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# Efficacy of Intermittent Peritoneal Dialysis in Pre Renal and Renal Acute Kidney Injury in Children

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**Abstract** **Original Research Article**

***Background*:** Acute kidney injury (AKI) is a major health problem in children worldwide. Intermittent Peritoneal Dialysis (IPD) has been reported as the preferred modality for the management of AKI in low-resource setting countries like Bangladesh. Its efficacy in different varieties of AKI is less emphasized. This study aims to assess the efficacy of IPD in pre renal and renal causes of AKI in children. ***Methods*:** This prospective, interventional study was conducted at Department of Paediatric Nephrology, Bangladesh Shishu Hospital and Institute from January 2020 to December 2021. Total 56 children aged between 1 month to 12 years of either sex, diagnosed as AKI stage 2 or 3 due to pre renal and renal causes who required IPD were included. All patients got IPD for 72 hours. Clinical and laboratory parameters were measured daily and compared between pre renal and renal group on day 3 to assess efficacy. ***Results***: In the pre renal group, 65.4% of patients were infants while in the renal group, 51.9% were aged 1-5 years. After 3 days of IPD, oedema improved in both groups but in renal group, more patients were still oedematous ($p<0.001$). Serum creatinine, blood urea levels and urea reduction ratio improved significantly in both groups with greater changes in pre renal group ($p<0.001$). In the renal group, 29.63% patients required hemodialysis and 7.4% required further IPD, whereas all pre renal patients improved with a single course of IPD without hemodialysis. ***Conclusion*:** Intermittent Peritoneal Dialysis is more effective in the treatment of pre renal AKI in children.

**Keywords:** Acute Kidney Injury, Intermittent Peritoneal Dialysis, Efficacy.

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## INTRODUCTION

Acute Kidney Injury (AKI) is common in developing countries rather than developed countries due to overcrowding, poor socio-economic conditions, and environmental factors. The global burden of AKI is 13 million per year, 85% of whom live in developing countries [1, 2]. In India, the incidence of AKI is shown in inpatient wards ranging between 5%- 9% and in Paediatric Intensive Care Units 25%-36% [3, 4]. In Bangladesh Shishu (Children) Hospital and Institute AKI prevalence in the Department of Paediatric Nephrology was 14.95% of all kidney diseases admitted and mortality was 40% in 2019. Among them, the prevalence of pre renal and renal AKI were 63% and 19% respectively, and post diarrheal hypovolemic AKI was the commonest (50%) pre renal cause [5].

So, AKI is a serious health issue in children. AKI situations are tragic; the deaths of young patients with AKI in developing countries can have devastating impacts on both the economic and social structure of families [6]. Most AKI patients who present in an advanced stage die because of the unavailability of dialysis [7-9].

Dialysis is an effective therapeutic modality for the management of AKI. Indications of acute dialysis in AKI include anuria/oliguria, severe medically uncontrolled volume overload and persistent hyperkalemia, severe metabolic acidosis unresponsive to medical management, uremia and sepsis [10, 11]. Available dialysis modalities for AKI management are- Intermittent Peritoneal Dialysis (IPD), Intermittent Hemodialysis (IHD) and Continues Renal Replacement Therapy (CRRT) [12].

Among them, peritoneal dialysis requires minimal equipment and infrastructure, is easy to perform, and remains the favoured dialysis option in developing countries where modern facilities are not widely available [13]. In the United States, AKI was reported in around 3.9/1000 admissions and around 27.1% of them needed dialysis support [14]. Even after significant advancement in the supportive care in critical care setup, the mortality in children requiring dialysis is still high 35-73% [15].

Conditions causing AKI can be classified into pre renal, renal and post renal groups [16, 17]. Dehydration, gastroenteritis, sepsis, haemorrhage, and cardiac failure are the most common causes of pre renal AKI [10, 18]. It results from decreased effective circulating arterial volume that leads to inadequate renal perfusion and a decreased GFR without damage to the renal parenchyma [18]. In patients with pre renal AKI, kidney function typically returns to baseline after adequate volume status is established or the underlying cause is treated [17].

On the other hand, Renal AKI includes a variety of disorders characterized by renal parenchymal damage, including sustained hypo perfusion and ischemia [11]. Haemolytic Uremic Syndrome (HUS), Acute Tubular Necrosis (ATN) due to bee sting, wasp bite, toxin, drugs and Acute Interstitial Nephritis, Post infectious Glomerulonephritis (GN), Rapidly Progressive Glomerulonephritis (RPGN), Henoch- Schonlein Purpura (HSP) nephritis, Lupus Nephritis are the important causes of renal AKI in children [4]. Acute IPD is currently the best modality for managing AKI due to primary renal disease [19].

ISN (International Society of Nephrology) recently set a goal of eliminating preventable and treatable deaths from AKI by 2025, a “0 by 2025” campaign and stressed on making PD more available in grass root level hospitals to achieve this goal. Therefore, this hospital-based study aimed to observe and compare the efficacy of intermittent peritoneal dialysis in the management of pre renal and renal causes of AKI in children. This study result would show the importance of optimizing IPD throughout the country in managing most of the pre renal AKI in an attempt to reduce the mortality and morbidity of children from AKI.

**Objective**

The objective of this study was to assess the efficacy of Intermittent Peritoneal Dialysis (IPD) in pre renal and renal causes of Acute Kidney Injury (AKI) in children.

## METHODOLOGY & MATERIALS

This prospective interventional study was conducted at Department of Paediatric Nephrology, Bangladesh Shishu Hospital and Institute (BSHI) from January 2020 to December 2021. A total of 56 patients aged between 1 month to 12 years diagnosed as AKI stage 2 or stage 3 with indications of peritoneal dialysis were included in the study where 26 patients in pre renal group and 30 in renal group. After dialysis started, 3 patients expired from renal group before completing 72 hours of PD. Finally, clinical and laboratory parameters of 53 patients were compared before (day 0) and after IPD at day 3(72 h) in both groups.

**Inclusion criteria**

1. Age between 1 month to 12 years of either sex
2. AKI stage 2 or 3 who required IPD.
3. AKI due to Pre renal cause (Dehydration, hypovolemia, shock following gastroenteritis, sepsis, and cardiac failure).
4. AKI due to renal causes such as Haemolytic Uremic Syndrome, Acute Interstitial Nephritis (Acute Tubular Necrosis due to toxin and drugs), Post infectious Glomerulonephritis, Rapidly Progressive Glomerulonephritis, Henoch-Schonlein Purpura Nephritis, and Lupus Nephritis.

**Exclusion criteria**

1. AKI due to obstructive uropathy
2. AKI on Chronic kidney disease
3. AKI with congenital anomalies of kidney and urinary tract
4. Patients with recent abdominal surgery, intestinal obstruction, peritonitis, or abdominal wall defects.

**Study Procedure**

After proper approval from the ethical review committee (ERC) of Bangladesh Shishu Hospital and Institute (BSHI), children with AKI attending the Department of Paediatric Nephrology unit of Bangladesh Shishu Hospital and Institute were assessed for eligibility as the study population. The purpose, procedure, importance, and benefit of the study were explained to the parents or local guardians. They were also assured about confidentiality. Proper informed written consent from the parents or local guardian was taken.

Immediately after receiving the patients, emergency medical management had been started at the CCN & D unit. Catheterization was done in all patients to monitor urine output. In the case of hypovolemic patients volume restoration was done by 0.9% normal saline 10-20 ml/kg over 30 minutes. Patients with volume overload were managed with I/V diuretics and other emergencies were managed according to hospital protocol. Blood samples for Arterial Blood Gas, Serum Creatinine, Blood Urea Nitrogen, Serum Electrolytes were collected immediately during the first intravenous line insertion. Those who did not respond to medical management were enrolled for peritoneal dialysis.

A detailed history was taken and thorough physical examinations were done. According to Kidney Disease: Improving Global Outcomes (KDIGO), AKI was defined when an increase in serum creatinine by ≥0.3mg/dl from baseline within 48 hours or increase in serum creatinine to ≥1.5 times baseline within the prior 7 days or urine volume was reduced by ≤0.5 ml/kg/hr for 6 hours. The most recent creatinine value prior to the development of AKI was considered the baseline creatinine level.

Children with AKI were divided into 3 age groups: < 12 months, 1 year to 5 years, and 5 years to 12 years. They were categorized as pre renal and renal AKI from their history and lab evidence (Blood Urea Nitrogen: Creatinine ratio). Hypovolemia due to gastroenteritis, haemorrhage, dehydration, and sepsis were grouped as pre-renal AKI. Haemolytic Uremic Syndrome (HUS), Acute Interstitial Nephritis and Acute Tubular Necrosis (snake bite, wasp bite, toxin-induced AKI), Post infectious Glomerulonephritis, Rapidly Progressive Glomerulonephritis (RPGN), Henoch-Schonlein Purpura (HSP) nephritis, and Lupus Nephritis were kept in the renal group.

**Ethical Consideration**

The ethics of this study were reviewed and approved by the ethical review committee of Bangladesh Shishu Hospital and Institute. All the parents or guardians were informed about the objectives of the study. The parents were informed that they had every right to withdraw themselves from the study. Written consent was obtained from them. Beneficence, non-maleficence, respect, justice, honesty, and dignity were practiced and maintained throughout the research duration.

**Statistical analysis of data**

All the data were processed and analyzed by using SPSS version 26. Quantitative data were expressed as mean±SD and median and interquartile range. To compare qualitative/categorical data between two groups, the Chi-square ($\chi 2$) test and where applicable Fisher-exact test was used and expressed as number (frequency). To compare quantitative or numerical variables between two groups' unpaired t-test and Mann-Whitney-U test were performed. For all statistical tests, p-value of less than 0.05 was considered statistically significant.

# RESULTS

**Table 1: Distribution of patients by socio-demographic characteristics (n=53)**

| Characteristics | | Pre renal (n=26) | Renal (n=27) | p value |
|---|---|---|---|---|
| **Age** | <12 months | 17 (65.4%) | 4 (14.8%) | 0.001 |
| | 1-5 years | 6 (23.1%) | 14 (51.9%) | |
| | 5-12 years | 3 (11.5%) | 9 (33.3%) | |
| **Gender** | Male | 20 (76.9%) | 20 (74.1%) | 0.81 |
| | Female | 6 (23.1%) | 7 (25.9%) | |
| **Residence** | Urban | 18 (69.2%) | 21 (77.8%) | 0.48 |
| | Rural | 8 (30.8%) | 6 (22.2%) | |

In the pre-renal group, 17 (65.4%) patients were from the < 12 months age group, and 6 (23.1%) patients were from 1-5 years age group while in renal group, 4 (14.8%) patients were from < 12 months age group and 14 (51.9%) patients were from 1-5 years age group. Fisher Exact test showed that there was significant statistical difference between the groups regarding age (p=0.001). No significant statistical difference was observed between the groups regarding gender and residence (p>0.05).

**Table 2: Comparison of baseline clinical parameters of study patients (n=53)**

| Clinical features | Pre renal (n=26) | Renal (n=27) | p value |
|---|---|---|---|
| **Oedema** | | | |
| Present | 9 (34.6%) | 23 (85.2%) | **<0.001** |
| Absent | 17 (65.4%) | 4 (14.8%) | |

At baseline, oedema was significantly more in renal group (85.2%) compared to pre renal group (34.6%) (p<0.001).

**Table 3: Comparison of baseline laboratory parameters of study patients (n=53)**

| Biochemical parameter | Pre renal (n=26) | Renal (n=27) | p value |
|---|---|---|---|
| Hemoglobin | 9.9 ±1.5 | 8.1 ±2.1 | 0.001 |
| Creatinine | 2.9 ± 1.4 | 7.2 ± 2.9 | <0.001 |
| Urea | 79.8 ± 36.3 | 103.8 ± 41.9 | 0.031 |
| pH | 7.2 ± 0.1 | 7.2 ± 0.1 | 0.684 |

| | | | |
|---|---|---|---|
| Bicarbonate | 8.5 ± 4.9 | 7.7 ± 4.2 | 0.531 |
| Sodium | 159.0 ± 21.9 | 138.7 ± 9.7 | <0.001 |
| Potassium | 4.2 ± 1.2 | 4.9 ± 1.1 | 0.023 |

Laboratory parameters of the patients showed that in pre renal group, creatinine level and blood urea were significantly higher in renal group compared to pre renal group (<0.05). There was no significant difference regarding pH and bicarbonate between two groups.

**Table 4: Comparison of clinical parameters of both group at day 3 after IPD (n=53)**

| Parameter | Pre renal (n=26) | Renal (n=27) | p value |
|---|---|---|---|
| Oedema | | | <0.001 |
| Present | 2 (7.7%) | 17 (73.9%) | |
| Absent | 24 (92.3%) | 10 (37.0%) | |

After PD, oedema was significantly more in renal group (73.9%) compared to pre renal group (7.7%) (p<0.001).

**Table 5: Comparison of urine output (ml/kg/hour) in both groups (n=53)**

| Urine output (ml/kg/hr) | Pre renal (n=26) | Renal (n=27) | p value |
|---|---|---|---|
| Before PD | 0.005 [0.00, 0.15] | 0.02 [0.00, 0.1] | 0.924 |
| After PD | 1.49 [0.96, 2.50] | 0.50 [0.14, 1.17] | <0.001 |

Before PD, there was no significant difference between the groups regarding urine output (p = 0.924). After PD, the urine output was significantly higher in pre renal group compared to renal group (p<0.001).

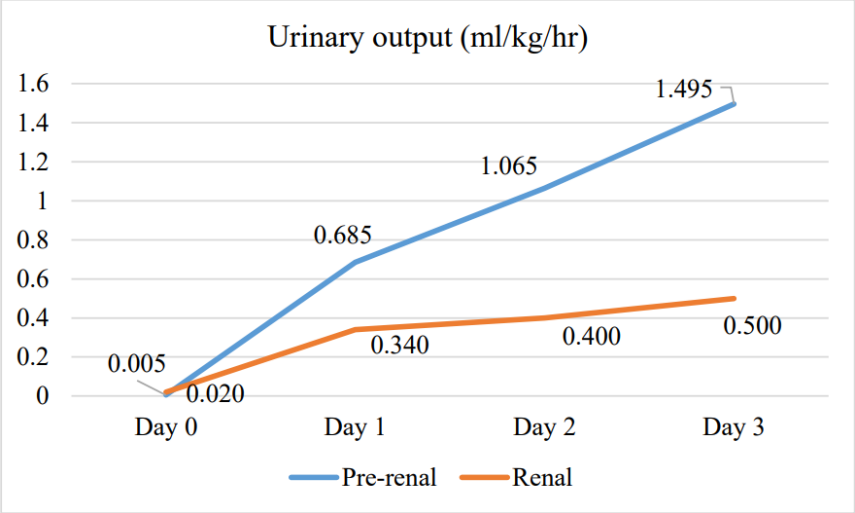


**Figure 1: Distribution of patients by urinary output (ml/kg/hr) (n=53)**

In pre-renal group, at day 0, the urinary output was 0.005 which increased to 0.685 on day 1, 1.065 on day 2, and finally 1.495 on day 3. Again, in renal group, at day 0, the urinary output was 0.02 which increased to 0.34 on day 1, 0.40 on day 2 and finally 0.50 on day 3.

**Table 6: Comparison of laboratory parameters of both group at day 3 after IPD (n=53)**

| Parameter | Pre renal (n=26) | Renal (n=27) | p value |
|---|---|---|---|
| Creatinine | 0.9 [0.6-1.5] | 3.8 [1.8-6.5] | <0.001 |
| Urea | 26.3 [15.8-42.7] | 59.9 [33.6-88.8] | <0.001 |
| pH | 7.4 ± 0.06 | 7.4 ± 0.09 | 0.79 |
| Bicarbonate | 16.7 [12.7-19.0] | 14.3 [12.2-18.3] | 0.213 |
| Urea reduction ratio | 62.4 [56.8-70.5] | 40.7 [28.9-51.3] | <0.001 |

After PD, there was no significant difference between the groups regarding pH and bicarbonate (p>0.05). However, the creatinine and urea levels were significantly higher in renal group compared to pre renal group (p<0.05). On the other hand, urea reduction ratio was significantly higher in pre renal group (p<0.05).

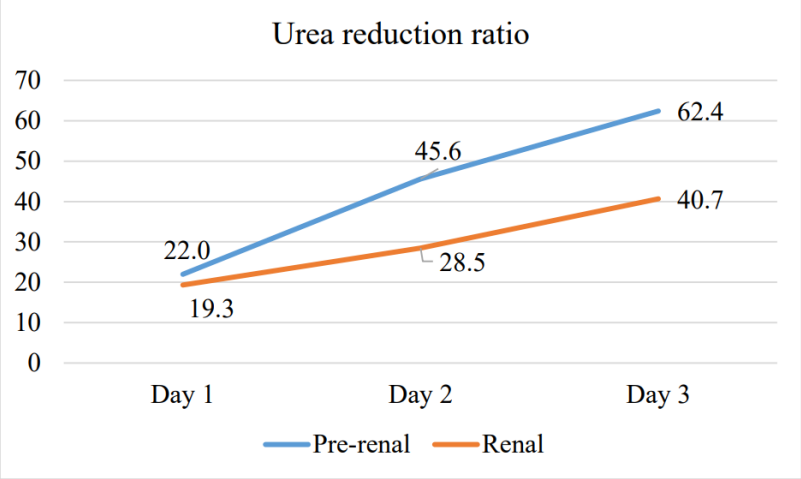


**Figure 2: Comparison of urea reduction ratio between the groups**

The urea reduction ratio on day 1 was 22.0 in pre renal group while in renal group it was 19.3. Mann Whitney U test showed that there was no significant difference between the groups regarding urea reduction ratio on day 1 ($p<0.059$). On day 2 and day 3, the urea reduction ratio was significantly higher in pre renal group compared to renal group ($p<0.001$).

**Table 7: Comparison of patients by improvement (in percentage) in after PD (n=53)**

| Biochemical parameters | Pre-renal (n=26) | Renal (n=27) | p value |
|---|---|---|---|
| Creatinine | 60.4 [56.8-70.5] | 40.7 [28.9-51.3] | <0.001 |
| Urea | 64.5 [44.8-73.6] | 36.5 [28.6-61.4] | 0.001 |
| $p^H$ | 1.7 [0.5-3.1] | 1.8 [0.9-2.4] | 0.79 |
| Bicarbonate | 53.7 [26.9-65.8] | 47.7 [32.2-67.7] | 0.986 |

After PD, the mean of improvement (in percentage) of creatinine was significantly higher in pre-renal group compared to renal group ($p<0.001$). Moreover, the mean of improvement (in percentage) of urea was significantly higher in pre-renal group compared to renal group ($p=0.001$). However, no significant statistical difference was observed between pre-renal and renal group regarding improvement in pH and bicarbonate.

**Table 8: Comparison of patients by Hemodialysis and re-IPD (n=53)**

| Characteristics | Pre-renal (n=26) | Renal (n=27) | p value |
|---|---|---|---|
| Hemodialysis | 0 (0.0%) | 8 (29.63%) | 0.004 |
| Re-IPD | 0 (0.0%) | 2 (7.4%) | 0.491 |

After PD, in pre renal group, no patient required hemodialysis or re-IPD while in renal group, 8 (29.63%) patients required hemodialysis and 2 (7.4%) required re-IPD. Fisher Exact test showed that there was a significant statistical difference between the groups regarding hemodialysis ($p=0.004$). No significant difference was found between the groups regarding re-IPD ($p=0.491$).

## DISCUSSION

Acute kidney injury (AKI) has emerged as a major public health problem that affects millions of patients worldwide [20]. It is a common cause of morbidity and mortality in both children and adults [21]. Peritoneal dialysis has been the preferred modality of RRT for patients with AKI for decades because it is both simple and safe and can be performed without the need for machinery or electricity, making it an ideal choice in a low-resource setting [22]. Several studies have reported that in low-resource setting PD can be used safely in the treatment of AKI and is associated with good outcomes and improved survival [13, 15, 23-25]. None of them focused on the efficacy of PD in different categories of AKI. As diarrhoeal diseases are endemic in our country, post diarrheal AKI is a common cause of pre renal AKI in Bangladesh [26]. Therefore, it's now time demanding to determine the efficacy of PD in pre renal and renal AKI so that PD can be made more available for managing pre renal AKI throughout the country.

In the pre-renal group, the majority of patients were younger than 12 months age group while in the renal group, the majority of patients were older than 1 year. This is because infants are more prone to develop diarrhoeal diseases. Bangladesh Demographic Health Survey (BDHS) 2014 reported incidence of diarrhoeal disease (in 2 weeks before the survey) in 1-6 months and

6-11 months were 6% and 6.7% respectively. As diarrhoeal diseases are common in infants in Bangladesh, AKI due to diarrhoea with hypovolemia was common in this age group in this study.

At baseline, oedema was more common in renal group (85.2%) compared to pre renal group (34.6%) ($p<0.001$). Following 3 days of peritoneal dialysis, significant improvement was observed in oedema control in pre renal group ($p<0.001$) compared to renal group. There was a significant improvement in urine output after 24 hours, 48 hours, and 72 hours of peritoneal dialysis in both pre renal and renal group but the rate of improvement was more satisfactory in pre renal group.

In this study, baseline creatinine and urea levels were significantly higher in renal group compared to pre renal group ($p<0.05$) because the severity of disease was more in renal group as they presented with oedema, and severe acidosis. After starting peritoneal dialysis, in pre renal group, creatinine, urea, pH and bicarbonate level improved significantly in 24 hours, 48 hours, and 72 hours. In renal group, creatinine, urea significantly reduced after dialysis. The reduction was highly significant from day 0 to day 1, then day 2 and 3. pH and bicarbonate level also improved significantly after dialysis. Urea reduction ratio also increased significantly from day 1 to day 2 and then day 3 in both groups but the rate of rising was more significant in pre renal group ($p<0.001$).

Following 3 days of peritoneal dialysis, creatinine and urea levels were reduced in both groups but significantly lower in pre renal group ($p<0.001$). As the baseline creatinine and urea were higher in renal group before dialysis, these levels remained higher than pre renal group after 3 days of PD. The mean of reduction (in percentage) of creatinine and urea were significantly higher in pre-renal group after PD. Urea reduction ratio and sodium level was significantly higher in pre renal group after PD.

Li *et al*., and Mishra *et al*., conducted retrospective studies where they found blood urea and serum creatinine values decreased significantly throughout dialysis, indicating effective purification [13, 27]. Choudhary *et al*., showed in their study that there was a significant improvement in acid-base parameters (pH, bicarbonate, and lactate) and blood urea and creatinine within 24 hours of PD which continued till the end of the procedure [28]. Abdullah, in a retrospective study continued PD for 3 days and showed the efficacy of PD in terms of reducing blood urea nitrogen and serum creatinine was significant [29]. Garg *et al*., conducted a prospective, observational study to determine the efficacy and outcome of PD in AKI patients in ICU and concluded that PD is effective in slow correction of the solutes and can be used in patients with haemodynamic instability [1].

In this study, after completion of 3 days of PD, 8 patients (29.63%) required hemodialysis and 2 patients (7.4%) required further IPD in the renal group. On the other hand, in pre renal group, all patients required a single IPD without haemodialysis. Afroz *et al*., has shown that out of 441 severe AKI cases, 277 patients (62.81%) were pre renal cases. Among these pre renal cases 64% responded to IPD, only 8.3% required HD later. On the other hand, out of 86 renal cases, only 23% responded well to IPD and 77% required HD later on [5].

**Limitations of the study**

For classifying as pre renal and renal AKI urinary markers (urine sodium, urine osmolality, fractional sodium excretion, fractional urea excretion, urine/plasma urea, urine/plasma osmolality, urine/plasma creatinine) could not be done as most patients presented with anuria.

## CONCLUSION AND RECOMMENDATIONS

This results of this study revealed that Intermittent Peritoneal Dialysis is more effective in pre renal causes of AKI in children. Intermittent Peritoneal Dialysis facilities for treating infants and children should be made more available in all district-level hospitals where paediatric care facilities are available.

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**Conflicts of Interest:** There are no conflicts of interest.

**Ethical Approval:** The study was approved by the Institutional Ethics Committee.

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