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Acute Kidney Injury Among Severe Trauma Patients in ICU

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ABSTRACT

Background: Trauma is a major public health burble and is associated with a high mortality rate. Acute kidney injury (AKI) has been demonstrated to be accompanied by adverse outcomes among trauma cases and development of AKI is closely accompanied by increased mortality and length of stay (LOS).

Objective: To determine the incidence and the associated risk factors of AKI in severe trauma patients and its outcome in the emergency intensive care unit (ICU).

Patients and Methods: This was a prospective study conducted on 104 patients with severe trauma at Mansoura University Hospital. Entire cases were classified into 2 groups; AKI cases; patients who met the RIFLE criteria for AKI and non-AKI cases. Entire cases were subjected resuscitation followed by physical examination and laboratory investigations. In addition, trauma scores were assessed.

Results: Forty-six percent of patients developed AKI by RIFLE criteria. There were significant differences among AKI and non-AKI in the context of sepsis, shock, coagulopathy and rhabdomyolysis. There were statistical significance serum creatinine (S.cr) levels at emergency room (ER), S.cr peak level at ICU, PH value at ICU, comorbidities, sepsis, shock, LOS, glomerular filtration rate (GFR) at ER and GFR with peak S.cr as independent predictors of AKI among sever trauma patients.

Conclusion: Risk factors of trauma-associated AKI included rhabdomyolysis, coagulopathy, nephrotoxic drugs, shock and sepsis. Development of AKI after severe trauma is closely accompanied by increased mortality and LOS. Early detection of AKI and management of risk factors of AKI can improve the outcome.

Keywords: Acute kidney Injury, Trauma patients Intensive care unit Risk Factors.

INTRODUCTION

Trauma has been considered the most frequent cause of death worldwide and remains the primary public health trouble in every country. On the other hand; international researches indicate that managing severely injured cases at trauma centers, which are better equipped to provide proper care, is accompanied by reduction in mortality by about 22% [(1)].

Severe trauma might encourage a hyper-inflammatory condition with a subsequent development of multi-organ dysfunction syndrome (MODS). Organ dysfunction is still the third main etiology of death in trauma cases, following hemorrhage and head trauma [(2)].

Acute kidney injury (AKI) is described as the abrupt loss of renal functions and a considerable drop in GFR with a subsequent retention of urea and other nitrogenous waste products and in the dysregulation of extracellular volume and electrolytes [(3)].

AKI in trauma patient is complicated and its cause is diverse, renal ischemia being the commonest etiology. Even though different researches have established that hypotension, rhabdomyolysis, venous thromboembolism, acidosis, shock and infections have been participating factors [(4)]. AKI has been demonstrated to be accompanied by adverse outcomes among trauma cases and development of AKI is closely accompanied by increased mortality and length of stay (LOS) [(5)]. The keystone of AKI management is still supportive, with specific therapy reserved for the rarer etiologies. As a result, the prevention of AKI and reduction of its consequences and duration are important aspects of its management [(6)].

The purpose of this study is to determine the incidence and the associated risk factors of AKI in severe trauma cases and its outcomes in the emergency ICU.

PATIENTS AND METHODS

Patients:

Study design:

This was a prospective observational analytical clinical study carried out on 104 patients who were presented by severe trauma to Emergency Department (ED) in Mansoura University Emergency Hospital (MUEH) from entrance to the Emergency Room (ER) and after admission to ICU over the period of one year (from December 2020 to December 2021). Entire cases were classified into 2 groups according to AKI development into; AKI cases: cases who met the ---------- (RIFLE) criteria for AKI and non-AKI cases: cases who didn't meet the RIFLE criteria for AKI.

Inclusion criteria:

Inclusion criteria involve cases of both genders with all age groups with severe trauma admitted to ICU.

Exclusion criteria:

Exclusion criteria involve patients who refuse to be included in the study, chronic renal impairment,

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diabetic nephropathy patients, obstructive uropathy, and pregnant patients.

Methods:

Resuscitation of the patient was performed which include; the primary survey that involves: airway maintenance with cervical spine protection, breathing and ventilation, circulation and control of blood loss: disability (coma and confusion) and exposure and environmental control. After that, all cases were subjected to the secondary survey which includes full history comprising age, sex, occupation, mode of trauma, time of trauma and resuscitation.

In addition, AMPLE history was also performed which involve a brief history was taken about any known drug allergies, current medication use, past medical history, last oral intake, and the immediate occasions leading up to the injuries.

Clinical examination involves the head and continuing in a caudal manner, examination of all regions in a systematic manner, comprising evaluation of the vital signs.

In addition, demographic data (name, age, and sex), data collected linked to trauma involved [type of trauma (polytrauma, cervical trauma, chest trauma, abdominal trauma and crush injuries), Glasgow Coma Scale (GCS), Injury Severity Score (ISS) and Revised Trauma Score (RTS)] were also collected.

Severe trauma patients included patients who meet any of the next criteria: ISS more than 12, Admission to an ICU for more than 24h, needing mechanical ventilation and urgent surgeries for intracranial, intrathoracic or intraabdominal injury, or for fixation of pelvic or spinal fractures. The GCS is evaluated in table (1) [(7)].

Table (1): Glasgow coma scale (GCS) [(7)].

Sign	Glasgow Coma Scale[1]	Pediatric Glasgow Coma Scale[2]	Score
Eye opening	Spontaneous	Spontaneous	4
	To command	To sound	3
	To pain	To pain	2
	None	None	1
Verbal response	Oriented	Age-appropriate vocalization, smile, or orientation to sound; interacts (coos, babbles); follows objects	5
	Confused, disoriented	Cries, irritable	4
	Inappropriate words	Cries to pain	3
	Incomprehensible sounds	Moans to pain	2
	None	None	1
Motor response	Obeys commands	Spontaneous movements (obeys verbal command)	6
	Localizes pain	Withdraws to touch (localizes pain)	5
	Withdraws	Withdraws to pain	4
	Abnormal flexion to pain	Abnormal flexion to pain (decorticate posture)	3
	Abnormal extension to pain	Abnormal extension to pain (decerebrate posture)	2
	None	None	1
Best total score			**15**
GCS sum score= (E+V+M); best possible score = 15/15; worst possible score = 3/15.			

Injury Severity Score (ISS) divides the body into 6 areas: head or neck, face, abdomen, chest, limbs, and external. Injuries in all regions are given an AIS score and the highest AIS scores in the three most severely injured areas are summed to form the ISS. ISSs have a range from one (minimal severity) to 75 (not survive); greater scores are associated with a higher possibility of mortality [8].

Table (2): Abbreviated Injury Scale (AIS) components

Score	Injury
1	Minor injury
2	Moderate injury
3	Serious injury
4	Severe injury
5	Critical injury
6	Virtually unsurvivable injury

Revised Trauma Score (RTS) was also evaluated as demonstrated in table (3) [9]

Table (3): Revised Trauma Score (RTS) [9].

Glasgow coma scale	Systolic BP (mm hg)	Respiratory rate	Coded value
13-15	>89	10-29	4
9-12	76-89	>29	3
6-8	50-75	6-9	2
4-5	1-49	1-5	1
3	0	0	0

RTS=0.9368 (GSCc)+0.7326 (SBPc)+0.2908 (RRc).

Hemodynamic condition of patients was noticed and reported throughout the period of initial resuscitations at ER till the patient become stable. Vasoactive drugs was started when mean arterial blood pressure (MAP) remained below 60mmHg. Systolic blood pressure (SBP) and diastolic blood pressure at admission and in ICU were also analyzed [10].

Also; shock was considered when SBP < 90mmHg needing volume replacement, blood products and vasoactive support for normalization [11].

Assessment of sepsis was assessed by using the quick Sepsis-Related Organ Failure Assessment (qSOFA). Essentially, evidence of 2 out of 3 qSOFA components (disturbed conscious level (DCL), respiratory rate ≥22breaths/ min, and SBP ≤100mmHg) in patients who were screened positive for infections might be utilized as a secondary screen to recognize cases at risk for deterioration. Exposure to nephrotoxic drugs was assessed during the period of ICU admission.

Concerning investigations, laboratory investigations included Complete blood count (CBC), Arterial

blood gases (ABG), Serum potassium and electrolytes. Renal function tests which included S.cr Serum, creatine kinase (CK) Coagulation profile. Radiological examinations involved Chest X-ray or CT chest, Pelvi-abdominal ultrasound, Abdominal CT or MRI scan and CT brain.

Outcome:

The outcome was assessed according to patient need RRT or not, need for vasopressors or not, need for mechanical ventilation, mortality or survival and length of hospital stay.

Ethical consideration:

The study approval was taken from IRB of Faculty of Medicine at Mansoura University. Informed written consent was acquired from all participants participating in the study. Confidentiality and personal privacy were respected. The researcher was available throughout the study. The research objectives were explained to the participants' relatives individually and in groups. Collected data weren't utilized for any other purposes. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

Data were fed to the computer and analysed by utilizing IBM SPSS Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22. Armonk, NY: IBM Corp. Qualitative data were defined by utilizing number and percent. Quantitative data were described by utilizing median and mean, SD for parametric data following testing normality using Kolmogrov-Smirnov test. Significance of the acquired results was judged at the (0.05) level. Qualitative data involved Chi-Square test to compare at least 2 groups, while Quantitative data between groups included Parametric tests which comprise Student t-test utilized to compare 2 independent groups and non-parametric tests which comprise Mann-Whitney U test was utilized to compare 2 independent groups. Diagnostic accuracy was evaluated by ROC curve. Binary stepwise logistic regression analysis was utilized for prediction of independent variables of binary outcome. Adjusted OR and their 95 percentage CI were measured.

RESULTS

There were no statistically significant differences in age and sex between non-AKI and AKI groups. On the other hand, this difference was near significant with male sex accounting for the majority of the studied population and higher age accounting for the majority of the AKI group. There were statistically significant differences among AKI and non-AKI with regard to GCS at ER (p=0.026). It is found that, patients were deteriorating in ICU, their GCS decreased and they were developed AKI more than patients where their GCS not decreased. With regard to, trauma scores of the studied patients, there were no statistically significant differences among AKI and non-AKI with regard to ISS. There were statistically significant differences among AKI and non-AKI with regard to type of trauma (P=0.04). The patients with AKI had

greater statistically significant difference global comorbidity in comparison with non-AKI patients (41.7% vs 21.4%) with (p value=0.026).

Table: (4): Sociodemographic data and clinical characters of trauma in studied groups.

	Non-AKI (N=56)	AKI (N=48)	Test of significance
Age/years, median (min-max)	26.5 (2-80)	47 (3-80)	Z=1.84, P=0.07
Sex N (%) Male Female	 44 (78) 12 (21.4)	 44 (91.7) 4 (8.3)	 χ^2=3.41 p=0.065
GCS at ER (mean± SD)	10.54±4.51	12.38±3.64	t=2.26 p=0.026*
GCS at ICU	10.75±5.14	9.46±4.94	t=1.30 p=0.196
ISS >15	44 (78.6%)	40 (83.3%)	χ^2=0.377 P=0.622
Type of trauma: N (%) Polytrauma Cervical trauma Chest trauma Abdominal trauma Crush injury and rhabdomyolysis	 47 (83.9) 4 (7.1) 1 (1.8) 0 (0) 4 (7.1)	 35 (72.9) 0 (0) 1 (2.1) 2 (4.17) 10 (20.8)	 χ^{2MC}=9.8 P=0.04*
Comorbidities N (%) -ve +ve	 44 (78.6) 12 (21.4)	 28 (58.3) 20 (41.7)	 χ^2=4.97 p=0.026*

Z: Mann Whitney U test, χ2: Chi-Square, AKI: Acute kidney injury, t: Student t test, *statistically significant, GCS: Glasgow Coma Score, ISS: injury severity score, ER: Emergency room, ICU: Intensive care unit.

Within the studied population, 48(46.2%) cases developed AKI by RIFLE criteria, with 12(11.5%) cases in stage Risk; 12(11.5%) patients in stage Injury, 24(23.1%) cases in stage Failure.

Table (5): Incidence of AKI in studied cases and types of AKI according to RIFLE classification.

Incidence of AKI	N (%)
AKI	48 (46.2%)
Non-AKI	56 (53.9%)
Total	104 (100%)
AKI classes	
Risk	12 (25%)
Injury	12 (25%)
Failure	24 (50%)

Many causes contributed to developing AKI and there was overlapping between them. There were statistically significant differences among AKI and non-AKI in the context of sepsis, shock, coagulopathy and rhabdomyolysis (P< 0.001, P=0.026, 0.006, P=0.04 correspondingly) as risk factors of developing AKI in trauma patients. The exposure to nephrotoxic drugs and I.V contrast increased the risk for developing AKI. On the other hand, there were no significant differences among AKI and non-AKI in terms of exposure nephrotoxic drugs, I.V contrast and operations.

Table (6): Comparative study of risk factors of AKI between Non-AKI and AKI groups.

Risk factors	Non-AKI N=56, N (%)	AKI N=48, N (%)	Test of significance
Sepsis	8 (14.3)	22 (45.8)	χ^2=12.53 P<0.001*
Shock	12 (21.4)	20 (41.7)	χ^2=4.97 P=0.026*
Coagulopathy	0	6 (12.5)	χ^2=7.43 P=0.006*
Nephrotoxic drug exposure	24 (42.9)	28 (58.3)	χ^2=2.48 P=0.116
underwent operation	26 (46.4)	22 (45.8)	P=1.0
Intravenous contrast	12 (21.4)	14 (29.2)	χ^2=0.825 P=0.364
Crush injury and rhabdomyolysis	4 (7.1)	10 (20.8)	χ^{2MC}=9.8 P=0.04*

χ2=Chi-Square test, *statistically significant, AKI: Acute kidney injury.

There were significant differences among AKI and non-AKI regarding WBCs, S.cr at ER, peak S.cr in ICU, S.cr on discharge, GFR at ER and GFR with peak s.cr level in ICU (P= 0.003, 0.013, <0.001, <0.001, p=0.03, p<0.001 correspondingly) as AKI cases had a greater level of WBCs and S.cr than non-AKI cases, but the GFR decreased in AKI patient. The mean hemoglobin level of people who developed AKI was lower than non-AKI people but without statistically significant differences among two groups.

As regard, ABG values, the AKI patients were more acidotic in comparison with the non-AKI cases with significant differences among AKI and non-AKI regarding the pH value at ER (P=0.014). There were significant differences among AKI and non-AKI with regard to HCO3 value at ER (p=0.009) as the AKI cases had minimal values of HCO3 in comparison with non-AKI cases.

Table (7): Comparison of laboratory findings between the studied groups.

Laboratory findings	Non-AKI N=56 (mean± SD)	AKI N=48 (mean± SD)	Test of significance
WBCs (10^3cells/cmm)	11.85 ± 2.31	17.5 ± 4.01	z=2.98 p=0.003*
Hb (g/dL)	10.26± 2.78	9.53± 2.37	t=1.29 p=0.196
S.cr at ER (mg/dl)	1.0 ± 0.21	1.2 ± 0.22	z=2.47 p=0.013*
S.cr peak in ICU (mg/dl)	0.8 ±0.17	2.92 ± 0.52	z=7.42 p<0.001*
S.cr on discharge (mg/dl)	0.70 ± 0.12	2.0 ± 0.43	z=3.68 p<0.001*
GFR at ER (mL/min/1.73 m^2)	92.6 ± 19.61	54.5 ± 11.34	z=2.13 p=0.03*
GFR with peak s.cr in ICU (mL/min/1.73 m^2)	130.7 ± 30.62	24.25 ± 5.67	z=4.79 p<0.001*
PH at ER	7.35±0.11	7.28± 0.188	t=2.51 p=0.014*
HCO3 at ER (mEq/L)	21.96± 4.90	19.25± 3.45	t=2.67 p=0.009*

t: Student t test *statistically significant, Z: Mann Whitney U test, WBCs: White blood cells, Hb: Hemoglobin, S.cr: Serum creatinine, ICU: Intensive care unit, ER: Emergency room. parameters described as mean± SD or as median (min-max).

The vital signs and RBS were worse in patients with AKI than non-AKI patients with statistically significant differences among two groups as regarding MAP and RBS. AKI cases had lower MBP measured at ER and at ICU than non-AKI cases with (p=0.008, 0.014 correspondingly). There was statistically significant higher RBS in AKI group in comparison to non-AKI group (p=0.039). There were no statistically significant differences among AKI and non-AKI with regard to heart rate.

Table (8): Comparison of vital sings and RBS values between Non-AKI and AKI patients.

Vital signs	Non-AKI N=56 (mean± SD)	AKI N=48 (mean± SD)	Test of significance
MAP at ER (mmHg)	88.24± 18.41	76.67± 17.32	t=2.69 p=0.008*
MAP at ICU (mmHg)	86.19± 16.94	77.47± 16.49	t=2.51 p=0.014*
Pulse at ER (beats/min)	90± 12.27	91± 13	t=0.403 p=0.687
Pulse at ICU (beats/min)	94.29± 21.74	94.29± 22.69	t=0.001 p=0.999
RBS (mg/dl)	132 ± 30.61	168 ± 38.61	z=1.95 p=0.039*

t: Student t test *statistically significant, Z: Mann Whitney U test, MAP: mean arterial pressure, RBS:random blood sugar, ICU: intensive care unit. parameters described as mean± SD or as Median (range).

There were significant differences among AKI and non-AKI with regard to the need for RRT, need for vasopressors, the LOS and mortality rate (P<0.001, P<0.001, P=0.027, P=0.03 correspondingly). AKI patients needed for vasopressor more than non-AKI patients and they remained for a longer period in the ICU and had greater mortality rate in comparison with the non-AKI patients. Respiratory complications are common in AKI patients and they were in need for mechanical ventilation than non-AKI patients but without statistically significant differences among two groups.

Table (9): Comparative study of patients' outcome between Non-AKI and AKI groups.

Outcome	Non-AKI N=56	AKI N=48	Test of significance
Need for RRT (N (%))	0	10 (20.8)	χ^2=12.91 P<0.001*
Need for mechanical ventilation (N (%))	28 (50.0)	32 (66.7)	χ^2=2.94 P=0.086
Need for vasopressors (N (%))	2 (3.6)	18 (37.5)	χ^2=19.16 P<0.001*
Length of hospital stay (days) [median (range)]	8 (1-35)	12.5 (1-36)	Z=2.21 P=0.027*
Mortality (N (%))	19 (33.9)	26 (54.2)	χ2=4.31 P=0.03*

*Statistically significant, Z: Mann Whitney U test, χ2=Chi-Square test, RRT: Renal replacement therapy. parameters described as median (min-max), n (%).

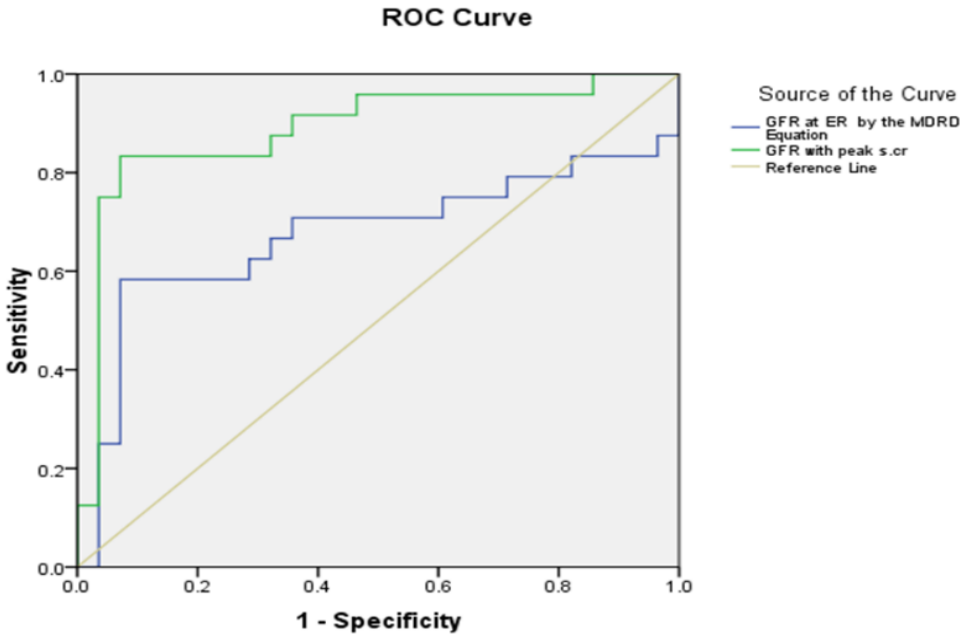

Figure (1): ROC curve of GFR at admission by the MDRD equation, GFR with peak S.cr in detection of AKI

Multivariable logistic regression analysis was performed to determine the predictors for the development of AKI among sever trauma patients. After adjustment of confounders, there were statistical significance S.cr level at ER, S.cr peak level at ICU, PH value at ICU, comorbidities, sepsis, shock, LOS, GFR at ER and GFR with peak s.cr as independent predictors of AKI among sever trauma patients (P= .001, .001, .028, .007, .001, .047, .03, .029, <0.001 correspondingly).

Table (10): Predictors of AKI among sever trauma patients.

Predictors	B	P value	OR	95.0% C.I. for odds ratio	
				Lower	Upper
S.CR at ER	-3.630	.001*	.027	.005	.134
S.cr ICU	6.757	.001*	859.630	30.758	24024.730
PH ICU	-13.553	.028*	.000	.000	.231
Comorbidities(+ve)	1.402	.007*	4.065	1.479	11.172
Sepsis(+ve)	1.837	.001*	6.278	2.174	18.133
Shock(+ve)	1.016	.047*	2.763	1.015	7.521
length of stay(days)	0.052	0.03*	1.06	1.004	1.10
GFR at ER	0.025	0.029*	1.025	1.003	1.049
GFR with peak s.cr	-0.087	<0.001*	.917	.875	.961
Overall % predicted=75.0%					

OR: Odd's Ratio, CI: Confidence Interval, S.cr: Serum creatinine, GFR: Glomerular filtrating rate, ER: Emergency room, ICU: Intensive care unit.

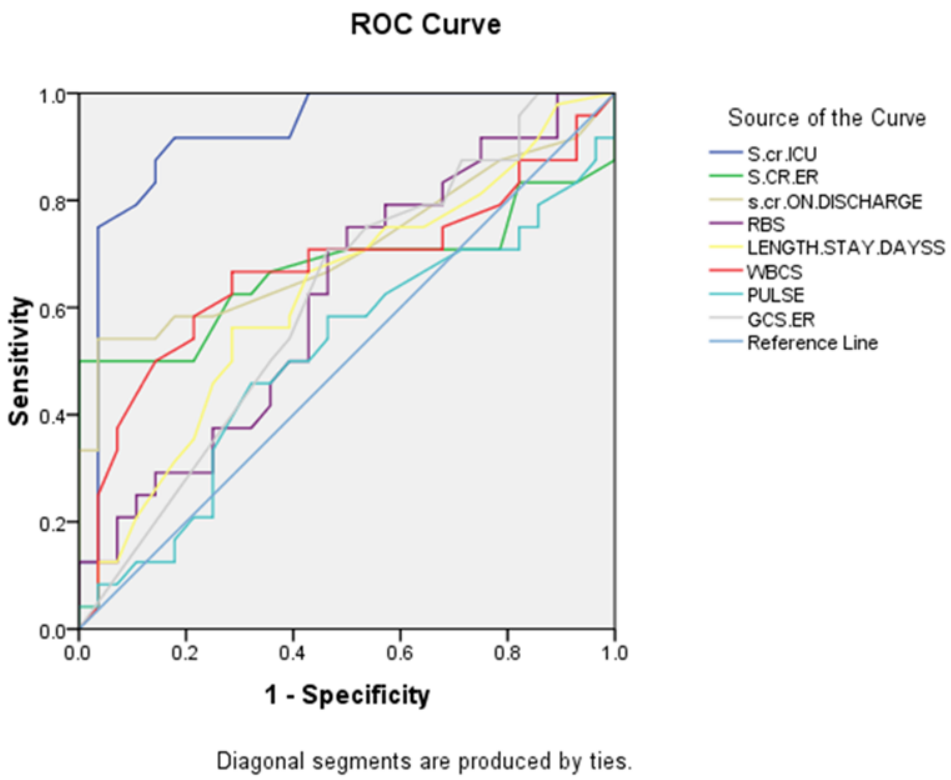

Figure (2): ROC curve of studied parameters in detection of AKI

DISCUSSION

Acute kidney injury (AKI) following trauma is a main adverse event independently accompanied by a prolonged LOS and increased mortality. Definitely, in the context of trauma cases admitted to the ICU, the incidence differs based on the basal features as well as on the severity of injuries [(12)].

A total of 104 cases with severe trauma were enrolled in the current study. The studied patients were then stratified according to the incidence of AKI. The incidence of AKI in the studied patients was 48 patients (46.2%). In the current study, there were 12 (25%) patients in stage Risk; 12 (25%) patients in stage Injury, 24 (50%) patients in stage Failure. This came in the same line with an Egyptian study conducted by **Zyada *et al.*** [(13)]**,** a total of 105 trauma cases were admitted to the ICU. Within the studied subjects, 53 (50.5%) cases developed AKI by RIFLE criteria, with 16 (15.2%) patients in stage Risk; 25 (23.8%) patients in stage Injury, 12 (11.4%) patients in stage Failure. However, another study conducted in 2020 by **Chico-Fernández *et al.*** [(11)]**,** a total of 5740 patients were involved in the study. Among them, 871 had AKI (15.17%), distributed by RIFLE R 458 (7.98%), RIFLE I 234 (4.08%), RIFLE F 179 (3.12%). In addition, 26 patients (0.45%) were categorized as RIFLE L and 35 patients (0.61%) as RIFLE E**.**

The discrepancies between both researches could be due to several elucidations. The main reason was due to the fact that; **Chico-Fernández *et al.*** [(11)] used an air-ambulance service, while in the current study the range of time transport is 0.5–24 h.

Also, **Søvik *et al.*** [(14)] reported that the incidence of post-traumatic AKI in the ICU was 24% of Twenty-four observational researches including 25,182 cases of which 13% (risk) mild, 5% (injury) moderate, and 4% (failure) severe AKI**.**

The most likely clarifications of such broad range are likely to be due to heterogeneity of studied trauma subjects for instance, age and injury severity, the type of ICU admission, the criteria utilized to describe AKI reflect the change in ISS, type of trauma, and mechanism of injury in the studied subjects, length of follow up and degree of trauma that vary among researches [(15)]**.**

Regarding ISS in the current study, all the cases had severe trauma and most of them had ISS>12. From 104 patients, 84 patients (80.8%) had ISS>15 at the time of admission with no significant changes among AKI and no-AKI. Thus; high ISS not used as predictors of AKI among sever trauma patients in the current study. Similarly, **Zyada *et al.*** [(13)]**,** reported that there were no significant differences among AKI and non-AKI as regarding ISS. ISS [median (range)] for AKI cases was [41 (16–59)] and non-AKI cases was [39.50 (25–59)]. ISS evaluates injuries but not their physiologic adverse events. A patient suffering from extensive brain damage and spinal cord injuries has a high ISS which isn't identical with hemorrhagic shock. In contrast, a patient with 4 long bones fractures has a low ISS but this patient

requires a particular amount of transfusion and to develop extensive rhabdomyolysis, and MODS. For such cause, ISS mightn't be by itself a precise predisposing factor of AKI [16].

In contrast, in a study executed by **Eriksson *et al.*** [17] they demonstrated a correlation between AKI and trauma degree. The ISS greater than forty could be used as a predisposing factor for AKI, but minimal injuries weren't accompanied by AKI in the multivariable regression. About 33% of AKI patients had ISS >40 while only 13.5% of non-AKI had ISS above 40.

Concerning the comorbidities, the present study reported that; patients with severe trauma, who developed AKI, had more comorbidities than patients with No AKI (41.7% vs 21.4% correspondingly). General prevalence of cardiac diseases, diabetes mellitus and hypertension was 10%, 4% and 6% correspondingly in AKI patients. This came in accordance with a study conducted by **Llompart-Pou *et al.*** [18]**,** where 2700 patients were included. AKI prevalence was greater in elderly and very elderly patients (201 (11.9%) in young adults, 36 (11.5%) in adult, 57 (22.1%) in elderly, 57 (23.4%) in very elderly group). In accordance **Zyada *et al.*** [13] have revealed that; AKI cases had lower MBP than non-AKI cases. MBP cut off point was <81.5 mmHg with Sensitivity (51.5%) and Specificity (71.2%).

Regarding SBP that was measured for all cases in ER in the present study, it was found that AKI patients had lower SBP than non-AKI patients. The SBP (mean± SD) for AKI cases in ER was (100.83±35.24 mmHg). Also, **Perkins *et al.*** [19] demonstrated that SBP for AKI patients was lower than non-AKI patients with (median and range) value of SBP for AKI cases was 116 (89–146) mmHg.

S.cr level and urine output (UOP) have been considered as the main indicators of renal dysfunction. Of note, an increase in S.cr is broadly utilized for the identification of emerging AKI [20].

In the present study, S.cr level and GFR at different times are utilized for detection of AKI among severe trauma patients. It is found that AKI cases had a significant higher level of S.cr than non-AKI cases, but the GFR significantly decreased in AKI patient. The cut off point for developing renal failure regarding S.cr in AKI patients in ICU was 1.25 mg/dl with sensitivity of 91.7% and specificity of 82.1%. The cut off point for GFR in AKI patients in ICU was 80.1 mL/min with sensitivity of 87.5% and specificity of 67.9%. The median value for peak S.cr level in ICU was 2.92 mg/dl. The median value for GFR level in ICU for AKI patients was 24.25 mL/min with. In agreement **Zyada *et al.*** [13] have displayed that; AKI cases had a higher level of S.cr than non-AKI cases with peak creatinine in AKI patients in ICU (median was 1.40 mg/dl & range from 0.70 to 7) and its cut off point was >1.01 with sensitivity of 86.8% and specificity of 82.7%. While creatinine clearance mean was 102.06 ml/min. However, **Zyada *et al.*** [13] used another biomarker of AKI (plasma NGAL level) and it has high specificity and sensitivity (90.6 and 84.6%). The present study didn't use it due to shortage of its kits in the hospital where the study took place**.**

As regard ABG in the current study, the AKI cases were more acidotic than the non-AKI cases with statistically significant differences among both groups. The PH value was statistically significant lower in AKI group in comparison with non-AKI group. The mean PH value of AKI cases at ER was 7.28 (p=0.014). Also, **Perkins *et al.*** [19] concluded that baseline blood gas analysis was more acidotic for AKI patients than non-AKI patients where median value of PH for AKI cases was 7.27 with p value < 0.0001.

Regarding hemodynamic condition the current study, concluded that, patients with shock or hemodynamic instability, were more liable to develop AKI than non-AKI (41.7% vs 21.4%) and thus; shock is a predictor of AKI among sever trauma patients with (p =.047). Shocked patients, who had AKI, were in need for vasopressor more than non-AKI patients (37.5% vs 3.6%). Similarly, **Chico-Fernández *et al.*** [11]**,** concluded that hemodynamic instability with the requirement of vasoactive support was more frequent in AKI cases (p < 0.001). Haemodynamic instability, coagulopathy and rhabdomyolysis were accompanied by the likelihood of posttraumatic AKI.

In the context of incidence of AKI as a complication of rhabdomyolysis in the current study, rhabdomyolysis developed in 10 (20.8%) patients of the AKI group versus 4(7.1%) of non-AKI cases. The recorded prevalence of AKI in rhabdomyolysis is ranging from 13 to about 50% and the prognosis in such cases is considerably worse and it is elucidated by the existence of further accompanying predisposing factors which include hypotension, metabolic acidosis, hypothermia, and coagulopathy [21]**.** Correspondingly, **Chico-Fernández *et al.*** [11] stated that, trauma ICU cases with AKI were more likely to be associated with rhabdomyolysis (p<0.001).

In the current study, sepsis was diagnosed in 45.8% of patients developing AKI. Likewise, **Zyada *et al.*** [13] revealed that sepsis is a predisposing factor for AKI development, in 43.4% of trauma cases who developed AKI in the ICU. Moreover, **Ostermann and Chang** [22], have found that sepsis is a main predisposing factor for AKI development, in 43% of AKI cases in the ICU. Also, **de Abreu *et al.*** [10] have reported that; of the 129 cases admitted to the ICU, 52 had AKI. The primary etiologies of AKI were sepsis in 27 cases (52%) and hypotension in 18 (34%)**.** While in another study reported by **Mohamed *et al.*** [23]**,** sepsis represents more than 1/2 of cases developing AKI, approximately 59% of whole admitted cases to the ICU.

In the present study, six (12.5%) cases developed coagulopathy and whole of them developed AKI indicating that trauma mediated coagulopathy is correlated with AKI development.

Similarly, **Zyada *et al.* [13]** showed that 11 (20.8%) cases developed coagulopathy and all of which developed AKI. The understanding of trauma-associated coagulopathy has improved in a significant manner in recent years. In the past, it was thought that crystalloid resuscitation, hypothermia, and metabolic acidosis were responsible for the coagulopathy detected in trauma cases; however in recent years, it has been established that ATC is an individual entity which could be developed even prior to the beginning of resuscitation.

In the current study the exposure to nephrotoxic drugs were statistically insignificant between non-AKI and AKI groups because of the adjustment of drug dosages based on creatinine clearance. The most frequently given nephrotoxic therapies in the current study were antimicrobials. Similarly, **Zyada *et al.* [13]**, showed that nephrotoxic drugs were statistically insignificant (developed in a single case). In contrast, cases developing AKI were more likely to be managed with nephrotoxic therapy (15.2% in AKI Vs 3.3% non-AKI) [19].

In the context of the length of ICU stay in the present study, AKI development was recorded to be accompanied by an increase in length of ICU stay. The median length of ICU stay for AKI cases was 12.5 days and the range was from 1 to 36 days. Similarly, **Chico-Fernández *et al.* [11]** reported that; patients developing AKI were associated with longer ICU stay ($p<0.001$).

This disagree with **Zyada *et al.* [13]** who reported that there was a reduction in the length of ICU stay in AKI cases than non-AKI and it was clarified by an increase in mortality rate among AKI cases**.** The difference between studies can also be explained by the fact that patient populations in the various researches differed broadly with regard to age, co-morbidities, and mechanism of trauma.

In the current study, it was demonstrated that the number of patients who need RRT among the selected severe trauma patients were ten (20.8%). This result is in harmony with other study on critically ill trauma patients, made by **de Abreu *et al.* [10]**, which has found that dialysis was required for 19 cases (36.5%)**.** Similarly, In the study executed by **[19],** Continuous RRT was required for 38 patients (21.4%) of AKI patients. Also, in another study made by **[14],** RRT was used in 10% of AKI patients and existence of AKI was accompanied by an increase in LOS and mortality, however renal recovery in AKI survivors was good. In contrast, the number of cases who require RRT were 3 (5.7%) in the study recorded by **Zyada *et al.* [13]**. This difference is explained by different risk factors of AKI.

The current study revealed that, there was a statistically significant increase in mortality rate among AKI cases compared to AKI free ones. The increase in mortality among trauma cases with AKI is may be multifactorial but is definitely accompanied by the degree of MOF. Likewise, **Zyada *et al.* [13]** have reported that the mortality rate of AKI cases was 45.3%, which was significantly greater for AKI cases versus non-AKI cases increase in mortality with greater degree of AKI once stratified by RIFLE. Similarly, **Chico-Fernández *et al.* [11],** demonstrated that the mortality in the RIFLE R category was 11.8%, RIFLE I 22.1%, RIFLE F 25%, in comparison with 9.7% in AKI free ones.

CONCLUSION

From the previous results, it is concluded that the combination of both RIFLE classification and S.cr level could be used as a promising confirmatory approach for AKI determination. AKI etiologies in trauma patients are multifactorial. Risk factors of trauma-associated AKI include rhabdomyolysis, coagulopathy, nephrotoxic drugs, shock and sepsis. Development of AKI after severe trauma is closely accompanied by increased mortality and hospital LOS. Initial recognition of AKI and management of its predisposing factors could enhance the outcomes.

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