

Original Research Article

A study of incidence, clinical and biochemical profile of acute kidney injury and comparison of p-rifle, akin and kdigo classification of acute kidney injury in paediatric intensive care unit of a tertiary care hospital

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ABSTRACT

Background: Acute kidney injury (AKI) is a condition characterised by decrease in kidney function, impacting kidney's ability to regulate fluid, electrolytes and acid-base homeostasis. AKI is commonly seen in children admitted in paediatric intensive care unit. The contributing factors of AKI have shifted from renal cause to multifactorial causes.

Methods: This observational study was conducted in PICU of SSG Hospital over a period of 6 months after ethics approval. 205 patients aged 1 month to 11 years were enrolled. AKI was diagnosed and staged according to P-RIFLE, AKIN and KDIGO classification. Demographic data, etiological factors, duration of stay, outcome, electrolyte imbalances were recorded. The etiological risk factors for AKI like sepsis, dehydration, shock, mechanical ventilation, nephrotoxic drug exposure, pneumonia, tetanus, viral encephalitis, road traffic accidents, head injury, snake bite and diabetic ketoacidosis were analysed.

Results: AKI was observed in 109 patients (53.17%), with highest incidence in infants (61.39%). Significant risk factors for AKI included mechanical ventilation (OR=3.1), sepsis (OR=3.9), shock (OR=7.6), and dehydration (OR=7.9). Mortality was higher in AKI patients (41.28%) compared to non-AKI patients (14.58%). P-RIFLE and KDIGO were more reliable than AKIN in diagnosing and staging AKI. Hypernatremia (20.18%) and Hyperkalemia (22.9%) were seen in patients with AKI. Ten patients needed peritoneal dialysis and rest responded to IV fluids.

Conclusion: AKI is common complication in PICU, affecting mortality and ICU stay. Early detection and electrolyte monitoring are crucial for improving patient outcomes.

Keywords: Acute kidney injury, Pediatric intensive care unit, Observational study, Etiology, Mortality, Electrolyte imbalance

INTRODUCTION

Acute kidney injury is characterized by abrupt and sustained decline in glomerular filtration rate (GFR) and inability of kidneys to regulate fluid, electrolytes and acid-base homeostasis. AKI is associated with significant mortality and morbidity, especially in critically ill children. The aetiology has changed from primary renal to multifactorial like sepsis, dehydration and nephrotoxic drug exposure particularly in hospitalized children. Some

factors such as age, sex is non-modifiable while exposure to nephrotoxic medications is controllable.

The definition of AKI has evolved rapidly since 2004 with introduction of risk, injury, failure, loss and end-stage renal disease (RIFLE), AKI network (AKIN) and kidney disease improving global outcomes (KDIGO) classifications.¹ The present study aims to find occurrence of AKI in PICU using different classification and comparison of different classifications, etiological

factors, study mortality due to AKI and electrolyte disturbances noted in AKI.

METHODS

The observational study was conducted over a period of 6 months in Department of Pediatrics, SSG Hospital Vadodara in the Pediatric Intensive Care Unit (PICU) after ethical approval on 3rd April 2024 (IECBHR/42-2024). Children aged 1 month to 11 years admitted in PICU during these 6 months were enrolled in the study. Exclusion criteria were parents refusing consent. Data on demographic details, serum creatinine values, glomerular filtration rate, urine output, sodium and potassium values were collected. Serum creatinine was measured at the time of admission and repeated 12 hourly.

Urine output monitoring 12 hourly till 7 days or till transfer to ward from PICU was done by catheterization, diaper weight or by collection in a container. Estimated Glomerular filtration rate was calculated by modified Schwartz formula. AKI was diagnosed based on P-RIFLE, AKIN and KDIGO criteria. Statistical analysis

was conducted using chi-square test and multivariate regression analysis.

RESULTS

Total 205 patients were enrolled of which 109 patients (53.17 %) had AKI in our study. The highest cases belonged to 1 month to 1 year age group with 61.39% of these patients developing AKI. Gender wise distribution of AKI cases was nearly equal with no statistically significant difference in AKI incidence between males and females. Etiological factors and their association with AKI were studied and dehydration (OR-7.97), shock (OR-7.67) have highest odds ratio, indicating a very strong association with AKI. Sepsis (OR-3.97) and mechanical Ventilation (OR-3.11) also showed a significant increased risk of AKI. Multiple etiological risk factors were present in a single patient in our study. Mortality was significantly high in patients with AKI (41.28 %) compared to 14.58 % in non-AKI patients. The median length of stay in ICU was 5.6 days in patients with AKI in our study also the shift to ward rates were less in patients with AKI.

Table 1: Acute kidney injury, age wise distribution.

Age group	No. of patients	%	AKI		non-AKI		P value
			No. of cases	%	No. of cases	%	
1 month to 1 year	101	49.27	62	61.39	39	38.61	0.0426
2-3 years	28	13.66	16	57.14	12	42.86	0.7143
4-6 years	25	12.20	13	52.00	12	48.00	0.8411
7-9 years	28	13.66	9	32.14	19	67.86	0.1701
10-11 years	23	11.22	9	39.13	14	60.87	0.5545
Total	205	100.00	109	53.17	96	46.83	0.447

Table 2: AKI-gender wise distribution.

Gender	AKI		Non-AKI		Total	P value
	Nos.	%	Nos.	%		
Male	51	48.57	54	51.43	105	0.9222
Female	58	58.00	42	42.00	100	0.1684
Total	109	53.17	96	46.83	205	0.4437

Table 3: Etiological factors in AKI positive cases.

Etiology	AKI	% out of 109 cases of AKI	Non-AKI	Total
Mechanical ventilation	100	91.7	75	175
Dehydration	42	38.5	7	49
Nephrotoxic drug	17	15.59	28	45
Shock	66	60.5	16	82
Sepsis	65	59.63	26	91
Tetanus	04	3.6	06	10
Road traffic accidents and head injury	03	2.7	07	10
Snake bite	01	0.9	00	01
Diabetic ketoacidosis	07	6.4	02	09
Pneumonia	13	11.92	25	38
Viral encephalitis	17	15.59	03	20

Table 4: Total occurrence of Aki and outcome.

AKI	Outcome			Total
	Still in ICU	Death	Shift to ward	
Yes	27 (24.77%)	45 (41.28%)	37 (33.94%)	109
No	19 (19.79%)	14 (14.58%)	63 (65.63%)	96
Total	46 (22.44%)	59 (28.78%)	100 (48.78%)	205

Table 5: P-rifle stage.

P-rifle stage	No. of cases	%
Stage 1	33	29.73
Stage 2	13	12.61
Stage 3	63	57.66
Total	109	100.00

Table 6: AKIN.

AKIN stage	No. of cases	%
Stage 1	44	44.44
Stage 2	21	21.21
Stage 3	34	34.34
Total	99	100.00

Table 7: KDIGO.

KDIGO stage	No. of cases	%
Stage 1	32	29.63
Stage 2	12	11.11
Stage 3	64	59.26
Total	108	100.00

Table 8: Intervention.

Intervention	AKI - positive	
	No. of cases	%
IV Fluids (correction)	79	72.5
Peritoneal dialysis	10	9.17
Maintenance IV fluids	20	18.34

According to P-RIFLE criteria 109 patients had AKI, 99 according to AKIN and 108 had AKI according to KDIGO criteria. 57.66 % patients were in stage 3 according to P-RIFLE criteria, 34.34 % were in stage 3 according to AKIN criteria and 59.26 % were in stage 3 according to KDIGO criteria. Thus, AKIN criteria underestimated the diagnoses and the severity staging of AKI in our study.

The maximum normalization of renal function was seen by day 2 of admission in PICU and 45.8 % showed normalisation of renal function according to P-RIFLE, 47.4 % showed normalisation according to AKIN and 45.8 % showed normalisation of renal function according to KDIGO criteria. Strongest predictors of death in patients with AKI were dehydration, sepsis and shock. There were 20.18 % patients with AKI with

hypernatremia and 11.9 % patients with AKI with hyponatremia. The percentage patients with normal sodium levels in AKI patients was 67.8 %. Hypernatremia and hyponatremia both have high death rates in AKI patients, suggesting that deviations in sodium levels might be associated with more severe outcomes in the context of AKI.

Out of the total AKI cases 22.9 % had hyperkalemia, 16.5 % patients had hypokalemia. A substantial proportion of AKI patients (60.5%) also have normal potassium levels. The strong association of hyperkalemia with severe outcomes (high ICU stay and mortality) shows the critical nature of managing potassium levels in patients with AKI. Total 109 patients had AKI and fluid deficit was corrected in 79 cases of AKI by giving correction with extra IV fluids and 20 patients were given normal

maintenance IV fluids and 10 patients (9.17 %) required peritoneal dialysis.

DISCUSSION

In our study 1 month to 1 year age group showed a significant percentage of AKI positive cases (61.39%). This finding is supported by various studies suggesting that infants are at higher risk for AKI due to immature renal physiology and a higher incidence of predisposing conditions like dehydration or infections. For instance, a study by Naik et al, found that infants and young children are more likely to experience severe AKI due to their smaller renal reserve and higher susceptibility to renal insults and the mean age of children in AKI group was 2.35 years.²

There was no significant difference in AKI among genders in our study which is similar to a study by Chisavu et al, in which they found no significant gender differences in AKI outcomes among hospitalized patients (3). From the data overall the high-risk etiological factors in this study were dehydration (OR=7.9701) and shock (OR=7.6744) have the highest odds ratios, indicating a very strong association with the risk of AKI. Sepsis (OR=3.9773), and mechanical ventilation (OR=3.111) also show a significant increased risk of AKI. Multiple etiological risk factors are present in single patient in our study. A study by Slater et al, also showed association between mechanical ventilation and AKI.⁴ In study by Krishnamurthy et al. 2013, 87 % patients with shock developed AKI.⁵ In the literature,

Sepsis prevalence, outcomes, and therapies (SPROUT) study, 6,925 patients were screened over five days and 569 were identified with severe sepsis, 391 had no/mild AKI and 102 (21%) had severe AKI.⁶ Total 205 patients were enrolled in our study, out of which 109 patients had AKI (53.17 %). Out of the total 109 cases of AKI 27 cases had more than 7 days ICU stay (24.77 %), 45 patients died (41.28%) and 37 patients were shifted to wards (33.94%). The data clearly show that AKI is associated with a significantly higher mortality rate. The higher percentage of AKI patients remaining in the ICU further reflects the severity and complications associated with AKI, requiring prolonged intensive care management. Fewer AKI patients being transferred to the ward underscores the fact that AKI patients generally have more severe illness or complications that delay recovery and transfer to wards. In a study done by Krishnamurthy et al in 2013 the incidence of AKI was 25.1 % in children admitted in PICU and mortality rate was 46.3 % in PICU admissions with AKI which is comparable to our study.⁵

The increased length of ICU stay for AKI cases may indicate that AKI often complicates the clinical picture, leading to longer recovery times. The severity of AKI and its treatment requirements may contribute to a more extended ICU stay. The longer ICU stays for AKI cases

could have implications for healthcare resource utilization. The mean duration of stay in ICU was 5.6 days in our study. In a study done by Gupta et al, 2016 mean duration of PICU stay in AKI group was 4.75 ± 1.99 days and non-AKI group had 3.75 ± 2.06 days.⁷ Total patients who had AKI according to P-rifle criteria are 109. AKIN criteria diagnose total 99 patients as having AKI in this dataset.

Maximum cases belong to stage 1 according to AKIN criteria. KDIGO diagnoses total 108 cases of AKI and 30 % cases belongs to stage 1; 11.11 % cases belong to stage 2 and maximum cases 59.26 % belongs to stage 3. In a study done by Thakkar et al 2018 according to P-rifle criteria 27.6 % in stage 1, 42.1 % in stage 2 and 48 % in stage 3 died and according to AKIN 38.5 % in stage 1, 50 % in stage 2 and 45.5 % in stage 3 died. In study by Thakkar et al.2018 as category increases mortality increases as per P-rifle staging.⁸

For all three criteria, Day 2 consistently shows the highest percentage of normalization. This indicates that the initial days are most effective for achieving normalization, and early interventions like fluid management might be critical. All criteria show a sharp decline in the percentage of normalization from day 1 to day 7. This trend implies that cases not normalized in the early days become progressively harder to normalize. There is no significant difference in the percentage of days taken for renal recovery according to the three criteria. In contrast in a study conducted by Tai et al, the rate of renal recovery in first 7 days of admission in early AKI cohort of patients was 70.4 %.⁹

The data suggest a strong association between hypernatremia and AKI. The proportion of AKI patients with hypernatremia (20.18%) is substantially higher than the proportion of non-AKI patients with hypernatremia (2.08%). The percentage patients with normal sodium levels in AKI patients is 67.8 %. In a study done by Lombardi et al, in the study population, 44,178 stayed in a normonatremic condition while in 12,783 (22.4%) a dysnatremic status occurred (hyponatremia in 8803 (15.5%), hypernatremia in 3980 (7.0%).¹⁰ The proportion of AKI patients with hypokalemia (16.5%) is higher compared to the proportion of non-AKI patients with hypokalemia (4.1%). A substantial proportion of AKI patients (60.5%) also have normal potassium levels. There is strong association of hyperkalemia with severe outcomes and mortality. In a study by Li et al serum K⁺ levels of 4.10– 5.49 mmol/l and ≥ 5.50 mmol/l were associated with a significantly increased 90-day and 1 year mortality in patients with AKI enrolled in their data set.¹¹

Total 109 patients had AKI and fluid deficit was corrected in 79 cases of AKI by giving correction with extra IV fluids and 20 patients were given normal maintenance IV fluids and 10 patients required peritoneal dialysis. In a study by Kapil et al, in their data set 59.4 %

patients required renal replacement therapy, in contrast in our data set majority patients responded to IV fluids and only 10 cases required renal replacement, indicating majority cases having volume depletion as cause for AKI.¹² In a study by Mehta et al, out of 458 patients included according to their inclusion criteria, 11 patients required dialysis which is comparable to our data set.¹³

The limitations of this study included that this data is from a single centre. There were confounding factors for outcome assessment in our study. In our study patients were studied for a duration of 7 days in PICU and outcome and recovery were not followed up after shifting them in wards.

CONCLUSION

The incidence of AKI was 53.17 % in PICU in our study with 1 month and 1 year age group contributing to maximum cases and there was no difference in gender and occurrence of AKI. P-RIFLE and KDIGO are comparable in diagnosing AKI, whereas AKIN underdiagnosed cases and severity of AKI. The highest etiological factors were dehydration, sepsis and shock and mechanical ventilation. There was 41.28 % mortality in patients with AKI and mean duration of stay was 5.6 days in AKI cases.

Highest normalisation of renal function was noted by day 2 and improvement chances worsened as days progressed. Only 10 patients needed peritoneal dialysis and rest responded to IV fluids indicating volume depleted status as cause for AKI. Thus, baseline renal function test is necessary in critically ill patients admitted in PICU to screen for AKI in critically ill children. Nephrotoxic drugs should be given only after hospital policy of documenting normal renal function test. Electrolytes should be monitored in patients with AKI. Proper fluid management is important in AKI patients.

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