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ORIGINAL ARTICLE

Emergency peritoneal dialysis via haemodialysis catheter for paediatric acute kidney injury in low-income settings: a life-saving procedure

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Abstract
Background The percutaneous insertion of a peritoneal dialysis (PD) catheter by a nephrologist offers a plausible alternative to surgical insertion, improving access to dialysis. We report the experience of the paediatric nephrology unit in Dakar, Senegal, initiating PD for children with acute kidney injury (AKI), using a haemodialysis catheter inserted via a modified Seldinger technique. This approach was chosen due to its availability and cost-free provision, addressing resource constraints effectively.
Methods This pilot case series study describes a cohort of nine children with AKI managed using this innovative technique between March and October 2024 in Dakar, Senegal.
Results Nine children, including two neonates with life-threatening AKI, were included. Mean age was 4.5 years, with a male-to-female ratio of 1.25. Infections accounted for 44.4% ($n=4$) of the cases. Catheter insertion in the peritoneal cavity was successful in eight out of nine cases; one mispositioned catheter (case 9) was removed and excluded from analysis. During the first week, no cases of bleeding or dialysate leakage occurred at the insertion site. Peritonitis was observed in two cases after > 2 weeks. Of the eight children with successful catheter placement, five stabilised on PD (62.5%); and of those five, two (40%) fully recovered kidney function. Three children (37.5%) succumbed to septic shock from the underlying infection.
Conclusions Within the "Saving Young Lives" programme, our small case series showed that a haemodialysis catheter can feasibly deliver paediatric emergency PD in Dakar. Safety, efficacy, and programme-level impact must be confirmed in larger, multi-centre studies before wider training and implementation.

Keywords Acute kidney injury · Peritoneal dialysis · Saving Young Lives · Haemodialysis catheter · Children

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Introduction

In children, KDIGO stage 3 acute kidney injury (AKI) can be life-threatening without timely dialysis access [1, 2]. Nearly 60% of the world's children live in World Bank-classified low- and middle-income countries (LMICs), where paediatric kidney disease often receives low priority because of resource constraints; paradoxically, these are the settings where PD is most needed yet least studied, leaving a critical evidence gap [3]. In such settings, peritoneal dialysis (PD) is crucial for managing AKI, as it requires fewer resources compared to haemodialysis (HD). The International Society of Nephrology (ISN) launched the '0 by 25' initiative to reduce mortality associated with stage 3 AKI globally by training medical teams in PD in low-income countries [4]. Since 2020, the '0 by 25' initiative has reported a 20% reduction in AKI-related mortality in low-income countries according to the 2023 ADQI consensus [5] and the WE-ROCK registry [6]; however, these gains derive mainly from urban referral centres and remain heterogeneous, with rural and under-resourced regions still under-represented. When standard equipment is unavailable, the International Society of Peritoneal Dialysis (ISPD) Guidelines recommend alternative life-saving solutions, such as makeshift PD catheters (e.g. gastric tubes, pleural drains, haemodialysis catheters) and locally prepared infusion solutions [1, 4, 7, 8].

A shortage of surgeons and operating rooms often complicates and limits emergency PD catheter surgical insertion. Percutaneous catheter insertion by nephrologists using the Seldinger method at the bedside [9] offers a viable alternative to surgical procedures, enabling rapid initiation of PD and improving access to dialysis treatment [10]. Although there are contraindications to percutaneous insertion, the literature supports that nephrologist-performed insertion increases the availability of PD [11–17].

The paediatric nephrology unit in Dakar, Senegal, joined the ISN's Saving Young Lives (SYL) programme in March 2024. This initiative provided training in percutaneous catheter insertion through international nephrology societies. Figure 1 captures a session from these courses, which laid the practical foundation for the study initiative described here. We report the first 8 months of acute peritoneal dialysis experience in children with a double-lumen haemodialysis catheter. This article presents a pilot case series study describing the insertion technique using the modified percutaneous Seldinger approach at the Dakar paediatric nephrology unit, along with the patients' outcomes.

Patients and methods

Population

We conducted this pilot case series study in the only paediatric nephrology referral unit in Dakar. This unit is part of a broader multicentre collaborative effort, being twinned with the paediatric nephrology service at Necker Enfants Malades Hospital (Paris, France) since October 2023 under the International Pediatric Nephrology Association (IPNA) Sister Centre Program. Haemodialysis catheters are freely available in Senegal, along with peritoneal dialysis solutions (Baxter©). Conversely, although also free, the availability of Tenckhoff-type PD catheters is low, with frequent stock-outs, which restricts their consistent use and can delay or limit timely treatment options for patients.

Children presenting with AKI characterised by acute uraemic syndrome, prolonged anuria with fluid retention, hyperkalaemia, and/or metabolic acidosis were included in the study. For PD treatment, a haemodialysis catheter was inserted into the peritoneal cavity as an emergency procedure using the modified percutaneous Seldinger technique. Children in whom the use of a Tenckhoff catheter was possible were excluded from the study.

Catheter insertion technique

The technique for percutaneous insertion into the peritoneal cavity of a double-lumen semi-rigid catheter designed for haemodialysis differs from the standard approach used for Tenckhoff catheters and is adapted from the Seldinger technique. It is performed by a paediatric or adult nephrologist, by percutaneous puncture without prior skin incision, allowing rapid bedside access. Local staff completed the SYL curriculum, comprising 1 day of didactic training and 1 day of hands-on catheter placement under supervision.

The procedure is described in Fig. 2. After rigorous asepsis and local anaesthesia, the venipuncture trocar contained in the catheter kit tray is connected to a 10 mL syringe filled with physiological saline. It is then introduced perpendicular to the abdominal wall, without prior incision of the skin, 1 to 2 fingerbreadths below the umbilicus on the midline or at the midpoint between the umbilicus and the line of the anterior superior iliac spines of the hip. This reduces the risk of perforation of the inferior epigastric artery, which runs along the lateral surface of the rectus abdominis sheath [2]. The operator perceives initial resistance during puncture when the needle crosses the linea alba, followed by a second sensation of resistance when the transversalis fascia and parietal peritoneum are crossed. Injecting the saline in the syringe without resistance

Fig. 1 **A** First training in 2019 by Dr Stefano Picca, Italy (ISN educational ambassador) and Pr Abdou Niang (Senegal). **B**–**D** Second training by ISPD/AFRAN/SFNDT mission in the percutaneous placement of Tenckhoff-type tunnelled KT in March 2024 at the Dalal Diam hospital in Dakar by the Caen team (Pr Lobbedez, Dr Béchade, Pr Annabel Boyer)

confirms correct needle insertion in the peritoneal cavity. Artificial ascites is then created using a perfusion device with 20–30 mL/kg of saline, inducing artificial ascites to distance the intestinal loops from the parietal peritoneum. The infuser is then disconnected, and the flexible metal guide contained in the catheter kit tray is inserted through the introducer needle, which is then withdrawn. The dilator is then introduced along the length of the metal guide. The catheter is then inserted to the depth of the umbilicus-to-pubis distance and directed into the peritoneal cavity towards the pubic region. The tip of the catheter, which is multiperforated, is slid into the Douglas cul de sac and may be checked by a plain abdominal X-ray (Fig. 2H). Proper catheter insertion is confirmed by adequate drainage of artificial ascites fluid. After clamping the catheter's two arterial and venous lines to prevent fluid backflow, it is securely attached to the skin above the umbilicus to maintain stability, and a sterile dressing is applied to reduce the risk of infection. Whilst one of the venous or arterial lines is clamped, the other is connected to the dialysis bag using a Luer lock tip with protection for the connection area or a compress soaked in iodised polyvidone. The dialysate is pre-heated using a thermostat to ensure patient comfort and enriched with heparin 500 UI/L to prevent blood clot formation, maintaining adequate dialysis flow. First-generation cephalosporin antibiotics are administered intraperitoneally. The first dialysis cycles have a calculated 20 mL/kg volume for a dwell time of 1 to 2 h. These parameters are chosen to ensure effective ultrafiltration and solute removal. Total fill-in volume, dwell time, and number of cycles are adapted based on the patient's clinical status and biochemical parameters.

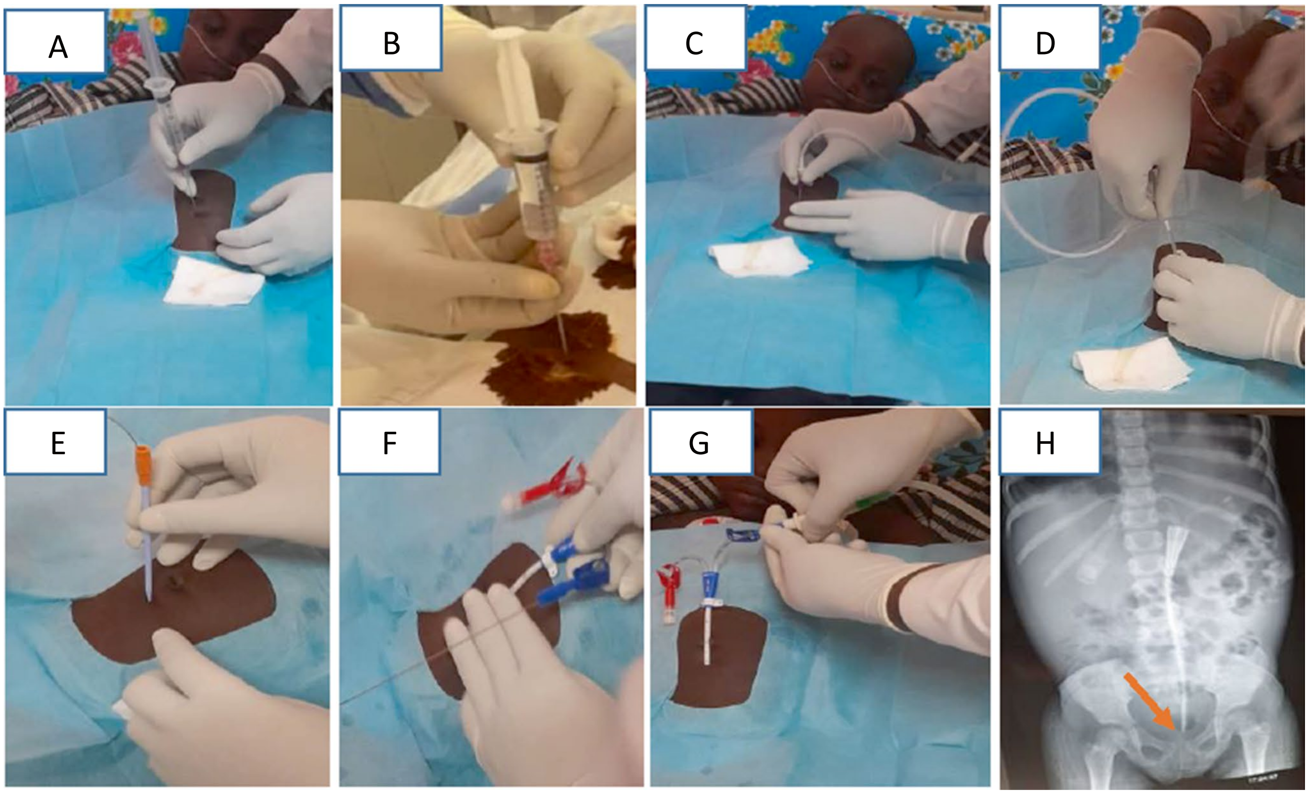

Fig. 2 Stepwise procedure for percutaneous haemodialysis catheter placement. **A** Maintain sterile conditions whilst administering local anaesthesia. **B** Percutaneous puncture using a trocar attached to a pre-filled 10 mL syringe. **C** Creation of artificial ascites through intra-peritoneal infusion of 20–30 mL/kg isotonic saline. **D** Introduction of a metal guide wire through the trocar. **E** Withdrawal of the trocar and tunnel dilatation. **F** Insertion of the double-lumen haemodialysis catheter using the guide. **G** Fixation of the catheter to the skin and connection with dialysate bag. **H** Confirmation of catheter placement in the peritoneal cavity and its pelvic direction via abdominal X-ray (abdomen without preparation)

Outcomes from using a modified Seldinger technique for peritoneal dialysis

Nine children referred for AKI and dialysis criteria were managed using this dialysis technique, enabled by the SYL programme's support in training and resources. The mean age of the children was 4.5 years (range 0–12 years), with a sex ratio (M/F) of 1.25. The characteristics of the children, the context in which the AKI occurred, and the outcome after catheter insertion are described in Table 1. In eight out of nine cases, the haemodialysis catheter was inserted at the patient's bedside, highlighting the adaptability of this technique in non-surgical settings. In one case, it was inserted in an ambulance during the evacuation of a neonate, further demonstrating its utility in emergencies. In eight out of nine cases, catheter insertion into the peritoneal cavity was successful, with a satisfactory fill-in volume and drainage. Correct positioning of the catheter was confirmed by abdominal X-ray in all cases (Fig. 2H). One failure was due to pre-peritoneal positioning of the catheter, resulting in dialysate infusion under the skin, which led to the catheter's removal and the child's transfer to haemodialysis. The seal between the catheter and the skin was satisfactory in the absence of an incision during insertion (Fig. 2G). There were no cases of dialysate leakage at the insertion site during the first week of dialysis. The drainage fluid was hematic during the first two PD cycles in two instances. In all eight cases, signs of AKI intolerance (acute uraemic syndrome, prolonged anuria with fluid retention, hyperkalaemia and/or refractory metabolic acidosis) were resolved within 24 to 72 h with positive ultrafiltration and adequate clearance (Fig. 3A, B). Dialysis adequacy was assessed daily using bedside criteria: (i) fall in serum potassium, (ii) correction of metabolic acidosis, (iii) net ultrafiltration, e.g. > 20 mL/kg per 24 h, and (iv) resolution of uraemic symptoms (irritability, seizures, pericardial rub) following ISPD guidance for acute PD in LMICs when kinetic measurements are unavailable [1].

There were no cases of peritonitis or catheter entry site infection during the first week (Table 1). More than 2 weeks after catheter insertion, two children developed a

Table 1 Characteristics and outcomes of nine patients treated with peritoneal dialysis using a double lumen haemodialysis catheter in the Paediatric Nephrology Unit, Dakar

Age	Gender	Context AKI stage 3	Place of insertion	Functional catheter	Duration of dialysis (days)	UF/clearance*	Catheter-related complications (week 2 and 3)	Outcome
5 years	F	ASD, VSD postop	At the bedside	Yes	3	Adequate	No	Full recovery
12 years	M	Severe malaria	At the bedside	Yes	5	Adequate	No	Full recovery
17 months	M	Anuric GN, Pearson's syndrome	At the bedside	Yes	21	Adequate	Dialysate leaking from the exit site, peritoneal infection	Partial recovery
24 months	F	Pyelonephritis, Horseshoe kidney, Pearson mitochondrial cytopathy	At the bedside	Yes	15	Adequate	Dialysate leaks. From the exit site, peritoneal infection	Partial recovery/ Switch CAPD
12 years	F	Anuric GN	At the bedside	Yes	30	Adequate	No	Partial recovery/ Switch HD
7 days	M	Neonatal sepsis	In the ambulance	Yes	1	Adequate	No	Died due to visceral failure
1 month	M	Neonatal sepsis	At the bedside	Yes	1	Adequate	No	Died due to septic shock
6 months	F	Infantile oxalosis	At the bedside	Yes	3	Adequate	No	Died due to visceral failure
6 years	M	Anuric GN	At the bedside	No	0	-	Infiltration of the abdominal wall due to pre-peritoneal placement	Switch to HD

F female, *M* male, *ASD* atrial septal defect, *VSD* ventricular septal defect, *CAPD* continuous ambulatory peritoneal dialysis, *GN* glomerulonephritis, *HD* haemodialysis

*Adequate clearance is defined as a positive ultrafiltration leading to the reduction of acidosis, uremia, and plasma potassium levels

leak at the catheter entry site, complicated by a peritoneal infection, which had a favourable outcome (Table 1). Two neonates died in septic shock with multivisceral failure. We also note the death of an infant with multiple bilateral obstructive lithiasis and nephrocalcinosis suggestive of infantile oxalosis. A 12-year-old girl was treated with PD for 1 month due to a shortage of in-centre haemodialysis unit capacity whilst awaiting insertion of a tunnelled HD line and transfer to chronic haemodialysis. Thankfully, no peritonitis occurred during this period. A child with AKI following cardiovascular surgery and a child with severe malaria recovered normal kidney function, allowing weaning from dialysis after 3 and 5 days, respectively. Following kidney function recovery, the catheter exit site healed rapidly within a few days after removal, aided by a simple dressing (Fig. 4). Partial kidney function recovery was noted in a 17-month-old infant with chronic kidney disease (CKD), in a 24-month-old infant with a horseshoe kidney complicated by pyelonephritis and manifesting a Pearson-type mitochondrial cytopathy phenotype.

Discussion

Our work demonstrates that in resource-limited settings, adapting PD methods to local contexts is particularly effective for treating AKI in children having an indication for dialysis. PD requires less technical skill and is less expensive than haemodialysis, as it involves simpler equipment and procedures that do not demand a highly specialised setup. In addition, PD can be used in children with haemodynamic instability and multivisceral failure. The method also allows for avoiding anticoagulation with a haemorrhage risk. Our experience also shows that a 'makeshift' dialysis catheter can be placed whilst the patient is in bed, enabling treatment to be started quickly. This approach offers an alternative to commercial dialysis catheters, which may be unaffordable for many patients in resource-limited settings. Whilst severe fluid restriction in neonates and infants exposes them to the risk of hypoglycaemia, the use of glucose PD solutions helps prevent the risk of hypoglycaemia [1]. Furthermore, PD

Fig. 3 IPNA sister centre service of Dakar: results of peritoneal dialysis using a double-lumen haemodialysis catheter in the SYL '0 by 25' programme. **A** Acute kidney injury in a 17-month-old infant with chronic kidney disease due to Pearson's syndrome. **B** Positive effluent in a 12-year-old boy with severe malaria

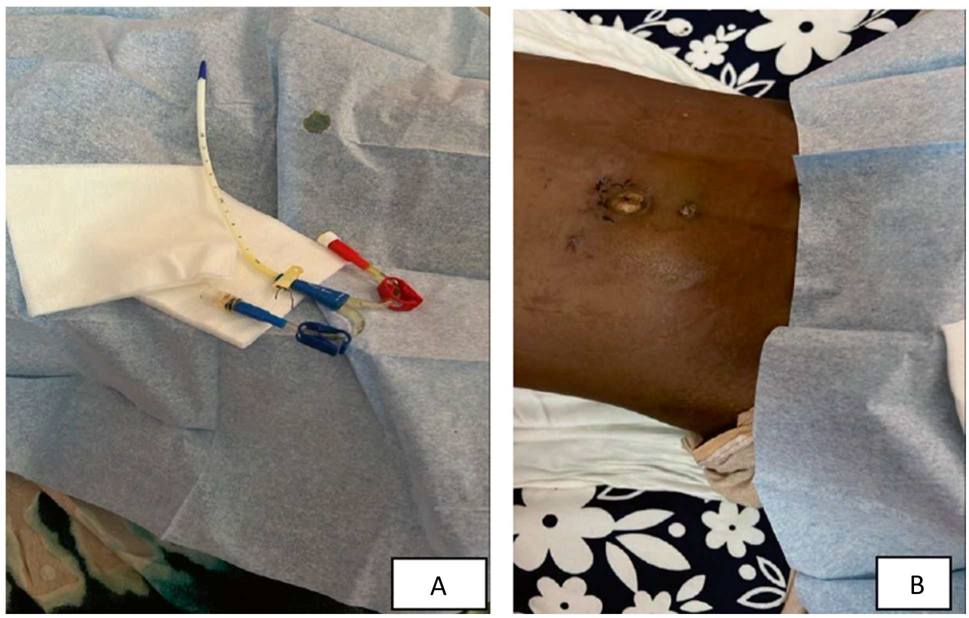

Fig. 4 Temporary catheter removal. **A** Double-lumen haemodialysis catheter removed by simple withdrawal. **B** Subumbilical scar at catheter exit site

preserves vascular access for future use and provides a gentler approach to fluid management and filtration compared to haemodialysis.

Pre-renal and parenchymal causes were the leading causes of AKI in our study, consistent with the literature in Africa and Senegal [14–16]. In children, most reversible causes of AKI, such as acute infectious glomerulonephritis, post-diarrhoeal haemolytic uraemic syndrome, malaria, and gastroenteritis, can be prevented [2, 16]. Despite its reversible nature, AKI is unfortunately responsible for 1.7 million deaths each year worldwide [4]. We believe that treating kidney failure is a human right, particularly a child's right, a principle strongly supported by the SYL programme through its efforts to provide access to peritoneal dialysis and training in resource-limited settings. The SYL programme, which is the result of an alliance between several international societies of nephrology [ISPD, ISN, IPNA, the European Peritoneal Dialysis Society (EuroPD), and now the Société Francophone de Néphrologie, Dialyse et Transplantation (SFNDT)], aims to save the lives of children with AKI by providing access to kidney replacement therapies through training in acute PD and dissemination of various PD techniques [2, 18, 19]. The SYL programme can be implemented in targeted and trained public health facilities and paediatric nephrology units as these serve as reference centres where the need for dialysis is high. Moreover, the SYL programme can be applied in Senegal because consumables are free for children and their families.

In addition to being easy to insert, the double-lumen haemodialysis catheter used as a PD catheter addresses the challenges of financial coverage and equipment importation in Senegal, effectively resolving these barriers. In resource-limited settings where standard PD catheters are unavailable, alternative options have been described in the literature, including intercostal thoracic drains, nasogastric tubes, or Foley urethral catheters inserted by mini-laparotomy [5, 18–21].

Detailed guidance for ensuring sterile conditions during catheter insertion is provided in the work of Nourse et al. [1]. In our patients, the catheter was successfully inserted whilst the patients were in bed in eight out of nine cases. One case required insertion in an ambulance during the evacuation of a neonate, demonstrating its practical applicability. The length and diameter of the double-lumen haemodialysis catheter are of minor importance, regardless of the child's age, especially as the intraperitoneal part was measured beforehand. In practise, the extra length of HD catheters—designed for vascular access—simply coils in the peritoneal cavity without impairing function, and although their smaller lumen (versus a Tenckhoff) confers higher resistance, the low viscosity of peritoneal dialysate maintains adequate flow even in very small children. Centre practise can vary considerably depending on surgical preferences and local expertise. Bedside insertion, when performed under strict sterile conditions, has been shown to be safe and did not lead to peritonitis or catheter blockage in our study during the first week. In a study by Esezobor et al. in Nigeria, intercostal chest tubes were used in 14 of 17 children requiring PD for the treatment of AKI, with complications of catheter blockage and peritonitis occurring in 4 (23.5%) and 2 (11.8%) patients, respectively [21]. McCulloch et al. demonstrated that low peritonitis rates are possible with aseptic techniques and appropriate dialysis staff training [22]. A study of 32 children with AKI in the Democratic Republic of Congo showed that the complication rate was 18%, including a low rate of peritonitis (6.2%), obstructed catheters (6.2%), and leaks (3.1%) [23]. Although on a smaller number of patients, our study did not observe any peritonitis or catheter blockage during the first week, suggesting that stringent sterile techniques and training may help minimise complications.

In the present series, we did not observe any cases of digestive perforation or dialysate leakage during the first week. Suturing the catheter by the two lateral fins to the skin ensures it remains straight within the peritoneal cavity, preventing lateral migration and enabling proper function. In addition, the catheter tip is flexible and supple, thus avoiding perforation of the peritoneal wall and viscera. However, there is still a risk of digestive perforation during the initial puncture with the trocar or when placing the catheter preperitoneally. The complications noted in our study occurred more than a week after insertion, with leaks and peritoneal infection in two cases. This confirms that this type of catheter should not be used for prolonged periods. In our case, it was maintained for 1 month in a young 12-year-old patient who was subsequently transferred to haemodialysis. Prolonged use was the main contributing factor to complications, highlighting the need for timely catheter replacement and strict infection control, mainly as all three fatalities resulted from underlying septic shock rather than catheter complications.

One week's peritoneal dialysis was sufficient to stabilise all children, enabling decisions about long-term management, such as transitioning to chronic dialysis or initiating palliative care where appropriate. Once kidney function had been restored, the catheter could be removed by simple withdrawal, using a simple suture at the puncture site. Suturing the exit site was easy with two or three stitches under local anaesthesia. Healing was rapid under a suitable dressing in a few days. This method increases the risk of leaks and infectious complications if dialysis exceeds 1 week, as noted in previous studies [1]. Without kidney function recovery, this temporary catheter can be replaced with a Tenckhoff-type catheter either in the operating theatre or at the child's bedside, allowing a more durable solution for extended dialysis whilst preserving vascular access sites and minimising complications.

Based on the preliminary findings of this pilot case series study, a structured emergency-PD protocol using readily available haemodialysis catheters could be beneficial and merit evaluation within the SYL programme in future multicentre studies, as by validating and standardising practises, we can further improve outcomes in resource-limited regions, such as Senegal (Fig. 5). The double-lumen catheter for haemodialysis could serve as an innovative peritoneal dialysis catheter when utilised with the modified percutaneous Seldinger technique, offering a viable solution. However, this modified Seldinger approach is most appropriate for children with AKI and potential for kidney recovery—such as post-infectious or postcardiac surgery cases—and is not intended for initial management of established kidney failure. Patients with kidney failure in our centre were transitioned to chronic PD or HD once stabilised.

We acknowledge that, with only nine patients, our findings are primarily descriptive and may not be broadly generalisable. More specifically, our pilot study limits the ability to draw definitive conclusions about efficacy or safety, as individual clinical circumstances can exert an outsized influence on the overall results. Selection bias is also possible (e.g. exclusion of patients eligible for Tenckhoff catheters). Moreover, the study is underpowered to detect rare complications—such as peritonitis—or to precisely quantify success and failure rates. The observed peritonitis rate (2/9; 22%) must be interpreted with extreme caution, given the cohort size and the potential confounding effect of prolonged use in one patient. Nevertheless, the 22% peritonitis rate and the high stabilisation rate observed provide promising early evidence of both viability and reliability, supporting the need for larger, prospective, multicentre studies to validate these findings. Such small, descriptive series are common—and often essential—for documenting emerging emergency

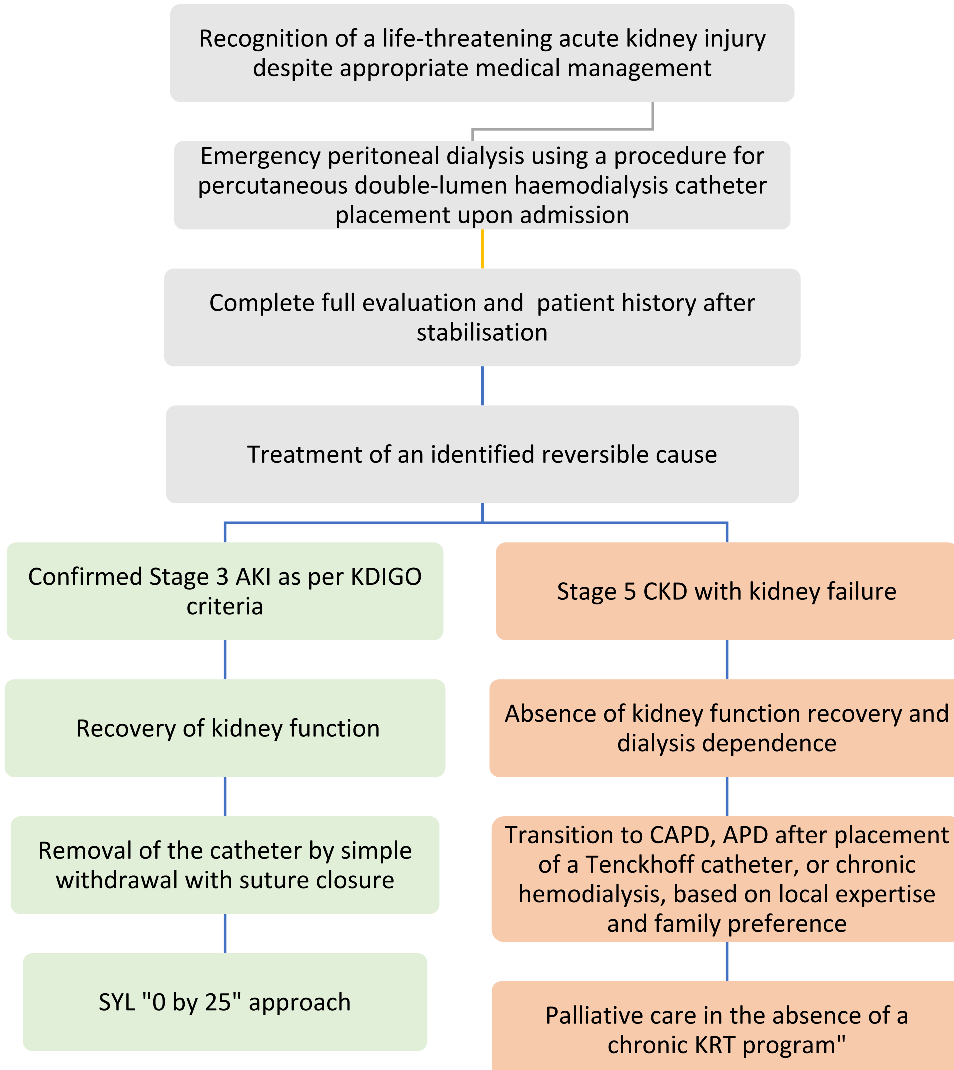

Fig. 5 Algorithm for peritoneal dialysis in children with acute kidney injury (AKI) using a procedure for percutaneous double-lumen haemodialysis catheter placement in a comparable context in Senegal as part of the Saving Young Lives (SYL) programme. AKI, acute kidney injury; APD, automated peritoneal dialysis; CKD, chronic kidney disease; CAPD, continuous ambulatory peritoneal dialysis; HD, haemodialysis; SYL, Saving Young Lives

paediatric nephrology techniques in low-resource environments, underscoring the exploratory nature of our report.

Finally, the absence of paediatric kidney transplantation services in Dakar and other resource-limited settings poses a significant challenge, necessitating the continuation of chronic dialysis for stage 5 CKD patients. This reality emphasises the need for broader healthcare policy support and infrastructure development to expand kidney replacement therapy options, from peritoneal dialysis to palliative care [24–26]. To close the 'paediatric PD catheter gap', we recommend centralised forecasting that accounts for paediatric demand when ordering supplies; stakeholder meetings between the Ministry of Health, suppliers, and clinical leaders to advocate for ring-fenced paediatric supplies; and NGO partnerships (e.g. IPNA, SYL) to establish emergency PD catheter consignment and distribution programmes. Such strategies have successfully improved paediatric PD access in other low-income countries. We recognise, however, that the continuation of palliative care in a resource-limited region may depend on multiple factors such as the child's age, the nature of the causative nephropathy, local expertise, treatment costs, and the family's perspective (psychosocial, social, and spiritual) on continuing therapy [27]. Ultimately, building on these early feasibility data, we hope that Senegal will eventually develop a paediatric kidney transplant programme. Such an advance could reduce the long-term need for dialysis and improve outcomes, whilst similar initiatives may warrant exploration in other resource-limited settings.

Conclusion

In cases of AKI in children, the modified Seldinger technique for peritoneal dialysis using a double lumen catheter for haemodialysis provides a viable option in resource-limited settings. This innovative method addresses critical barriers such as resource constraints and limited infrastructure, thereby increasing access to dialysis and improving survival rates for young children in need. To optimise outcomes, multidisciplinary training for healthcare providers and structured protocols must be prioritised. Scaling this approach across Senegal and other regions in similar contexts could significantly reduce morbidity and mortality in paediatric AKI cases.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00467-025-06933-9.

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Author contribution Stefano Pica, Thierry Lobbdez, Abdou Niang, Ahmed Tall Lemerabott, Olivia Boyer, Rémi Salomon, Bechade Daireaux Clémence, and Annabel Boyer were the trainers for peritoneal dialysis and peritoneal access using the percutaneous Seldinger technique. The first two authors inserted the catheters and monitored the children undergoing dialysis. All authors contributed to the drafting and correction of the manuscript. Evgenia Preka translated the initially French-written manuscript into English.

Data availability De-identified individual-participant data (demographics, clinical variables, catheter-procedure details and outcomes) are archived in the secure files of the Paediatric Nephrology Service, Dakar. The datasets generated and analysed during the current case series study are available from the corresponding author on reasonable request and with approval of the local ethics committee.

Declarations

Ethical approval and consent to participate This study was conducted in accordance with the Declaration of Helsinki and was approved by the local ethics committee (CNERS Sénégal, protocol ID N°0000060/MAS/CNRS/SP). To respect confidentiality, an identification code was assigned to each patient. Informed consent from parents was obtained prospectively, including specific consent for the use of patient photographs**,** in accordance with ethical guidelines for publishing identifiable data.

Conflicts of interest The authors declare no competing interests.

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