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# A Study of Acute Kidney Injury in Children at Sohag University Hospital

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## ABSTRACT

**Background:** Acute Kidney Injury (AKI) is a prevalent and critical illness in pediatric patients, marked by an abrupt deterioration in kidney function, resulting in the buildup of waste products, electrolyte disturbances, and disruption of fluid balance. AKI is associated with significant morbidity and mortality, especially in pediatric populations. Despite its importance, there is limited data on the spectrum, etiology, and outcomes of AKI in children in Upper Egypt.
**Objective:** This study aimed to investigate the demographics, causes, clinical features, and outcomes of AKI in children admitted to Sohag University Hospital.
**Methods:** A combined retrospective and prospective cohort study was conducted at Sohag University Hospital-Pediatric Department from January 2022 to December 2022. The study included 150 children aged between 1 month and 16 years who were diagnosed with AKI based on the KDIGO criteria. Data were collected about patients' demographics, clinical presentation, laboratory findings, fluid status, and outcomes.
**Results:** About half of AKI cases (50.7%) occurred in children under one year of age. About 67 (44.7%) of patients were males, while 83 (55.3%) were females. The primary causes of AKI were pre-renal causes (78%), with gastroenteritis and dehydration being the most common (45.3%). Intrinsic renal causes accounted for 19.3% of cases, with hemolytic uremic syndrome (HUS) and pyelonephritis being prevalent and about 3.4% glomerulonephritis. Post-renal causes were observed in 2.7% of cases. The study found that 23.3% of patients were hypertensive at admission, and 10.7% were hypotensive. Anemia was present in 68.7% of cases, thrombocytopenia in 23.3%, and leukocytosis in 62%, with three cases of survivors developing chronic kidney disease (CKD). **Conclusions:** AKI is a significant contributor to pediatric morbidity in Sohag University Hospital, with pre-renal causes being the most common.
**Keywords:** Acute kidney injury, Children, Sohag University Hospital, Pediatric Nephrology, Renal failure, Egypt.

## INTRODUCTION

AKI is a critical and swiftly progressing medical disorder marked by a sudden deterioration in Kidney function, resulting in the buildup of metabolic waste, disruption of fluid and electrolyte homeostasis, and possible life-threatening complications. This condition is particularly concerning in pediatric populations, where it contributes substantially to morbidity and mortality. AKI is a clinical condition that results from a number of underlying pathologies rather than an illness in and of itself, each with its own etiological and pathophysiological mechanisms [(1)].

The prevalence of AKI in children varies worldwide, largely depending on the geographical location, healthcare infrastructure, and population characteristics. In developed countries, the incidence of pediatric AKI in hospitalized patients ranges between 2% to 9%, with a significantly higher incidence in critically ill children admitted to intensive care units (ICUs). However, in resource-limited settings like Egypt, data on the incidence and outcomes of pediatric AKI are sparse. Most of the available studies are either hospital-based or focused on specific subgroups, leaving a gap in the comprehensive understanding of AKI's burden on the pediatric population [(2)].

In Egypt, the incidence of AKI among children is particularly concerning, given the high prevalence of conditions such as dehydration, sepsis, and other infectious diseases, which are prominent contributors to AKI. Additionally, socioeconomic factors, limited access to healthcare, and delayed presentation to medical facilities exacerbate the severity of AKI in children. In Sohag Governorate, these issues are compounded by the rural nature of the area, where healthcare resources are often scarce, and awareness of early symptoms of kidney dysfunction is low [(3)].

The etiological factors of AKI in children are broadly categorized into prerenal, intrinsic renal, and postrenal causes. Prerenal causes, accounting for most pediatric AKI cases, are often related to conditions that impair renal perfusion without causing direct damage to the renal parenchyma. Common prerenal causes include dehydration due to acute gastroenteritis (AGE) and sepsis [(4)]. Intrinsic renal causes, such as acute tubular necrosis (ATN), HUS, and acute glomerulonephritis, involve direct damage to the kidney tissue. Postrenal AKI, which is less common, results from a blockage in the urinary tract that impedes the passage of urine [(5)].

Management of AKI in pediatric patients include treating the underlying etiology, sustaining kidney function, and avoiding or managing complications such as fluid overload, electrolyte disturbances, and uremia. Despite advances in medical care, AKI remains a condition with significant short- and long-term consequences, particularly when not promptly recognized and treated. Children who survive an episode of AKI are at risk for developing CKD, with potential progression to end-stage renal disease (ESRD), necessitating long-term dialysis or kidney transplantation [(6)].

This study aimed to fill the existing knowledge gap by investigating the incidence, etiology, clinical presentation, and outcomes of AKI in children admitted to Sohag University Hospital. By identifying the key risk factors and the most common causes of AKI in this



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population, the study seeks to provide insights that could guide preventive strategies and improve the management of AKI in pediatric patients. Moreover, understanding the local epidemiology of AKI will aid in the development of context-specific clinical guidelines and policies that address the unique challenges faced in resource-limited settings.

Given the burden of AKI on pediatric patients, especially in regions like Sohag, it is crucial to conduct studies that not only document the incidence and outcomes but also explore the socio-economic and healthcare factors that contribute to delays in diagnosis and treatment. This study was, therefore, an essential step towards improving pediatric kidney care in Sohag and similar settings, ultimately aiming to reduce the morbidity and mortality associated with AKI in children.

## MATERIAL AND METHODS

This study was a combined retrospective and prospective cohort study conducted at the Pediatric Department of Sohag University Hospital, a tertiary care center in southern Egypt. The study aimed to investigate the incidence, etiology, clinical characteristics, and outcomes of AKI in children. The study was carried out over a one-year period from January 2022 to December 2022.

The study included pediatric patients aged from one month to 16 years who were diagnosed with AKI either upon admission or during their stay at the hospital. AKI was diagnosed according to the KDIGO criteria, which stipulate an elevation in serum creatinine of > 0.3 mg/dL within 48 hours, an increase in serum creatinine to ≥ 1.5 times the baseline within the preceding seven days, or a urine output of < 0.5 mL/kg/h for 6 hours. The baseline creatinine levels were determined using either the lowest serum creatinine value recorded in the past three months or normal age-specific reference ranges when previous values were unavailable.

**Inclusion criteria:** Pediatric patients aged 1 month to 16 years. Patients with a diagnosis of AKI based on the KDIGO criteria. Both male and female patients were included.

**Exclusion criteria:** Patients with irregular follow-up. Patients with incomplete medical records. Patients whose legal guardians declined to participate in the trial.

For the retrospective part of the study, data were extracted from patient medical records, including demographic information, clinical presentation, laboratory results, and imaging findings. For the prospective part, patients underwent a detailed clinical evaluation, including a complete medical history and physical examination. Data collected included the following:

- **Demographics:** Age, sex, and residence.
- **Clinical history:** Previous medical history, perinatal history, nutritional status, family history of renal diseases, and medication history.
- **Physical examination:** Assessment of fluid status, vital signs, anthropometric measurements, and detailed systemic examination.
- **Laboratory investigations:** These included complete blood count, renal function tests, serum electrolytes, blood gases, and urine analysis. Specific tests were conducted as needed to identify underlying etiologies, such as renal ultrasound for structural abnormalities.

**AKI was staged according to the KDIGO criteria:**

- **Stage 1:** Increase in serum creatinine to 1.5–1.9 times baseline or by ≥ 0.3 mg/dL, or urine output < 0.5 mL/kg/h for 6–12 hours.
- **Stage 2:** Increase in serum creatinine to 2.0–2.9 times baseline, or urine output < 0.5 mL/kg/h for ≥ 12hours.
- **Stage 3:** Increase in serum creatinine to ≥ 3.0 times baseline or to ≥ 4.0 mg/dL, initiation of renal replacement therapy, or urine output < 0.3 mL/kg/h for ≥24 hours or anuria for ≥ 12hours.

**Ethical consideration: Approval was obtained from Sohag Faculty of Medicine Research Ethics Committee before study onset. For the prospective part of the study, informed written consents were obtained from patients' legal guardians for participation in the research. Because the review was retroactive, the informed consent requirement was not applicable to participants. Every patient's data were handled in accordance with ethical standards, fully respecting their anonymity and privacy. The study adhered to the Helsinki Declaration throughout its execution.**

### *Statistical analysis*

IBM SPSS software package version 20.0 was used to examine the data that was input into the computer. Numbers and percentages were used to describe the qualitative data. Range (minimum and maximum), mean ± SD, median, and interquartile range (IQR) were used to characterize quantitative data. Frequencies and percentages were used to display categorical variables. Based on the data distribution, relevant statistical tests were used to compare the groups. A p-value ≤ 0.05 was deemed statistically significant.

## RESULTS

About half of AKI cases (50.7%) occurred in children below 1 year of age. Children aged 6 to 12 years represented 26.7% of the cases, followed by those between 1 and 6 years (20%), and only 2.7% were older than 12 years. There were 67 (44.7%) males, and 83 (55.3%) females. As regards weight, about 63% of patients were between the $5^{th}$ and $90^{th}$ centiles, the median weight was 8.95 (IQR 5.20-22) and about 85% of patients height were between the $5^{th}$ and $90^{th}$ centiles, the median of height/length was 72.5 (IQR 63.0-117.0) (Table 1).

**Table (1):** Clinico-demographic data of the studied cases (n=150)

| | Patient's data | Studied cases N=150 | % |
|---|---|---|---|
| **Sex** | Male | 67 | 44.7 |
| | Female | 83 | 55.3 |
| **Age (years)** | <1 year | 76 | 50.7 |
| | 1-<6 year | 30 | 20 |
| | 6-12 year | 40 | 26.7 |
| | >12 year | 4 | 2.7 |
| | **Range** | 0.09-15 | |
| | **Median** | 0.9 | |
| | **IQR** | 0.4-7 | |
| **Weight (kg)** | **Median** | 8.95 | |
| | **IQR** | 5.20-22 | |
| **Height (cm)** | **Median** | 72.5 | |
| | **IQR** | 63.0-117.0 | |

The association between age group and KIDGO staging in this study we found that most patients 59 (39.9%) below 1 year was in stage 1 (Table 2).

**Table (2):** Association between age group and KIDGO staging

| Age group | <1yr N=76 | 1-<6yr N=30 | 6-12yr N=40 | >12yr N=4 |
|---|---|---|---|---|
| **Stage 1** | 59<br>39.9% | 23<br>15.3% | 25<br>16.7% | 4<br>2.7% |
| **Stage 2** | 5<br>3.3% | 0<br>0% | 5<br>3.3% | 0<br>0% |
| **Stage 3** | 12<br>8% | 7<br>4.7% | 10<br>6.7% | 0<br>0% |

The most common clinical presentations found in studied patients were vomiting (77.3%), poor oral feeding (67.3%), and diarrhea (47.3%). Other symptoms included pallor (25.3%), convulsions (22.7%), and abdominal pain (20.7%), oliguria (24%), anuria (18.7%), polyuria (7.3%) and (40%) of the patients presented with severe dehydration, (26%) with moderate dehydration, and (18%) were fluid overloaded. Hypertension was observed in 23.3% of the patients, while 10.7% were hypotensive (Table 3 and figure 1).

**Table (3):** Clinical presentation of the studied cases (n=150)

| Clinical presentation | Studied cases (N=150) | % |
|---|---|---|
| Vomiting | 116 | 77.3 |
| Dehydration | 105 | 70 |
| Poor oral feeding | 101 | 67.3 |
| Diarrhea | 71 | 47.3 |
| Pallor | 38 | 25.3 |
| Oliguria | 36 | 24 |
| Hypertension | 35 | 23.3 |
| Convulsion | 34 | 22.7 |
| Abdominal pain | 31 | 20.7 |
| Anuria | 28 | 18.7 |
| Overload | 27 | 18 |
| Fever | 20 | 13.3 |
| Hypotension | 16 | 10.7 |
| Difficult breathing | 14 | 9.3 |
| Dark urine | 13 | 8.7 |
| Acidotic breathing | 11 | 7.3 |
| Polyuria | 11 | 7.3 |

The prerenal AKI in this study was found in 78% of our patients, mostly caused by GE and dehydration in 45.3%, while 19.3% had renal AKI, and 2.7% had post-renal AKI (Table 4).

**Table (4):** Causes of AKI in studied cases (n=150)

| **Causes of AKI** | | **N=150** | **%** |
|---|---|---|---|
| **Prerenal AKI** | Gastroenteritis | 68 | 45.3 |
| | Diabetic ketoacidosis | 26 | 17.3 |
| | Sepsis | 16 | 10.7 |
| | Nephrotic syndrome | 2 | 1.3 |
| | Cardiogenic shock | 2 | 1.3 |
| | Bartter syndrome | 2 | 1.3 |
| | Multi organ failure | 1 | 0.7 |
| **Renal AKI** | Hemolytic uremic syndrome | 10 | 6.7 |
| | Pyelonephritis | 11 | 7.3 |
| | glomerulonephritis | 5 | 3.4 |
| | Lupus nephritis | 1 | 0.7 |
| | Hypoxia | 1 | 0.7 |
| | Acute interstitial nephritis | 1 | 0.7 |
| **Post renal AKI** | Bilateral ureteric stones | 2 | 1.3 |
| | Vesicoureteral reflux | 1 | 0.7 |
| | Neurogenic bladder | 1 | 0.7 |

The serum creatinine levels on admission ranged from 1 to 13.5 mg/dl, with a median of 1.9 mg/dl (Table 5). Respiratory support was needed for 83 (55.3%) of studied patients as 61 (40.7%) of them needed nasal oxygen and 22 (14.6%) of them needed mechanical ventilation (MV) with a mortality rate 12.7% in ventilated patients. About twelve patients required hemodialysis, primarily. The indications for dialysis in our patients were due to volume overload with anuria in 7 patients, uremic manifestations in 4 patients, and uncontrolled hyperkalemia in 1 patient. The most common etiology of AKI in patients who needed dialysis was HUS in 7 cases.

**Table (5):** Assessment of kidney function on admission

| **Serum creatinine** | **Range** | 1-13.5 |
|---|---|---|
| | **Median** | 1.9 |
| **Initial GFR** | **<15** | N=49 |
| | **15- <30** | N=60 |
| | **30- <45** | N=25 |
| | **45- <60** | N=10 |
| | **60-90** | N=6 |

As regards serum Na level and fluid status on admission, 96.3% of patients with volume overload had hyponatremia, 73.3% of patients with severe dehydration had hypernatremia, and most of patients with moderate dehydration had normal serum Na level with highly statistically significant association (p <0.001) (Table 6).

**Table (6):** Relation between fluid status and Na level on admission (n=150)

| **Fluid status at presentation** | | **Na status (mEq/l)** | | | **P value** |
|---|---|---|---|---|---|
| | | **Hyponatremia** | **Normal** | **Hypernatremia** | |
| **Normal** | **Count** | 0 | 18 | 0 | <0.001 |
| | **%** | 0.0% | 100% | 0.0% | |
| **Mild dehydration** | **Count** | 0 | 6 | 0 | |
| | **%** | 0.0% | 100% | 0.0% | |
| **Moderate dehydration** | **Count** | 0 | 34 | 5 | |
| | **%** | 0.0% | 87.2% | 12.8% | |
| **Severe dehydration** | **Count** | 0 | 16 | 44 | |
| | **%** | 0.0% | 26.7% | 73.3% | |
| **Overload** | **Count** | 26 | 1 | 0 | |
| | **%** | 96.3% | 3.7% | 0.0% | |

In our study the patients with high initial GFR had a better fate than those with low GFR, as shown in table (5), with a high statistical significance (p <0.001) (Table 7).

**Table (7):** Relation between initial GFR and fate in studied cases (n=150)

| Initial GFR | N=150 | % | Fate | No. | % |
|---|---|---|---|---|---|
| **<15** | 49 | 32.7 | Improvement<br>CKD<br>Death | 24<br>3<br>22 | 16<br>2<br>14.7 |
| **15- <30** | 60 | 40 | Improvement<br>CKD<br>Death | 45<br>0<br>15 | 30<br>0<br>10 |
| **30- <45** | 25 | 16.7 | Improvement<br>CKD<br>Death | 20<br>0<br>5 | 13.3<br>0<br>3.3 |
| **45- <60** | 10 | 6.7 | Improvement<br>CKD<br>Death | 9<br>0<br>1 | 6<br>0<br>0.7 |
| **60-90** | 6 | 4 | Improvement<br>CKD<br>Death | 6<br>0<br>0 | 4<br>0<br>0 |
| **Range** | 2.96 – 76.50 | | | | |
| **Mean ± SD.** | 23.41 ± 15.64 | | | | |
| **Median (IQR)** | 18.32(12.55 – 30.60) | | | | |
| **P value** | <0.001 | | | | |

According to KIDGO staging of AKI in this study, there was a statistically significant association between KIDGO staging and fate (p <0.02), with most patients (73.8%) in stage 1 were improved (Table 8 & figure 2)).

**Table (8):** Relation between KIDGO staging and fate in studied cases (n=150)

| Stages of KIDGO | | Fate | | | | P value |
|---|---|---|---|---|---|---|
| | | Improvement | CKD | Death | Total N. | |
| **Stage 1** | **Count** | 82 | 1 | 28 | 111 | 0.02 |
| | % | 73.8% | 0.9% | 25.2% | 74% | |
| **Stage 2** | **Count** | 6 | 0 | 4 | 10 | |
| | % | 60% | 0% | 40% | 6.7% | |
| **Stage 3** | **Count** | 16 | 2 | 11 | 29 | |
| | % | 55.2% | 6.9% | 37.9% | 19.3% | |
| **Total %** | % | 70% | 1.3% | 28.7% | 100% | |

Figure (3) showed that morbidity and mortality about 69.3% of studied cases were improved, 2% progressed to CKD, and 28.7% died. The causes of death in our patients were septic shock in 24 patients, hemorrhage and hypovolemic shock in 4 -patients, heart failure in 4 patients, sever pneumonia in 5 patients, sever metabolic acidosis in 3 patients, HIE in 1 patient, anaphylactic shock in 1 patient, CNS infection in 1 patient. The causes of CKD in our patients were HUS, neurogenic bladder and VUR.

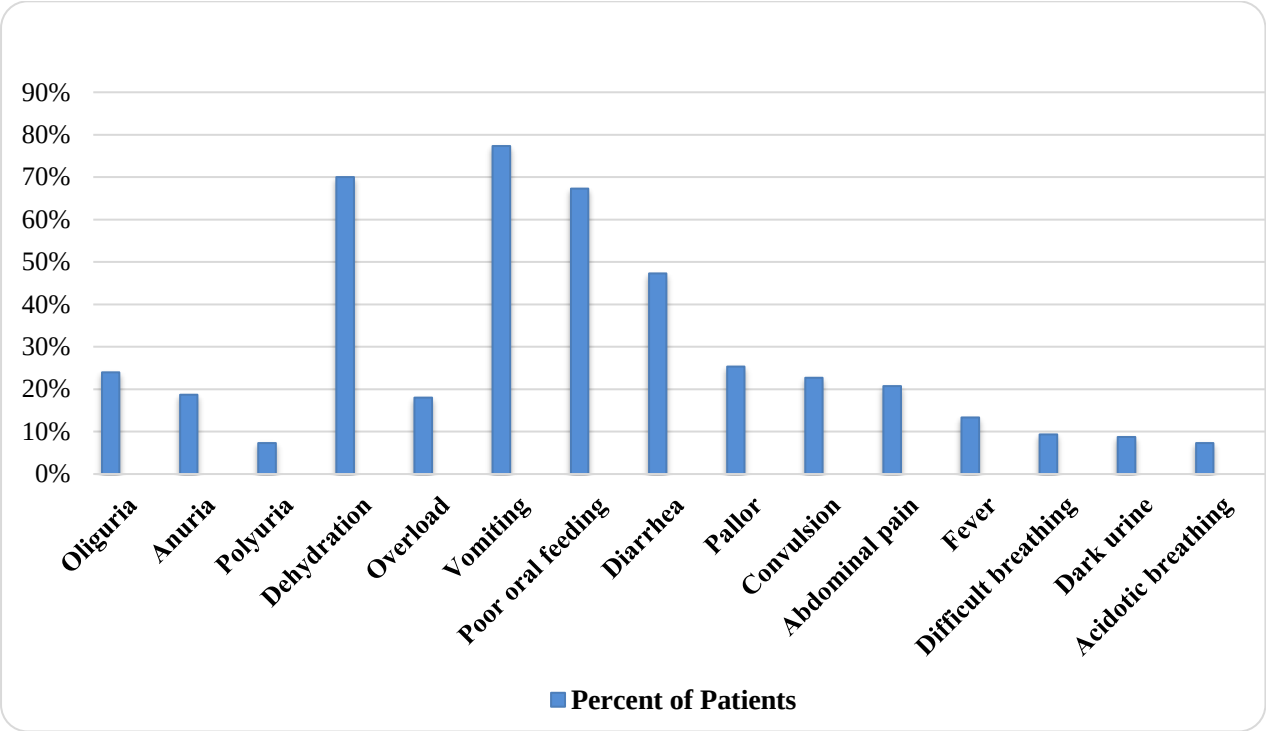


**Figure (1):** Clinical presentation of the studied cases.

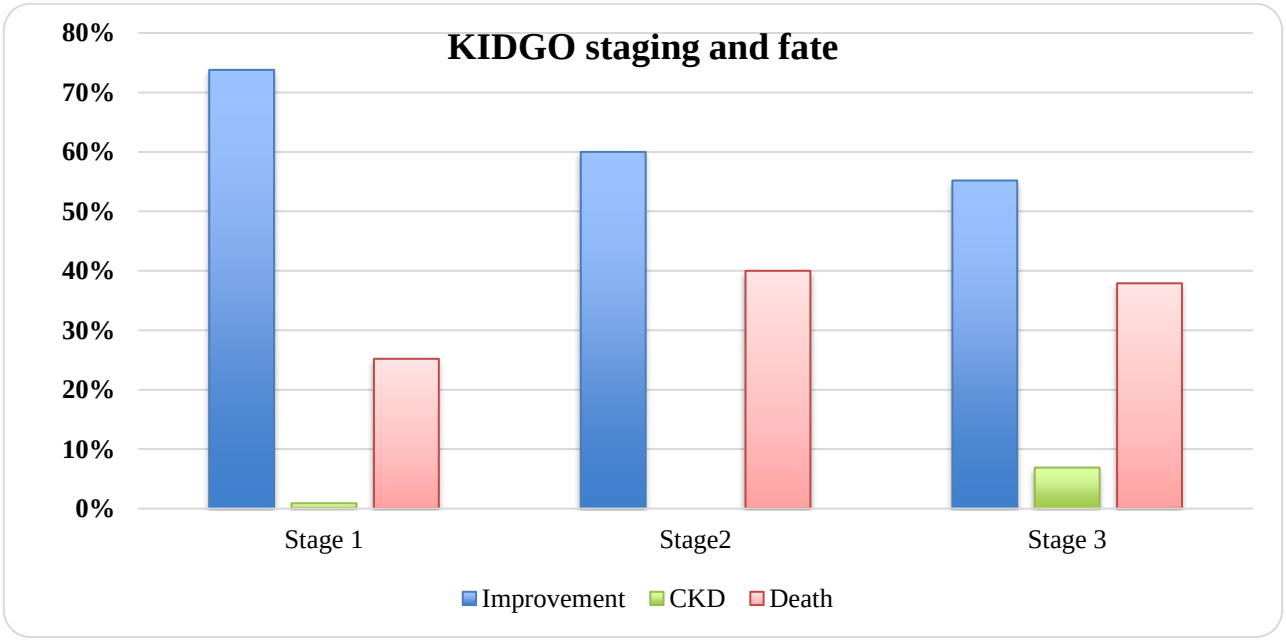


**Figure (2):** Relation between KIDGO staging and fate in studied cases.

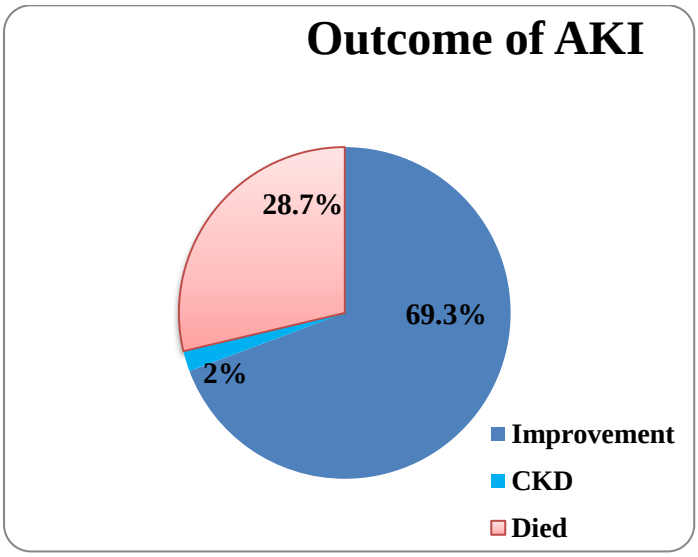


**Figure (3):** Outcome of AKI of the studied cases.

## DISCUSSION

This study aimed to investigate the demographics, etiology, clinical characteristics, causes, and outcomes of AKI in children at Sohag University Hospital's Pediatric Department. A combined retrospective and prospective cohort study was conducted, including 150 pediatric patients who either presented with AKI or developed it during their hospital stay. The median age of the patients in this study was 0.9 years (IQR 0.4–7), with an age range from 0.09 to 15 years. There was a slight female predominance, with 67 males (44.7%) and 83 females (55.3%), resulting in a male-to-female ratio of 0.8:1. The most affected age group was infants below 1 year, accounting for 50.7% of cases, followed by children aged 6-12 years (26.7%), 1-6 years (20%), and those above 12 years (2.7%). These findings differ from a study conducted in Eastern India in 2022, where a male predominance was noted, with a male-to-female ratio of 1.7:1. In that study, the most common age group was 5-15 years, which accounted for 46.9% of cases [(7)]. A similar pattern of male predominance was reported in a study in Pakistan, where the mean age was 7.5 years [(8)].

In this study, AKI was most classified as stage 1 across all age groups, with 77.6% of infants under 1 year, 76.7% of children aged 1-6 years, 62.5% of those aged 6-12 years, and all patients above 12 years falling into this category. These results are consistent with earlier studies conducted between 2012 and 2013, which reported a higher incidence of AKI in younger children, particularly those under 6 years of age [(9, 10)].

The median height and weight of the studied children were 72.5 cm (IQR 63.0-117.0) and 8.95 kg (IQR 5.20-22) respectively. These findings align with a 2023 study in Eastern India, which reported a median weight of 16 kg and a median height of 106.5 cm among AKI patients [(11)]. While, another study found a mean weight of 7.8 kg among patients, highlighting variations in patient populations across different regions [(12)].

The most common clinical manifestations in this cohort were vomiting (77.3%), diarrhea (47.3%), pallor (25.3%), convulsions (22.7%), and abdominal pain (20.7%), with gastroenteritis (GE) being the most prevalent underlying cause. These results differ from a study in Nigeria, where fever, vomiting, and convulsions were the predominant symptoms, and post-infectious glomerulonephritis (PIGN) and obstructive urolithiasis were the leading etiologies [(13)]. Similarly, a study in Eastern India revealed that the most prevalent symptoms were fever and shortness of breath, with GE and sepsis as the primary causes [(7)].

Regarding fluid status, severe dehydration was observed in 40% of patients, moderate dehydration in 26%, and mild dehydration in 4%, while 18% had fluid overload and 12% were euvolemic. These findings contrast with the results of a study in Eastern India, where fluid overload and shock were more prevalent [(7)].

In terms of AKI classification, prerenal causes were predominant in this study, accounting for 78% of cases, with gastroenteritis of 45.3%, diabetic ketoacidosis of 17.3%, and sepsis of 10.7% were the most common underlying conditions. Renal AKI was observed in 19.3% of patients, primarily due to pyelonephritis (7.3%) and HUS (6.7%), while postrenal AKI was rare (2.7%). These results are in line with other study that has reported prerenal causes as the leading contributors to AKI in pediatric populations [(1)].

The mean serum creatinine level on admission was 2.65 ± 2.26 mg/dl, with a range of 1.0–13.50 mg/dl. These findings are consistent with a study in Eastern India, where the mean serum creatinine level was 2.19 ± 1.43 mg/dl [(12)]. Urine output (UOP) on admission was normal in 50% of patients, oliguria in 24%, anuria in 18.7%, and polyuria in 7.3%, differing from a Nigerian study where oliguric patients constituted the highest percentage [(13)].

Blood pressure assessments revealed that 23.3% of patients were hypertensive and 10.7% were hypotensive. These findings are consistent with findings from an Indian study [(6)]. Hemodialysis was required in 8% of cases, a significantly lower percentage compared to other studies, such as one in India, which reported that 36.8% of AKI patients required hemodialysis [(1)].

In terms of laboratory findings, anemia was present in 68.7% of patients, leukocytosis in 62%, and thrombocytopenia in 23.3%. These results are comparable to those from other studies, such as one in Eastern India, where similar hematological abnormalities were reported [(11, 12)]. Additionally, hypernatremia and hyperkalemia were observed in 33.3% and 37.7% of patients respectively, which is consistent with previous studies that reported similar electrolyte disturbances in AKI patients.

Metabolic acidosis was present in 66.7% of patients, with diabetic ketoacidosis being the most severe form. This is comparable to findings from studies in Eastern India and Nigeria, which also reported a high prevalence of metabolic acidosis among AKI patients [(11, 13)].

In summary, the outcomes of this study revealed

a significant burden of AKI among pediatric patients at Sohag University Hospital, with a substantial mortality rate of 28.7%. The findings underscore the critical need for early identification and management of prerenal causes, particularly gastroenteritis and dehydration, to prevent the progression to AKI. The study also highlighted the importance of continuous monitoring and supportive care, especially in cases of severe AKI, to improve patient outcomes. Further research is warranted to explore targeted interventions that could reduce the high mortality and morbidity associated with pediatric AKI.

## CONCLUSION

This study provided valuable insights into the prevalence, etiology, and outcomes of AKI in children admitted to Sohag University Hospital. The findings underscored the critical need for early recognition and prompt management of AKI to mitigate adverse outcomes. Moreover, the study highlighted the importance of improving diagnostic and therapeutic strategies to enhance pediatric renal care. Further research is recommended to explore the long-term effects of AKI in children and to develop targeted interventions aimed at reducing its incidence and improving patient prognosis.

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