the patients in the cohort of Chand et al. (4) were less than 10 years old, which in our opinion had a significant impact on the primary patency rate. The primary patency rates in the current series at 1- and 2-year were 92.3% and 84.6%, respectively, which are consistent with those reported in the literature (1-3). In our opinion, our satisfactory 1- and 2-year primary patency rates were highly related to implementation of preoperative vascular mapping

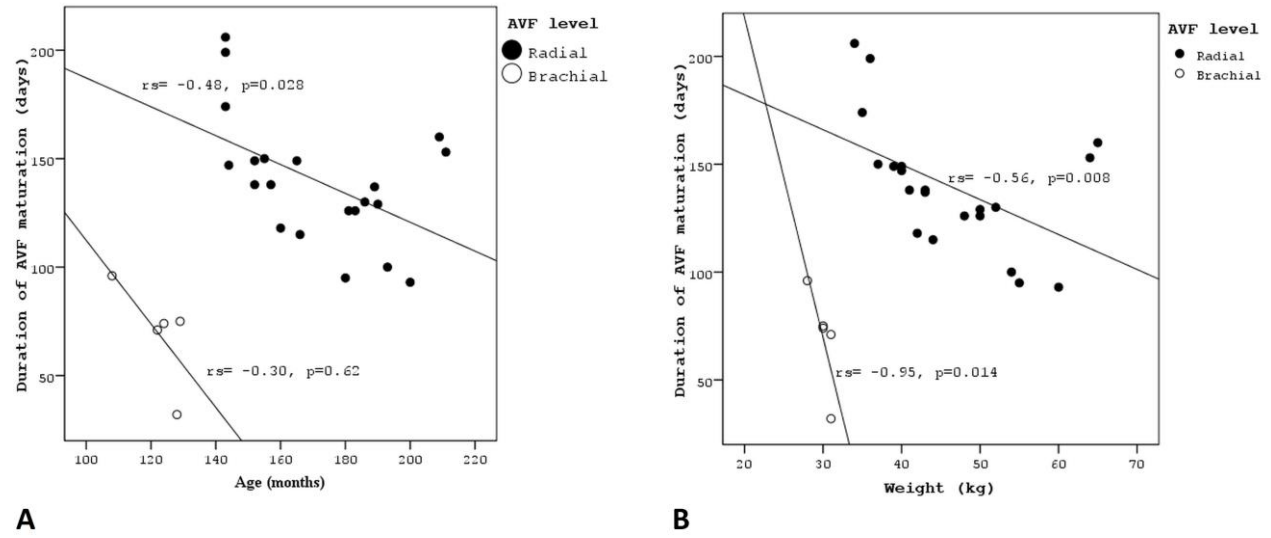

Fig. 2. Scatter plot of the duration of AVF maturation regarding age and weight

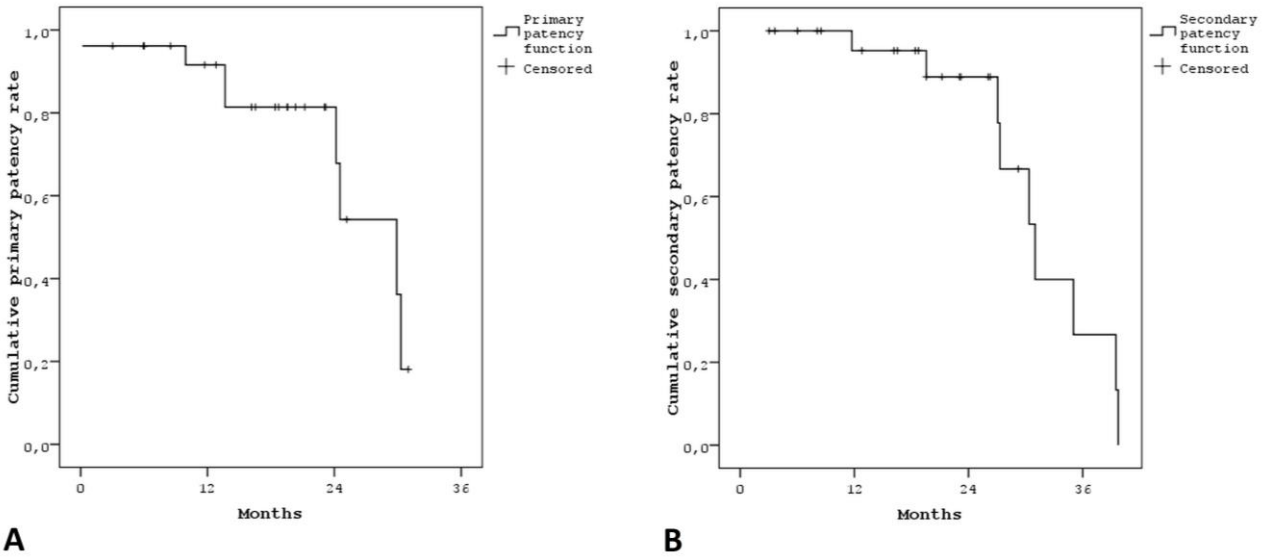

Fig. 3. Kaplan-Meier survival curves for primary and secondary patency rates

which directed us to create, rather than a radial-level AVF, a brachial-level AVF in patients with tiny distal vessels. This issue was also indirectly supported through the results shown in Table 2 and Figure 2. Patients with relatively small radial level vessels were abstained from the creation of a radial-level AVF, and they accordingly received a brachial-level AVF. These patients were considerably younger and had a lower body weight. Additionally, with the progressing technological advancements, the adoption of micro-vascular techniques supported the creation of a durable and functional AVF in the long-term with a favourable influence on patency rates (4-7). As far as possible, we implemented micro-vascular surgical techniques with the use of high-magnification loupes and at least 8.0 or higher suture material to create a fine-tuned anastomosis. This, from our point of view, also had a noteworthy influence on our patency rates.

In general, the waiting period for AVF maturation is around 8–12 weeks (3-7,8). The median duration of AVF maturation in the current series was slightly longer than 16 weeks which in our opinion, affect the validity of our high patency rates at 1 year. When thrombosis was considered as the reason for the many mid-term AVF failures was considered (1-7), our longer waiting period of AVF maturation would have led to an increase in size of the autologous vein graft wall, which constituted an additional favourable benefit for our high patency rates. Furthermore, the duration of AVF maturation was significantly lower in patients who received brachial-level AVFs. In the current series, the rate of PDC use as an initial RRT method was 19.2%. In time, eight of the 21 patients in whom the RRT method was PPD

received PDC, making the rate of PDC use 50%. Using a PDC to achieve vascular access for RRT has several downsides (2). In comparison to AVF, while the higher rate of infection is by far the most prominent problem, other disadvantages include thrombosis and inconsistent blood flow rates and, correspondingly, inadequate dialysis rates (10). The NKF's K-DOQI guideline recommends permanent access placement in paediatric patients weighing more than 20 kg. On the other hand, while PDCs were less than ideal for long-term access in paediatric patients, there remains several conditions in which a PDC still remains the best option because the paediatric patients are much more likely to be transplanted earlier, and their time on dialysis may be much shorter (1,3-5,10). In the cohort of Kim et al.(3) 42.6% of the patients were transplanted in a median duration of 36 months. Meourani et al. (5) reported a significant reduction in kidney transplantation wait times of up to a median of 89 days. In comparison to the Middle East (0.77 per million patient/year), the average rate of paediatric kidney transplantation was considerably higher in Europe (8 per million patient/year) (11). Contrary to the developed countries, the reported annual paediatric renal transplantation rate in our country is gradually increasing but remains low, which favours the creation of surgical AVF in paediatric ESRD patients. From this point of view, short-term dialysis using a PDC could be sufficient. In our opinion, this approach may be appropriate in developed countries with high paediatric renal transplantation rates, and with developed renal transplantation programmes (10). For this reason, surgical AVF creation may be more suitable until the number of paediatric renal transplantation programmes becomes sufficient in our country.

Because the study population was small, the primary and secondary patency rates in patients who received radial and brachial level AVFs could not be compared. In our opinion, along with the retrospective design of the study, the lack of comparison of patients receiving different AVF levels was a major limitation of the study.

What is most remarkable in the current series was that the preference for AVFs in the appropriate child in the appropriate setting is no longer a matter of debate. AVF is the most durable and effective RRT modality which is encouraged for use in paediatric patients with ESRD. The weight and the level of AVF have a considerable influence on the duration of AVF maturation. Finally, AVF still remains the procedure of choice in regions where paediatric kidney transplantation programmes are not completely set up and that have resultant long transplantation waiting periods.

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