**A.O. Asinobi**
**A.D. Ademola**
**R.M. Akuse**

*Review Article*

# Paediatric Peritoneal Dialysis in a Developing Country: Practice, Challenges and Opportunities

**Corresponding Author** (✉)

**A.D. Ademola**
Department of Paediatrics, University College Hospital Ibadan, Oyo State, Nigeria / Department of Paediatrics, Faculty of Clinical Sciences, College of Medicine, University of Ibadan, Oyo State, Nigeria
dr_deboademola@yahoo.co.uk
+2348033962606

**A.O. Asinobi**
**A.D. Ademola**
Department of Paediatrics, University College Hospital Ibadan, Oyo State, Nigeria.
Department of Paediatrics, Faculty of Clinical Sciences, College of Medicine, University of Ibadan, Oyo State, Nigeria

**R.M. Akuse**
Department of Paediatrics, Ahmadu Bello University Teaching Hospital, Zaria, Kaduna State, Nigeria
Department of Paediatrics College of Medical Sciences, Ahmadu Bello University, Zaria, Kaduna State, Nigeria

**Abstract**

**Background:** The practice and challenges of peritoneal dialysis (PD) in a developing country may be uniquely different from what obtains in developed countries.
**Method:** A review of the practice and challenges of PD in Nigeria as a case study and documentation of opportunities for improvement
**Review:** There has been renewed interest in the provision of PD to children in acute kidney injury in Nigeria and this has led to adaptations such as use of nasogastric tubes as PD catheters and use of constituted PD fluid. The use of adaptations is lifesaving but complication rates may be higher than with the use of standard gadgets. Other challenges include limited availability and high cost of PD catheters and PD fluid. There are also challenges with the availability of expertise for the insertion of PD catheters and the PD procedure.
Opportunities to advance paediatric PD include sustained efforts to provide PD with the use of adaptations, collection of data on outcomes of PD, advocacy for more support from government, non-governmental organisations and industry in the forms of insurance coverage, access to consumables and/or training in paediatric PD.
**Conclusion:** Sustained provision of PD with adaptations, documentation of outcomes, and advocacy may lead to improvement in paediatric PD services.

**Key words:** Peritoneal dialysis, children, developing countries, sub-Saharan Africa, Nigeria, acute kidney injury, end-stage renal disease.



## Introduction

Peritoneal dialysis is a form of renal replacement therapy that utilizes the peritoneal membrane as dialyzer. It is a suitable modality for renal replacement therapy in acute kidney injury (AKI) and in end-stage renal disease (ESRD).[1,2] It has manual and automated forms that are applied in both AKI and ESRD. Advantages of peritoneal dialysis compared to other forms of renal replacement therapy include its simple technological and infrastructural requirements. It can therefore be adapted for use in low resource settings and in developing countries.[3-6] Peritoneal dialysis does not require vascular access making it suitable for the provision of renal replacement in neonates and young children in whom vascular access is a challenge. Other advantages are that it does not require systemic anticoagulation. It also provides gradual correction of fluid overload and may be a more suitable form of renal replacement therapy in children with haemodynamic instability compared with intermittent haemodialysis. Peritoneal dialysis is associated with gradual correction of electrolyte abnormalities and removal of nitrogenous waste and is less likely to cause disequilibrium syndrome compared to haemodialysis.[1]

Relative contraindications to peritoneal dialysis include presence of adhesions in the abdomen.[1] Others are lack of an intact peritoneal cavity such as in diaphragmatic hernia or pleuroperitoneal fistula.[7] The most common complication of peritoneal dialysis is peritonitis.[8] Other complications include pericatheter leakage of peritoneal dialysis fluid and peritoneal dialysis catheter outflow obstruction.[1] However, peritoneal dialysis is suitable for the management of paediatric AKI in many patients in low resource settings, and may also be useful in the management of ESRD in those settings.[9,10] This review is to discuss the practice of peritoneal dialysis in Nigeria, the challenges, the opportunities and to provides recommendations on the way forward. The review is potentially relevant to many countries in sub-Saharan Africa.

**History of Paediatric Peritoneal Dialysis**

Globally, the use of peritoneal dialysis was first reported in children in 1948 in a child who was managed in the United States of America.[11] Milestones that have led to the wide use of peritoneal dialysis in children include the following: the development of nylon catheters, and commercially available peritoneal dialysis catheters which made it possible to apply peritoneal dialysis for the short term management of children and infants with AKI.[12] The development of long term indwelling peritoneal dialysis catheters (the Tenckhoff Catheter), combined with automated dialysis fluid delivery and a system for continuously purifying dialysate fluid prior to infusion led to the use of peritoneal dialysis as a form of chronic renal replacement therapy in children. The development of plastic peritoneal dialysis bags led to the development of continuous ambulatory peritoneal dialysis (CAPD), and widespread use of peritoneal dialysis for the management of paediatric patients in ESRD.[13-15] Understanding of the limitations of CAPD in terms of peritoneal dialysis adequacy led to the development of new machines for automated dialysate delivery.

**History of Paediatric Peritoneal Dialysis in Nigeria, West Africa.**

Peritoneal dialysis in Africa started in Egypt and South Africa in 1962-1963.[16] In Nigeria, peritoneal dialysis in adult patients started in 1965.[16] The first records of peritoneal dialysis in children in Nigeria was on children who had peritoneal dialysis for 'acute uraemia' at the University College Hospital Ibadan between 1968 and 1972.[17] Thereafter and for many years, acute peritoneal dialysis was the only available modality for renal replacement therapy and was the initial therapy for patients in ESRD. The peritoneal dialysis was usually carried out with rigid catheters and peritoneal dialysis fluid was manufactured locally in the hospital in glass bottles. Haemodialysis became available in Nigeria in 1981 at the Lagos University Teaching Hospital after which there was a gradual decline in peritoneal dialysis in favour of haemodialysis among the adult population who formed the bulk of the dialysis patients. The decline in peritoneal dialysis affected children as peritoneal catheters and fluids were no longer readily available for the management of children who needed dialysis. However, paediatric haemodialysis was not usually possible in very young children because paediatric size haemodialysis consumables, i.e dialyzers, blood lines and vascular catheters, were not readily available. [18] A gradual return of peritoneal dialysis among paediatric patients started at around 2004 and centres began to use adapted peritoneal dialysis catheters such as nasogastric tubes, chest tubes and urinary catheters to provide peritoneal dialysis.[3,19,20] An epidemic of paediatric AKI, when about 83 infants and toddlers from all over the country developed AKI after taking a teething mixture, "*My pikin*" that was tainted with diethylene glycol, also contributed to the popularization of paediatric peritoneal dialysis in the country.[21] Many centres had to provide renal replacement therapy for these children, and only peritoneal dialysis was feasible, because the children involved were mainly infants and age appropriate consumables for haemodialysis were not available . Centres could carry out dialysis because peritoneal dialysis offers the advantage of technical simplicity, and the possibility of making adaptations to the technique.[3,20,21] The adaptations included use of nasogastric tubes as peritoneal dialysis catheters, and peritoneal dialysis fluid constituted from locally available intravenous solutions . Only two of the 83 affected children survived, however, there has been renewed interest and growing popularity of peritoneal dialysis for paediatric AKI since then. The saving young lives (SYL) initiative by the International Society of Peritoneal Dialysis (ISPD), International Pediatric Nephrology Association (IPNA) and the International Society of Nephrology (ISN) is also contributing to the advancement of peritoneal dialysis in the country through training of doctors and nurses.[22,23] In Nigeria at the moment peritoneal dialysis usually takes place in Teaching hospitals or Federal Tertiary Hospitals. These are settings that either have paediatric nephrologists, adult nephrologists who are interested in peritoneal dialysis, and provide haemodialysis services for adults. The centres are usually located in the urban centres, and these centres may not be easily accessible to children and adolescents in the rural areas.[19,24] Therefore, there is still a need to further expand peritoneal dialysis in the country for children and even adults with AKI. Additionally, peritoneal dialysis should be a potentially cheaper way compared to haemodialysis to provide initial renal replacement therapy for ESRD in the country- if peritoneal dialysis fluid is produced locally, thereby reducing the costs. Renal replacement therapy for paediatric end-stage renal disease is rare in most countries in sub-Saharan Africa. Paediatric chronic peritoneal dialysis in sub-Saharan Africa is available only in South Africa and Sudan as of now. [25] Table 1 provides a summary of studies published on paediatric peritoneal dialysis from sub-Saharan Africa.

**Peritoneal dialysis compared with other forms of renal replacement therapy for paediatric acute kidney injury.**

There are no randomized control trials of different renal replacement therapies for AKI in children.[1] The outcome of AKI from observational studies is more related to the underlying illness and presence of haemodynamic instability evidenced by the use of vasopressors and hypotension rather than the mode of renal replacement therapy.[26,27] In one study continuous veno-venous haemofiltration was associated with better ultrafiltration, solute control and caloric intake than peritoneal dialysis, but did not have survival advantage over peritoneal dialysis.[28] Another study found that outcome of peritoneal dialysis for children with AKI was similar to reported outcomes with continuous renal replacement therapy.[27] The studies were limited by small sample size, lack of standardisation in terms of patients and modality of renal replacement therapy, and single centre design. The available reports do not indicate that peritoneal dialysis is inferior to the other forms of renal replacement therapy in the management of AKI. Furthermore, there has been many reports of successful use of peritoneal dialysis for the management of AKI in sub-Saharan Africa even with adaptations to the peritoneal dialysis techniques.[3,4,10,20,29]

**Types of Peritoneal dialysis**

Peritoneal dialysis may be classified based on whether it is used for the management of AKI or ESRD and if it is manual or automated.[1,30] Chronic peritoneal dialysis for ESRD may take the forms of continuous ambulatory peritoneal dialysis (in which exchanges are carried out manually during the day), or continuous cyclic peritoneal dialysis in which exchanges are automated, carried out with a peritoneal dialysis cycler and at night.[31] For the management of AKI, acute peritoneal dialysis may be carried out manually or with the peritoneal dialysis cycler.[1] Acute peritoneal dialysis with standard or adapted gadgets has been reported to take place in about 11 Nigerian centres and in about 8 countries in sub-Saharan Africa. However, more centres may have carried out paediatric acute peritoneal dialysis than is documented in literature.[3,4,10,19,20,24,25,32-34] . On the other hand, chronic peritoneal dialysis is carried out in only two countries in sub Saharan Africa which are Sudan and South Africa.[25] Chronic peritoneal dialysis is not yet available in Nigeria. Recent studies on paediatric peritoneal dialysis in sub-Saharan Africa are indicated in Table 1.

**Dialysis bags and solutions:**
Most commercially available dialysis solutions are glucose based. The commercially available strengths are 1.5% Dextrose (1.36% Glucose), 2.5% Dextrose (2.27% Glucose), 4.25% Dextrose (3.86% Glucose).[31] While glucose based solutions are relatively cheap and effective, they may be associated with production of glucose degradation products, which may lead to long term peritoneal membrane dysfunction. The dysfunction will be more relevant for patients on chronic peritoneal dialysis. Glucose based solutions may also be influenced by membrane characteristics for glucose transportation. Individuals who are fast transporters for glucose may have decreased ultrafiltration with glucose based solutions. Furthermore, peritoneal dialysis using glucose based solutions may be associated with development of hypoalbuminaemia. Non- dextrose based solutions such as icodextrin and amino acid based peritoneal dialysis fluid are available. The non-dextrose based solutions avoid some of the drawbacks associated with the use of glucose based solutions but are generally more expensive.[31]

Dialysis solutions usually contain sodium at 132-134 meq/L, but do not contain potassium. For the bicarbonate generating base, commercial peritoneal dialysis fluids historically contain lactate. More recently solutions containing bicarbonate or a mixture of both lactate and bicarbonate have become available. Double and triple bag compartment systems are now available, with the bicarbonate in one of the compartments. The compartments are broken, and bicarbonate based peritoneal dialysis fluid is generated just before use. Lactate based fluids may be associated with the development of lactic acidosis in the patient in shock or hepatic failure. Use of bicarbonate based fluid may also be associated with long-term preservation of peritoneal membrane function.[1,31,35]

Commercial CAPD fluids are usually available in 1.5, 2.0, 2.25, 2.5, 3.0 or 5.0 Litre (L) bags. The most widely available in Nigeria are 2L bags, and sometimes 5 L bags. For the management of paediatric AKI in Nigeria, often commercially available CAPD fluids are used. Some paediatric nephrologists have had to constitute peritoneal dialysis fluid using commercially available intravenous, glucose and electrolyte solutions .[3,4,20,36] Constitution of peritoneal dialysis fluid may be lifesaving when commercial CAPD fluids are not available.[10,20] The ISPD has published guidelines on how to constitute peritoneal dialysis fluid from commercially available intravenous and glucose solutions. [1] Strict attention should be paid to asepsis and the number of solutions to mix should be kept to the minimum required to minimize the risk of infections. [1] Table 1 shows the types of fluids used for paediatric peritoneal dialysis in recent studies from sub-Saharan Africa.

**Peritoneal Dialysis Cyclers:**
Peritoneal dialysis cyclers are mechanized devices that assist in the delivery and drainage of dialysis fluid. The total volume of dialysis fluid, the fill volume, and the time on dialysis is specified while the machine calculates the number of cycles and the duration of each cycle. They are usually programmed once a day and have the potential to reduce nursing time for peritoneal dialysis.[1,31] The challenges are the cost of the machines and the need for electricity.[1] Where, they may not be able to deliver appropriate volumes such as in neonates and young infants, these group of patients would require manual peritoneal dialysis.[1] Peritoneal dialysis cycler may be useful in units in sub-Saharan Africa that see many patients with AKI requiring dialysis because of the association with reduction in nursing time. They may however need to be powered by inverters or generators during electrical power outages. In sub-Saharan Africa regular use of the peritoneal dialysis cycler for children with AKI is done in some centres in South Africa and is reported in Ivory Coast. [33] (See Table 1)

**Peritoneal dialysis access**: Forms of peritoneal dialysis catheters that have been used are soft catheters, rigid catheters and peritoneal dialysis catheter adaptations. The soft catheters such as the Tenckhoff and the Cook Catheters (Cook Medical Inc, Bloomington, IN, USA) are the preferred catheters for peritoneal dialysis.[31] The surgically inserted Tenckhoff catheter is considered the optimal access for peritoneal dialysis in children.[1,27,37,38] The surgical technique may however require waiting time for the surgeon, and the operating theatre. When facilities for surgical placement are not readily available, the Tenckhoff or Cook catheter inserted at the bed side by modified Seldinder or Seldinger technique respectively can be used.[1,27,39-41] The Cook catheters include the pigtail pleurocard catheter or the multipurpose drainage catheters and are recommended for use in neonates and infants, while the Tenckhoff Catheter inserted by the bed-side is recommended in older children.[1,27,39-41] In sub-Saharan Africa, Tenckhoff and Cook catheters are used more or less routinely in South Africa for paediatric acute kidney injury.[42] Use of the surgically inserted Tenckhoff catheter for paediatric AKI has been reported in Ivory Coast.[33]Tenckhoff catheters have been used with the support from the Sustainable Kidney Care Foundation in Ghana, Cameroon, Togo and Ivory Coast.[43] In Ghana, support from the National Health Insurance up to the tune of USD 216 also makes access to Tenckhoff catheters possible.[43]Tenckhoff catheters placed by modified Seldinger technique have also been reported from a centre in Lagos Nigeria.[29] In Zaria and Ibadan, peritoneal dialysis has been carried out in a few patients with Tenckhoff catheters which were donated free. The limiting factor for the use of the Tenckhoff catheter by modified Seldinger technique in Nigeria is mainly the cost and availability of the catheters and the kit for the insertion.

When soft catheters are not available rigid catheters can be used. They are inserted using a stylet. They are inserted on the ward, are less expensive and easier to remove than the soft catheters but may carry a higher risk of perforation of internal organs or blood vessels.[1,25,31] Rigid catheter may also be associated with more frequent catheter outflow obstruction, more frequent need for catheter replacement and worse pericatheter leakage than soft catheters.[37,38,41] Rigid catheters are not suitable for chronic dialysis. Use of rigid catheters for paediatric AKI is reported from Sudan.[25] They were also used in Nigeria for dialysis in both adults and children especially before haemodialysis became available. Some centres in Nigeria use the rigid PD catheter regularly while some others use it from time to time.[3] In Nigeria, and elsewhere in sub-Saharan Africa, peritoneal dialysis catheter adaptations with nasogastric, and intercostal drainage tubes have been used successfully and may be lifesaving when standard PD catheters are not available or affordable.[3,10,20,36] (See Table 1) Peritoneal dialysis catheter adaptations may, however, be associated with higher risk of flow related problems, infection, and peritoneal dialysis leaks than soft catheters and are not advocated for routine use.[1,3]

The standard catheter for chronic peritoneal dialysis is the Tenckhoff catheter which is inserted surgically or laparoscopically. In most parts of sub-Saharan Africa including Nigeria, there are no chronic peritoneal dialysis programs, however, as peritoneal dialysis for AKI develops further interest is likely to grow, and practice of chronic peritoneal dialysis catheter insertion and chronic peritoneal dialysis may follow.

**Peritoneal Dialysis Procedure in a low resource setting.**

The case reported earlier in this journal typifies in many ways the experience, challenges, innovations and adaptations that are made to provide renal replacement therapy for AKI in Nigeria and sub-Saharan Africa. Many times in sub-Saharan Africa, peritoneal dialysis for AKI has been carried out with adapted peritoneal dialysis catheters such as nasogastric tubes.[3] The catheter may be inserted by the paediatric resident via a surgical technique. The bladder is catheterized, and the abdomen is prefilled with normal saline. A point in the midline about 2cm below the umbilicus is selected for the abdominal wall incision. The site is infiltrated using local anaesthesia. A stab is made in the abdominal wall until a 'give' is felt indicating that the scalpel has penetrated the abdominal wall and it is in the peritoneal cavity. There will also be leakage of the intravenous fluid that had been instilled into the peritoneal cavity. The distance from the umbilicus to the pubic symphysis provides a rough guide of the length of the nasogastric tube that will be in the peritoneal cavity. Additional fenestrations are made in the distal end of the nasogastric tube such that the fenestrations will all be within the peritoneal cavity when the tube has been inserted. An introducer is inserted through one of the fenestrations to stop just short of the tip of the nasogastric tube. The nasogastric tube is then inserted through the incision into the peritoneal cavity. It is held in place and the introducer is withdrawn. The catheter is then pushed further into the pelvis. The incision is then sutured to prevent any leakages around the catheter.[3] Other techniques that have been used is inserting the adapted peritoneal dialysis catheter through a surgical technique without the introducer, or requesting the surgical team to insert the nasogastric tube (adapted peritoneal dialysis catheter) into the peritoneal cavity. We have also inserted the nasogastric tube into the peritoneal cavity by a modified Seldinger technique using the kit for the modified Seldinger insertion of vascular catheters.

The adapted peritoneal dialysis catheter is connected to a three-way tap, and the CAPD fluid is connected to the three-way tap via a buretrol. An infusion giving set is used to connect the third limb on the three way tap to a 'urine bag' which serves to collect the effluent.[3] Heparin is usually added at 250-500 units per litre to the peritoneal dialysis fluid. The patients are also usually on systemic antibiotics (e.g.i.v ceftriaxone at 50-100 mg/kg/day single daily dose). The exchanges are carried out manually by resident physicians and interns. Peritoneal dialysis fluid is usually instilled into the abdomen at 10-20 mls/kg during each cycle. Dialysis fluid volume may be gradually increased to 30-40 ml/kg if well tolerated. The exchanges take place over about 60 minutes with an inflow of about 10 minutes a dwell of about 40 minutes and an outflow of about 10 minutes with a gradual increase in dwell time. The exchanges are recorded on a chart which indicates the time and volume of the inflow and the time and volume of the outflow. Once the peritoneal dialysis is started or established, the patient's fluid intake is usually increased to ¾ -1 x maintenanceunless the patient has marked features of fluid overload.[3]

The patient's fluid input and urine output are monitored. The total volume of peritoneal dialysis fluid instilled into the patient for the day, the total volume of peritoneal dialysis effluent and the ultrafiltration is determined. The patient is assessed for any signs of dehydration. The patient is also regularly evaluated for features of peritonitis such as fever, abdominal tenderness and/or cloudy peritoneal dialysis effluent. The peritoneal dialysis flow will be assessed for catheter outflow obstruction, or peri-catheter leakage. Ideally the serum electrolyte, urea and creatinine is done daily, and if the patient's serum potassium is less than 4 mmol/l, potassium is added to the dialysis fluid to achieve a concentration of 4 mmol/L.

Ordinarily the peritoneal dialysis is stopped when the oliguria has resolved and the serum creatinine level is normal or near normal. The presence of features of peritonitis may, however, lead to early discontinuation of dialysis especially when adapted catheters and equipment are used for peritoneal dialysisis. In our practice of acute peritoneal dialysis, clinical features of peritonitis do not usually develop until about the 5th day on dialysis. Ideally prevention and management of peritonitis should follow the standard guidelines but we are limited as many times peritoneal dialysis is carried out if adaptations rather than with the standard equipment.[44] In our practiceif the patient develops features of peritonitis, peritoneal dialysis is usually stopped and the patient switched to haemodialysis if this is feasible but if not the patient is usually switched to conservative management for AKI.
Extracorporeal continuous renal replacement therapy is not yet available in Nigeria and in most other parts of sub-Saharan Africa.

Other complications associated with peritoneal dialysis in our experience are bleeding around the catheter, blood-stained peritoneal dialysis effluent, abdominal wall and scrotal oedema, in some cases minimal evisceration of omentum after removal of the peritoneal dialysis catheter has been noticed.

Pericatheter leaks are usually treated by reducing the dwell volume to about 10-15 mls/kg, or by applying surgical glue to the incision site around the catheter. Sutures may also be applied around the incision site to stop pericatheter leaks. For catheter outflow obstruction, the catheter is usually flushed or the patient's position or catheter is adjusted to see if the catheter outflow improves. However, if the catheter outflow obstruction persists, the catheter may need to be changed. Bloody peritoneal dialysis effluent usually resolves spontaneously with conservative management, but the patient's vital signs should be monitored closely for any features of deterioration. Meticulous attention to details during catheter insertion should prevent major bleeds or internal organ trauma. Oedema of the abdominal wall, and scrotal oedema may be because one of the fenestrations is at the level of the abdominal wall and may necessitate changing the peritoneal dialysis catheter, haemodialysis or conservative management of AKI. Dehydration is a recognized complication of peritoneal dialysis especially with hourly cycles. Intravenous or oral fluid intake is usually increased to ¾ to 1 X daily maintenance requirements when peritoneal dialysis is commenced or established. Careful attention to fluid input and output and ultrafiltration will help to identify features of dehydration early. Management will include correction of the fluid deficit based on the degree of dehydration, and use of isotonic peritoneal dialysis fluids. Omental evisceration, which occurred in a few patients, did well with surgical management usually carried out at the bedside by the paediatric surgical team.

Survival till discharge following peritoneal dialysis for AKI in sub-Saharan Africa ranges from 58.8-75% of patients. Studies are needed on factors that predict mortality among patients with AKI who undergo peritoneal dialysis. Mortality may be higher in neonates, which may be partly related to need for supportive care such as temperature control and associated comorbidities. Use of standard catheters and equipment is also likely to lower rates of complications in general.[3]

**Challenges**

Challenges with peritoneal dialysis in Nigeria include the poverty, limited availability and high cost of peritoneal dialysis consumables, lack of medical insurance cover for peritoneal dialysis, and the need for more skilled and trained manpower Nigeria has a population of 200 million and about 60% of the population are aged 19 years and below while about 16% are aged less than 5 years. The country has a Gross Domestic Product per Capita of 2028.2 USD. About 54% of the population earn below the poverty line earn less than 1.90 USD per day. The National minimum wage is about 18000 naira (50 USD) per month for Federal Government employees. The federal government has only recently approved a minimum wage of 30000 (84 USD) per month and it is hoped that the new wage will be implemented soon. The cost of a 2L bag Peritoneal dialysis fluid is 6500 naira (18USD). The cost of the Tenckhoff Peritoneal dialysis catheter with the insertion kit is about 50, 000 naira (140 USD), the Cooke Catheter costs 75,000 naira (209 USD) while the rigid catheter costs 10,000 naira (28 USD). Obiagwu in Kano Nigeria found a mean cost of 311 USD for peritoneal dialysis among 8 patients with AKI.[6]

Many times parents are required to pay out of pocket for medical care of the children including laboratory investigations, medications and the purchase of consumables for peritoneal dialysis. The National Health Insurance has recently been expanded such that all Nigerian citizens can be registered under the program but it does not yet cover peritoneal dialysis. Other challenges associated with paediatric peritoneal dialysis in Nigeria are the limited availability of peritoneal dialysis fluid and catheters, and that skills for peritoneal dialysis catheter insertion are not widely available. Peritoneal dialysis services are not yet available in every state in Nigeria, and where states have peritoneal dialysis units they tend to be located in the urban rather than in the rural areas. Payment of import duties and the absence of local production of peritoneal dialysis fluid and standard consumables may also contribute to the high cost of peritoneal dialysis.

**Opportunities and recommendations**

The possibility of carrying out successful peritoneal dialysis manually with the use of adapted catheters and constituted fluids provides opportunity to provide life-saving renal replacement therapy for children with AKI in low resource settings. The knowledge, collaborations and skills for carrying out peritoneal dialysis using adaptations and constituted peritoneal dialysis fluid should therefore be promoted. The standard peritoneal dialysis fluid consumables especially the catheters and the dialysis fluid should also be made available and affordable as they may be associated with less complications than adaptations. Increased use of peritoneal dialysis, will lead to increased demand for the consumables, the increased demand may drive down the cost of peritoneal dialysis consumables as companies may be able to bring products into the country in bulk quantities. Ultimately local production of peritoneal dialysis fluids and consumables may become feasible. The government should support the management of children with AKI including the provision of peritoneal dialysis to reduce the financial burden on families. Inclusion of acute peritoneal dialysis under the existing National Health Insurance program may make it easier for families to access the standard PD catheters and consumables. The National Health Insurance also covers access to laboratory investigations and medications and relieves some of the overall financial burden of patient care, but awareness is low. There is therefore the need to disseminate information regarding the availability, opportunities and processes for enrolment in the National Health Insurance. Removal of import duties to be paid on peritoneal dialysis gadgets and consumables may also make peritoneal dialysis consumables and gadgets more affordable in Nigeria.

There is also the need to continue to collect data on about paediatric AKI, chronic kidney disease and outcome of peritoneal dialysis. Reliable data on the burden of paediatric AKI and the successful use of peritoneal dialysis in the treatment of paediatric AKI will potentially aid advocacy for government to support the cost of providing peritoneal dialysis for children. Indeed, the PNAN has started a National Paediatric Registry to collect data on Paediatric AKI but there is need for more centres to join and contribute data to the registry. There is also the need to get data on the burden of AKI among children who live in rural areas and to develop strategies for the management of AKI in rural areas and access to peritoneal dialysis when indicated. Advocacy for peritoneal dialysis has the potential to significantly increase access to dialysis in developing countries.

Advocacy should be carried out by doctors, parents of children with kidney disease, Nigerian Association of Nephrology (NAN), the Paediatric Nephrology Association of Nigeria (PNAN) and other Non-governmental organisations (NGOs). Advocacy should be made to the government, politicians, philanthropists and multilateral organizations to support peritoneal dialysis for children including access to peritoneal dialysis consumables. The NAN and PNAN should open discussions with the government for the inclusion of peritoneal dialysis for AKI inthe National Health Insurance. Multinationals and Philanthropists may also be approached to provide consumables and gadgets for the management of children with AKI who need dialysis. International Organizations like the ISN, IPNA and the ISPD should not relent in providing training opportunities in form of fellowships and support for Continuing Medical Education programs for the development of peritoneal dialysis in developing countries. The training should focus on practical skills such as insertion of peritoneal dialysis catheters and patient monitoring and physicians, nurses, and relevant surgical specialties should be included. There may also be a need to extend training to secondary health workers in rural areas, who may be serving the larger proportion of the population. A combination of sustained efforts to provide standard peritoneal dialysis for children with AKI who require renal replacement therapy as much as possible in spite of the odds, training, advocacy and political will, may eventually lead to the provision of standard peritoneal dialysis for AKI, and ultimately for children in ESRD.[25]

In conclusion peritoneal dialysis is an effective way of providing renal replacement therapy for children in AKI and ESRD. With the availability of haemodialysis in Nigeria, there was a decline in peritoneal dialysis. More recently there is a renewed interest in peritoneal dialysis as a form of renal replacement therapy in the sub-region, with adaptations such as nasogastric tubes being used for peritoneal dialysis catheters, and the use of constituted peritoneal dialysis fluids. Challenges include limited availability and cost of peritoneal dialysis catheters and peritoneal dialysis fluids. There are also challenges with the availability of expertise for the insertion of PD catheters and peritoneal dialysis. Advocacy by doctors, health workers, parents of patients with kidney diseases, NGOs, national and regional nephrology Associations for increased government support for peritoneal dialysis is needed. Inclusion of peritoneal dialysis for children with AKI in the National Health Insurance coverage, and provision of gadgets and consumables for peritoneal dialysis by multinationals and philanthropists may help to improve access to peritoneal dialysis. Continued education and training support from the international nephrology associations such as the ISN, IPNA and ISPD will lead to increased access to standard peritoneal dialysis for AKI and may ultimately lead to the establishment of chronic peritoneal dialysis programs.

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**Authors' contributions**
All the authors, AOA, ADA, RMA took part in the writing of sections of the first draft, All the authors reviewed and made significant contributions to the manuscript. ADA coordinated the writing process. RMA conceptualized the paper, All the authors approved the final draft.

**Table 1:** Review of papers from sub-Saharan Africa on paediatric peritoneal dialysis.

| Author | Year of publication | City, Country | Study year | Number of participants | Acute/ chronic PD | Type of catheter | Mode of insertion | Manual or automated | Type of PD fluid | Outcome |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Anochie[45] | 2006 | Port-Harcourt, Nigeria | Jan 1985 - Dec 2004 | 27 | Acute | Acute peritoneal dialysis catheter | PD catheter inserted by the nephrologist or paediatrician | Manual | Commercial CAPD fluid | 21 patients (77.8%) survived till discharge |
| 2. Ademola, Asinobi[3] | 2012 | Ibadan, Nigeria | Feb 2004- Mar 2011 | 27 | Acute | Nasogastric tubes and rigid catheter | Bedside | Manual | CAPD | 19 (70%) survived till discharge, two of them still needed dialysis but left against medical advice. |
| 3. Obiagwu[20] | 2012 | Kano, Nigeria | NA | 1 | Acute | Improvised catheter- nasogastric tube. | Not stated | Manual | Constituted PD fluid | Survived |

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| 4. Callegari[32] | 2013 | Kumasi, Ghana | 2012-2013 | 28 | Acute | Single cuff, Tenckhoff style | Modified Seldinger method by nephrologist and surgical insertion by general surgeons | | | Survival till discharge in 21 (75%). Recovery of renal function in 14 (50%). In-hospital mortality in 7 (50%). |
| 5. Francis Fredrick[10] | 2013 | Da res salaam, Tanzania | NA | 1 | Acute | Improvised PD catheter-Suprapubic catheter (adapted: with extra fenestrations made) | 'Surgical' Small incision and dissection of tissues to the rectus sheath | Manual | Constituted fluids | Survived |
| 6. Abdelraheem[25] | 2014 | Khartoum, Sudan | Jan 2005-Dec 2011 | 659 with AKI, PD in 365 (52.4%) | Acute PD (Chronic PD in 9) | Rigid Catheter (Switch to HD or Soft PD catheter for patients who need PD for > 5 days) | Bedside for rigid catheters. By paediatric resident, fellow or paediatric nephrologist, Mode of insertion of soft catheters not stated | Manually | Dianeal ------ | Specific mortality of patients with AKI who had PD was not stated. 65.3% of patients with AKI survived till discharge |
| 7. Esezobor[4] | 2014 | Lagos, Nigeria | Jul 2010-Mar 2013 | 17 | Acute PD | Intercostal drains used as catheters | Seldinger technique, bedside | Manual | CAPD-glucose added to increase strength as necessary | 10 (58.8%) survived till discharge |
| 8. Diarrassouba[33] | 2015 | Yopougon, Cote D'ivoire | 5yrs (Dec 2008-Nov 2013) | 22 children had PD, but PD was indicated in 33 | Acute | Tenckhoff Catheters (20), Redon Drains(2) | Surgical by Surgeon under g.a | Manual & automated | CAPD fluid | 18 (64%) survived, 10 (45%) recovered renal function, 4 (18.2%) progressed to CKD |
| 9. SYL Abdou N et al[43] | 2016 | All sites combined | 27 May 2013-Feb 2016- | 197 | Acute | | Cuffed PD catheter | Manual | Commercial CAPD fluid or constituted fluid | 143 (73%) survived till discharge |
| | | Abidjan, Cote d'ivoire | | 24 | | Cuffed PD catheters | Surgical: By surgeons | Manual | Commercial CAPD fluid | 18(75%) survived till discharge |
| SYL | 2016 | Accra, Ghana | | 14 | Acute | Cuffed PD catheters | Inserted at the bedside by nephrologist | Manual | Commercial CAPD fluid | 10 (71.4%) survived till discharge, 8 (57%) recovered renal function |

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| SYL | 2016 | Cotonou, Togo | | 26 | | Cuffed PD catheters | Inserted at the bedside by nephrologist | Manual | Commercial CAPD fluids or constituted fluids | 19 (73.1%) survived till discharge, 15 (57.7%) recovered renal function. |
| SYL | 2016 | Kumasi | | 88 | | Improvised catheters and Cuffed PD catheters | Catheters inserted by nephrologist | Manual | Constituted PD fluid and Commercial CAPD fluid | 62 (70.5%) survived till discharge, 48 (54.5%) recovered renal function |
| SYL | 2016 | Mbingo | | 43 (14 were below the age of 18) | Acute | Cuffed PD catheters | Surgical and in the operating theatre: Surgeons | Manual | Commercial CAPD fluid + locally constituted PD fluid | 34 (79%) survived till discharge, Recovery of renal function in 20 (46.5%) |
| 10. Adedoyin[36] | 2016 | Ilorin, Nigeria | NA | 1 | Acute | Not stated | Not stated | Manual | Constituted PD fluid | Survived |
| 11. Solarin[29] | 2017 | Lagos, Nigeria | Oct 2015 – Dec 2016 | 17 | Acute | Tenckhoff and Cooke catheters | Seldinger technique | Manual | Comercial CAPD fluid and constituted PD fluid | 12 patients (70.5%) survived till discharge. 11 (64.7%) regained renal function |
| 12. Nepfumbada[42] | 2018 | KwaZulu-Natal, South Africa | Jan 2010 until Dec 2014 | 40 | Acute | pediatric Tenckhoff catheter | Surgical | Manual | Dianeal PD-2 with Dextrose 1.25% or 4.25% | 35% survival |

AKI: Acute kidney injury, CAPD: Continuous Ambulatory Peritoneal Dialysis, PD: Peritoneal dialysis, Feb: February, Mar: March, Dec: December, Jan: January; Jul: July, Nov: November, HD haemodialysis, g.a: General anaesthesia, CKD: Chronic Kidney Disease, SYL: Saving Young Lives Program NA (Not available)



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