Acute peritoneal dialysis in children with acute kidney injury at the University of Abuja Teaching Hospital, Abuja, Nigeria: a report of 12 months experience in a developing country

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Abstract

Background: Acute peritoneal dialysis (APD) is becoming a common modality of renal support in children with acute kidney injury (AKI) in developing countries.

Objectives: To describe the details of APD among children with AKI at the University of Abuja Teaching Hospital, Abuja, Nigeria

Methods: A retrospective review of children with AKI that had manual APD with an improvised nasogastric tubes from January to December 2017

Results: Forty-three AKI cases were managed in the study period out of which 19 were treated with APD (dialysis access rate of 100%). Ten (52.6%) were males. Causes of AKI included sepsis in 9 (47.3%), hypovolaemia from diarrhoea in 4 (21.1%), acute glomerulonephritis in 3 (15.8%) and acute tubular necrosis from severe malaria fever in 3 (15.8%). Their ages ranged from 1 month to 72 months with a mean age of 30.9 months and a mean weight of 10.9 kilograms. Peri-catheter leakages (9, 47%), outflow obstruction (6, 31.6%), peritonitis (5, 26.3%), hyperglycaemia (4, 21.1%) and hypokalaemia (4, 21.1%) were the complications seen. Klebsiella species (4) and Staphylococcus aureus (1) were the bacteria isolated. Five of the 19 children died giving a mortality rate of 26.3%.

Conclusion: APD remains a lifesaving, cheap and affordable mode of renal replacement therapy in a developing country like Nigeria. Fortunately, complications from APD are also manageable and they should not discourage its use.

Keywords: Manual acute peritoneal dialysis; improvised acute peritoneal catheter; resource constrained setting.

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Introduction

Acute kidney injury (AKI) is an abrupt decline in renal excretory function characterized by a reversible increase in the blood concentration of creatinine and nitrogenous waste products, often with a decrease in urine output and by the inability of the kidney to regulate fluid and electrolyte homeostasis[1].

Mortalities in AKI in children requiring dialysis are still high, between 35-73%[1-6]. This high mortality exists partly because some seriously ill children are now surviving long enough to make the use of dialysis therapy becoming imperative[7]. Mortality in AKI is also closely linked to its underlying causes, as sepsis, cardiac surgery, and multiple organ failures tend to have a worse prognosis, but, those with isolated AKI tend to survive better[8]. Other risk fac-

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tors like hypotension, the need for mechanical ventilation and young patients have also been identified to be associated with the worst outcome no matter the dialysis modality instituted[9-10].

Although a variety of dialysis modalities such as peritoneal dialysis (PD), intermittent haemodialysis (IH), and continuous hemofiltration or haemodialfiltration (CRRT) are available for AKI, the choice of dialysis is influenced by several factors including the aetiology of the underlying disease, the size of the patient, haemodynamic stability, goals of dialysis, previous abdominal surgeries, presence or absence of peritoneal defects, and availability of dependble vascular access[8]. However, more centres in developing countries are successfully adapting PD in the management of their paediatric patients with AKI[11-19].

The advantages of PD over other modalities of renal replacement therapy include its cost being relatively cheap, and that it bypasses the need for vascular access that can be troublesome in young infants. Other advantages include the relative ease of inserting PD catheters in the smallest infants as compared to gaining vascular access, the availability of a wide range of acute peritoneal dialysis (APD) catheters and the suitability in haemodynamically unstable patients because of the gradual ultrafiltration and solute clearance in PD[8].

Even, when PD catheters are not readily available, clinicians in developing countries have improvised with intercostal drains and nasogastric tubes with a remarkable good outcome[12,17]. However, the slow and gradual nature of PD is also a drawback as it makes it a sub-optimal option for patients with severe volume overload or life-threatening hyperkalaemia or for the removal of various toxins[8].

Because data on the appropriate choice of modality in a specific AKI situation is still very limited[8], and because no renal replacement modality has been shown to be superior to another in patients with AKI[8], the need for more clinicians to publicize their experiences with APD has become important, and cannot, therefore, be over-emphasized.

In this retrospective study, we describe the techniques applied in providing APD, the complications that resulted from APD, as well as, the mortality pattern in a cohort of children with AKI between January to December 2017 at the University of Abuja Teaching Hospital (UATH), Gwagwalada, Abuja, Nigeria.

Methods

Study area and setting

This is a retrospective analysis of children with AKI that were managed with APD at the UATH, Gwagwalada, Abuja, Nigeria. UATH is a 350 bedded hospital. Although a tertiary health centre, it also offers primary and secondary health services to its teeming clienteles. It serves as a referral Centre for other hospitals within the FTC and the surrounding States of Benue, Kogi, Kaduna Nasarawa and Niger States.

Ethical consideration

The Research and Ethics Committee of the UATH provided permission to use the data of this cohort of children. Informed consent was also obtained from the parents/caregivers with the assurance that pictures of children in this article will remain anonymized and unidentifiable. The procedures followed in this study were also in accordance with the ethical standards of the Research and Ethics Committee of the UATH and with the Helsinki Declaration of 1975, as revised in 2008.

Study design and population

By December 2016, the paediatric nephrology unit of the UATH had developed an electronic data capturing system (on Microsoft Excel Worksheet) for collecting information on children managed for AKI. This information includes, but is not limited to age, gender, birth-order, anthropometry, socio-economic conditions of family/caregivers, level of education of the caregivers, religion, ethnicity, family history of renal disease, presenting symptoms and signs, aetiology of AKI at diagnosis, the peak/severity of AKI, hospital-acquired AKI or community-acquired AKI. It also includes admission date and duration, daily records of urine output, relevant laboratory investigations such as serum creatinine both at baseline and at follow-up, and the final outcomes of AKI in the first 3-month of its diagnosis.

Methods for acute peritoneal dialysis

The first step in the offering of APD is to give informed education on the need for dialysis. Consent to surgical placement of the peritoneal catheter is then obtained from the parents or other legal caregivers of the patient. As a guiding rule in our protocol, APD is prescribed for children with a body weight of less than 25 kg. Contraindications to APD include the presence of omphalocoele, gastroschisis, diaphragmatic hernia, bladder exstrophy, recent abdominal surgery, and abdominal malignancy[8].

Nasogastric tubes of varying sizes (8-14 French) were used as improvised acute peritoneal catheters, and are surgically placed in the subumbilical region, and secured with a pulse string by the paediatric surgeons. The preferred Tenckhoff catheter or the flexible Cook Mac-Loc catheter 20 are not readily available or are often out of stock when needed. Surgical placement of the nasogastric tubes takes place at a designated room in the paediatric ward. Full asepsis procedure is always observed. Figure 1 shows a surgically placed nasogastric tube.

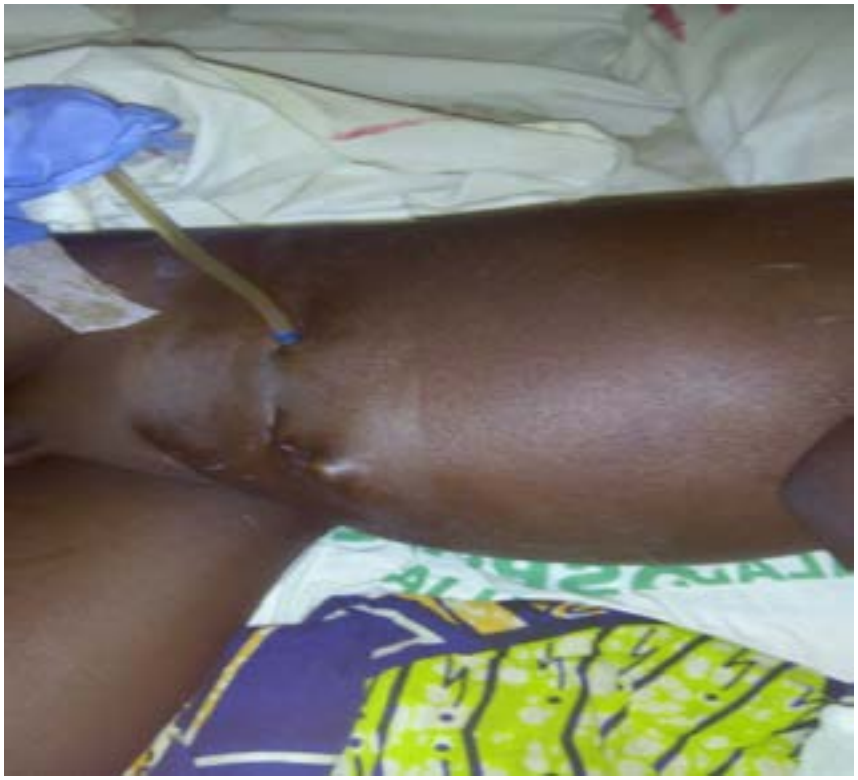

Figure 1

Constipation, when present, is treated with soap and water enema before the catheter implantation. The urinary bladder is catheterized with an idwelling urethral catheter before the procedure. A closed system utilizing buretrols (manufactured by Fresenius Medical, Hamburg, Germany; see Figure 2) is used to measure fill and drainage volumes.

Figure 2

APD was carried out with 1.5% and 2.5% Dextrose commercially available continuous ambulatory peritoneal dialysis fluid (Fresenius Medical Care, Bad Homburg, Germany)'

Five hundred units of heparin are added to every 1- litre of dialysis fluid in the first 48 hours of APD (unless the patient has a coagulopathy when heparin is contraindicated). Heparin use is also extended if there are fibrin strands in the dialysate effluents. To reduce the risk of peritonitis, 5 mg of gentamicin and 25 mg of vancomycin were routinely added to every litre of dialysis fluid. Four mmol of potassium chloride is also added to a litre of dialysis fluid whenever patient's serum potassium is <3.5mmol/L (close serum monitoring for hypokalaemia is done) unless there are concerns regarding a potential sudden rise in serum potassium[21]. Hyperglycaemia (random blood sugar >6.6 mmol/l) is treated by adding 4 units of insulin to 1 litre of 1.5% Dextrose strength, and 7 units of insulin to 1-litre of 2.5% Dextrose strength[22]. The blood glucose is then monitored closely and the dose of insulin tailored to the patient's needs. Insulin is also not to be added to the last exchange of a treatment session in order to minimize the risk of hypoglycaemia occurring after dialysis has been stopped. The patient's hydration status and fluid balance are assessed frequently and the volume of the ultrafiltrates controlled by altering the glucose concentration, exchange volume, and the frequency of exchanges. If hypovolaemia develops, the dialysis is stopped temporarily, and IV normal saline administered. Peritonitis is suspected when the peritoneal effluents become cloudy, with raised white blood cells count (> 100/μL with 50% neutrophils), the presence of bacteria on Gram stain, abdominal pain and abdominal distension[23]. The catheter exit site may also become

erythematous, swollen, tender, and discharge. Empirical treatment is with intravenous vancomycin (estimated glomerular filtration rate guided) until the antibiotic choice is influenced by the antimicrobial sensitivity pattern of the cultured peritoneal fluid.

The initial dialysis prescription is with a Fill volume of 10mls/kg body given over a Fill time of 5 minutes, a Dwell time of 5 minutes, and a Drain time of 5 minutes until the drain is clear of blood or fibrin (usually takes about 6 cycles). The regular dialysis prescription cycle is over 60 minutes, with a Fill time of 5 minutes, a Dwell time of 45 minutes and a Drain time over 5 minutes. Usually, 60 cycles of dialysis are envisaged, but session may exceed 60 cycles until there is a sustained recovery of renal function evidenced by a continued fall in serum creatinine over 36 hours of sampling. The recovery in renal function is also heralded by the conversion of oliguria/anuria to a production of adequate urine (defined as ≥ 1 ml/kg/hour in an infant and ≥ 0.5ml/kg/hour in an older child). The Fill volume is also increased from 10 ml/kg to 30 ml/kg, gradually by 10ml/kg/day, and as tolerated by the patient. The exchanges were done manually by the paediatric residents in nephrology posting.

Close monitoring of patients on APD include daily serum electrolytes, glucose and hydration status, monitoring the cycles of dialysis to ensure good flow, checking for turbidity of dialysis drains, checking for peri-catheter leakage, fluid input/output chart, and vital signs. Samples of peritoneal drains are also sent for cell count and culture and sensitivity at the start and end of APD, and whenever the effluent becomes turbid.

Results

An annual prevalence of 26 AKI cases per 1000 children was recorded with 43 AKI cases from 1634 children seen during the 12 months period. Fourteen children were managed conservatively, while 29 children that required dialysis had access to it (access rate of 100%). Ten children had haemodialysis, while 19 had APD.

Of the 19 children with APD, 10 (52.6%) were males, with the age range of 1 month to 72 months, with a mean age of 30.95 ± 24.56 months, and a mean weight of 10.9 ±5.8 kg. The mean duration for patients on admission was 14.32 ± 7.62 days. Figure 3 shows a one month old neonate undergoing APD.

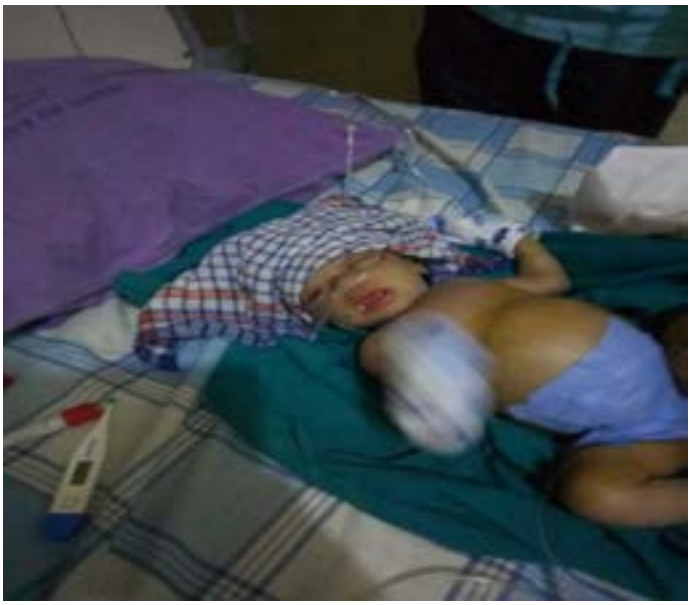

Figure 3

Causes of AKI included sepsis in 9 (47.3%), hypovolaemia from diarrhoea in 4 (21.1%), acute glomerulonephritis in 3 (15.8%) and acute tubular necrosis from severe malaria fever in 3 (15.8%). The majority (16, 84.2%) were in the Failure category using the pRIFLE classification. Five patients died with a mortality rate of 26.3%.

Table 1. Some characteristics of the 19 children with acute kidney injury managed with acute peritoneal dialysis

Characteristics	Number (%)
Age groups in months	
<12	6(31.6)
12-60	11(57.9)
>60	2(10.5)
Gender	
Male	10(52.6)
Female	9(47.4)
pRIFLE	
Risk	0(0)
Injury	3(15.8)
Failure	16(84.2)
Causes of AKI	
Sepsis	9 (47.3)
Hypovolaemia from diarrhoeal disease	4(21.1)
Acute glomerulonephritis	3(15.8)
Acute tubular necrosis from severe malaria	3(15.8)
Outcome	
Dead	5(26.3)
Alive	14(73.7)

Table 2 reveals that all the 19 patients that received peritoneal dialyses were hypervolaemic presenting with severe uncontrolled hypertension, pulmonary oedema, and multiple seizures. Increasing serum creatinine levels despite conservative management was also the commonest laboratory indication for the dialysis, observed among all the patients. The mean serum creatinine levels significantly reduced from 630. 2 ± 373.2 μmol/L before the APD, to 305.1± 137.3 μmol/L at the end of the last cycle of APD ($p \leq 0.001$).

Table 2. Indications for acute peritoneal dialysis among the 19 children with acute kidney injury

Indications for dialysis#	Number (%)
Clinical	
Congestive heart failure/severe uncontrolled hypertension/pulmonary oedema/multiple seizures	19 (100)
Anuria	4(21.1)
Bleeding diatheses/severe anaemic heart failure	4(21.1)
Uncontrolled hypertension/multiple seizures	3(15.8)
Coma/severe hypertension (hypertensive encephalopathy)	2(10.5)
Laboratory#	
Increasing serum creatinine levels*	19 (100)
Uncontrollable metabolic acidosis	15(78.9)
Protracted uncontrollable hyponatraemia	13(68.4)
Uncontrollable hyperkalaemia	11(57.9)
Uncontrollable hypernatraemia	9 (47.4)
Uncontrollable hypocalcaemia	3 (15.8)

*The mean serum creatinine levels reduced from 630. 2 μmol/L before the APD, to 305.1μmol/L at the end of APD ($p \leq 0.001$). #=multiple responses possible

Table 3 depicts the details of acute peritoneal dialysis among the 19 children with an acute kidney injury. A mean number of 65 ± 25 manual cycles of APD and a mean highest dialysis fill volume of 27±6 ml per kilogramme body weight were observed. Five patients died with a mortality rate of 26.3%.

The complications seen among the 19 patients with APD included peri-catheter leakages (9, 47%), catheter outflow obstruction (6, 31.6%), peritonitis (5, 26.3%), hyperglycaemia (4, 21.1%) and hypokalaemia (4, 21.1%). Klebsiella species (4) and Staphylococcus aureus (1) were the bacteria isolated. Catheters were re-implanted in 3 of the 6 children that had outflow obstruction. Mortality rate was 26.3%, accruing from the 5 children that died. Apart from one patient that spent 30 days on admission, the other 4 children (80% of the mortality) that died spent ≤ 4 days on admission. Causes of AKI in the five children that died included sepsis in 4 children and acute glomerulonephritis in the same child that spent 30 days on admission (received 65 cycles of dialyses). Renal recovery was complete (when eGFR becomes ≥ 100 ml/min/1.73m^2 24) at 3 months of follow-up among the 14 children that survived.

Table 3. The details of acute peritoneal dialysis among the 19 children with acute kidney injury

Serial no.	Age in months	Gender	Weight in kg	Duration on admission in days	Cause of the acute kidney injury	No. of peritoneal dialysis cycles*	Highest volume of Fill as ml/kg#	Highest pre-dialysis Urea in µmol/L	Last dialysis Urea level in µmol/L	Highest pre-dialysis Creatinine level in mmol/L	Last dialysis Creatinine level in mmol/L	Outcome of dialysis
1	72	M	20.7	20	Sepsis	60	30	33	23	1126	554	Survived
2	1	M	1.8	30	Sepsis	65	30	21.5	21	659	234	Died
4	30	M	10.9	15	Sepsis	60	30	28.2	23.5	998	486	Survived
7	7	M	8	3	Sepsis	35	20	28.3	26	314	155	Died
8	3	M	5.4	3	Sepsis	45	25	22.5	18	390	127	Died
12	60	M	17.7	18	Acute glomerulonephritis	55	25	41.5	16.6	2058	567	Survived
14	48	F	13.4	21	Sepsis	59	30	42	25.9	764	251	Survived
15	24	F	9.6	15	Sepsis	117	30	35.9	13.1	685	363	Survived
18	3	F	2.5	10	Hypovolaemia/diarrhoeal	40	20	35	32	524	332	Survived
19	1	F	2.2	27	Hypovolaemia/diarrhoeal	60	30	36	36	370	176	Survived
25	72	M	20	3	Acute glomerulonephritis	60	30	33.9	34	831	334	Died
27	60	M	18.5	15	Acute glomerulonephritis	60	35	38	36	877	265	Survived
29	24	F	10.2	10	Hypovolaemia/diarrhoeal	79	40	46	29	557	354	Survived
33	36	F	15	15	Malaria	70	25	39.7	17	575	294	Survived
34	48	F	13.4	18	Malaria	59	25	34.1	25.9	653	207	Survived
35	24	F	9.6	15	Hypovolaemia/diarrhoeal	119	30	35.9	13.1	685	363	Survived
39	3	M	5.4	4	Sepsis	25	10	22.5	18	390	190	Died
40	48	F	13.4	14	Sepsis	59	25	34.1	25.9	658	457	Survived
41	24	F	9.6	16	Malaria	110	30	35.9	33.7	685	101	Survived

* A mean number of 65 cycles of APD among the 19 patients

A mean highest dialysis fill volume of 27ml per kilogramme body weight among the 19 patients.

Discussion

With a mortality rate of 26.3%, this article has supported the notion that APD is a lifesaving renal support for children with AKI in a developing country like Nigeria. The 100% dialysis access rate underscores the fact that when adequate education is given to parents of children with AKI, parents would strive to make the fund available for APD. The study shows that even when the Tenckhoff or the flexible Cook Mac-Loc catheters for APD are expensive and/or are not readily available, improvising with nasogastric tubes still gave an acceptable favourable outcome. While the process of administering APD manually is laborious and time-consuming, the fact that many more children with AKI are surviving is reassuring to the already overworked clinicians in developing countries. This study also shows that solute clearance was efficient with the manual APD as the mean serum creatinine levels of the patients significantly reduced from 630. 2 µmol/L before the APD, to 305.1µmol/L at the end of APD provision.

However, a lot can still be done in making PD accessible to more children needing it. For examples, paediatric nephrologists in Nigeria and other sub-Saharan coun-

tries can serve as advocates in making APD part of the services to be covered by the countries' health insurance schemes. The International Society for Peritoneal Dialysis, the International Paediatric Nephrology Association, and the International Society of Nephrology should continue to advocate for the promotion, expansion, and improvement of PD services in sub-Saharan Africa and in Nigeria. More nephrologists can be trained in the provision of PD services[17]. Age of the nephrologists should not be a disqualifying barrier for persons willing to learn the principle and practise of PD[25]. With a careful choice of patients, APD can remain an affordable renal replacement intervention when children failed conservative management, realising that the cost of 2-litres of dialysis fluid is six thousand five hundred naira (18 US Dollars) only. Bearing 6000 naira (16USD) as the cost of the closed system of buretrols, the APD is still cheaper for subjects with decreasing weights of less than 25kg. For an older child weighing more than 25kg, the cost of haemodialysis at 28,000 naira (90 USD) per session would by far more economically cheaper. As more centres in Nigeria engage in providing APD services, and with a higher demand for PD consumables, the cost of APD sessions is even expected to fall progressively. However, we are not unmindful of the fact that the cost of the dialysis fluid may be out of reach of many Nigerians in many part of the country.

The mortality rate of 26.3% of children exposed to APD in this study was lower than the 29%, 30%, 36.8%, and 41% reported by Solarin et al[13], Ademola et al[17], Mishra et al[14], and Esezobor et al[12] by children who also received APD in similar resource-constrained settings. The low mortality rate could be related to the reversible pattern of most cases (68.4%, sepsis and hypovolaemia) of the AKI in this study.

It is also instructive that the majority (80%) of these deaths occurred within 4 days of admission, probably reflecting the fact that mortality may be more closely related to the severity of the AKI as (they presented in Failure-pRIFLE, and all had hypervolaemia with pulmonary oedema). Mortality in the child with acute glomerulonephritis suggests a rapidly progressive glomerulonephritis with clinical deterioration despite the receipt of 65 cycles of dialysis. Gladly, no death is primarily linked to the process of providing APD in this cohort.

While variations exist for aetiology of paediatric AKI within countries and across continents, the findings of sepsis in 9 (47.3%), hypovolaemia from diarrhoea in 4 (21.1%), acute glomerulonephritis in 3 (15.8%) and acute tubular necrosis from severe malaria fever in 3 (15.8%) in this study did not differ greatly from causes of AKI that have been reported earlier in other low-resource settings[11-13,15,17,26-28]. These findings contrast with those in developed countries, where AKI occurs mainly as a consequence of advancements in open-heart surgery and in bone-marrow and solid-organ transplantation[29,30].

The study reveals hypervolaemia with uncontrolled hypertension, pulmonary oedema, multiple seizures, and increased serum creatinine levels despite conservative management to be the common indications for dialysis. Similar indications were also noted by earlier researchers[12,13,31,32]. The common complications of peri-catheter leakages, catheter outflow obstruction, peritonitis, hyperglycaemia and hypokalaemia saw in this study have also been reported elsewhere[12,13,16,17]. The hyperglycaemia and the hypokalaemia were also adequately treated. The relatively high burden of peritonitis of 26.3% in this study could be related to the use of the nasogastric tube as an improvised APD catheter with its attendant peri-catheter leakages. The peritonitis still occurs despite the use of a closed drainage system and prophylaxes antimicrobials (gentamycin and vancomycin) in the dialysis fluid and despite the attempts at adhering to asepsis. The Klebsiella species and Staphylococcus aureus bacteria isolated from the peritoneal fluid sample were also sensitive to levofloxacin which the patients received promptly.

All the survivors in this cohort also had a full renal recovery (estimated glomerular filtration rate $\geq$ 100 ml/min/1.73m^2) at 3 months of follow-up at the renal clinic.

Limitation

The few numbers of patients described in this article have limited statistical analyses to a simple description.

Conclusion

This study has shown that APD is a simple, safe, and efficient way of providing renal replacement therapy to children with AKI in a developing country. It shows that even when complications exist, these are treatable, and do not reduce the favourable outcome from PD.

While efforts in making standard APD catheters to become more available and accessible (in order to reduce the complications attributable to nasogastric tubes as impro-

vised APD catheters) are to be encouraged, more children should be prevented from having AKI via education of parents and the strengthening of preventive nephrology. Since sepsis, diarrhoeal disease, post-infectious glomerulonephritis and malaria infection are the causes of AKI in this study; prevention of AKI is expected to be cheaper. Thus, opportunities for prevention will include educating the populace on the need to improve basic personal and environmental sanitation, control of malaria with the use of insecticide-treated bed-nets and environmental control of mosquitoes, and the prompt application of oral and intravenous rehydration for diarrhoea[33]. Empirical treatment algorithms based on locally available epidemiological studies on sepsis will reduce the burden of septic AKI[33]. While preventive measures in AKI are advised, they are also fraught with many challenges including the misconception that AKI is a disease of hospitalized patients, cultural barriers that impair early seeking treatment of AKI and/or that make people prefer traditional medicine for AKI[33]. A considerable lack of understanding and recognition of AKI among physicians, allied personnel and the lay public also makes AKI be underdiagnosed and under-reported, thus, affecting the allocation of resources for the prevention of AKI[33]. Furthermore, since AKI is not associated with any specific symptoms and the diagnosis is largely based on measurement of laboratory parameters, it is essential that caregivers be educated on the risks for AKI and equipped with the knowledge for early recognition, timely intervention and effective follow-up[33].

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Conflict of interest

The authors declare that potential conflict does not exist

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