

Acute Peritoneal Dialysis Adequacy among Children at a National Referral Hospital in Kenya: A Cross-Sectional Study in a Resource-Limited Setting

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Abstract

Background: Acute peritoneal dialysis (PD) is an important renal replacement therapy for children with acute kidney injury (AKI), particularly in resource-limited settings. Inadequate PD may result in persistent uremia, prolonged hospitalization, increased mortality, and transition to hemodialysis. Dialysis adequacy is commonly assessed using urea and creatinine clearance, which are influenced by prescription parameters such as fill volume, dwell time, and dialysate dextrose concentration. However, there is limited data on target clearance values for children undergoing acute PD. This study aimed to assess PD adequacy and describe urea and creatinine clearance among children receiving acute PD at a national referral hospital in Kenya.

Methods: A cross-sectional study was conducted at Kenyatta National Hospital, a teaching and referral hospital in Nairobi, Kenya. We enrolled children who were starting peritoneal dialysis over a period of 5 months in the paediatric renal unit. Records of total drain volumes and serum and effluent concentrations of electrolytes, urea, and creatinine before and after 24 hours of dialysis were obtained via questionnaires. Daily urea and creatinine clearance were calculated for each child. A paired t-test was used to compare mean serum urea and creatinine concentrations before and after the first 24 hours of dialysis because measurements were obtained from the same participants and the data was approximately normally distributed. Descriptive analysis was used to compare solute clearance between groups of dialysate dextrose concentrations.

Results: 64 children were enrolled at a median age of 18 days, and 43% were female. The median daily creatinine clearance was 5.13 L/day/1.73m², and the median daily urea clearance was 1.03. There was a statistically significant reduction in mean serum urea and creatinine after the first day of dialysis. Sick neonates were at a higher risk of developing AKI than infants and older children.

Conclusion: Peritoneal dialysis achieved measurable clearance of urea and creatinine among patients admitted to the paediatric renal unit at Kenyatta National Hospital.

BACKGROUND

Peritoneal dialysis (PD) is a well-established modality of kidney replacement therapy that utilizes the peritoneal membrane as a semi-permeable surface for fluid and solute exchange, a principle recognized since the 19th century[1]. Access to the peritoneal cavity is achieved through a surgically placed catheter, used to infuse dialysate and drain waste products and excess fluid[2].

Solute transport occurs primarily by diffusion along concentration gradients, with additional movement via convection, while water removal is mediated through ultrafiltration across aquaporin channels[3].

The adequacy of PD depends on prescription parameters including dialysate composition, fill volumes, dwell time, and fluid balance[4].

Standard dialysate solutions contain dextrose at concentrations of 1.5%, 2.5%, and 4.25%, with higher concentrations used to augment ultra filtration incases of fluid overload. However, hyperglycemia is a recognized complication sometimes necessitating insulin therapy[5]. Dialysate also contains various electrolytes such as sodium, calcium, magnesium and lactate[6].

Fill volumes (the amount of PD liquid infused into the peritoneal space during a dialysis session) are typically initiated at 10ml/kg in children and increased gradually to a maximum of 40ml/kg, balancing solute clearance against the risk of leakage and elevated intra-peritoneal pressure(IPP)[5].

Dwell times (duration during which dialysate fluid remains in the peritoneal cavity) generally range from 30 minutes to 3 hours [4], with shorter durations favoring ultrafiltration and longer durations enhancing solute clearance [7].

Adequacy is conventionally assessed using urea clearance (Kt/V) and creatinine clearance, normalized to total body water and body surface area, respectively[8].

While adult guidelines from the National Kidney Foundation Disease Outcome Quality Initiative (K/DOQI) recommend a daily $Kt/V > 0.3$ and daily creatinine clearance $> 9L/day/1.73m^2$ as minimal adequacy targets, these thresholds may not be directly applicable to children with AKI, who often exhibit altered urea distribution volumes, increased protein catabolism, and negative nitrogen balance [8]. Paediatric-specific standards remain undefined, and available evidence is limited to small prospective studies[8][9].

In sub-Saharan Africa, PD remains the most accessible form of kidney replacement therapy for children with AKI due to its relative simplicity and lower resource requirements compared with hemodialysis. However, data on PD adequacy in African paediatric populations are scarce. To address this gap, we conducted a study to describe urea and creatinine clearance among children receiving acute PD at a national referral hospital in Kenya.

METHODS

We conducted a cross-sectional study to evaluate the adequacy of PD among children admitted to the paediatric renal unit at KNH. The unit primarily admits children undergoing PD. Informed consent was obtained from guardians, and assent was secured from children ≥ 6 years. The sample size was calculated using the formula for estimating a population mean:

where n is the minimum required sample size, $Z_{\alpha/2} = 1.96$ for a 95% confidence level, $\sigma = 20.4$ (standard deviation of creatinine clearance from Rocco et al.), and $E = 5$ (the margin of error). The minimum required sample size was 64 participants.

Eligibility criteria included a documented diagnosis of AKI and management with PD. AKI was defined according to the Kidney Disease: Improving Global Outcomes (KDIGO) guidelines[10]. PD was performed using surgically placed Tenckhoff catheters. 3 children were excluded due to significant leakage ($n = 2$) and bleeding ($n = 1$). Improvised dialysate and manual exchanges were used for PD. Only children who

completed the first 24-hour PD session were enrolled, as an assessment of dialysis adequacy was based on measurements obtained after the initial 24hours. Recruitment was by consecutive sampling.

Clinical and laboratory data were abstracted from medical records, including baseline and 24-hour serum electrolytes, urea, and creatinine. Effluent urea and creatinine concentrations and drain volumes were obtained from the patient’s file and daily dialysis charts and recorded in a questionnaire. Daily solute (urea and creatinine) clearance was calculated as:

Clearance= Effluent volume * (Effluent solute concentration/Serum solute concentration)

Urea clearance was normalized to total body water (TBW), while creatinine clearance was normalized to 1.73m2 body surface area (BSA), using pediatric-specific formulas. Demographic, anthropometric, and PD prescription data were extracted from patient records and dialysis charts using a structured data collection form. Data were analyzed using R version 4.0.2. Comparison of solute clearance between 1.5% and 2.5% dialysate dextrose concentrations was descriptive. Pre- and post-dialysis serum solute values were compared using paired t-tests.

RESULTS

A total of 64 children were enrolled between September 2024 and January 2025. Participant characteristics are summarized in Table 1.

Table 1. Participant characteristics (n=64).

Characteristic	Value	Reference range
Median age, days (IQR)	17.5days (14-78)	–
≤ 28 days, n (%)	44(68.8%)	–
29days- 1 year, n (%)	6 (9.4%)	–
>1- 11years, n (%)	14 (21.8%)	–
Female, n (%)	28 (43.8%)	–
Male, n (%)	36 (56.2%)	–
Median BSA, m ² (IQR)	0.19 m ² (0.18-0.27)	Age-dependent paediatric BSA

Abbreviations: BSA, body surface area; IQR, interquartile range.

The renal function and electrolyte parameters before dialysis

All children had azotemia, while 40 (62.5%) had decreased urine output <0.3 ml/kg/hour. Hypernatremia and hyperkalemia were present in 32 (50.0%) and 23 (35.9%) children, respectively (Figure 1).

Figure 1: The renal function and electrolyte parameters before dialysis

Figure 1 summarizes the clinical and laboratory abnormalities observed among children with AKI.

Peritoneal dialysis prescription

The dialysis prescription components analyzed were fill volume, dialysate dextrose concentration, and dwell time. The mean fill volume was 9.3 ± 1.4 ml/kg. Most children received 1.5% dextrose dialysate (59, 92.2%), while 5 (7.8%) received 2.5% dextrose. A dwell time of 1 hour was used in 63 (98.4%) children, with only one child prescribed a 2-hour dwell time (Table 2).

Table2. Peritoneal dialysis prescription (n=64)

Prescription	Mean ±SD/Frequency	%	Reference Range
Fill volume per kilogram (ml/kg)	9.3 ±1.4	–	10-40ml/kg
Dialysate concentration of dextrose			
1.5%	59	92.2	Standard concentration
2.5%	5		Higherosmotic concentration
Dwell time			
1 hour	63	98.4	Variable by prescription
2 hours	1		Variable by prescription

Change in serum urea and creatinine following peritoneal dialysis(PD)

Serum urea and creatinine levels decreased significantly after 24 hours of PD (paired t-test, p < 0.001) (Table 3).

Table3. Change in serum urea and creatinine values following PD.

Parameters	Mean pre-Dialysis	Mean post-dialysis	Reference Range	T-test p-value
Serum urea(mmol/L)	53.06mmol/L	32.28mmol/L	2.5-7.1mmol/l	0.0001
Serum creatinine(μmol/L)	602.2μmol/L	289.4μmol/L	Age-adjusted paediatric reference range	0.0001

PD adequacy and clearance rates

The parameters used to assess PD adequacy are summarized in Table 4. The median effluent and serum creatinine concentrations were 268 $\mu\text{mol/L}$ (IQR 143.0–438.8) and 289.4 $\mu\text{mol/L}$ (IQR 172.3–461.2), respectively. The median effluent and serum urea concentrations were 29.06 mmol/L and 32.28 mmol/L, respectively, while the median total drain volume was 645 ml (IQR 502–1120).

The median daily creatinine clearance was 5.13 L/day/1.73 m² (IQR 2.34–7.38), and the median daily urea clearance (Kt/V) was 1.03 (IQR 0.76–3.31) (Table 4).

Table4. Indicators used to assess adequacy, actual and expected clearance rates in PD.

Indicators	Median	IQR	Reference Range
Effluent creatinine($\mu\text{mol/L}$)	268	143-438.8 $\mu\text{mol/L}$	No established reference range
Serum creatinine ($\mu\text{mol/L}$)	289.4	172.3-461.2 $\mu\text{mol/L}$	Age-adjusted paediatric reference range
Effluent urea (mmol/L)	29.06	22.46-41.91 mmol/L	No established reference range
Serum urea (mmol/L)	32.28	22.52-44.75 mmol/L	2.5-7.1mmol/L
Total drain volume in 24hours (ml)	645	502-1120mls	Prescription dependent
Actual clearance			
Daily urea clearance (Kt/V/day)	1.03	0.76- 3.31	Target dependent on PD prescription
Dailycreatinine clearance(L/day/1.73m ²)	5.13	2.34-7.38 L/day/1.73m ²	No universally established acute PD target
Expected clearance			
Daily urea clearance (Kt/V/day)	0.69	0.30-0.74	Expected clearance from literature
Dailycreatinine clearance(L/day/1.73m ²)	10.57	4.04-13.8 L/day/1.73m ²	Expected clearance from literature

Relationship between fill volume, dialysate dextrose concentration, and daily urea and creatinine clearance

Relationship between fill volume and urea/creatinine clearance

Fill volume per kilogram showed weak positive correlations with daily urea clearance ($r = 0.037$, $p = 0.78$) and creatinine clearance ($r = 0.14$, $p = 0.33$), neither of which was statistically significant (Figure 2).

Differences in urea and creatinine clearance by dialysate dextrose concentration

Median urea and creatinine clearance were higher among participants receiving 2.5% than 1.5% dextrose dialysate. However, only a small proportion of participants received 2.5% dialysate (Figure 2).

Figure2. Relationship between fill volume, dialysate dextrose concentration, and daily urea and creatinine clearance.

Higher fill volumes and dextrose concentrations were associated with increased urea and creatinine clearance.

DISCUSSION

In this study, the median daily creatinine clearance was 5.13 L/day/1.73 m², and the median daily urea clearance (Kt/V) was 1.03. These findings are comparable to those reported in studies of children undergoing acute PD following cardiac surgery, in which daily creatinine clearance ranged from 4 to 10 L/day/1.73 m² and adequate solute clearance was achieved, with favorable clinical outcomes [8, 9]. Despite differences in patient populations and study methodology, these findings support the ability of PD to achieve clinically meaningful solute removal in pediatric patients requiring renal replacement therapy.

Neonates accounted for most children requiring PD in this study (68%). Their predominance likely reflects the high burden of neonatal AKI, driven by factors such as sepsis, birth asphyxia, immature renal function, and hemodynamic instability, as well as referral patterns to tertiary centers[11][12]. These findings highlight the importance of early recognition of AKI in neonates and strengthening access to paediatric dialysis services.

Participants receiving 2.5% dialysate demonstrated higher solute clearance than those with 1.5% dialysate, consistent with previous reports[13]. However, the small number of participants in the 2.5% subgroup limits definitive comparisons. The use of higher dextrose concentrations should be balanced against the risks of hyperglycemia and peritoneal fibrosis [14].

Although higher fill volumes were associated with greater urea and creatinine clearance, the relationship was not statistically significant. This finding contrasts with previous reports showing improved solute clearance with higher fill volumes [15]. Nevertheless, careful increases in fill volume within recommended limits (10–40 ml/kg) may be considered in selected patients with persistently elevated serum urea and creatinine levels [5].

Azotemia (100%) and oliguria (62.5%) were the most common findings among study participants. Similar observations have been reported in both paediatric and adult populations, in which azotemia, hyperkalemia, and oliguria were common indications for dialysis [6],[16] . These findings underscore the importance of early recognition and referral of children with suspected kidney failure to centers capable of providing PD.

Serum urea and creatinine levels decreased significantly within the first 24 hours of PD (Table 3). This contrasts with a previous study in which significant reductions were observed after 2–3 days of dialysis[17]. The earlier response in our cohort may reflect the higher median daily Kt/V achieved (1.03; IQR 0.76–3.31), suggesting that locally delivered PD can achieve substantial solute clearance in children with AKI.

This study was limited by its single-center design, small sample size, short duration, limited dwell time variation, and exclusion of patients with early catheter complications. These factors may have limited generalizability and introduced bias. Additionally, the use of retrospective clinical data may have introduced measurement variability and reduced reproducibility. Larger multicenter studies are needed to validate these findings.

CONCLUSION

The achieved Kt/V and creatinine clearance were comparable to published paediatric acute PD studies, supporting the effectiveness of PD in children with AKI. Neonates accounted for most dialysis recipients, highlighting their increased risk of AKI. Azotemia and oliguria were common presentations. Larger studies are needed to further evaluate the safety and efficacy of hypertonic dialysate solutions.

Abbreviations

- AKI
- Acute Kidney Injury
- BSA
- Body surface area
- CrCl
- Creatinine clearance
- ESRD
- End Stage Renal Disease
- IQR
- Interquartile Range
- K/DOQI
- Kidney Foundation Disease Outcome Quality Initiative
- KDIGO
- Kidney Disease: Improving Global Outcomes
- KNH
- Kenyatta National Hospital
- Kt/V
- Urea clearance
- PD
- Peritoneal dialysis

TBW
Total Body water

Declarations

Ethics approval and consent to participate

Ethics approval was obtained from the Kenyatta National Hospital- University of Nairobi Ethics and Research Committee. The study was conducted in accordance with the principles of the Declaration of Helsinki. Informed consent was acquired from guardians of all the participants.

Study reference number: P445/05/2024

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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No funding was received for the conduct of this study.

Author's contributions

DN developed the proposal, collected data, analyzed the results, and drafted the manuscript. BA supervised the study, reviewed, and edited the research and manuscript. DW reviewed and edited the research and manuscript. CM supervised data collection and reviewed the manuscript.

All authors have read and approved the final manuscript.

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Figures

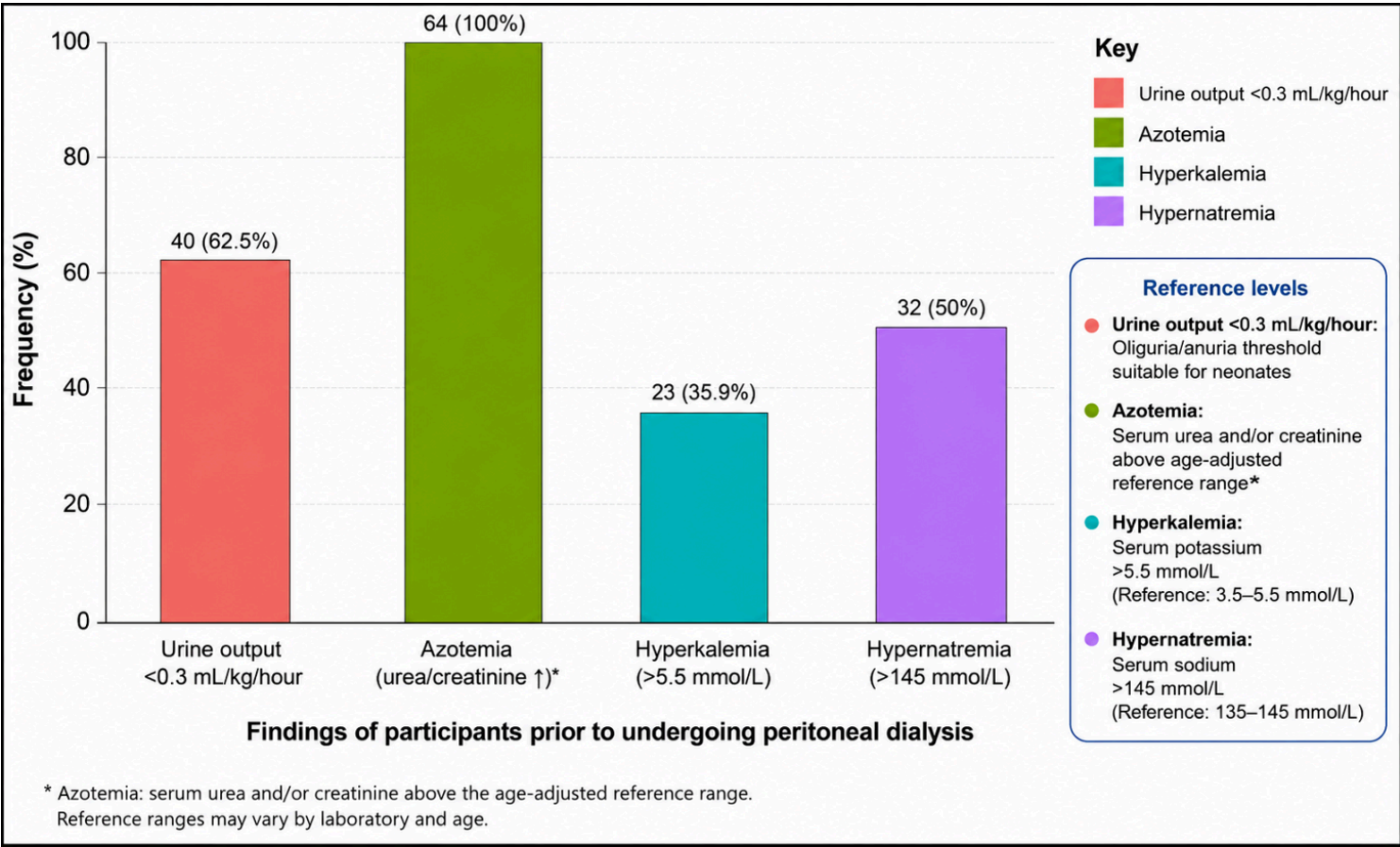


Figure 1

The renal function and electrolyte parameters before dialysis.

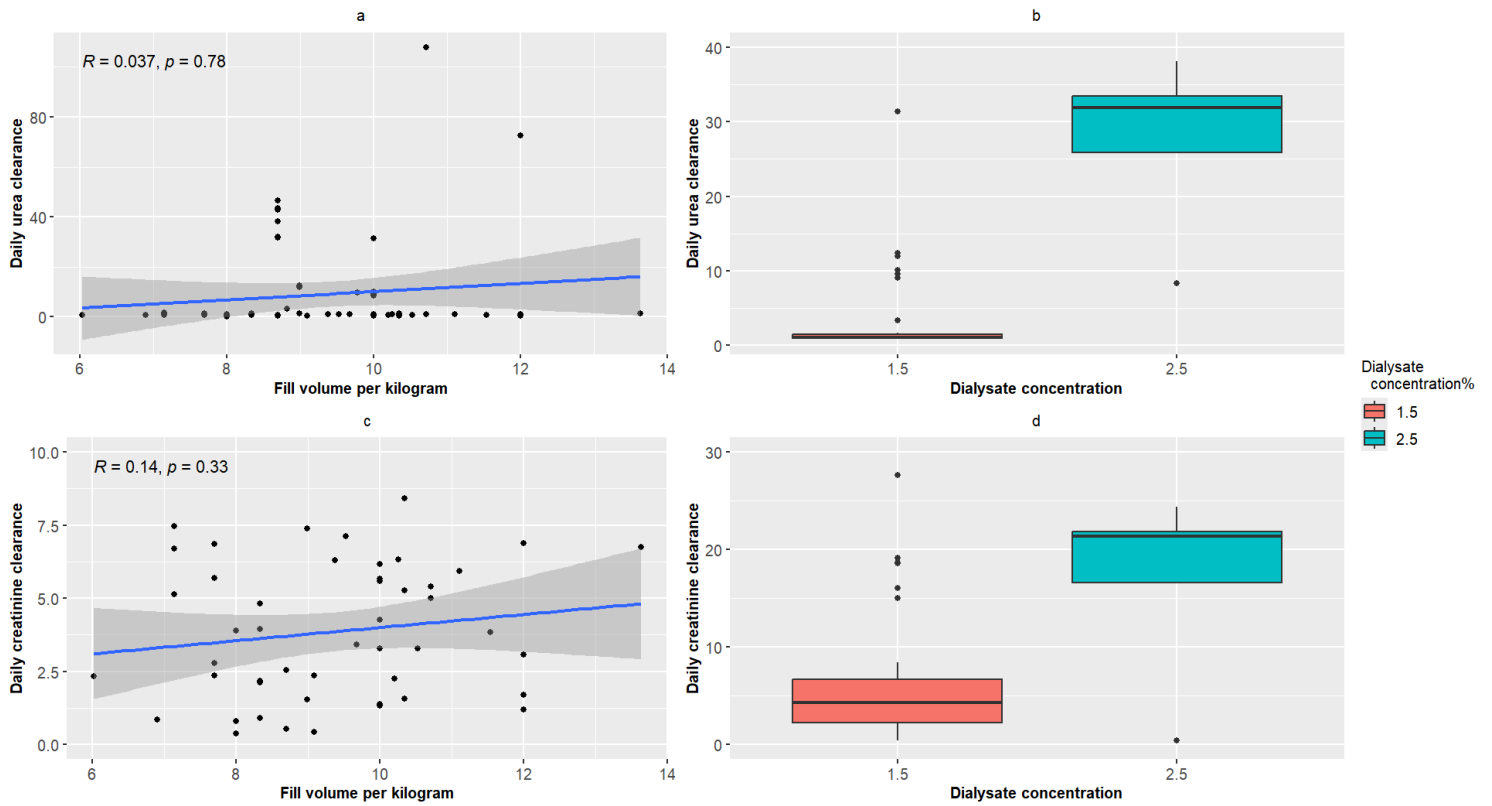


Figure 2

Relationship between fill volume, dialysate dextrose concentration, and daily urea and creatinine clearance.