Patency of permanent vascular access creation in paediatric patients with end stage renal disease

Ho Hui Lian, MD[1,2,3], Ahmad Sukari Halim, FCCP (Belgium)[1,2], Arman Zaharil Mat Saad, MS (Plastic)[4], Wan Azman Wan Sulaiman, MS (Plastic)[1,2], Mohamad Ikram Ilias, MMed (Paediatrics)[5]

[1]Reconstructive Sciences Unit, School of Medical Sciences, Universiti Sains Malaysia, Kubang Kerian, Kelantan, Malaysia, [2]Hospital Universiti Sains Malaysia, Health Campus, Universiti Sains Malaysia, Kelantan, Malaysia, [3]Department of Surgery, Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia, [4]Plastic and Reconstructive Surgery, MSU Medical Centre: Shah Alam, Selangor, Malaysia, [5]Department of Paediatrics, School of Medical Sciences, Universiti Sains Malaysia, Kubang Kerian, Kelantan, Malaysia.

SUMMARY

Renal transplant is the first-line therapy in paediatric patients with end-stage renal disease (ESRD). Wong HS and Goh BL reported up to 79% of 1061 paediatric patients still require long-term haemodialysis (HD).1 The lack of deceased and living donors is attributable to the poor awareness, cultural and religious grounds. Permanent vascular access (PVA) in paediatrics therefore, serves more as a long term treatment rather than a bridging therapy. We observed 5 children and an adolescent, all with previous indwelling catheters, who underwent arteriovenous fistula (AVF) creation and report the outcomes. The aim of this report is to determine the factors that influence the long-term patency of paediatric AVF. Factors such as body weight, vessel diameter, preoperative preparations, microsurgical technique and postoperative maintenance are discussed. In addition, considerations on the choice and timing of PVA is highlighted.

INTRODUCTION

In Malaysia, patients receiving dialysis increased from 15,087 in 2006 to 37,183 In 2015. Out of these 37,183 patients, 1061 were under the age of 20 were receiving renal replacement therapy (RRT). Out of these 1061 patients, 79% were on haemodialysis (HD) and only 21% received renal transplants.[1] Owing to the age of the patients at referral, size of vessels and accessibility to renal transplant, decision on the choice of vascular access is challenging. Therefore, it is important to weigh all the pros and cons of the dialysis options available, specifically the permanent vascular access (PVA), peritoneal dialysis (PD) and central venous catheter (CVC). Kidney Disease Outcomes Quality Initiative (K-DOQI) guidelines by the United States of America's National Kidney Foundation (NKF) recommends placement of permanent access in dialysis patients aged 0 to 19 years who weigh more than 20 kg and are unlikely to receive a transplant within one year. Implementation of "fistula first" has also been started for the paediatric group who require long-term HD.

In the Universiti Sains Malaysia (USM) hospital, majority of the paediatric patients are offered PD, only a minority of patients who developed complications from the ultrafiltration such as repeated infections from PD or clinically not suitable e.g., having a stoma, were offered fistula creation by the treating physician. The number of patients having new fistula creation in USM is only 5 or less each year. Even though most paediatric HD patients met the weight criteria and were expected to wait for more than one year to receive a kidney transplant for AVF upon initiation of HD, PD was chosen over AVF creation.

In this report, we look at five paediatric patients, all with pre-existing CVC and who had undergone AVF creations performed by a single surgeon. The potential factors affecting the patency rates are discussed.

CASE REPORTS

Five patients were referred. All these patients already had their HD initiated via a CVC inserted into the internal jugular vein (IJV) for temporary dialysis access with two of the patients having thrombosis from the catheterization, with a length of HD dependence ranging from 1 month to 3 years.

The weights of the patients ranged from 15 to 36kg and age between 9 and 16 years old. Four patients had RCF created and one had snuffbox AVF. Preoperatively, all patients had ultrasound assessment for the continuity and compliance of the superficial veins. All AVFs were performed with end-to-side anastomosis with interrupted monofilament sutures. No anticoagulation prophylaxis was given. Patients were seen routinely at 2 and 6 weeks postoperatively for suture removal and reassessment with ultrasound done prior to first cannulation of the fistula. Maturation of fistulas ranged from 6 weeks to 4 months.

For postoperative assessment for adolescents, the KDOQI "Rule of 6s" is used to determine the maturity of the fistula - at least 6 mm in diameter, <6 mm depth from skin and has a blood flow >600 mL/min[3] with leniency to "4s"allowed. In younger children, the fistula is considered matured with clinically strong palpable thrill and good colour Doppler signals.

Primary failure of fistula includes inadequate maturation, thrombosis, failure of first and subsequent cannulations and other complications leading to non-functional AVFs.

This article was accepted: 05 July 2021
Corresponding Author: Ho Hui Lian
Email: hohuilian@ums.edu.my

Table I: Summary of patients' details and the outcomes of arteriovenous fistulas

No	Age	Sex	Weight (Kg)	Causes of ESRD	Other Comorbid	Reason of AVF creation	Mode of HD before AVF	Procedure	Time to Maturation of AVF	Early Complications	Primary or Secondary Failure	Current Condition / Fate of AVF
1	12	M	32.7	SRNS	Nil	Occlusion in CVC	Hickman catheter	Right RCF	8 weeks	Thrombosis proximal to the anastomotic site*	Secondary	Functioning well
2	9	M	15.0	Solitary kidney with reflux nephropathy	Imperforate anus (VACTERL association)	Diverting colostomy precludes PD	IJV catheter	Left RCF	6 weeks	Nil	Secondary	Thrombosed after 18 months of HD
3	10	M	30.2	SRNS	Nil	UF failure in PD	IJV catheter	Left RCF	8 weeks	Nil	N/A	Functioning well, currently in the 4th year of HD
4	12	F	18.7	SRNS	Nil	UF failure in PD	Previous 3 CVC insertions in different settings	Left RCF	4 months	Vessel calibre and flow never achieve satisfactory results	Primary	AVF was never utilised
5	16	M	36.0	SRNS	Kimura disease	long-term HD	IJV catheter	Left Snuffbox AVF	8 weeks	Nil	Secondary	Stenosed after 3 years of HD

AVF - arteriovenous fistula; SRNS - steroid resistant nephrotic syndrome; PD - peritoneal dialysis; VACTERL - vertebral defects, anal atresia, cardiac defects, tracheoesophageal fistula, renal anomalies, and limb abnormalities; HD - haemodialysis; IJV - internal jugular vein; UF - ultrafiltration; CVC - central venous catheterization; RCF - radiocephalic fistula
*Successfully salvaged with open thrombectomy

Secondary AVF failure is permanent failure after the AVF has met dialysis suitability criteria with subsequent abandonment. Out of the four RCFs and one snuffbox AVF, there was one primary failure (patient's weight: 18.7kg), three secondary failures (patients' weight: 36kg, 32.7kg, 15kg) with one salvageable by open thrombectomy and one functioning well currently in his fourth year of HD via the RCF created (patient's weight: 30.2kg). Patient with primary failure of the fistula previously had three CVCs in different settings prior to fistula creation which is significantly more when compared with the rest. One of the patients with secondary failure had Hickman catheter prior to RCF creation in which thrombus was detected proximal to the anastomotic site and salvaged with open thrombectomy. Secondary failure in the snuffbox AVF occurred at the third year of HD and require new fistula creation. Four out of five patients have nephrotic syndrome diagnosed prior to ESRD. Another patient had reflux nephropathy with underlying VACTERL syndrome (Table I).

DISCUSSION

Outcomes of PVA encompass not only the surgical techniques, but also the extensive preoperative assessments and preparations, post-operative care and maintenance. It is common to have patients with CVC inserted at the time of first consultation for AVF. CVC is beneficial for patients expected to have renal transplant in a short time or those requiring urgent dialysis. It is also recommended for children less than 10kg in weight, whose vessel caliber is expected to be small, rendering fistula creation a challenge to the surgeon. However, it is at a disadvantage in terms of catheter-related infections, thrombosis, fibrin sheath formation, catheter malfunction and short life span with medial survival of 4 to 10.6 months. Complications to central vessels also make future arteriovenous access creation difficult. Based on our case series of 5 patients, weight does not seem to be the predictor of patency, rather, the number of previous central venous catheterizations. Commonly, central venous stenosis is only apparent when AVF is established where there is increased in blood flow in the limb. Creation of AVF in paediatric patients are feasible and its long-term outcome has been evaluated in many reports.[3,4,5] A patient as small as 10kg has been described to have successful fistula creation.[3]

Preoperative preparations and proper venous mapping of the patients using colour doppler ultrasound are therefore very important in the patency rate of the PVA created. All patients with renal dysfunction should have their conditions managed as potential long-term dialysis candidates. Therefore, the aim should be to achieve maximal use from each access site. It is important to advocate the "distal before proximal" and "autogenous before prosthetic" rule in providing paediatric permanent HD access. Since all our patients had prior history of CVC insertions, the conditions of the vein must be assessed by careful preoperative clinical examination and a central venogram is mandatory. By achieving a perfect anastomosis only is not enough if the fistula created cannot be utilised for HD due to proximal thrombosis or stenosis; or inability to achieve adequate flow due to proximal venous branches that are not ligated intraoperatively. Technical victories that result in functional failures serve no purpose.

Intraoperatively, several fundamental rules should be adhered to achieve good patency. The rules for suturing are that the forceps must never grasp the intima, the adventitia is incised and not resected, high pressure clamps must be avoided and the thinnest possible needles are to be used. Vessels are only handled by the adventitia. In the literature, vessel diameters are often not specified when assessing the outcome of the fistula, instead substituted by the weight of the patients.[4] Thus, the timing for access creation should be based upon circumstances and local expertise of patients.

In Malaysia, the frequent paediatric vascular access sites are the wrist AVF, BCF, cuffed and non-cuffed catheters, artificial graft and venous graft in descending order.[1] RCF is the preferred choice in USM as the children can maintain a more comfortable position during HD, comparing to ulnar-basilic fistula and the snuffbox AVF. Comparing to BCF and BBF, RCF is chosen in order to start with a more distal access and not requiring transpositions of the vein. Study has shown that the location of AVF did not significantly affect primary or secondary patency in paediatric age group.[5]

Care and maintenance of AVF pose a challenge in the paediatric group, especially the exhaustion of vascular access in the future. Venous neointimal hyperplasia, hemodynamic and surgical stressors as well as inflammatory stimuli from dialysis needles can pose risks to AVF failures.[3,6] At the histological level, venous neointimal hyperplasia is characterized by the presence of myofibroblasts, angiogenesis and the accumulation of extracellular matrix components.[6] Buttonhole needling of HD AVF results in less complications and interventions compared to the rope-ladder technique.

ESRD itself is a prothrombotic state. An underlying diagnosis of nephrotic syndrome in these patients further constitutes a significant risk factor for thrombosis due to the increased synthesis of thrombosis-promoting factors, including factors V and VIII and fibrinogen; impaired fibrinolytic activity, attributable to decreased concentrations of both plasminogen and tissue-plasminogen activator (tPA), while at the same time the inhibitors of fibrinolysis, including plasminogen activator inhibitor-1 and α2-plasmin inhibitor, are elevated.[5] All our patients did not receive anticoagulants as we do not advocate the usage of systemic anticoagulation for vascular access surgery due to the increased incidence of bleeding and lack of benefit in primary patency.[7]

Predictors of patency of AVF in children is still a continuing study. Sisli et al. recently reported a 34.6% AVF loss over a duration of 21 months follow up in children.[5] Almási-Sperling and colleagues studied the patency rates in correlation to the maturation intervals and first access cannulation in paediatric patients.[8] Vonapanitase, which is a recombinant human type 1 pancreatic elastase that can facilitate rapid AVF dilatation and maturation by causing persistent vasodilatation, fragmenting the elastin fibres and inhibiting adventitial myofibroblast migration to the intima has been described.[9] Local application of antiproliferative agents such as coII-R, paclitaxel-coated balloons and

Vascugel, which is the cultured human aortic endothelial cells, were introduced in the attempt of maintaining patency.

Therefore, early referral for fistula creation is advised among patients who are expected to require HD in the near future to avoid complications from CVC. Preoperative preparation of vessels preservation on the decided side of upper limb is important, preference of non-dominant arm first and start distally then, work proximally. Postoperative anticoagulant should be considered in patients with diagnosis of nephrotic syndrome, which essentially is one of the major causes that leads to ESRD in paediatrics.

Paediatric patients who are unlikely to receive renal transplant within one year of ESRD diagnosis should have AVF as the preferred mode of haemodialysis. It is imperative to have preoperative Doppler ultrasound and central venogram in patients with previous CVC prior AVF creation to rule out central venous obstruction. Primary and secondary patency of AVF require intricate interplay of preoperative planning, meticulous microsurgical techniques, and AVF maintenance.

CONCLUSION

High index of suspicion on the vessel patency in patients with previous CVC should be confirmed routinely with central venogram before undertaking AVF creation. Patency of AVF include all aspects of preoperative preparations, proper assessments of candidates, techniques of surgeons and postoperative care and maintenance. Cause of unfavourable results and higher risk of complications such as prior indwelling catheter can be omitted with the "fistula first" policy.

REFERENCES

1. Wong HS and Goh BL (Eds). Twenty Forth Report of the Malaysian Dialysis and Transplant 2016, Kuala Lumpur 2018
2. Vascular Access 2006 Work Group. Clinical practice guidelines for vascular access. Am J Kidney Dis 2006; 48(1): 176-247.
3. Gradman W, Lerner G, Mentser M, Rodriguez H, Kamil ES. Experience with Autogenous Arteriovenous Access for Hemodialysis in Children and Adolescents. AnnVasc Surg 2005; 19(5): 609-12.
4. Wartman S, Rosen D, Woo K, Gradman W, Weaver F, Rowe V, et al. Outcomes with arteriovenous fistulas in a paediatric population. J Vasc Surg 2014; 60(1): 170-5.
5. Sisli E, Gür A. Mid-term outcome of arteriovenous fistula in paediatric patients with end-stage renal disease: A single centre experience. Eastern J Med 2019; 24(2): 130-4.
6. Mandel-Shorer N, Tzvi-Behr S, Harvey E, Revel-Vilk S. Central venous catheter-related venous thrombosis in children with end-stage renal disease undergoing haemodialysis. Throm Res 2018; 172: 150-7.
7. Regus S, Almási-Sperling V, Lang W. Paediatric Patients Undergoing Arteriovenous Fistula Surgery without Intraoperative Heparin. J Vasc Access 2016; 17(6): 494-8.
8. Almási-Sperling V, Galiano M, Lang W, Rother U, Rascher W, Regus S, et al. Timing of first arteriovenous fistula cannulation in children on haemodialysis. Pediatr Nephrol 2016; 31(10): 1647-57.
9. Franano FN, Hance K, Bland K, Burke S. PRT-201 dilates outflow veins and improves maturation rates in a rabbit model of AVF. Nephrol Dial Transplant 2007; 22: 155-6.