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Cohort Study

Outcomes of arteriovenous fistula for hemodialysis in pediatric age group

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ABSTRACT

Introduction: The feasibility of arteriovenous fistula (AVF) creation in pediatric patients has long been documented, but few studies have evaluated the forms and long-term outcomes. The aim of this article is to highlight the types, techniques and outcomes of AVFs in pediatric age group.

Methods: This is multi-center, retrospective, single cohort study, including all the cases of pediatric (less than 18 year old) cases underwent AVF creation during four years (2015–2019). The following data were obtained from the patients' medical records and analyzed; socio-demographics, etiology of renal failure (RF), history of dialysis and transplantation, type and site of AVF, the outcomes and complications.

Results: The study included 108 patients, 89 patients (82.4%) were female. The mean age was 13 years. The most common cause of RF was the urological causes which were found in 34 cases (31.5%), followed by nephrotic syndrome (32 cases, 29.6%), glomerulonephritis (27 cases, 25%), and polycystic kidney disease (12 cases, 11.1%). The decision for choosing access site was performed only by clinical examination in 96 patients (88.9%) while duplex ultrasound was requested for 12 cases (11.1%). The operation was done under local anesthesia in 81 cases (75%) and general anesthesia in 27 cases (25%). The procedure was performed in the wrist in 58 cases (53.7%) and in cubital fossa in 50 cases (46.2%). The most common early complication was hematoma (12 cases, 11.1%), followed by ecchymosis (10 cases, 9.3%), infection (8, 7.4%), seroma (4, 3.7%) and thrombosis (3, 2.8%). The one-year primary patency rate was found in 95 patients (88%) and two-year patency rate in 86 patients (79.6%).

Conclusion: Native AVF in pediatric is the first choice dialysis access even in pediatric population. Radiocephalic in the non-dominant hand is the most preferred site.

1. Introduction

Adequate vascular access is the key factor for a successful hemodialysis (HD). The first AVF was described by Brescia et al., in 1966 and subsequently it has become the most preferred vascular access. This is due to its low complication rates and long life span [1]. The ideal vascular access, according to the National Kidney Foundation–Dialysis Outcomes Quality Initiative (NKF-DOQI) guidelines, should deliver an adequate flow rate in combination with durability and a low rate of complications [2]. An arteriovenous fistula (AVF) is generally considered to be the optimum access for HD in adults and, as suggested by an emerging body of evidence, also in children [3].

Previously, the access most commonly used in children was central venous (CV) catheter. Despite the increasing focus on the potential

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morbidity associated with CV lines, their usage rate at hemodialysis initiation has increased in the recent years, with usage rates of 89% for children <13 years of age and 64% in those 13–19 years of age [4].

The feasibility of AVF creation in pediatric patients has long been documented, but few studies have evaluated the forms and long-term outcomes [5]. The aim of this article is to highlight the types, techniques and outcome of AVFs in pediatric age group.

2. Patients and methods

Ethical standard: approval has been taken from Musil cardiac center. An informed written consent was taken from the patient and patient's family. The study has been written in line with STROCSS guidelines [6].

Registration: The research was registered in Chinese Clinical Trial Registry. The registration number is ChiCTR2100047387.

Design and setting: This is multi-center, retrospective, single cohort study, including all the cases of pediatric (less than 18 year old) cases underwent AVF creation during four years (2015–2019).

Data collection: The following data were obtained from the patients' medical records and analyzed; socio-demographics, etiology of RF, history of dialysis and transplantation, type and site of AVF, the outcomes and complications.

Operative Intervention: The choice of AVF formation was dependent on a number of factors, including vessel anatomy, previous access history, hand dominance, and child/parental choice (particularly relevant for girls concerned with cosmesis). A single-stage cephalic-based AVF at the wrist or elbow was the first choice fistula; when this was not possible a brachiobasilic AVF was made in two stages. A vascular surgeon evaluated the patient's venous and arterial suitability by performing a thorough physical examination, vein mapping using duplex scan was performed in selected patients. Duplex scan of subclavian vein was performed only if there was a history of temporary central venous line. The minimum acceptable venous size limit on duplex scan was 1.5 mm. Temporary dialysis access routinely inserted in the internal jugular vein of dominant hand. The AVFs were created according to the standard end to-side anastomosis method with a continuous running suture and few cases side to side anastomosis according to the surgeon preference. Flow control was performed by vascular clamps after giving I.V heparin. Loupe magnification was used in all the cases without using operating microscope.

Postoperative intervention: low dose I.V heparin was used in selected patients, based on the immediate results of the AVFs such as a weak fistula flow after anastomosis and high risk for thrombosis. Patients were evaluated through physical examinations on the first postoperative day and at 3rd post-operative day, one week, two weeks, and 6 weeks after AVF creation. The decision of whether AVF may be used for HD was made at 6–8 weeks after AVF creation with duplex ultrasonography. Further follow-up with duplex ultrasonography was performed when delayed maturation or surgical complications were detected. Primary patency (i.e., intervention-free access survival) was defined as the interval from AVF creation until any intervention designed to maintain or re-establish patency; simply, it is the time interval of patency. Primary-assisted patency (i.e., thrombosis-free access survival) was defined as the interval from AVF creation until access thrombosis, or the time interval of patency, including intervening manipulations designed to maintain the functionality of a patent AVF. Secondary patency was defined as the time interval from AVF creation until access failure or thrombosis, or the time interval of patency including intervening manipulations designed to re-establish the functionality in a thrombosed AVF [6]. Primary failure was defined as the inability to use the AVF even once.

Data analysis: The data were registered into an excel sheet, after coding of the information, they were transferred into an a SPSS (Statistical Package for Social Sciences) file. Descriptive statistics as mean, range, frequency and percentage were used to present the data.

3. Result

The study included 108 patients, 89 patients (82.4%) were female, 19 cases (17%) were male. The mean age was 13 years ranging from 4 to 18 years, the mean body weight was 34 kg ranging from 18 to 58 kg. The most common cause of RF was the urological causes (such as) found in 34 cases (31.5%), followed by nephrotic syndrome (32 cases, 29.6%), glomerulonephritis (27 cases, 25%), polycystic kidney disease (12 cases, 11.1%) and other miscellaneous causes (3 cases, 2.7%). The patients had previous temporary vascular accesses (CV lines) in right internal jugular vein (78 patients, 72.2%), left internal jugular vein (20, 18.5%), left subclavian vein (6, 5.5%), and right subclavian vein (4, 3.7%). The decision for choosing access site was performed only by clinical examination in 96 patients (88.9%) while duplex ultrasound was requested for 12 cases (11.1%). The CV lines were performed in the dominant hand in 86 cases (79.6%), and in non-dominant hand in the remaining cases (22 cases, 20.4%). The operation was done under local anesthesia in 81 cases (75%) and general anesthesia in 27 cases (25%). The procedure was performed in the wrist in 58 cases (53.7%) and in cubital fossa in 50 cases (46.2%). They were in non-dominant side in 93 cases (86.1%) and in dominant side in 15 patients (13.9%). The AVFs were created in the form of end to side in 106 patients (98.1%) and side to side in other 2 cases (1.9%) The most common early complication was hematoma (12 cases, 11.1%), followed by ecchymosis (10 cases, 9.3%), infection (8, 7.4%), seroma (4, 3.7%) and thrombosis (3, 2.8%). The one-year primary patency rate was found in 95 patients (88%) and two-year patency rate in 86 patients (79.6%).

4. Discussion

The Kidney Disease Outcome Quality (KDOQI) 2006 recommendations and the International Pediatric Fistula First Initiative in 2004 emphasized the need for considering AVF as the first choice for pediatric HD [7]. Surgical expertise plays an important role in the success of an AVF creation. Since Bourquelot et al., in 1978, several surgeons have claimed that microsurgery techniques in AVF creation can reduce early failure rate, diminish maturation time, longer access survival rates [8,9]. In the creation of the AVF, Loupe magnification was used in all of the cases. Not every child needing chronic HD is a suitable candidate for AVF. Key factors that need to be considered are the age and size of the child, the condition of their vessels and the anticipated duration of HD before transplantation or change of dialysis modality. Using microvascular surgical techniques, AVFs can be successfully created even in children weighing <10 kg [10].

The preferred sites for AVF placement include, in order, radial artery to cephalic vein (radiocephalic), brachial artery to cephalic vein (brachiocephalic), and brachial artery to basilic vein (brachiobasilic, with or without transposition [11]. Alternatively, an ulnar artery to basilic vein AVF can be created. A femoral artery to saphenous vein AVF has been described but it is rarely used [12]. In this study, 53.7% of the AVFs were brachiocephalic and 54.3% were radiocephalic. The decision of where to form an AVF depends on a number of factors and needs to be individualized to each child's circumstances. Vessel anatomy, previous access history, hand dominance, intention for self-cannulation, body mass index, child or parental choice and surgical expertise should all be considered. An AVF in the non-dominant arm allows for self-needling of the AVF, easy use of the dominant arm during dialysis and also limits any potential neurovascular complications to the affected arm [13]. In the current study, they were in non-dominant side in 93 cases (86.1%) and in dominant side in 15 patients (13.9%). A prospective series in children that included mainly radiocephalic AVFs has shown excellent primary and primary-assisted patency rates of 78% and 94%, respectively [14]. However, primary failure and inadequate function is more common with radial AVFs than with brachial AVFs as documented in a meta-analysis in adult [15]. In this study, The procedure was performed as radiocephalic in 58 cases (53.7%) and as brachiocephalic in 50 cases

(46.2%).

Physical examination is best performed in a warm and child friendly environment. Careful history and examination of both arms is performed to identify any factors that may be associated with AVF failure, such as previous CV lines, repeated venipuncture, hypotension, heart failure, non-visible veins despite tourniquet application and the quality of arterial pulse, to assess for arterial occlusion or impairment of arterial flow [16,17]. Venous dilatation can be assessed by measurement of venous caliber before and after tourniquet application, and venous continuity can be assessed by manual percussion and palpation of the vessel [18]. Duplex ultrasound scanning by the surgeon, or venography, can provide crucial information regarding the adequate vessel size, venous stenosis, or occlusion, and should be considered whenever the vein size was questionable so that the best location for AVF placement can be precisely determined [19]. In this study, the surgeon relied mainly on the physical examination, it was adequate in about 96 cases (88.9%), preoperative scanning was indicated only in 12 cases (11.1%). When AVF was first attempted in children, a 50% immediate failure rate was reported [19]. Over the years, advances in AVF creation, especially with increased surgical experience, have shown primary failure rates as low as 5%. In the current report, one-year primary patency rate was 88% and two-year primary patency rate was 79.6%.

When AVF was first attempted in children, a 50% immediate failure rate was reported [20]. Over the years, advances in AVF creation, especially with increased surgical experience, have shown primary failure rates as low as 5%. Wartman and associates evaluated the outcomes of 101 AVFs and demonstrated primary and secondary patency rates at 2 years as 83% and 92%, respectively while Chand and colleagues reported primary patency rate of 57% at 6 months and secondary patency rate of 100% at 1 year [21,22]. In the current report, one-year primary patency rate was 88% and two-year primary patency rate was 79.6%.

In conclusion, native AVF in pediatric is the first choice dialysis access even in pediatric population. Radiocephalic in the non-dominant hand is the most preferred site.

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Ethical approval

The manuscript approved by ethical committee of the University of Sulaimani.

Consent

Consent has been taken from the patients and the family of the patients.

Author contribution

Okba F.Ahmad, Omar M.Hamodat, Fahmi H.Kakamad, Rabea S. Abduljabbar: cardiothoracic surgeons who manages the cases, follow up, and final approval of the manuscript Fahmi H.Kakamad, Abdulwahid M. Salih, Mohammed Q.Mustafa, Marwan N.Hassan, Shvan H.Mohammed: literature review, writing the manuscript, final approval. Diyar A.Omar, Tomas M.Mikael, Kayhan A.Najar, Dahat A.Hussen: literature review and final approval of the manuscript.

Registration of research studies

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Guarantor

Fahmi Hussein Kakamad is Guarantor of this submission.

Declaration of competing interest

None to be declared.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amsu.2021.103100.

References

[1] M.J. Brescia, J.E. Cimino, K. Appel, B.J. Hurwich, Chronic hemodialysis using venipuncture and a surgically created arteriovenous fistula, N. Engl. J. Med. 275 (1966) 1089–1092 9.
[2] National Kidney Foundation NKF KDOQI guidelines, Clinical practice guidelines and clinical practice recommendations. 2006 updates. Haemodialysis adequacy, peritoneal dialysis and vascular access, Am. J. Kidney Dis. 48 (1) (2006) S1–S322.
[3] A. Ma, R. Shroff, D. Hothi, M.M. Lopez, F. Veligratli, F. Calder, et al., A comparison of arteriovenous fistulas and central venous lines for long-term chronic haemodialysis, Pediatr. Nephrol. 28 (2013) 321–326.
[4] US Renal Data System, Annual Data Report: Atlas of Endstage Renal Disease in the United States, National Institute of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 2006, 2006.
[5] P. Bagolan, A. Spagnoli, G. Ciprandi, S. Picca, G. Leozappa, A. Nahom, et al., A ten-year experience of Brescia-Cimino arteriovenous fistula in children: technical evolution and refinements, J. Vasc. Surg. 27 (1998) 640–644.
[6] R. Agha, A. Abdall-Razak, E. Crossley, N. Dowlut, C. Iosifidis, G. Mathew, for the STROCSS Group, The STROCSS 2019 guideline: strengthening the reporting of cohort studies in surgery, Int. J. Surg. 72 (2019) 156–165.
[7] A.N. Sidawy, R. Gray, A. Besarab, M. Henry, E. Ascher, M. Silva Jr., et al., Recommended standards for reports dealing with arteriovenous hemodialysis accesses, J. Vasc. Surg. 35 (2002) 603–610.
[8] D.H. Chand, R.P. Valentini, International pediatric fistula first initiative: a call to action, Am. J. Kidney Dis. 51 (2008) 1016–1024 30.
[9] P. Bourquelot, O. Cussenot, P. Corbi, G. Pillion, M.F. Gagnadoux, A. Bensman, C. Loirat, et al., Microsurgical creation and follow-up of arteriovenous fistulae for chronic haemodialysis in children, Pediatr. Nephrol. 4 (1990) 156–159.
[10] M. Gallieni, R. Saxena, I. Davidson, Dialysis access in europe and north America: are we on the same path? Semin. Intervent. Radiol. 26 (2009) 96–105.
[11] P. Bourquelot, L. Wolfeler, L. Lamy, Microsurgery for hemodialysis distal arteriovenous fistulae in children weighing less than 10kg, Proc. Eur. Dial. Transpl. Assoc. 18 (1981) 537–541.
[12] National kidney foundation-dialysis outcomes quality initiative NKF-DOQI clinical practice guidelines for vascular access, Am. J. Kidney Dis. 30 (1997). S150–S19.
[13] G.J. chwartz, A. Munoz, M.F. Schneider, New equations to estimate GFR in children with CKD, J. Am. Soc. Nephrol. 20 (2009) 629–663.
[14] R. Shroff, F. Calder, S. Bakkaloğlu, E.V. Nagler, S. Stuart, L. Stronach, et al., Vascular access in children requiring maintenance haemodialysis: a consensus document by the European Society for Paediatric Nephrology Dialysis Working Group, Nephrol. Dial. Transplant. 34 (2019) 1746–1765.
[15] H.J. Son, S.K. Min, S.I. Min, Y.J. Park, J. Ha, S.J. Kim, Evaluation of the efficacy of the forearm basilic vein transposition arteriovenous fistula, J. Vasc. Surg. 51 (2010) 667–672.
[16] P.P. Rooijens, J.H. Tordoir, T. Stijnen, J.P Burgmansd, A.A.E.A Smet de, T.I Yo, Radio cephalic wrist arteriovenous fistula for hemodialysis: meta-analysis indicates a high primary failure rate, Eur. J. Vasc. Endovasc. Surg. 28 (2004), 583–58.
[17] I.J. Ramage, A. Bailie, K.S. Tyerman, J.H. McColl, S.G. Pollard, M.M. Fitzpatrick, Vascular access survival in children and young adults receiving long-term hemodialysis, Am. J. Kidney Dis. 45 (2005) 708–771.
[18] M. Malovrh, Native arteriovenous fistula: preoperative evaluation, Am. J. Kidney Dis. 39 (2002), 1218–122.
[19] K. Cagli, A. Uzun, M.V. Emir, Bakuy. Correlation of modified allen test with Doppler ultrasonography, Asian Cardiovasc. Thorac. Ann. 14 (2006) 105–108.
[20] W.S. N, G. Lerner, M. Mentser, H. Rodriguez, E.S. Kamil, Experience with autogenous arteriovenous access for hemodialysis in children and adolescents, Ann. Vasc. Surg. 19 (2005) 609–612.
[21] J.V. Wander, E.S. Moore, O. Jonasson, Internal arteriovenous fistulae for dialysis in children, J. Pediatr. Surg. 5 (1970) 533–538.
[22] National Kidney Foundation, KDOQI Clinical practice guidelines and clinical practice recommendations for 2006 updates: haemodialysis adequacy, peritoneal dialysis and vascular access, Am. J. Kidney Dis. 48 (2006) S1–S32.