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ORIGINAL ARTICLE

Electrolyte Imbalances in Cholera: Focusing on Hypokalemic Patterns and Renal Complications

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ABSTRACT

Background: Cholera causes severe diarrhea, which may precipitate hypokalemia, dysnatremia, and acute kidney injury. This study aimed to evaluate the incidence, severity, and associated clinical factors of cholera-related electrolyte disturbances, focusing on hypokalemia and renal complications.

Methods: This prospective, multicenter, hospital-based observational study included 166 patients with *Vibrio cholerae* infection, aged 15–80 years, admitted to Azadi and Kirkuk General hospitals in Iraq between April and October 2022. The study included 67 females and 99 males. Medical history was obtained from all patients. Among the 154 patients with hypokalemia, diarrhea was categorized as mild in 61 patients (39.6%), moderate in 65 (42.2%), and severe in 28 (18.2%). Twelve patients had normal serum potassium levels and were not included in the hypokalemia-specific analyses. Serum potassium, sodium, and chloride levels were measured. Hypokalemia was defined as mild (3.0–3.5 mmol/L), moderate (2.5–3.0 mmol/L), or severe (<2.5 mmol/L). Acute kidney injury was diagnosed according to the KDIGO guideline.

Results: Among patients with hypokalemia, 50 (32.5%) had mild, 34 (22.1%) had moderate, and 70 (45.5%) had severe hypokalemia. Severe hypokalemia was observed in 17 of 28 diabetic patients (60.7%) and represented the largest hypokalemia category among hypertensive patients, occurring in 25 of 58 patients (43.1%). Moderate hypokalemia was present in 11 of 26 patients with kidney stones (42.3%), while mild and moderate hypokalemia were each observed in 4 of 11 patients with chronic kidney disease (36.4% each). Diarrhea severity and vomiting were significantly associated with hypokalemia severity. Acute kidney injury developed in 21 patients (12.7%), and 11 patients (6.6%) required hemodialysis. Six deaths were recorded, corresponding to a mortality rate of 3.6%.

Conclusion: Cholera was associated with clinically important electrolyte disturbances, particularly hypokalemia. Hypokalemia severity was related to diarrhea severity, vomiting status, and lower serum sodium and chloride levels. Early electrolyte correction and renal monitoring are important in hospitalized cholera patients.

Key words: Cholera; *Vibrio cholerae*; Hypokalemia; Electrolyte imbalance; Acute kidney injury; Dehydration.

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INTRODUCTION

Cholera is an acute watery diarrheal disease caused by the bacterium *Vibrio cholerae* and has long been recognized as a life-threatening infection with pandemic potential [1]. Estimating the global burden of cholera is challenging because many cases go unreported; however, epidemiological studies suggest that between 1.3 million and 4.0 million cases occur annually, resulting in approximately 21 000 to 143 000 deaths worldwide [2, 3].

Most cholera cases and deaths occur in endemic regions of Asia, Africa, and Latin America, with Africa remaining particularly vulnerable because of climate change, extreme weather events, fragile health systems, and recurrent outbreaks [2, 4]. Deaths from acute diarrhea are largely attributable to severe dehydration and the resultant electrolyte imbalances [3]. Laboratory findings in cholera patients frequently reveal hypokalemia, hypocalcemia, and metabolic acidosis [3, 5].

The clinical and biochemical manifestations range from mild dehydration to severe electrolyte disturbances, including hyponatremia, hypernatremia, hypokalemia, hypocalcemia, and metabolic acidosis [3].

Cholera-associated fluid loss can precipitate acute kidney injury (AKI). Dehydration and infection-related tubular injury reduce renal function and exacerbate electrolyte imbalances because the kidneys are essential for maintaining sodium and potassium homeostasis [5, 6]. In outbreak studies, hypokalemia is among the most prevalent electrolyte abnormalities [5].

Recent join-point analyses show that cholera mortality declined among males and remained stable among females worldwide but increased substantially in the African region between 1990 and 2019 [7]. Country-specific data illustrate the ongoing public-health challenge; for example, Cameroon experienced four cholera epidemics between 2018 and 2023, with an overall case-fatality rate of 2.7% and the highest mortality among individuals over 65 years of age [8].

The present study aimed to evaluate the incidence, severity, and associated clinical factors of cholera-related electrolyte disturbances, focusing on hypokalemia and renal complications.

MATERIALS AND METHODS

Study design, setting, and participants

This prospective, multicenter, hospital-based observational study enrolled 166 patients with confirmed *Vibrio cholerae* infection, with or without acute kidney injury (AKI). The study included 67 females and 99 males, aged 15–80 years. Patients were recruited from Azadi Teaching Hospital and Kirkuk General Hospital in Kirkuk city, Iraq, between 25 April and 1 October 2022. Ethical approval was obtained from the Ethics Committee of the College of Medicine, University of Kirkuk (No. 43, dated 31 May 2021).

Microbiological diagnosis of *Vibrio cholerae*

Stool samples were collected from all 166 patients with watery diarrhea and placed in sterile universal bottles containing Cary–Blair transport medium. Samples were delivered to the laboratories of the participating hospitals within 8 h. Collection and processing were performed according to WHO guidance for the detection of *V. cholerae*.

For enrichment, stool samples were inoculated into alkaline peptone water (APW, pH 8.4). After incubation for 6–8 h at 37°C, the broth was subcultured onto thiosulfate-citrate-bile-salts-sucrose (TCBS) agar and incubated for 24 h. Yellow colonies on TCBS agar and lactose-negative or slightly pink colonies on MacConkey agar were presumptively identified as *V. cholerae*. The isolates were subcultured as pure cultures on nutrient agar. Oxidase testing was then performed; development of a dark purple color within 10 s on filter paper was interpreted as a positive reaction. Final confirmation was performed using the API-20E system (BioMérieux, France).

Clinical assessment and definitions

Clinical history, including comorbidities, and physical examination findings were collected using a structured questionnaire. Diarrhea severity was classified according to the frequency of loose bowel movements as mild (<5 times/day), moderate (5–10 times/day), or severe (>10 times/day). Hypokalemia was classified as mild (3.0–3.5 mmol/L), moderate (2.5–3.0 mmol/L), or severe (<2.5 mmol/L) [9]. Acute kidney injury was diagnosed according to the Kidney Disease: Improving Global Outcomes (KDIGO) guideline [10].

Laboratory measurements

Blood samples were collected at presentation before treatment initiation. Serum K^+, Na^+, Cl^-, blood urea, and serum creatinine were measured in the laboratories of the participating hospitals according to routine laboratory procedures and manufacturers' instructions. Serum K^+, Na^+, and Cl^- were measured using FUJI DRI-CHEM SLIDE Na-K-Cl (FUJIFILM, Japan). Blood urea and serum creatinine were measured using routine hospital biochemical methods.

Inclusion criteria

Patients were included if they met the following criteria:

i. Confirmed diagnosis of cholera based on positive stool

culture.

ii. Rice-water stool with dehydration assessed using WHO scales [11].

iii. Controlled diabetes mellitus with HbA_{1c} <7%, hypertension with no regular antihypertensive treatment or treatment with calcium-channel blockers only, or chronic kidney disease not requiring dialysis.

Exclusion criteria

Patients were excluded if they met any of the following criteria:

i. Polyuria for any reason, including uncontrolled diabetes mellitus.

ii. Addison's disease.

iii. Chronic kidney disease requiring renal replacement therapy.

iv. Uncontrolled diabetes mellitus with HbA_{1c} >7%.

v. Hypertension treated with angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, beta-blockers, loop diuretics, thiazide diuretics, or potassium-sparing diuretics.

vi. Co-infection with other enteropathogens, such as *Shigella* or *Salmonella*.

vii. Pre-hospital intravenous fluid resuscitation or potassium supplementation.

viii. Current diuretic therapy, including loop diuretics, thiazide diuretics, or potassium-sparing diuretics.

ix. Pregnancy.

Statistical analysis

Data were analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables, including age and serum electrolyte concentrations, were summarized as means and standard errors (SE). The 95% confidence intervals (CI) were calculated for the primary electrolyte markers. Categorical variables, including sex, comorbidities, diarrhea severity, vomiting status, hypokalemia severity, acute kidney injury (AKI) stage, hemodialysis requirement, and mortality, were summarized as frequencies and percentages.

Normality of continuous variables was assessed using the Shapiro–Wilk test, and homogeneity of variances was assessed using Levene's test. For continuous variables that met the assumptions of normality and homogeneity, comparisons among the three hypokalemia severity groups were performed using one-way analysis of variance (ANOVA). Categorical variables were compared using Pearson's chi-square test, and the Fisher–Freeman–Halton exact test was used when expected cell counts were less than 5. A P value <0.05 was considered statistically significant, and a P value <0.01 was considered highly significant.

Because the study was observational, all statistical findings were interpreted as associations or group differences rather than causal effects.

RESULTS

Baseline demographic and clinical characteristics

A total of 166 patients with cholera were included in the study. The mean age was 49.40 years. Sixty-seven patients (40.4%) were female and 99 (59.6%) were male. Among the total cohort, 154 patients (92.8%) had hypokalemia and 12 (7.2%) had normal serum potassium levels. Among the 154 hypokalemic patients, diarrhea was mild in 61 (39.6%), moderate in 65 (42.2%), and severe in 28 (18.2%). Hypokalemia was mild in 50 patients (32.5%), moderate in 34 (22.1%), and severe in 70 (45.5%). Regarding associated comorbidities among hypokalemic patients, 58 (37.7%) had hypertension, 28 (18.2%) had diabetes mellitus, 11 (7.1%) had chronic kidney disease (CKD), and 26 (16.9%) had kidney stones, as shown in Table 1.

Table 1. Baseline demographic and clinical characteristics

Characteristic	Value
Overall cohort (n = 166)	
Mean age (years)	49.40
Female sex	67 (40.4%)
Male sex	99 (59.6%)
Hypokalemia	154 (92.8%)
Normal serum potassium	12 (7.2%)
Hypokalemic patients (n = 154)	
Mild diarrhea	61 (39.6%)
Moderate diarrhea	65 (42.2%)
Severe diarrhea	28 (18.2%)
Mild hypokalemia	50 (32.5%)
Moderate hypokalemia	34 (22.1%)
Severe hypokalemia	70 (45.5%)
Hypertension	58 (37.7%)
Diabetes mellitus	28 (18.2%)
Chronic kidney disease	11 (7.1%)
Kidney stones	26 (16.9%)
Hypertensive hypokalemic patients (n = 58)	
No antihypertensive treatment	38 (65.5%)
Calcium-channel blocker	20 (34.5%)

Values are presented as n (%) unless otherwise stated. Percentages were calculated using the denominator shown in each subsection heading. The 12 normokalemic patients were not included in hypokalemia-specific diarrhea or comorbidity analyses.

Table 2. Clinical features and comorbidities by hypokalemia severity among hypokalemic patients

Variable	Total	Mild (n = 50)	Moderate (n = 34)	Severe (n = 70)	P value
Diarrhea severity					
Mild diarrhea	61	24 (39.3%)	4 (6.6%)	33 (54.1%)	**0.001**
Moderate diarrhea	65	19 (29.2%)	16 (24.6%)	30 (46.2%)	
Severe diarrhea	28	7 (25.0%)	14 (50.0%)	7 (25.0%)	
Vomiting status					
Vomiting	92	13 (14.1%)	21 (22.8%)	58 (63.0%)	**0.001**
No vomiting	62	37 (59.7%)	13 (21.0%)	12 (19.4%)	
Comorbidities					
Hypertension	58	16 (27.6%)	17 (29.3%)	25 (43.1%)	0.223
Diabetes mellitus	28	5 (17.9%)	6 (21.4%)	17 (60.7%)	0.135
Chronic kidney disease	11	4 (36.4%)	4 (36.4%)	3 (27.3%)	0.366
Kidney stones	26	9 (34.6%)	11 (42.3%)	6 (23.1%)	**0.010**

Values are presented as n (% within row). Only hypokalemic patients were included in this analysis (n = 154). Pearson's chi-square test was used; the Fisher–Freeman–Halton exact test was used when expected cell counts were less than 5.

Clinical features and comorbidities according to hypokalemia severity

The distribution of diarrhea severity differed significantly across hypokalemia severity groups (P = 0.001). Among patients with mild diarrhea, 24 (39.3%) had mild hypokalemia, 4 (6.6%) had moderate hypokalemia, and 33 (54.1%) had severe hypokalemia. Among patients with moderate diarrhea, 19 (29.2%) had mild hypokalemia, 16 (24.6%) had moderate hypokalemia, and 30 (46.2%) had severe hypokalemia. Among patients with severe diarrhea, 7 (25.0%) had mild hypokalemia, 14 (50.0%) had moderate hypokalemia, and 7 (25.0%) had severe hypokalemia, as shown in Table 2.

Vomiting status was also significantly associated with hypokalemia severity (P = 0.001). Among the 92 hypokalemic patients with vomiting, 13 (14.1%) had mild hypokalemia, 21 (22.8%) had moderate hypokalemia, and 58 (63.0%) had severe hypokalemia. In contrast, among the 62 hypokalemic patients without vomiting, 37 (59.7%) had mild hypokalemia, 13 (21.0%) had moderate hypokalemia, and 12 (19.4%) had severe hypokalemia.

Regarding comorbidities, severe hypokalemia was observed in 43.1% of hypertensive patients and 60.7% of diabetic patients. Among patients with CKD, mild and moderate hypokalemia were each observed in 36.4%. Among patients with kidney stones, moderate hypokalemia was observed in 42.3%. Kidney stones were significantly associated with hypokalemia severity (P = 0.010), whereas hypertension, diabetes mellitus, and CKD were not significantly associated with hypokalemia severity, as shown in Table 2.

Serum chloride and sodium levels according to hypokalemia severity

Serum chloride and sodium levels differed significantly across hypokalemia severity groups ($P < 0.001$ for both). Mean serum chloride was lowest in the severe hypokalemia group (90.13 ± 0.21 mmol/L; 95% CI: 89.72–90.54), followed by the moderate group (93.24 ± 0.16 mmol/L; 95% CI: 92.93–93.55), and the mild group (106.28 ± 0.18 mmol/L; 95% CI: 105.93–106.63). Mean serum sodium was also lowest in the severe hypokalemia group (126.72 ± 0.38 mmol/L; 95% CI: 125.98–127.46), followed by the moderate group (130.19 ± 0.09 mmol/L; 95% CI: 130.01–130.37), and the mild group (134.96 ± 0.10 mmol/L; 95% CI: 134.76–135.16), as shown in Table 3.

Acute kidney injury, hemodialysis, and mortality

During the study period, 21 patients (12.7%) developed acute kidney injury (AKI). Among these patients, 4 (19.0%) had KDIGO stage 1 AKI, 6 (28.6%) had KDIGO stage 2 AKI, and 11 (52.4%) had KDIGO stage 3 AKI. Eleven patients (6.6% of the total cohort and 52.4% of AKI patients) required hemodialysis; all were classified as KDIGO stage 3. Six deaths occurred (3.6% of the total cohort and 28.6% of AKI patients), and all occurred among patients with KDIGO stage 3 AKI who required hemodialysis. Four deaths were cholera-related because of severe hypovolemia, electrolyte disturbance, and AKI, whereas two deaths were attributed to unrelated respiratory illness and an incidental brain mass, as shown in Table 4.

Table 3. Serum chloride and sodium levels by hypokalemia severity

Marker	Mild hypokalemia (n = 50)	Moderate hypokalemia (n = 34)	Severe hypokalemia (n = 70)	P value
Serum chloride (mmol/L)	106.28 ± 0.18^{c}	93.24 ± 0.16^{b}	90.13 ± 0.21^{a}	**<0.001**
95% CI	105.93–106.63	92.93–93.55	89.72–90.54	
Serum sodium (mmol/L)	134.96 ± 0.10^{b}	130.19 ± 0.09^{ab}	126.72 ± 0.38^{a}	**<0.001**
95% CI	134.76–135.16	130.01–130.37	125.98–127.46	

Values are presented as mean ± standard error (SE), followed by 95% confidence intervals (CI). Analysis included hypokalemic patients only (n = 154). One-way analysis of variance was used. Different superscript letters denote significant between-group differences; shared letters denote no significant difference.

Table 4. Acute kidney injury, hemodialysis requirement, and mortality

Outcome	Overall cohort (n = 166)	Among AKI patients (n = 21)
No AKI	145 (87.3%)	—
Any AKI	21 (12.7%)	21 (100.0%)
KDIGO stage 1	4 (2.4%)	4 (19.0%)
KDIGO stage 2	6 (3.6%)	6 (28.6%)
KDIGO stage 3	11 (6.6%)	11 (52.4%)
Required hemodialysis	11 (6.6%)	11 (52.4%)
Deaths	6 (3.6%)	6 (28.6%)

All patients requiring hemodialysis were classified as KDIGO stage 3. All deaths occurred among patients with KDIGO stage 3 AKI who required hemodialysis.
AKI, acute kidney injury; KDIGO, Kidney Disease: Improving Global Outcomes.

DISCUSSION

The present study evaluated electrolyte disturbances, hypokalemia patterns, and renal complications among hospitalized patients with cholera. The main findings were that hypokalemia was highly prevalent, severe hypokalemia represented the largest category among hypokalemic patients, serum sodium and chloride levels decreased with increasing hypokalemia severity, and both diarrhea severity and vomiting status were significantly associated with hypokalemia severity. Acute kidney injury (AKI) occurred in 12.7% of patients, and all deaths occurred among patients with KDIGO stage 3 AKI who required hemodialysis.

Cholera remains an important public health problem, particularly in settings affected by inadequate sanitation, overcrowding, population displacement, conflict, and limited healthcare resources. Although cholera may cause severe dehydration and life-threatening illness, its clinical presentation can vary widely, and some patients may present with symptoms resembling acute gastroenteritis [12]. In the present study, the mean age was 49.40 years, and males represented 59.6% of the cohort. This male predominance may reflect local exposure patterns, occupational factors, social contact, or healthcare-seeking behavior; however, these factors were not directly measured in this study. These findings differ from a study conducted in Sana'a, Yemen, where the mean age of cholera patients was lower, and females represented a larger proportion of cases [13]. Such differences may be explained by variation in outbreak setting, population structure, exposure sources, and case ascertainment.

In the present cohort, most hypokalemic patients had mild or moderate diarrhea, whereas severe diarrhea was recorded in a smaller proportion. This does not contradict the recognized severity of cholera, because different studies may capture different clinical spectra. For example, a retrospective report from Mayotte, France, described cholera patients treated in intensive care for hypovolemia, representing a more severe subgroup than the broader hospital-based cohort included in the present study [14]. Therefore, the distribution of diarrhea severity in the current study should be interpreted in relation to the study setting and inclusion criteria.

Comorbidities may influence the clinical course of cholera and may modify the risk or severity of electrolyte disturbances. In the present study, hypertension and diabetes mellitus were common among hypokalemic patients, and severe hypokalemia was the largest category among patients with these comorbidities. These findings are broadly consistent with a Syrian conflict-related cholera cohort, in which diabetes and hypertension were reported among cholera patients and were associated with longer hospital stay [15]. Similarly, cohort data from the Syrian cholera outbreak highlight the clinical relevance of comorbidities and disease severity among patients with acute watery diarrhea during outbreak settings [16]. Electrolyte abnormalities are also commonly reported among diabetic patients in hospital settings, and diarrheal illness may further aggravate disturbances in potas-

sium, sodium, and fluid balance [17]. Nevertheless, because the present study was observational and subgroup sizes were limited, it cannot be determined whether diabetes or hypertension independently caused more severe hypokalemia.

Patients with chronic kidney disease (CKD) represented a small but clinically important subgroup. Reduced renal reserve may impair the ability to compensate for rapid gastrointestinal fluid and electrolyte losses during cholera. Although hypokalemia is a recognized complication of cholera, data specifically addressing cholera-related hypokalemia among patients with pre-existing CKD remain limited. The present study also found a significant association between kidney stones and hypokalemia severity. This finding should be interpreted cautiously. Kidney stone disease may reflect underlying metabolic abnormalities, altered urinary chemistry, or tubular dysfunction in some patients; however, the present study did not measure urinary citrate, urinary electrolytes, acid-base status, or renal tubular function. Therefore, this association should be considered hypothesis-generating and requires further investigation [18].

Serum sodium and chloride levels decreased significantly with increasing hypokalemia severity. Patients with severe hypokalemia had the lowest mean chloride level and the lowest mean sodium level. These findings are compatible with the pathophysiology of secretory diarrhea, in which large gastrointestinal losses of water and electrolytes may exceed renal and colonic compensatory capacity. Similar mechanisms have been discussed in relation to dysnatremia in gastrointestinal disorders, where diarrhea and other gastrointestinal losses may contribute to sodium disturbances [19]. However, fecal electrolyte losses, renal transporter activity, and acid-base parameters were not directly assessed in the present study. Therefore, the observed pattern should be interpreted as an association between biochemical abnormalities rather than direct proof of a specific mechanism.

Both diarrhea severity and vomiting status were significantly associated with hypokalemia severity. This finding is clinically plausible because cholera-related diarrhea can produce substantial potassium and bicarbonate losses, while vomiting may contribute to chloride depletion, volume contraction, and worsening electrolyte imbalance. Emergency department data from patients with vomiting and diarrhea also suggest that different gastrointestinal symptoms may be associated with different electrolyte patterns [20]. In the present cholera cohort, vomiting was more frequent among patients with severe hypokalemia, supporting the need for early electrolyte assessment in patients with high-output diarrhea or vomiting.

The association between diarrhea frequency and hypokalemia severity is consistent with the expected physiology of cholera, where ongoing fluid loss may lead to progressive depletion of potassium and other electrolytes. Pediatric studies of dehydrating diarrhea have also reported electrolyte disturbances, including hyponatremia and hypokalemia, in patients with acute diarrheal illness [21]. Similarly, hypokalemia has been reported among children with acute watery diarrhea, especially in those with frequent stool passage or vomiting [22]. Although these pediatric findings cannot be directly generalized to the adult population in the present study, they support the broader clinical importance of monitoring potassium and other electrolytes during acute diarrheal illness.

The incidence of AKI in the present study was 12.7%, and 6.6% of the total cohort required hemodialysis. This indicates a clinically important burden of renal complications among hospitalized cholera patients. In outbreak and resource-limited settings, delayed presentation, prolonged dehydration, and limited access to early rehydration may contribute to the development of AKI. The World Health Organization has continued to report multi-country cholera outbreaks, highlighting the ongoing burden of severe cholera and the challenges faced by affected healthcare systems [23]. Previous studies of cholera-related AKI have emphasized dehydration, hypovolemia, metabolic acidosis, and severe electrolyte abnormalities as important contributors to renal injury and adverse outcomes [5]. In the present study, all patients requiring hemodialysis had KDIGO stage 3 AKI, and all deaths occurred in this subgroup.

The observed mortality rate was 3.6%, with four deaths directly related to cholera complications and two deaths attributed to unrelated conditions. This mortality rate is higher than the commonly targeted case-fatality threshold of less than 1% for appropriately managed cholera outbreaks [23]. However, direct comparison should be cautious because the present study was hospital-based and may have included a higher proportion of severe cases. The concentration of deaths among patients with dialysis-requiring AKI suggests that renal complications and severe electrolyte disturbance are important markers of poor outcome in hospitalized cholera patients.

This study has several strengths. It was prospective, multicenter, and focused on clinically relevant electrolyte and renal outcomes in cholera patients from Kirkuk. It also assessed hypokalemia severity in relation to diarrhea severity, vomiting, comorbidities, sodium and chloride levels, AKI stage, hemodialysis requirement, and mortality. These features provide useful local data on the clinical and biochemical profile of cholera during hospitalization.

Several limitations should also be acknowledged. The hospital-based design may introduce selection bias, because milder cholera cases managed outside hospital settings were not included. Comorbidities were assessed partly through clinical history and structured questionnaire data, which may be affected by recall or reporting bias. Baseline renal function was not available for all patients, making it difficult in some

cases to distinguish AKI from previously unrecognized CKD. The sample size was relatively small for some subgroup analyses, particularly CKD and kidney stones, which limits the precision of these estimates. Finally, fecal electrolyte losses, acid–base parameters, renal tubular markers, and detailed timing of fluid therapy were not fully assessed, limiting mechanistic interpretation.

CONCLUSION

Cholera was associated with clinically important diarrhea and marked electrolyte imbalance, particularly hypokalemia. Hypokalemia severity was significantly associated with diarrhea severity and vomiting status, and severe hypokalemia was accompanied by lower serum sodium and chloride levels. Comorbid conditions, including hypertension, diabetes mellitus, chronic kidney disease, and kidney stones, may influence potassium disturbances in cholera patients. Acute kidney injury occurred in 12.7% of patients, and mortality was concentrated among those with KDIGO stage 3 acute kidney injury requiring hemodialysis. These findings support early electrolyte assessment, renal monitoring, and prompt correction of fluid and electrolyte abnormalities in hospitalized cholera patients.

ETHICAL DECLARATIONS

Ethics Approval and Consent to Participate

This study was conducted in accordance with the ethical principles for human research. Ethical approval was obtained from the Ethics Committee of the College of Medicine, University of Kirkuk, Iraq (Approval No. 43, dated 31 May 2021). Written informed consent was obtained from all participants.

Consent for Publication

Not applicable.

Availability of Data and Material

The datasets generated 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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This study was self-funded.

Use of Generative Artificial Intelligence

The authors declare that ChatGPT, a generative AI tool developed by OpenAI, was used solely to enhance clarity and grammatical accuracy during the final editing phase. It was not used for content generation, data analysis, or interpretation.

Authors' Contributions

All authors contributed equally to the study conception and design. All authors reviewed the manuscript and approved the final manuscript.

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