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Role of Interventional Radiology in Hemodialysis for Pediatric Age Groups with Difficult Access (Tunneled Permanent Venous Catheter with Difficult Access)

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Abstract

Background: Hemodialysis in infants and young children is an effective and safe form of renal replacement therapy but problems with vascular access limit its use in the long-term. **That study aimed to** highlight the role of the interventional radiologist to get venous access for pediatric age group patients presented with chronic renal impairment notably cases with difficult venous access using permanent tunneled venous dialysis catheter (PermiCath). **Methods:** This observational study was carried out on 20 patients presented to Radiology Department at Kafr Elsheikh Main University hospital. Participants were exposed to full clinical history, previously available examinations, and radiological examination. **Results**: 9 cases had done AV shunt (45 %) and 11 cases were AV shunt free (55%). 15 cases were PD-free (75 %) and 5 cases were dialyzed by PD (25%). The total number of catheters inserted was 36 catheters and the number of catheters that were removed was 16 catheters. 11 catheters were removed due to mal / nonfunctioning (30.6%), 8 catheters were thrombosed (22.2 %), 2 catheters were partially slipped (5.6%), 1 catheter was removed due to fibrin sheath (2.8%). 3 catheters were removed due to catheter-related blood born infection (8.3%), and no catheters were removed from exit site infection. 2 catheters were removed electively after AV shunt working (5.6%). **Conclusion:** The placement of tunneled cuffed central venous catheters for hemodialysis by interventional radiologists is safe and effective with very low complication rates in children, especially with difficult venous access.

Keywords: Radiology; Hemodialysis; Pediatric; Difficult Access; Tunneled Permanent; Venous Catheter

1.Introduction

Despite hemodialysis (HD) in the pediatric age group was described since 1955. However, HD of infants and too young children were still considered inappropriate, technically unmanageable, or frankly dangerous by many intensivists and nephrologists. The paucity of literature on the subject reflects the reluctance to use HD in the face of high morbidity and mortality rates [1]

Chronic Renal Failure (CRF) or chronic kidney disease (CKD) is defined as a persistent impairment of kidney function, in other words, abnormally elevated serum creatinine for more than 3 months or calculated glomerular filtration rate (GFR) less than 60 ml per minute / $1.73m^2$. It often involves a progressive loss of kidney function necessitating renal replacement therapy. When a patient reaches end-stage renal disease (ESRD) with GFR less than 15 mL/min, the chronic renal replacement therapy is initiated. Chronic renal replacement therapy (RRT) includes renal transplantation, chronic dialysis through Peritoneal dialysis and Hemodialysis (AV fistula or graft and central venous catheter (PermiCath)) [2].

The use of a large bore tunneled central venous catheter "PermiCath" in the central veins (internal jugular, femoral or hepatic vein) allows dialysis immediately following the catheter insertion. Placement with imaging guidance (US/fluoroscopy) is highly recommended, especially in patients with multiple prior catheters who may have central venous stenosis [3].

Cuffed tunneled catheters were inserted in the case of patients requiring long-term dialysis whose vessels were not favorable for creating AVF. Cuffed catheters are often the only form of chronic hemodialysis access in young children since their relatively small vasculature may not support fistula construction or graft placement [4].

CVCs remain the favored access type in all pediatric age groups despite international recommendations to the contrary. The preference for CVCs in the pediatric age groups is only partially explained by the technical challenge of AVF placement, high complication rate from peritoneal dialysis and multiple difficulties facing renal transplantation. [5]. HD in infants and young children is an effective and safe form of renal replacement therapy but problems with vascular access limit its use in the long-term [1].

The current research aimed to highlight the role of the interventional radiologist to get venous access for pediatric age group patients presented with chronic renal impairment notably cases with difficult venous access using permanent tunneled venous dialysis catheter (PermiCath).

2.Patients and methods

That observational study was carried out on 20 patients presented to Radiology Department at Kafr Elsheikh Main University hospital. The study was done after being approved by the Research Ethics Committee and all participants provided their informed consent.

Inclusion Criteria were children < 18 years, ESRD with the following criteria (waiting for renal transplantation, failed renal graft, failed AV fistula/graft and not amenable for AV fistula (small vessels, lack of surgical expertise, concomitant co-morbidity).

Exclusion Criteria were patient >18 years, Children with acute kidney injury and patient with functioning AV fistula.

All patients were subjected to full clinical history, previously available examinations, and radiological examination.

Methods and techniques:

The patient lied in a supine position after revising the site of the puncture to prepare the position of other machines as US and reference monitors within the Cath-Lab theater according to the puncture site. Under conscious sedation using induction by inhalation anesthesia followed by intra-venous drugs and in some cases which need deep general anesthesia using laryngeal mask placement for more safety according to the situation if clinically indicated.

All patients underwent continuous monitoring of their heart rate, blood pressure, and oxygen saturation. Under complete aseptic techniques regarding patient safety.

By using US guidance, we started with local anesthesia using a 3 or 5-cm syringe injection using lidocaine, after that, we used an angiocath 16 G or puncture needle of the same Gauge to puncture the target vein, usually by using the in-plane technique which allows us to visualize the needle throughout its course from the skin to the target vein. when we get our venous access, injection of a small dose of contrast medium for better visualization of the pathway to the right atrium under fluoroscopic guidance and determine the presence of central venous stenosis or occlusion and/or collateralization which may be a sequel to previous attempts in different institutes, and in some cases, digital subtraction venography may be of value to determine best site of guide wire negotiation to by-pass site of stenosis if present.

According to the venography, we can determine if there is a central venous stenosis or not (direct access to the right atrium through a normal anatomical vein or collateral veins with stenotic/ non-visualized normal anatomical veins):

- If there is no central venous stenosis, we introduce a stiff guide wire 0.035 with an angled tip under fluoroscopic guidance to reach the right atrium and then to IVC or SVC according to the puncture site.
- If the internal jugular approach is done, the wire is introduced to the right atrium, then, reaches the IVC for better stabilization and more important to avoid any risk of cardiac arrhythmia from the effect of the tip of the guide wire touching the wall of the right atria or right ventricle, and also for the technical purpose to give more support during dilatation by dilators and during insertion of peel away sheath, together with avoidance of a wrong placement of the catheter inside a dilated azygous vein instate of SVC.
- On the other hand, in the femoral approach, the controversial is done; the wire is advanced through SFV, CFV, and CIV to reach the IVC to the right atrium and then pushed to SVC for more safety and stability. In the trans-hepatic approach, we use the convex probe and usually we target the middle or left hepatic vein, then introduce the wire to IVC, right atrium, and SVC.
- We measured the distance from the skin to the right atrium and accordingly we determine the length of our subcutaneous tunnel, choosing the proper permanent tunneled catheter length. The tunneled permanent catheter has a cuff at its proximal portion near its hub and a non-split double-lumen system with a step-tip catheter is used (Medcomp). We make our subcutaneous tunnel by fixing the tip of the catheter to a tunneling device which is introduced through chosen exit incision on the chest wall, thigh, or upper abdomen according to chosen approach, and pulled through the venous entry incision by using an ante-grade manner.
- The cuff of the catheter is implanted in the subcutaneous tunnel about 2-3 cm away from the catheter exit site and about 4 cm away from the venous site. The tunneling device is removed. After that, we perform tissue dilatation on the guide wire by dilators of variable size, starting with the smallest one to the largest one in the PermiCath sit, then advance a peel-away sheath on a guide wire, then we remove the peel-away dilator and wire leaving the sheath alone, usually, it has a one-way valve, then we insert the tip of PermiCath through the sheath with splitting apart the peel-away sheath allowing it to be removed with adjustment of the catheter to be in the right atrium.
- In case of central venous stenosis associated with multiple collaterals, we use soft guide wire 0.035 for better negotiation to the site of stricture supported by vertebral catheter 5 Fr to easily manipulate and select the target vein then when we reached the right atrium, we exchanged the soft wire with stiff wire through the vertebral catheter, then withdrawal of vertebral catheter is done and complete our steps.

- In case of catheter exchange, we preferred to use two stiff wires to remove the old catheter and to insert a new one in the same track to get more stabilization during exchange without the need for a peel-away sheath in exchange.
- In the end, testing the blue and red lines of our catheter in a 10-20 cm syringe to evaluate the suction flow.
- Then we flush the two lines with saline and inject heparin or Taurolock (better as it has antimicrobial, antifungal, and anticoagulant effects) to prevent blood clotting inside the catheter.
- Fixation of the hub to the skin and sometimes, we preferred to get an extra-suture at the skin near the exit site to make it tight aiming to decrease the possibility of minor oozing that may be seen getting through along the recently inserted catheter just after finishing especially in congested patients due to long time abstinence from dialysis before getting this new access.
- Cover the hub with a sterile dressing and position the patient in a semi-sitting position if the catheter is inserted through the jugular puncture.

Statistical analysis:

Statistical analysis was done by SPSS v26 (IBM Inc., Armonk, NY, USA). Quantitative variables were presented as mean and standard deviation (SD). Qualitative variables were presented as frequency and percentage (%).

3. Results

Demographic data, causes of renal failure and renal function were presented in **Table 1**.

Distribution of the studied cases that required more than a single intervention and their distribution according to the site of puncture were presented in **Table 2**

Distribution of the studied cases according to AF shunt operation and peritoneal dialysis were presented in **Table 3**

Distribution of the studied cases according to causes of PermiCath removal in cases done more than one procedure. The total number of catheters inserted was 36 catheters and the number of catheters that were removed was 16 catheters. **Table 4**

Descriptive analysis of the studied cases according to the duration of PermiCath working before removal (PermiCath survival) was presented in **Table 5**

Table 1: Distribution of the studied cases according to demographic data, causes of renal failure and renal function

		No.	%
Gender	**Male**	11	55.0
	Female	9	45.0
Age (years)		9.30 ± 3.28	
Cases with a single interventional procedure		10	50
Cases with more than one interventional procedure (including different puncture accesses and/or exchanges):		10	50
Two		6	30
Three		2	10.0
Four		2	10.0
Causes of renal failure			
Glomerulonephritis (GN)		6	30.0
Genetic	**ARPKD**	2	10.0
	Cystinosis	1	5.0
Neurofibromatosis		1	5.0
HUS and thrombophilia		1	5.0
Urological problems	**Urological problems (PUV)**	3	15.0
	Urological problems (VUR)	1	5.0
Unknown		5	25.0
Renal function			
Serum Creatinine (mg/dl)		9.93 ± 3.61	
Serum Urea (mg/dl)		171.4 ± 54.58	

ARPKD: autosomal resistive polycystic kidney disease, HUS: hemolytic uremic syndrome, PUV: posterior urethral valve, VUR: vasico-ureteric reflux. Data presented as mean ± SD or frequency (%)

Table (2) Distribution of the studied cases that required more than a single intervention (number of further procedures required = 16), distribution of the studied cases according to the site of puncture (n = 27)

	N=16	%
Type of new intervention required		
Catheter removal and insertion of another catheter using a new access	7	43.8
Simple catheter exchange on top of a guide wire	9	56.3
Approach	**N = 27**	**%**
Right jugular	8	29.6
Left jugular	10	37.0
Right or left subclavian	0	0.0
Right Femoral	4	14.8
Left Femoral	0	0.0
Hepatic	5	18.5

Data presented as frequency (%)

Table (3) Distribution of the studied cases according to AF shunt operation and peritoneal dialysis

	N=20	%
AF shunt operation		
No	11	55.0
Yes	9	45.0
Peritoneal dialysis (PD)		
No	15	75.0
Yes	5	25.0

Peritoneal dialysis (PD)

Table (4) Distribution of the studied cases according to causes of PermiCath removal in cases done more than one procedure

PermiCath	No.	%
Non-functioning	**11**	**30.6**
Thrombosed, one of them was broken during withdrawal	8	22.2
Partially slipped	2	5.6
Fibrin sheath	1	2.8
Sepsis	**3**	**8.3**
Exit site infection	0	0.0
Blood born infection	3	8.3
Elective AF shunt working	2	5.6

Table (5) Descriptive analysis of the studied cases according to the duration of PermiCath working before removal (PermiCath survival)

	No.	Mean ± SD
Duration of PermiCath working (/months)	16	9.06 ±4.91
Non-functioning	11	9.82 ±5.53
Thrombosed	8	11.50 ± 4.72
Partially slipped	2	2.0 ± 0.0
Fibrin sheath	1	12.0
Sepsis	3	9.0 ± 2.65
Elective	2	5.0 ± 1.41

SD: standard deviation

4.Cases

15 years old male patient with ESRD was sent to our department for PermiCath insertion. There was a previous history of failed AV shunt, but no history of PD. In venography, there was complete upper central venous occlusion with no access for venoplasty and also occluded bilateral thrombosed both femoral veins. So, the Decision for the transhepatic approach was the last resort, using US guidance to target the left hepatic vein, then insertion of a stiff guide wire to the IVC and reach the right atrium, followed by serial dilatations, and insertion of Peel-away sheath to allow insertion of PermiCath. **Figure 1**

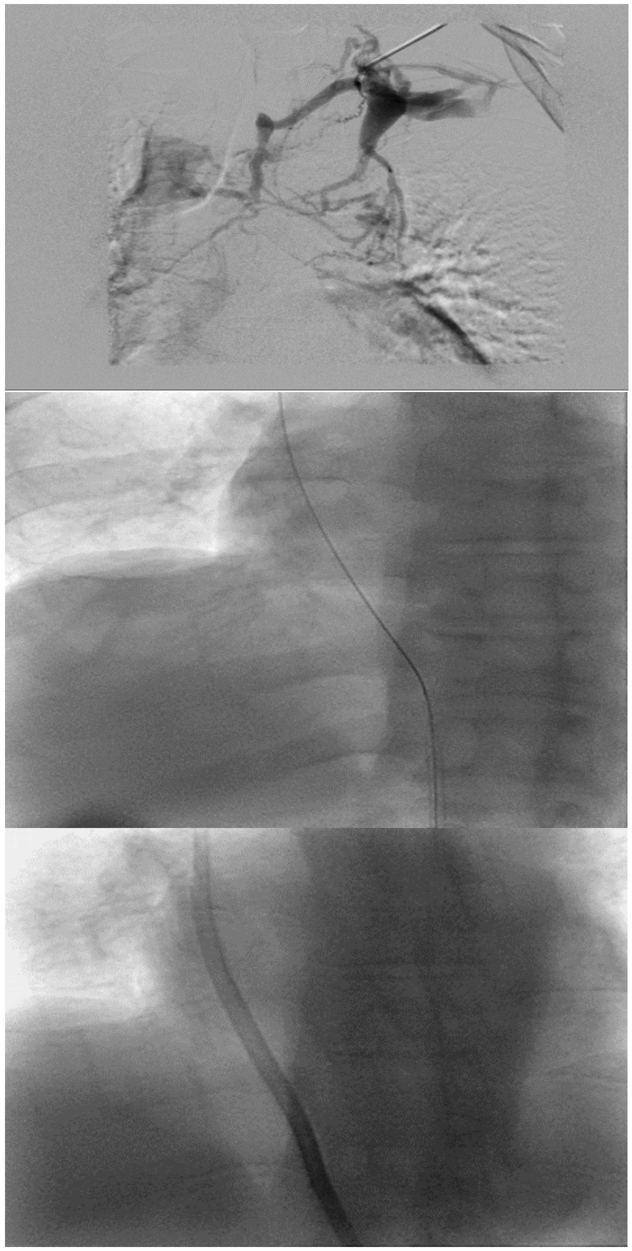

Fig. (1) In venography, there was complete upper central venous occlusion and also occluded bilateral thrombosed both femoral veins. Using US guidance to target the left hepatic vein, then insertion of a stiff guide wire to the IVC and reach the right atrium, followed by serial dilatations, and insertion of Peel-away sheath to allow insertion of PermiCath

5. Discussion

There are multiple causes for ESRD mentioned in our study and other studies, this is compatible with another research reported that the incidence and etiology of kidney failure are age-dependent and vary according to geography and nationality, reflecting the changing nature of the pediatric service [6].

We prefer and recommend inserting catheters in the upper limb more than the lower limb and this could be noted in our study where 18 puncture accesses are chosen for the upper limb which represents 66.6 % compared to 4 times on the lower limb which represent 14.8 % and this matches with other research reported that KDOQI recommends insertion of CVC in the upper limb before lower limb. the low incidence of lower limb catheter placement is likely attributed to the high incidence of infection rate, more liable for kinking and slipping, and most important to preserve iliac vessels for RT [7].

In our study, the most common cause for PermiCath removal was mal /non-functioning (11 catheters) representing 30.6% and the 2nd cause was sepsis namely CRB (3 catheters) representing 8.3 % and lastly, two catheters were removed electively representing 5.6 %. The percentage of mal/non-function in our study is a little bit higher than that mentioned by another study reported that the percentage of mal/ non-function was 22%. Actually, mal/non-function is the most common reason for catheter removal in this study [8].

In our study, the initial management done by a pediatric nephrologist for catheter malfunction was an intraluminal injection of Taurolock U, if failed, another interventional procedure is done, mostly catheter removal and exchange on guide wire on the same VA as it is valid. this is similar to the opinion of two other publications reported that in case of catheter malfunction, whether related to fibrin sheath formation or not, tissue-type plasminogen activator or urokinase dwell was the first line of treatment in our routine practice In case of failure, patients were brought to the angiography suite for other mechanical interventions [7, 8].

Fibrin sheath is one of the causes of malfunction in our study. This is similar to other study reported that, fibrin sheath begins to form at the catheter entry site into the vessel as an inflammatory response to the presence of a foreign body and cause malfunction when sheath extends around or over the tip of the catheter. Treatments of fibrin sheaths include catheter exchange with or without balloon disruption of the sheath and catheter stripping with a snare [9].

One of the complications is a catheter fracture or broken during removal and this happened with one catheter in our study, during catheter withdrawal, the PermiCath was broken, and we tried to get the intravascular portion of the catheter through an incision near the venous site, however, we couldn’t, because of massive bleeding which was like a spurter from venous hypertension sequel to central venous stenosis. We sutured the incision, covered it by dressing, and ask for vascular surgical consultation.

Another long-term complication is CVS which occurred in most of our cases due to multiple trials of cannulation and catheterization which is compatible with another opinion which reported that CVS is usually secondary to catheterization which in turn leading to endothelial injury from catheter insertion or movement in the vasculature, followed by intimal hyperplasia and fibrosis, however, he reported also that high flow fistula may result in CVS from the high flow which leads to intimal injury, despite of that we could not rule out the possibility of congenital vascular deformities [10].

In our study, we dilate the stenosis by dilator sits followed by catheter insertion. In some cases, there was total central venous occlusion with failure of getting or passing through, directing us to search for another central vein as we have done in all cases that underwent trans hepatic approaches.

The percentage of sepsis namely CRB is closely related to that mentioned by other research who reported that the percentage of CRB was 10 % and lower than mentioned by another publication who reported that CRB, which was the 1st cause of catheter removal, represents 42% [8, 11].

We removed the infected catheter in one session, waiting for 4-5 days while the patient received empirical AB and after that, we insert a new PermiCath on the other side in another session.

So, the total number of catheter replacement was 16, of which 9 catheters were wire-guided exchanges which represent 56.3 % and 7 catheters were removed and replaced (new catheter with a new puncture) which represent 43.8%. The percentage of wire-guided exchanges is less than that reported by other study which was 68 .6 % and the percentage of catheter removal and replacement is higher than that reported in this study which was 31.4 %, in general, the percentage of wire-guided exchanges is still more than of catheter removal and replacement which is compatible with this study [11].

In our study, 9 cases had AV fistula operation accounting for 45%. All of these cases had CVC whether temporal or permanent catheters before AVF operation or/and during maturation of AVF, in some cases, PermCath is inserted in one arm and the AVF was done on the contralateral arm. In our study, the PermCath is not removed until the patient dialyzed via AV shunt for multiple sessions to make sure of its patency and to assess its flow rate.

In our study, 5 cases were dialyzed by PD which represents 25%. This closely matches with another two publications reported that peritoneal dialysis has been used particularly in children less than 10 kg in weight attributing the cause to the technical difficulties and challenges to getting vascular access [3, 13].

We agree with another two publications that the incidence of HD is much more than PD and our percentages are relatively close to them, HD represents 93.5 % and 89.9 % respectively and the PD represents 6.5% and 2.7 % respectively, actually, HD shouldn’t be compared with PD here in Egypt due to very high incidence of complication namely peritonitis from PD [4, 14].

In our study, none of our cases were prepared for or underwent renal transplantation due to multiple reasons. Despite recent improvements in chronic dialysis therapies for children, the quality of a child's life with a successful renal transplant is far superior to life on chronic dialysis [9].

6. Conclusion

Tunneled central venous catheters should be used only for bridging purposes in pediatric patients receiving hemodialysis until the patients get more permanent accesses (AV shunt) or renal transplantation. The placement of tunneled cuffed catheters for hemodialysis by interventional radiologists is safe and effective, with very low complication rates in children, especially with difficult venous access. Combined US and fluoroscopic guidance during the procedure is essential with meticulous handling.

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Author contribution

Each author participated equally to the research.

Conflicts of interest

No conflicts of interest.

References

[1] R. Shroff, E. Wright, S. Ledermann, C. Hutchinson, L. Rees. Chronic hemodialysis in infants and children under 2 years of age. Pediatr Nephrol. Vol.18,pp.378-83,2003.

[2] GM. Chertow, E. Burdick, M. Honour, JV. Bonventre, DW. Bates. Acute kidney injury, mortality, length of stay, and costs in hospitalized patients. J Am Soc Nephrol.vol.16,pp.3365-70,2005.

[3] OK. Olaitan, EF. Hollinger. Dialysis Access. In: Saclarides TJ, Myers JA, Millikan KW, editors. Common Surgical Diseases: An Algorithmic Approach to Problem Solving. New York, NY: Springer New York;. pp. 83-7,2015.

[4] FI. Fadel, HN. Abdel Mooty, HM. Bazaraa, SM. Sabry. Central venous catheters as a vascular access modality for pediatric hemodialysis. Int Urol Nephrol.vol.40,pp.489-96,2008.

[5] D. Borzych-Duzalka, R. Shroff, G. Ariceta, YC. Yap, F. Paglialonga, H. Xu, et al. Vascular Access Choice, Complications, and Outcomes in Children on Maintenance Hemodialysis: Findings From the International Pediatric Hemodialysis Network (IPHN) Registry. Am J Kidney Dis.vol.74,pp.193-202 ,2019

[6] D. Youssef, M. Neema t-Allah. Hemodialysis in children eleven years in a single center in Egypt. Iran J Kidney Dis,vol.7,pp.468-74,2013.

[7] CE. Lok, TS. Huber, T. Lee, S. Shenoy, AS. Yevzlin, K. Abreo, et al. KDOQI Clinical Practice Guideline for Vascular Access: 2019 Update. Am J Kidney Dis.vol.75,pp.1-164,2020.

[8] B. Peynircioglu, F. Ozkan, M. Canyigit, GA. Pamuk, S. Geyik, BE. Cil, et al. Radiologically placed tunneled internal jugular catheters in the management of chronic hemodialysis and long-term infusion therapies in the pediatric population. J Vasc Interv Radiol.vol.18,pp.875-81,2007.

[9] O. Salvatierra, M. Millan, W. Concepcion. Pediatric renal transplantation with considerations for successful outcomes. Semin Pediatr Surg.vol.15,pp.208-17,2006.

[10] Y. Zhao, T. Cui, Y. Yu, F. Liu, P. Fu, L. Zhou, et al. Successful tunneled catheter placement in a hemodialysis patient with idiopathic multiple central venous stenoses. Hemodial Int.vol.1,pp.8:200-4,2014.

[11] AM. Onder, J. Chandar, M. Saint-Vil, G. Lopez-Mitnik, CL. Abitbol, G. Zilleruelo. Catheter survival and comparison of catheter exchange methods in children on hemodialysis. Pediatr Nephrol.vol.22,pp.1355-61,2007.

[12] WN. Hayes, AR. Watson, N. Callaghan, E. Wright, CJ. Stefanidis. Vascular access: choice and complications in European paediatric haemodialysis units. Pediatr Nephro.vol.l27,pp.999-1004. ,2012.

[13] AB. Lumsden, MJ. MacDonald, RC Allen, TF Dodson. Hemodialysis access in the pediatric patient population. Am J Surg.vol.168,pp.197-201,1994.

[14] I. Hazza, R. Al-Mardini, G. Salaita. Pediatric renal transplantation: Jordan's experience. Saudi J Kidney Dis Transpl.vol.24,pp.157-61,2013.

[15] I. Madden, M. Blaauw, N. Baugh, L. Rees, R. Shroff. Chronic peritoneal dialysis in children. Paediatr Child Health.vol.30,pp.319-27,2020.