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Original Research Article

Determining Prevalence and Outcome Assessment of Severe Acute Kidney Injury in Children in A Critical Care Nephrology Unit

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Abstract

Aim: The aim of the present study was to see the prevalence, etiology, clinical profile, and immediate outcome of community-acquired acute kidney injury (AKI) in a pediatric critical care nephrology setup.

Methods: This observational study was conducted over a period of 2 and half years at department of Pediatrics, AIIMS, Patna, Bihar, India. A total of 640 critically ill children with different kidney diseases along with fluid electrolytes and acid-base imbalances were admitted to the CCN and D unit during this study period. Among 640 patients, 500 were with AKI. Age ranged from 5 days to 17 years.

Results: Most (48%) of the study patients were from lower-income families, 25% were from lower middle-income families, 16% from middle-income families, and 11% from higher-income families. Among the 500 cases of AKI, 325 (65%) were pre-renal, 90 (18%) were renal, and 85 (17%) were post-renal. Overall 37% died, 48% improved and 15% had taken LAMA. Of 136 neonatal AKI, 70 died. Among 223 infants, 85 had died, between 1-year and 5-year age group 18 had died, among 62 children in older than 5 years group, 12 had died. The highest recorded mortality was found in neonates and infants. Among the neonatal AKI, neonatal sepsis was the most common cause. The overall outcome was worst and the highest mortality was seen in all cases.

Conclusion: Higher number of severe AKI was found to be associated with high mortality especially in neonates and infants in critical care nephrology setup. Post diarrheal hypovolemic AKI was the most common cause, followed by sepsis, GN, HUS, and PUVs. AKI with CCF, hypertensive crisis, severe hypernatremia, and severe metabolic acidosis needs to be managed adequately with early dialysis support.

Keywords: Acute Kidney Injury, Critically Ill-Children, Pediatric Critical Care Nephrology And Dialysis.

Introduction

Acute kidney injury (AKI) is one of the most common conditions seen in the Pediatric Intensive Care Unit (PICU) setup. Studies show that AKI is independently associated with poor outcome.[1] Much of the available data on clinical course of patients with AKI is from western literature.[2] However, incidence and risk factors of AKI in our country may be different from western

countries, so there is a need to study the most common diseases/conditions causing AKI which can help in detecting the AKI at the earliest and in developing strategies for prevention and treatment of AKI.

Acute kidney injury (AKI) is a disorder of multiple causes,with manifestations ranging from minimal increase in serum creatinine to kidney failure. It is a common complication inpatients admitted to an intensive care unit (ICU), and its incidence varies according to the population assessed and criteria used. Studies demonstrate that up to one-third of the children hospitalized[3,4] and between 5% and 89% of the children hospitalized in pediatric intensive care unit (PICU)have some degree of AKI.[5-7]

Previous studies have shown the different impacts of AKI on critically ill children. However, all have found that AKI is associated with a longer hospital stay and higher mortality.[8-10] The burden of AKI has increased in both developed and developing countries.[11] Etiological spectrum of AKI as reviewed in medical literature shows wide variation between developed and developing countries. In the developed world, AKI is usually a hospital-acquired disease, whereas in developing countries, community acquired AKI is frequently reported.[11,12] There is a lack of data regarding etiology and outcome of community-acquired AKI in children. As critically ill children with AKI have high morbidity and mortality, it is necessary to investigate prevalent causes at the regional level and to see the predictors of the worst outcome. So that we can detect patients at an early stage, and identify risk group that may benefit from prompt treatment.[2,13]

The aim of the present study was to see the prevalence, etiology, clinical profile, and immediate outcome of community-acquired acute kidney injury (AKI) in a pediatric critical care nephrology setup.

Materials And Methods

This observational study was conducted over a period of 2 and half years at department of Pediatrics, AIIMS, Patna, Bihar, India. A total of 640 critically ill children with different kidney diseases along with fluid electrolytes and acid-base imbalances were admitted to the CCN and D unit during this study period.

Among 640 patients, 500 were with AKI. Age ranged from 5 days to 17 years. The diagnosis of AKI was based on AKIN definition and classification.[13] Neonatal AKI was also categorized by KDIGO Proposed criteria for AKI.[14] AKI stage III was considered when (i) either serum creatinine ≥ 4 mg/Dl on admission or (ii) oliguria <0.3 mL/kg/h or anuria for >12 h along with raised serum creatinine >3 times from baseline normal creatinine for age. For neonate AKI stage III was considered when (i) either serum creatinine ≥ 2.5 mg/dL on admission or (ii) oliguria <0.3 mL/kg/h for 24 h or anuria for >12 h along with raised serum creatinine >3 times from baseline normal creatinine for age.[14] All AKI cases were at AKIN stage III. The etiology of AKI was divided in to pre-renal, renal and post-renal. History and clinical presentations suggestive of pre-renal cause along with blood urea to creatinine ratio >20:1 were used to categorize prerenal AKI. Similarly history, clinical presentations, biochemistry, immunological parameters suggestive of intrinsic renal cause and blood urea to creatinine ratio <20:1 was considered intrinsic renal AKI. Any history, clinical features suggestive of obstructive uropathy along with previous medical records and investigations, known case of obstructive uropathy when admitted with AKI following surgical intervention or urosepsis were considered as post-renal causes. As the majority of cases were an uric, so we could not perform fractional excretion of sodium (FE Na %). The children were analyzed regarding their cause of admission, disease

pattern, duration of hospital stay, and immediate hospital outcome. Children presented with AKI on preexisting chronic kidney disease (CKD), renal tubular disorders with comorbidities were excluded from this study.

Study procedure

At admission all patients underwent several investigations; complete blood count (CBC), arterial blood gas (ABG), serum electrolytes, serum albumin, serum creatinine, urea, serum calcium, inorganic phosphate, blood grouping, and other necessary investigations. Only children with the following were judged to require dialysis: symptomatic fluid overload such as difficult to control blood pressure and or pulmonary edema in the presence of oliguria; features of uremia manifesting as poorly controlled seizures, deterioration in level of consciousness, intractable vomiting, or bleeding from mucosal surfaces; severe hyperkalemia; severe metabolic acidosis or severe hyponatremia (serum sodium <110 mmol/L) or hypernatremia(serum sodium>170 mmol/L) not amenable to medical interventions. Serum creatinine or urea levels were not the only parameters used as the sole basis for dialysis. Intermittent hemodialysis (IHD) and sustained low-efficiency dialysis (SLED) facilities are available in CCN and D. Emergency hemodialysis was chosen for those who did not respond to intermittent peritoneal dialysis (IPD) or had rapidly progressive glomerulonephritis (RPGN). Kidney biopsy was performed in patients who had features of rapid deterioration of kidney functions over a period of days, weeks, or months and where pre-renal and post-renal causes were not present. Biopsy-proven crescentic GN were only included under crescentic GN category and other renal histopathology who had features like RPGN but histopathology did not show crescents were kept under acute GN. Shock was defined as the presence of at least two of the following: tachycardia (heart rate > 2SD for age and sex) or capillary refill time> 3 s. Hypotension was called when systolic blood pressure falls below <70+ (age in year x 2) mmHg. Hypertension was defined as >95th percentile blood pressure for age, height, and gender. Hypertensive crisis was defined as blood pressure >99th centile with convulsion. Metabolic acidosis was considered severe when pH<7.1, moderate if pH >7.1–7.2, mild pH>7.2–7.35. Duration of hospital stay was categorized as <7 days, 7–14 days, 15–30 days, and >30 days. Patients were followed up until discharge. Demographic parameters and short-term outcomes, complete recovery, leave against medical advice (LAMA) and death were recorded. Complete renal recovery in the case of AKI was defined as normal serum creatinine for age (0.2–0.4 mg/dL for infants, 0.3–0.7 mg/dL for 1–12 years, 0.5–1 mg/dL >12 years) and normal blood pressure at discharge.

Statistical analysis

Statistical analysis was performed by Statistical Package for the Social Sciences (SPSS) software program, version 23.0, chi-square test was performed to find out the predictor of poor outcome, and a value of $P < 0.05$ was considered significant.

Results

Table 1: Demographic data of study children

Age distribution	5 days to 28 days	1 month to 1 year	Older than 1 year to 5 years	Older than 5 years to 17 years
	125 (25%)	**240 (48%)**	**75 (15%)**	**75 (15%)**
Male:female	90:35	160:80	50:25	48:27
Socio economic	Lower income	Lower middle	Upper middle income	High income

status		income		
	240 (48%)	125 (25%)	80(16%)	55 (11%)
Residence	Urban	Rural	Urban Slum	
	200 (40%)	150 (30%)	150 (30%)	
Parental educational status	Illiterate	Primary level	Secondary level	Higher University secondary graduate level
	60 (12 %)	100 (20%)	125 (25%)	120 (24%) 95 (19%)

Most (48%) of the study patients were from lower-income families, 25% were from lower middle-income families, 16% from middle-income families, and 11% from higher-income families. Among the study patients 40% were urban residents, 30% rural residents, and 30% from urban slum. Regarding parental educational status it was found that 12% of the parents were illiterate but among the rest 20% primary grade, 25% secondary grade, 24% higher secondary grade, and 19% were university graduates.

Table 2: Distribution of causative diseases of the studied children

Pre-renal AKI *N* = 325 (65%)		**Renal AKI *N* = 90 (18%)**		**Post-renal AKI *N* = 85 (17%)**
Post diarrheal hypovolemic AKI	150	Acute glomerulonephritis with (AGN, other than APSGN	40	Posterior urethral valve (PUV) 65
Septicemia with AKI	110	Hemolytic uremic syndrome (HUS) Diarrhea positive (D +VE) = 3 Diarrhea negative (D-VE) = 14	20	Vesico ureteric reflux (VUR) with ureterostomy with septicemia 10
Perinatal asphyxia (PNA) with septicemia with AKI	35	AKI following Wasp envenomation	10	AKI following fulguration in PUV with urosepsis
Congenital heart disease with pneumonia/ sepsis, drugs-angiotensin converting enzyme inhibitor (ACEi)	25	Crescentic Glomerulonephritis (CrGN)	08	Prune belly syndrome (PBS) 03
Frequently relapsing nephrotic syndrome (FRNS) with hypovolemic shock with septicemia	05	Henoch Schonlein purpura with nephritis (HSPN)	04	
		Lupus nephritis (LN) Class IV	03	
		AKI with dysplastic kidney	02	
		Poly cystic kidney	02	

		diseases (PCKD)		
		Acute post streptococcal glomerulonephritis (APSGN)	01	

Among the 500 cases of AKI, 325 (65%) were pre-renal, 90 (18%) were renal, and 85 (17%) were post-renal.

Table 3: AKI outcome of different age groups

Age groups	Total no.	Improved	LAMA	Death
0–28 days	136	44	22	70
>28 days–1 year	223	110	28	85
>1 year–5 year	79	46	15	18
>5 year–18 year	62	40	10	12
Total	500	240 (48%)	75 (15%)	185 (37%)

Overall 37% died, 48% improved and 15% had taken LAMA. Of 136 neonatal AKI, 70 died. Among 223 infants, 85 had died, between 1-year and 5-year age group 18 had died, among 62 children in older than 5 years group, 12 had died. The highest recorded mortality was found in neonates and infants.

Table 4: Causes of neonatal AKI and outcome

Disease pattern	Total no.	Improved (44)	LAMA (22)	Death (70)
Neonatal sepsis	50	12	8	32
PUV	32	20	3	14
PNA	28	9	7	9
Congenital heart disease with pneumonia, ACEi, sepsis	26	3	4	15
Total	136	44	22	70

Among the neonatal AKI, neonatal sepsis was the most common cause. The overall outcome was worst and the highest mortality was seen in all cases.

Discussion

In this series pre-renal (65%) cause of AKI was higher; post diarrheal hypovolemic AKI and sepsis were most common. A higher rate of death was found in pre and post-renal cases of AKI. Among renal causes, RPGN and HUS were the most common. Most renal causes of AKI needed dialysis. Crescentic GN was found in seven cases and in rest of the RPGN biopsy was suggestive of other renal histopathology. PNA, congenital heart diseases were commonly found in neonatal AKI. PUV was the most common post-renal cause of AKI. A study of AKI in Bangladeshi children showed similar results of 63% pre-renal AKI mostly diarrheal, higher rate of mortality was found in infants with AKI. HUS, wasp envenomation, and AGN were the common renal cause of AKI in the previous study.[15]

In many studies, HUS was found as the major renal cause of AKI in children,[15] but in this study RPGN was higher. Most probably in critical care setup severe hypertensive crisis and associated comorbidities, need for ICU all were important factors for higher number of RPGN in this study. There was a significant trend of higher mortality with higher AKI stage. Young age was associated with higher mortality rate in children with severe AKI in keeping

consistency with previous reports.[15,17] The reasons for this finding are not known but may be related to the relatively high prevalence of sepsis in younger children and hemodynamic instability.

Most of the children with AKI had more than one indication for dialysis, which might be one of the important causes of increased risk of death. CCF, hypertensive emergency, severe hypernatremia, severe metabolic acidosis had significant ($P < 0.001$) association with poor outcomes. In contrast, other features of AKI such as shock, hypovolemia, hypokalemia, hyperkalemia, and hyponatremia were not significantly associated with in-hospital mortality. In the published literature, these features have also been inconsistently associated with mortality.[18] Tresa et al.[19] showed GN and obstructive stone disease as the major bulk of pediatric AKI in Pakistan as stone disease is more prevalent there, which is completely opposite to this study. The epidemiology of AKI has changed due to therapeutic advances and a growing trend to present secondary to other pathologies.[20] Patients undergoing cardiac surgery are at high risk of AKI.[21]

But in this study, no AKI patients were admitted after cardiac surgery although in this children's hospital regular cardiac surgeries are conducted, possibly due to standard postsurgical management in the cardiac intensive care unit at this hospital. Severe sepsis and septic shock are risk factors for AKI.[21] Flynn JT also reported post-operative sepsis as a predominant cause of AKI in pediatric population.[22]

Conclusion

Higher number of severe AKI was found to be associated with high mortality especially in neonates and infants in critical care nephrology setup. Post diarrheal hypovolemic AKI was the most common cause, followed by sepsis, GN, HUS, and PUVs. AKI with CCF, hypertensive crisis, severe hypernatremia, and severe metabolic acidosis needs to be managed adequately with early dialysis support. Longer hospital stay and need for dialysis and mechanical ventilation predicted an adverse outcome. Pre-renal AKI is mostly showed complete renal recovery as compared with renal cause.

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