Original Article

Outcomes of Extra-Anatomic Surgical Bypass in Treatment of Central Venous Occlusive Disease in Pediatric Chronic Hemodialysis Patients: One-Year Follow-Up

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ABSTRACT

Background: For children with end-stage renal disease, maintaining the patency of the hemodialysis vascular access is still crucial. Arteriovenous access is significantly hampered by venous hypertension caused by central venous occlusive disease (CVOD). CVOD is managed with limited data regarding the role of endovascular intervention in pediatrics, surgical bypass is a salvage technique for the dialysis access, resulting in prolonged patency and satisfactory outcomes.

Objectives: Our prospective, observational study is to assess the effectiveness and results of surgically treating juvenile patients with CVOD associated with hemodialysis.

Patients and Methods: 15 pediatric patients with end-stage renal disease and CVOD receiving hemodialysis via upper extremity access received extra-anatomic surgical bypass. The study started from June 2021 until May 2022. Patients included in the study were attending the Vascular Outpatient Clinic at Ain Shams University Hospitals and Nasser Institute at Cairo.

Results: Axillary to Rt Subclavian bypass 3 (20%) and Lt Subclavian to Rt Subclavian bypass 3 (20%) are the most commonly used bypass configurations. Rt Axillary to Lt Subclavian bypass 2 (13.33%), Rt Cephalic to Lt Subclavian bypass 2 (13.33%), and Rt Axillary to Rt femoral bypass 2 (13.33%). The other bypasses: Lt Cephalic to Rt Subclavian, Rt Subclavian to Lt Subclavian and Lt Axillary to Lt Femoral are (6.66%). Within 48 hours, patients completed 4-hour hemodialysis sessions using previous access; 15 instances (100%) had technical success, while 13 cases (86.6%) had functional success. There were no documented in-hospital deaths or morbidities. At one, three, six, and twelve months, the primary patency rates were 93.3, 86.6, 66.6, and 46.6%, respectively and the secondary patency rates were 100%, 93.3%, 73.3%, and 53.3%, respectively.

Conclusion: Extra-anatomic surgical bypass is an effective method for management of CVOD in hemodialysis pediatric patients providing symptomatic relief of venous hypertension, prolonged patency, and satisfactory outcome.

Key Words: Central venous occlusion, pediatric hemodialysis, venous hypertension.

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INTRODUCTION

It is estimated that chronic renal failure occurs in three to five children per million annually. Of these, 23% will require prolonged hemodialysis support[1]. According to the KDOQI (Kidney Disease Outcomes Quality Initiative) guidelines, patients who weigh >20 kg and who are unlikely to receive a transplant within 1 year should have arteriovenous fistula (AVF) for dialysis[2].

However, although the utilization of AVFs increased after the Fistula First Breakthrough Initiative[3], central venous catheters (CVCs) remain the predominant method for hemodialysis among children[4]. This led to the increased incidence of catheter-associated central vein stenosis or occlusion and increased the need for a new access at a different side by 2-fold[5].

The subclavian vein, the brachiocephalic vein, and the superior vena cava may all develop central venous occlusive disease (CVOD). Patients often arrive with inadequate dialysis, face or breast enlargement, and upper-limb edema[6] (Figure 1).

Fig. 1: A. left arm swelling and collateral veins on neck or chest

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Management of venous hypertension due to access related CVOD is controversial. Symptomatic relief can be achieved by ligation. However, this sacrifices a functional access, which may be very precious[7].

There is a dearth of information about endovascular intervention in the treatment of CVOD in children. The benefit of a surgical bypass is that it may alleviate CVOD symptoms while preserving the current dialysis access and ensuring long-term patency[8].

The contralateral subclavian vein, contralateral internal jugular vein, ipsilateral internal jugular vein, ipsilateral saphenous vein, ipsilateral femoral vein, and right atrium are among the outflows from surgical bypasses that are often performed using prosthetic grafts[9].

Although surgical bypass is associated with some morbidity, but it results in prolonged patency. Therefore, the surgical techniques have an important place in management and salvaging existing access before decision of ligation[10].

PATIENTS AND METHODS

This study was conducted on (15) Pediatric patients with end stage renal disease on regular hemodialysis via upper extremity access who underwent extra-anatomic surgical bypass to treat symptomatic venous hypertension due to central venous occlusive disease. All patients had low dose aspirin 75mg post-operatively. The study period started from June 2021 until May 2022. Patients included in the study were attending the Vascular Outpatient Clinic at Ain Shams University Hospitals and Nasser Institute for Research & Treatment at Cairo.

Inclusion criteria

We included pediatric patients with end stage renal disease (ESRD) who receive regular hemodialysis via upper extremity access complicated by central venous occlusion disease and patients' age range from 4 to 18 years and their weight is more than 20kg. When one or more of the following criteria appeared: venous hypertension symptoms (upper-extremity edema, facial or breast swelling, collateral veins on neck or chest) or signs (prolonged bleeding from puncture site and elevated venous pressure during dialysis).

Exclusion criteria

Patients with weight less than 20 kg, patients with immature access, patients with congenital anomalies of superior vena cava, patients with Superior vena cava syndrome. Hemodialysis patients with thrombosed fistulae or thrombosed AVGs and patients with CVOD not related to hemodialysis were also excluded. Also, our age limit is 18 years old.

Imaging Investigations

Duplex ultrasound was carried out to confirm the diagnosis and to define the site of occlusion. Fistulography carried out only when duplex was not conclusive and some patients were referred to our center with CT venography.

Statistical methods

For statistical analysis, this research employed IBM SPSS version 23 (Statistical Package for Social Science; IBM Corp., Armonk, NY, USA). For parametric data, the mean, standard deviations, and ranges were shown; for non-parametric data, the median and interquartile range (IQR) were displayed. Qualitative factors were also shown as percentages and numbers. The following was the p-value that was deemed significant: *P-value* < 0.05 indicates significance (S), *P-value* < 0.01 indicates highly significant (HS), and *P-value* > 0.05 indicates non-significant (NS).

Procedure Description

All procedures were performed under general anesthesia. The decision of the bypass technique was planned to reconstruct the shortest possible length of bypass. Two incisions were carried out; the first one was infra-clavicular incision to expose a patent segment of the fistula vein before the obstructed segment (the cephalic, axillary or subclavian vein) and the second one was for the outflow vein through infra-clavicular incision on the contralateral side to expose the subclavian vein or through transverse groin incision on the ipsilateral side to expose the femoral vein. The patients had 8 mm supported polytetrafluoroethylene graft as a conduit and all grafts were tunneled extra-anatomically, either as a necklace curved crossover subcutaneous bypass between bilateral infraclavicular incisions or tunneled subcutaneously along the midaxillary line and lateral abdomen to the ipsilateral femoral vein (Figure 2). A postprocedural completion venography was performed to confirm the patency of the outflow. All patients received low dose aspirin 75 mg post-operatively.

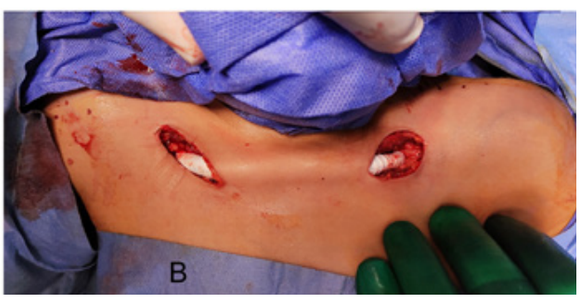

Fig. 2: B. Left subclavian vein to Right subclavian vein bypass (necklace bypass)

RESULTS

The study included 15 patients, 10 (66.67%) males and 5 (33.33%) females, their age ranged from 7 to 18 with

a mean of 11.66± 3.26 years. The weight of the studied patients ranged from 24 to 45 Kg with a mean of 32± 5.83Kg

The site of AVF was brachiocephalic in 11 (73.33%) patients and brachiobasilic in 4 (26.67%) patients, 7 (46.66%) patients had AVF on the right side and 8 (53.33%) patients had AVF on the left side. The age of AVF ranged from 1 to 5 years with a mean of 2. 05 ± 1.14 years. Regarding the history of CVC, ipsilateral was found in all patient 15 (100%), and contralateral in 8 (53.33%) patient (Table 1).

We used different configurations of bypasses, shown in the following table (Table 2).

Regarding the functional success, all patients underwent 4-hour hemodialysis sessions using their preexisting access within 48 hours after the procedure, and all patients had thrill restoration postoperatively and symptom remission within 1 week. At one, three, six, and twelve months, the primary patency rates were 93.3, 86.6, 66.6, and 46.6%, respectively. At one, three, six, and twelve months, the secondary patency rates were 100, 93.3, 73.3, and 53.3%, respectively (Figure 3).

Fig. 3: A case of bilaterally brachiocephalic veins total occlusion; A. showing preoperative prominent collateral veins on neck, chest and abdomen till groin

Table 1: Access characteristics

Characteristics	Number	Percentage
Side of fistula		
Right side	7	46.66%
Left side	8	53.33%
Age of fistula (years)		
Mean ± SD	2.05± 1.14	
Range	1 - 5	
Type of fistula		
Brachiocephalic	11	73.33%
Brachiobasilic	4	26.67%
Previous placement of central venous catheter	15	100%

Table 2: Type of bypass

Type of bypass	Number	Percentage
Lt Axillary to Rt Subclavian	3	20%
Lt Subclavian to Rt Subclavian	3	20%
Lt Cephalic to Rt Subclavian	1	6.66%
Lt Axillary to Lt femoral	1	6.66%
Rt Axillary to Lt Subclavian	2	13.33%
Rt Cephalic to Lt Subclavian	2	13.33%
Rt Axillary to Rt femoral	2	13.33%
Rt Subclavian to Lt Subclavian	1	6.66%

Table 3: Comparison between cases with primary patency and cases without primary patency after 1 year of follow up

	Primary patency		*P value*
	Yes (N=7)	No (N=8)	
Demographic data			
Age			
Mean ±SD	11.2±3	12±3.5	0.68
Weight			
Mean ±SD	30.2±3.8	33.5±7	0.30
AVF			
Site			
Brachiocephalic	4(57.1%)	7(87.5%)	0.18
Brachiobasalic	3(42.9%)	1(12.5%)	
Side			
Right	2(28.6%)	5(62.5%)	0.18
Left	5(71.4%)	3(37.5%)	
CVOD			
LT Innominate veins			
No	3(42.9%)	4(50%)	0.78
Yes	4(57.1%)	4(50%)	

	Primary patency		*P value*
	Yes (N=7)	No (N=8)	
LT subclavian veins			
No	5(71.4%)	6(75%)	0.87
Yes	2(28.6%)	2(25%)	
RT Innominate veins			
No	6(85.7%)	3(37.5%)	0.05*
Yes	1(14.3%)	5(62.5%)	
RT subclavian veins			
No	5(71.4%)	5(62.5%)	0.71
Yes	2(28.6%)	3(37.5%)	
Study intervention			
Rt Axillary to Lt Subclavian bypass	1(14.3%)	1(12.5%)	
Lt Cephalic to Rt Subclavian bypass	0	1(12.5%)	
Lt Subclavian to Rt Subclavian bypass	2(28.6%)	1(12.5%)	
Lt Axillary to Rt Subclavian bypass	2(28.6%)	1(12.5%)	0.36
Rt Cephalic to Lt Subclavian bypass	0	2(25%)	
Rt Subclavian to Lt Subclavian bypass	1(14.3%)	0	
Lt Axillary to Lt femoral bypass	1(14.3%)	0	
Rt Axillary to Rt femoral bypass	0	2(25%)	

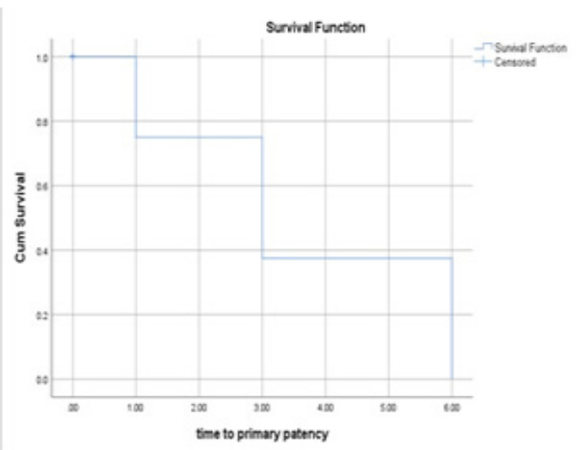

Fig. 4: Kaplan Meier survival curve analysis for primary

DISCUSSION

The increasing prevalence of end-stage renal failure (ESRD) in children emphasizes how critical it is for practitioners to understand how to handle access-related issues[11].

Central venous stenosis may be treated with endovascular therapy, surgery, or clinical monitoring. Ligation relieves symptoms and is well tolerated, although it prevents functional access. In symptomatic situations, repeated endovascular venoplasty is the preferred option to alleviate obstructive symptoms and preserve the fistula. Unfortunately, there aren't many articles or statistics about the pediatric population's use of endovascular intervention[12]. In two patients younger than a year, De Buys Roessingh *et al*. reported a successful endovascular recanalization of superior vena cava (SVC) stenosis by femoral approach[13].

Three out of four patients with central venous stenosis were successfully managed, according to Rinat and his colleagues. Two patients had their AVFs tied, and the symptoms of the condition gradually improved. An SVC vein to right atrium bypass was made for the third patient with SVC blockage[14]. Adult case series and studies provide almost all of the evidence for surgical venous bypasses in CVOD. Among the 10 adult patients who underwent surgical reconstruction for central venous blockage, Dammers *et al*. observed a 75% one-year primary patency rate[15]. Ten of the twenty adult patients in a different trial by Saravana *et al*. were remained patent at the 12-month follow-up. With balloon venoplasty and stenting, two of the ten patients who received patent grafts had effective aided patency. Two out of three patients died during follow-up from heart-related problems, and two patients (10%) had graft infection[16].

We included in our study 15 children who had extra-anatomical surgical venous bypasses and who (100%) demonstrated technical success as evidenced by thrill restoration after surgery and symptom resolution within 1 week. At 6 and 12 months, the cumulative patency rates were 11 (73.3%) and 8 (53.3%), respectively.

Two patients (13.3%) in our research had late graft infection; both were ligated, although one of them (6.67%) passed away from severe sepsis. One patient (6.67%) had a rupture and significant bleeding.

Additionally, Saravanan *et al*. noted in their research how crucial long-term antiplatelets are to preserving a healthy graft. More details on the duration and advantages of antiplatelet treatment, however, must be included in other series of a similar kind. Every patient in our research received a prescription for 75 mg of aspirin, which is a modest dosage.

Another worry is that the synthetic graft won't be able to grow with the kid. Since most of our patients have

stunted development, we tunneled all of the grafts in a curved fashion with extra length to prevent any issues from arising from the child's growth.

CONCLUSION

Extra-anatomic surgical bypass is a safe and effective method for management of Central venous occlusive disease in hemodialysis pediatric patients and has the advantage of being a salvage technique for maintaining the existing dialysis access and also providing symptomatic relief of venous hypertension, prolonged patency and satisfactory outcome.

CONFLICT OF INTERESTS

There are no conflicts of interest.

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