Clinical Characteristics, Outcomes, and Prognosis among Cancer Patients with Acute Kidney Injury: A Single-Center Study at Sohag Cancer Center

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ABSTRACT

Background: Acute kidney injury (AKI) is a frequently occurring complication in patients with cancer that can arise from cancer, its treatment, or other complications. **Objective:** This study aimed to evaluate the epidemiological and clinical characteristics and outcomes of AKI among cancer patients in Egypt.

Patients and Methods: This study was conducted at the Intermediate Care Unit (ICU) of Sohag Oncology Center, Sohag, Egypt. This was a retrospective study of 80 cancer patients diagnosed with AKI and admitted to the ICU with AKI between September 2022 and June 2023.

Results: The median age of the participants was 58 years. Approximately 52% were females, 95% were diagnosed with solid tumors, and 57% received chemotherapy. According to the RIFLE criteria, 59% of the participants were classified as "Failure", 36% as "Injury", and 5% as "Risk". Approximately 66% of the patients presented with normal consciousness, 82% with repeated vomiting, 99% with fatigue and anorexia, and 88% with hypovolemia. The serum creatinine (SCr) concentration, urea concentration, and international normalized ratio (INR) significantly decreased from presentation to discharge (Pvalue <0.001, <0.001, and 0.031, respectively). However, sodium, potassium, and calcium levels and the glomerular filtration rate (GFR) significantly increased (P=0.004, 0.011, <0.001, and <0.001, respectively). Here, 68% of patients were discharged without the need for dialysis, 18% needed dialysis, and 14% died. Disturbed consciousness (OR=0.14; p = 0.003) and hypovolemia (OR=0.49; p = 0.001) were found to be independent predictors of participant improvement.

Conclusion: AKI was more prevalent among elderly females with solid tumors. Common symptoms at presentation were vomiting, fatigue, anorexia, electrolyte imbalances, and hypovolemia. However, additional research is needed to determine the impact of AKI on cancer outcomes.

Keywords: Acute Kidney Injury; Cancer; Prognosis; Dialysis; Risk Factors.

INTRODUCTION

Acute kidney injury (AKI) is a frequent complication that occurs in cancer patients and can be caused by the cancer itself, by treatment, or by complications such as sepsis or hypercalcemia. Extensive research has been conducted on AKI-related factors in cancer patients. Hemodynamic instability, sepsis, and nephrotoxins, which are also present in other critically ill patients, have been identified as contributing factors [1,2].

Research has shown that AKI is more common among cancer patients than among patients without cancer. However, the incidence of AKI related to cancer can vary depending on several factors, such as the type and severity of the cancer, any complications associated with it, and the type of supportive or interventional treatment provided. Considering these factors when studying AKI in cancer patients is important because they can greatly influence its development. According to **Cheng *et al.*,** 7.5% of cancer patients develop AKI [3].

Another study in Palestine by **Nazzal *et al.*** reported that the incidence of cancer-related AKI was 6.9% based on the adjusted RIFLE criteria and regardless of the tumor type or time of admission. The risk of AKI increases with the presence of congestive heart failure, chronic kidney disease (CKD), sepsis, or hypercalcemia. Additionally, the mortality risk was seven times greater among cancer patients with AKI than among those with overall cancer-related mortality [4]. Furthermore, the incidence of AKI among cancer patients receiving systemic cancer therapies was 9.3%. AKI risk further increased with the use of diuretics and angiotensin-converting enzyme inhibitors/angiotensin receptor blockers [5].

A major concern with AKI is its potential to hinder optimal anticancer treatment, cause drug-related toxicity, prolong hospitalization, and increase treatment costs [6,7]. Thus, awareness of the risk factors, causes, and prognoses of AKI among cancer patients is necessary to prevent renal injury progression, the development of CKD and related mortality and to enhance medication adjustment and proper management of cancer.

The aim of this study was to provide epidemiological data on the risk factors and outcomes of AKI in cancer patients referred to a tertiary healthcare facility in Egypt.

PATIENTS AND METHODS

Survey Design and Data Collection

This study was conducted at the Intermediate Care Unit (ICU) of Sohag Oncology Center, Sohag, Egypt. This was a retrospective study of 80 cancer patients

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diagnosed with AKI and admitted to the ICU with AKI between September 2022 and June 2023.

Patient demographic data, including patient name, age, sex, type of cancer, chemotherapy, and radiotherapy treatment, and the number of cycles were recorded. Full laboratory data, including complete blood count, liver function test results, and serum electrolytes, were collected, and daily serum urea and creatinine levels were recorded during follow-up.

All patients were assessed for hypovolemia through vital signs and for the presence of causes of hypovolemia, mainly vomiting and diarrhea. The volume status was monitored through monitoring of pulse, blood pressure, and urine output; abdominal ultrasound was performed for all patients to assess kidney echogenicity.

Inclusion and Exclusion Criteria

Patients were included in the study if they were diagnosed with any type of cancer and aged between 25 and < 60 years any patient older than 60 years or who was suffering from any comorbidities was excluded.

Ethical Approval

This study complied with the protocol, the guidelines of Good Pharmacoepidemiologic Practice (GPP), and applicable regulatory/ government requirements and followed the Declaration of Helsinki. Documented approval from the Egyptian Ministry of Health and Population Ethics Committees (IRB/IEC) was obtained.

Statistical analysis

SPSS for Windows® version 22 was used to code, process, and analyse the gathered data. The study displayed descriptive statistics as numbers (n) and prevalence (%).Binary logistic regression models were employed to predict the impact of different laboratory characteristics on the development of AKI in patients admitted to the ICU. A logistic regression model was used to obtain odds ratios (ORs) and 95% confidence intervals (CIs). The suitability of binary and ordinal logistic regression models was assessed by applying the Hosmer–Lemeshow test. A p-value less than 0.05 was considered to indicate statistical significance.

RESULTS

Population Demographics and Clinical Characteristics

In the present study, 80 cancer patients were included, 52% of whom were females. The median age of the participants was 58 years (Interquartile range (IQR): 50-67). Most of the patients were diagnosed with solid tumors (95%), and 85% had metastases. Breast cancer (12%) and hepatocellular carcinoma (10%) were the most prevalent types of tumors among the study population. According to the RIFLE criteria, approximately 59% of the participants were classified as "Failure", 36% as "Injury," and 5% as "Risk". Regarding treatments, 57% of the patients received chemotherapy, 15% received radiation, and 49% underwent surgery. The most common number of chemotherapy cycles was 3 (16%), for a median duration of 15 days. The analysis of chemotherapy types revealed diverse treatment approaches, with gemcitabine/carboplatin (16%) and cyclophosphamide/ adriamycin (12%) being the most frequently administered (Table 1).\

Table (1): Demographic Characteristics:

Participants Characteristics	N = 80[1]
Age (Years)	58 (50, 67)
Gender	
Female	42 (52%)
Male	38 (48%)
Tumor Type	
Solid Tumor	76 (95%)
Hematological Cancer	4 (5.0%)
Metastasis	
Metastasis	68 (85%)
No Metastasis	12 (15%)
Radiotherapy	
Received Radiotherapy	12 (15%)
Not Received Radiotherapy	68 (85%)
Chemotherapy	
Received Chemotherapy	46 (57%)
Not Received Chemotherapy	34 (42%)
Surgery	
Have a Surgery	39 (49%)
Not Having a Surgery	41 (51%)
RIFLE Score	
Failure	47 (59%)
Injury	29 (36%)
Risk	4 (5.0%)
Diagnosis	
Gastric Carcinoma	6 (7.5%)
Acute Myeloid Leukemia	1 (1.3%)
Anorectal Carcinoma	2 (2.5%)
B-cell Lymphoma (NHL)	1 (1.3%)
Breast Cancer	10 (12%)
Colon Cancer	6 (7.5%)
Prostate Cancer	1 (1.3%)
Cholangiocarcinoma	2 (2.5%)
Chordoma (Mass in Spinal Cord at Lumbar Region)	1 (1.3%)
Double Malignancy (Urinary Bladder Carcinoma and Hepatocellular Carcinoma)	1 (1.3%)
Endometrial Carcinoma	2 (2.5%)
Gall Bladder Carcinoma	4 (5.0%)
Hepatocellular Carcinoma	8 (10%)

Participants Characteristics	N = 80[1]
Hodgkin's Lymphoma	2 (2.5%)
Labium Tumor (Melanoma)	1 (1.3%)
Lung Cancer	3 (3.8%)
Lymphoma	1 (1.3%)
Malignancy of Unknown Origin (MUO)	1 (1.3%)
Malignant Umbilical Mass	1 (1.3%)
Multiple Myeloma	6 (7.5%)
Ovarian Carcinoma	5 (6.2%)
Pancreatic Carcinoma	2 (2.5%)
Peritoneal Mesothelioma	1 (1.3%)
Recto-Sigmoid Carcinoma	1 (1.3%)
Right Parotid Adenocarcinoma	1 (1.3%)
Skin Tumor (Metastatic Squamous Cell Carcinoma)	1 (1.3%)
Urinary Bladder Carcinoma	9 (11%)
No. of Chemotherapy Cycles	
12 Cycles	1 (1.3%)
2 Cycles	4 (5.0%)
3 Cycles	13 (16%)
4 Cycles	9 (11%)
5 Cycles	4 (5.0%)
6 Cycles	5 (6.2%)
8 Cycles	10 (12%)
Not Received Chemotherapy	34 (42%)
Frequency of Chemotherapy Cycles (Days)	
Median (IQR)	15 (0, 21)
Type of Chemotherapy Received	
ABVD	3 (3.8%)
Cyclophosphamide/Adriamycin	10 (12%)
FLOFOX	1 (1.3%)
Gemcitabine/Carboplatin	13 (16%)
Gemcitabine/Cisplatin	1 (1.3%)
Not Received Chemotherapy	34 (42%)
Paclitaxel	1 (1.3%)
Paclitaxel/Carboplatin	3 (3.8%)
Taxotere/Carboplatin	1 (1.3%)
Etoposide/Carboplatin	1 (1.3%)
Denosumab 120 mg	8 (10%)
Capecitabine	1 (1.3%)
Zoledronic Acid	3 (3.8%)

[1]Median (IQR); n (%)

Clinical presentation of cancer patients with AKI

The general presentations of the patients in the ICU are presented in table 2. Approximately 53 (66%) of the patients presented with normal consciousness levels, 66 (82%) with repeated vomiting, 79 (99%) with fatigue and anorexia, and 49 (61%) with no diarrhea. Additionally, 70 (88%) patients presented to the ICU with hypovolemia.

Table (2): Presentation to the intermediate care unit:

Patients Presentation	N = 80[1]
Disturbed Conscious Level	
Normal Conscious Level	53 (66%)
Disturbed Conscious Level	27 (34%)
Repeated Vomiting	
No Repeated Vomiting	14 (18%)
Repeated Vomiting	66 (82%)
Fatigue and Anorexia	
No Fatigue or Anorexia	1 (1.3%)
Fatigue and Anorexia	79 (99%)
Diarrhea	
No Diarrhea	49 (61%)
Diarrhea	31 (39%)
Hypovolemia	
No Hypovolemia	10 (12%)
Hypovolemia	70 (88%)

[1]n (%)

Comparison of Laboratory Findings at Presentation and Discharge

Compared to the concentration at the time of admission, the median serum creatinine and serum urea concentration significantly decreased at discharge, as did the median international normalized ratio (INR). However, sodium, potassium, and calcium levels significantly increased at discharge. In addition, the median glomerular filtration rate (GFR) significantly increased also at discharge (Table 3).

Table (3): Laboratory values at admission and discharge:

Participants Characteristics	At Admission (N = 80[1])	At Discharge (N = 80[1])	p value[2]
Serum Creatinine (mg/ dL)	2.85 (2.20, 3.80)	1.55 (1.30, 2.42)	**<0.001**
Serum Urea(mg/dL)	161 (129, 201)	82 (66, 136)	**<0.001**
HGB (g/dL)	9.30 (8.47, 10.38)	9.45 (8.80, 10.60)	0.3
WBCs(mcL)	8 (6, 11)	8 (6, 10)	0.8
PLTs ($x10^9$/L)	188 (153, 262)	197 (153, 252)	>0.9
ALT (U/L)	50 (24, 101)	41 (21, 87)	0.6
AST (U/L)	49 (23, 90)	43 (25, 80)	0.5
Total Bilirubin (µmol/L)	1.30 (1.20, 1.65)	1.30 (1.20, 1.53)	0.7
Sodium (mEq/L)	131 (127, 133)	135 (130, 137)	**0.004**
Potassium (mEq/L)	3.95 (3.10, 4.90)	4.20 (3.98, 4.70)	**0.011**
Calcium (mg/dL)	8.65 (7.90, 9.20)	8.90 (8.70, 9.30)	**<0.001**
INR	1.20 (1.10, 1.30)	1.10 (1.10, 1.20)	**0.031**
GFR (ml/min)	24 (16, 31)	46 (28, 58)	**<0.001**

[1]Median (IQR)

[2]Wilcoxon rank sum test

Laboratory Findings of Patients with AKI at Discharge in Relation to Clinical Outcomes

The serum creatinine concentration, urea concentration, and INR significantly decreased, along with significant increases in sodium and potassium levels in improved patients compared to dialyzed patients and dead patients. Additionally, there was a significant difference in the GFR among the three groups at discharge (Table 4).

Table (4): Laboratory values and patients' status at discharge

Lab Values at Discharge	Died (N = 11[1])	Dialysis (N = 15[1])	Improved (N = 54[1])	p value[2]
Serum Creatinine (mg/ dL)	2.10 (1.55, 2.85)	6.00 (5.30, 6.80)	1.35 (1.20, 1.70)	**<0.001**
Serum Urea (mg/ dL)	97 (78, 167)	251 (220, 298)	74 (61, 88)	**<0.001**
HGB (g/dL)	9.20 (8.45, 11.25)	9.10 (8.60, 9.85)	9.85 (9.20, 10.55)	0.2
WBCs (mcL)	9.1 (6.1, 10.0)	8.3 (6.6, 11.2)	8.2 (6.2, 9.5)	0.8
PLTs ($x10^9$/L)	180 (104, 252)	210 (180, 262)	192 (153, 222)	0.4
ALT (U/L)	41 (35, 114)	77 (34, 116)	36 (20, 82)	0.093
AST (U/L)	71 (37, 88)	64 (28, 89)	42 (23, 75)	0.2
Total Bilirubin (µmol/L)	1.4 (1.2, 2.8)	1.3 (1.2, 1.5)	1.3 (1.2, 1.4)	0.6
Sodium (mEq/L)	131.0 (128.5, 136.0)	126.0 (125.0, 130.5)	136.0 (133.0, 138.0)	**<0.001**
Potassium (mEq/L)	4.20 (3.65, 4.35)	6.10 (5.90, 6.30)	4.20 (3.90, 4.30)	**<0.001**
Calcium (mg/dL)	8.90 (8.55, 9.35)	9.10 (8.65, 9.90)	8.90 (8.80, 9.28)	0.8
INR	1.30 (1.15, 1.40)	1.20 (1.15, 1.25)	1.10 (1.10, 1.20)	**0.002**
GFR at Discharge(ml/min)	32 (22, 47)	9 (9, 11)	55 (42, 63)	**<0.001**

[1]Median (IQR)

[2]Kruskal-Wallis rank sum test

Clinical Outcomes of Cancer Patients with AKI

Here, 63 (79%) patients were discharged from the ICU without the need for dialysis, 54 (68%) improved, 15 (19%) needed dialysis, and 11 (14%) died. Additionally, 60 (75%) patients had bilateral echogenic kidneys, 34 (42%) of whom were classified as Grade 1 (Table 5).

Table (5): Patient outcomes at discharge from the intermediate care unit

Participants Characteristics	N = 80[1]
Need Dialysis	
Need Dialysis	17 (21%)
Did Not Need Dialysis	63 (79%)
Echogenicity	
Bilateral Echogenic Kidneys	60 (75%)
Normal	20 (25%)
Grade of Echogenicity	
Normal	20 (25%)
1	34 (42%)
2	26 (32%)
Prognosis	
Died	11 (14%)
Dialysis	15 (18%)
Improved	54 (68%)
Survival	
Died	11 (14%)
Lived	69 (86%)

[1]n (%)

Logistic Regression Model:

Univariate logistic analysis revealed that disturbed consciousness, and hypovolemia were associated with decreased odds of improvement among cancer patients with AKI. Multivariate logistic regression analysis revealed that disturbed consciousness and hypovolemia were independent predictors of improvement in cancer patients with AKI (Table 6).

Table (6):Logistic Regression Model of Factors Affecting Patients' Improvement

Status (Improved or not)		Value Mean (SD)	OR (Univariable)	OR (Multivariable)
Echogenicity	Normal	0.8 (0.4)	-	-
	Bilateral Echogenic Kidneys	0.6 (0.5)	-0.17 (-0.41 to 0.07, p=0.172)	-0.08 (-0.29 to 0.13, p=0.435)
Metastasis	No Metastasis	0.8 (0.5)	-	-
	Metastasis	0.7 (0.5)	-0.09 (-0.38 to 0.21, p=0.553)	-0.13 (-0.39 to 0.12, p=0.304)
Conscious Level	Normal Conscious Level	0.8 (0.4)	-	-
	Disturbed Conscious Level	0.4 (0.5)	-0.35 (-0.56 to -0.14, **p=0.001**)	0.14 (0.44 to 0.50, **p=0.003**)
Repeated Vomiting	No Repeated Vomiting	0.6 (0.5)	-	-
	Repeated Vomiting	0.7 (0.5)	0.13 (-0.15 to 0.40, p=0.369)	0.09 (-0.16 to 0.34, p=0.472)
Diarrhea	No Diarrhea	0.6 (0.5)	-	-
	Diarrhea	0.9 (0.3)	0.32 (0.12 to 0.52, **p=0.003**)	0.19 (-0.01 to 0.39, p=0.063)
Hypovolemia	No Hypovolemia	0.2 (0.4)	-	-
	Hypovolemia	0.7 (0.4)	0.54 (0.25 to 0.84, **p<0.001**)	0.49 (0.20 to 0.78, **p=0.001**)

DISCUSSION

The present observational study investigated the incidence of and risk factors for impaired kidney function among cancer patients admitted to the ICU in a tertiary oncology center in Egypt. To our knowledge, this is the first study to analyze AKI in cancer patients in Egypt. Our study revealed that the majority of AKI patients were old-aged, female (52%), diagnosed with solid tumors (95%), had metastasis (85%), and received chemotherapy (57%).

Old age and female sex are two of the nonmodifiable risk factors for AKI among cancer patients for several reasons. First, changes in total body water occur due to a reduction in lean body mass, leading to drug overdose. Second, a lowered GFR can go unrecognized among those patients despite normal serum creatinine levels. Third, hypoalbuminemia can cause a decrease in the binding of drugs to proteins, which leads to an increase in the concentration of free drugs. Additionally, elderly individuals are more likely to experience vasoconstriction due to excessive levels of angiotensin II and endothelin, as well as an increase in oxidatively modified biomarkers. These factors can increase the risk of nephrotoxicity and AKI among these patients [8].

In our study, AKI was more prevalent among patients with solid tumors. Approximately 12% of patients were diagnosed with breast cancer, 11% with urinary bladder carcinoma, and 10% with hepatocellular carcinoma. However, the risk among these patients has not been quantified in the literature. Consistent with our findings, **Siddiq *et al.*** [9] revealed an increased risk of AKI among patients with hematologic malignancies, breast cancer, colon cancer, or urinary tract cancer.

Jin *et al.* [10] reported that 50.1% of gastrointestinal cancer patients had cancer-related AKI. **Kang *et al.*** [11] observed an increased rate of AKI among patients with hematologic malignancies, followed by urinary tract cancer and hepatocellular carcinoma. A high incidence of AKI among patients with colon or rectal cancer was also reported [12].

Chemotherapy in cancer patients poses a significant and increasing risk of nephrotoxicity, resulting in AKI, hypomagnesemia, thrombotic microangiopathy (TMA), nephrotic syndrome, isolated tubulopathies, focal segmental glomerulosclerosis (FSGS), membranoproliferative glomerulonephritis (GN), acute interstitial nephritis, chronic tubulointerstitial fibrosis, hypertension, nephrogenic diabetes insipidus, and CKD [13].

Here, a combination of gemcitabine (gemzar) and carboplatinwas administered to 16% of the study population, and a combination of cyclophosphamide (endoxan) and doxorubicin (adriamycin) was used in 12% of the patients, followed by denosumab(xgeva) in 10% of the patients.

The nephrotoxicity of these drugs has been described in several reports. It is believed that TMA is the primary kidney lesion in patients treated with gemcitabine[14]. Carboplatin, which is a second-generation drug, is recognized to be less nephrotoxic than cisplatin and can lead to kidney damage through the induction of electrolyte disturbance and hypomagnesemia; therefore, the administration of magnesium supplements during therapy might be clinically beneficial [15].

Additionally, cyclophosphamide-induced nephrotoxicity might be caused by hemorrhagic cystitis and the development of the syndrome of inappropriate antidiuretic hormone secretion (SIADH); therefore, the dose of the drug needs to be adjusted according to renal function [16]. Doxorubicin, an antitumor antibiotic, is also linked to TMA, nephrotic syndrome, focal segmental glomerular sclerosis, and AKI among cancer patients [16]. Although few studies have examined the association between denosumab and the occurrence of AKI, initial reports suggest an increased risk of AKI among patients receiving this drug [17].

Notably, 42% of our population did not receive chemotherapy. These results underscore the heterogeneity in cancer diagnoses and treatment regimens within the studied cohort, emphasizing the need for personalized therapeutic strategies in oncology management.

Assessing the volume status and ensuring adequate perfusion to the kidneys are crucial for preventing toxic effects, as are adjusting the dosage based on renal clearance. Assessment of volume status, adequate kidney perfusion, and dose reduction based on renal clearance are necessary to prevent toxic effects [9].

According to the RIFLE criteria, the degree of AKI in approximately 59% of our population was categorized as “failure,” followed by “injury” (36%) and “risk” (5%). This is considered higher than that reported in the literature. **Ahmed *et al.*** [18] reported that the incidences of risk, injury, failure, loss, and end-stage renal disease were 25.9%, 29.24%, 15.56%, 17.92%, and 11.32%, respectively, in all departments of a university hospital in Cairo. **Shafie *et al.*** [19] reported that 24% of ICU-admitted patients were classified as at risk,28.2%, and 47.8% as failing at Alexandria University Hospital.

Zein *et al.* [20] also applied the RIFLE criteria among Egyptian AKI patients admitted to the ICU at Aswan University Hospital and reported that the numbers of patients at risk, injury, and failure were 44.3%, 29.9%, and 25.8%, respectively. This difference may reflect the severity of kidney damage among cancer patients admitted to the ICU.

AKI among cancer patients is multifactorial [2]. Several prerenal causes may lead to cancer-induced AKI, including hypotension, sepsis, hypovolemia, and

preexisting vascular or cardiovascular diseases. Additionally, vomiting and diarrhea due to some malignancies and chemical treatment can increase the incidence of dehydration and AKI [21,22]. In our study, the common presentations of AKI patients in the ICU were repeated vomiting (82%), fatigue and anorexia (99%), and hypovolemia (88%).

In our study, the absence of hypovolemia at presentation was significantly associated with an increase in the odds of improvement in AKI incidence of 51% among cancer patients. Additionally, AKI patients with a disturbed consciousness were more likely to improve in the ICU (OR=0.14, p-value= 0.003). In Egypt, hypovolemic shock was the most common cause according to **Zein *et al.*** [20] and the second most common cause according to **AbdElHafeez *et al.*** [23] among critically ill patients admitted to the ICU. However, AKI is rare according to **El-Badawy *et al.*** [24]**.**

In AKI patients with hypovolemia, early adequate and balanced fluid resuscitation predicts a good prognosis and is necessary to achieve adequate cardiac output, renal perfusion and glomerular filtration rate (GFR)[25,26].

Electrolyte disturbance is commonly encountered in cancer patients and is usually accompanied by the occurrence of AKI [27]. Our study population showed a significant decrease in the serum creatinine concentration, urea concentration, and INR, while the serum sodium concentration, potassium concentration, calcium concentration, and GFR significantly increased upon discharge compared to the baseline values. Moreover, the improved patients showed a significant decrease in the serum creatinine concentration, urea concentration, and INR, with significant increases in the serum sodium concentration, potassium concentration, and GFR compared with those of the dialyzed and dead patients at discharge.

Previous studies have shown that variability in sodium and potassium concentrations is involved in the progression and poor prognosis of ICU patients [28]. It is hypothesized that sodium fluctuations may predispose patients to AKI through the induction of osmotic stress, damage to the kidney, and the induction of cytokine and reactive oxygen species generation [29].

It was also suggested that high potassium concentrations are associated with the development, progression, and prognosis of AKI [28,30]. Potassium levels in our study were greater among dialyzed patients than among improved patients, which is consistent with the findings of **Chen *et al.*** [28]**,** who reported an association between high potassium levels and poor prognosis among ICU patients with AKI.

Patients with cancer often have decreased creatinine production due to various factors, such as loss of cell mass, low protein intake, cachexia, inflammation, volume expansion, or medications; all these factors are independent of the kidney. Therefore, the sensitivity of SCr is limited among cancer patients[31].

A low estimated glomerular filtration rate (eGFR) was recognized as a risk factor for AKI [32]. **Hatakeyama *et al.*** observed a more than 30% reduction in the eGFR among patients with solid tumors, including kidney, urinary tract, pancreatic, liver, and gallbladder tumors [33]. Additionally, **May *et al.*** [34] reported that a≥ 30% decrease in the eGFR increased the 1-year mortality risk among hematological cancer patients with AKI. **James *et al.*** [35]showed that a low eGFR, along with the presence of proteinuria, were risk factors for the development of AKI, disease progression, and mortality. These findings highlight the critical role of the eGFR in the prediction and prognosis of AKI among cancer patients.

Here, 19% of AKI cancer patients underwent dialysis, while 14% died. The remaining 68% of patients improved at discharge without requiring dialysis. Additionally, approximately two-thirds of the patients had bilateral echogenic kidneys, 42% of whom had grade one echogenic kidney.

In the study conducted by **Christiansen *et al.*** [12]**,** only 5.1% of cancer patients with any stage of AKI required dialysis within 1 year of AKI. **Salahudeen *et al.*** [6] showed that dialysis was required in 4% of cancer patients with AKI and was associated with worse survival. The 28-year mortality rate among those patients was 66%-88%. The high requirement of our study might be attributed to the old age of the patients, late referral to a nephrologist, or small sample size.

The mortality rate in our study is comparable to that of **El-Badawy *et al.*** [24]**,** who reported a mortality rate of 14% among critically ill patients with AKI in the ICU of Benha University Hospital. In contrast, **Zein *et al.*** [20]**, ElHafeez *et al.*** [23]**, and Ahmed *et al.*** [18] reported mortality rates of 35.1%, 31.7%, and 47.2%, respectively, among critically ill patients in the ICUs of Aswan University Hospital, Alexandria Teaching Hospital, and all other departments of Al-Zahraa University Hospital. The difference might be attributed to the small sample size, the type of included patients, and the grade and severity of AKI among them.

Nonetheless, our study has several limitations, including its observational study design, small sample size, and lack of use of urine output data for detecting AKI; thus, only the SCr concentration was used in the RIFLE criteria, and long-term mortality and CKD development were not assessed. Additionally, a lack of data regarding any concomitant medications and unmeasured confounders may have affected the findings.

CONCLUSION

In summary, most of the cancer patients with AKI in our center were eldry females diagnosed with solid

tumors, mainly breast, urinary bladder, or liver tumors; had metastasis; and were receiving chemotherapy. The most common presentations of those patients were vomiting, hypovolemia, fatigue, and anorexia. The main electrolyte disturbances among the participants were potassium and sodium, especially among dialyzed patients. Additionally, renal function test results, including creatinine, urea, and the glomerular filtration rate (GFR), were impaired at admission but improved in most of the patients at discharge. Moreover, the presence of hypovolemia and loss of consciousness at presentation were positively associated with a good prognosis. However, large-scale research is needed to further explore the epidemiological and clinical characteristics of cancer patients with AKI and the implications for cancer treatment.

Availability of data and materials: The data used and analyzed in this study are available from the corresponding author upon reasonable request.

Contributions:
Conceptualization: NMA, AMAI, AME and JM; Methodology: MAN, and MAEA; Formal analysis and investigation: NMA; Writing - original draft preparation: SAA; Writing - review and editing: NMA, SAA, and AMI; Supervision: NMA and AMI. All the authors critically revised and substantially contributed to the writing of the manuscript. All the authors read and approved the final manuscript.

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Abbreviations:
AKI: Acute kidney injury
CI: Confidence interval.
CKD: Chronic kidney disease.
eGFR: Estimated glomerular filtration rate.
FSGS: Focal segmental glomerulosclerosis.
GFR: Glomerular filtration rate.
GGP: Good Pharmacoepidemiologic Practice.
GN: Glomerulonephritis.
ICU: Intermediate Care Unit.
INR: International Normalized Ratio.
IQR: Interquartile Range.
OR: odds ratio.
SCr: Serum creatinine.
SIADH: syndrome of inappropriate antidiuretic hormone secretion.
TMA: Thrombotic Microangiopathy.

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