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KDIGO (Kidney Disease: Improving Global Outcomes) criteria as a predictor of hospital mortality in cirrhotic patients

LIVER

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Original Article

ABSTRACT

Background/Aims: Acute kidney injury (AKI) is frequent in cirrhotic patients and is associated with a poor prognosis. Recently, the Kidney Disease: Improving Global Outcomes (KDIGO) organization recommended new criteria for the diagnosis and staging for AKI. The aim of this study was to evaluate the presence of AKI according to KDIGO criteria in cirrhotic patients admitted to the hospital and to determine its association with hospital mortality.

Materials and Methods: This retrospective study included 277 cirrhotic patients admitted to the intensive care unit and gastroenterology service of a tertiary referral hospital from January 2008 to January 2012. AKI was diagnosed and classified according to the KDIGO criteria.

Results: The overall incidence of AKI in cirrhotic patients was 39%, and the overall hospital mortality was 15.5%. Patients without AKI had a hospital mortality rate of 2.4%, whereas the mortality rate for patients with AKI was 36.1%. The peak AKI stage detected during hospitalization was stage 1 for 58 patients (53.7%), stage 2 for 20 patients (18.5%), and stage 3 for 30 patients (27.7%). Mortality was found to be associated with the presence, stage, and progression of AKI. Multivariate analysis showed that AKI was an independent factor significantly associated with mortality (odds ratio: 9.1; 95% confidence interval: 2.89–29.1; p<0.001).

Conclusion: KDIGO criteria can be used to evaluate AKI in cirrhotic patients. The prevalence of AKI in patients with cirrhosis is high, and AKI is associated with mortality. If early preventive measures are taken, it may be possible to prevent AKI progression and thus mortality.

Keywords: Hospital mortality, acute kidney injury, liver cirrhosis

INTRODUCTION

The clinical course and outcome in cirrhotic patients is highly dependent on the development of complications (1). Acute kidney injury (AKI) is very frequent in cirrhotic patients. It is seen in up to 20% of cirrhotic patients hospitalized for various reasons and is associated with a bad prognosis (2-4).

The definition of AKI in cirrhotic patients is difficult (5). Serum creatinine and the calculated glomerular filtration rate (GFR) do not reflect renal functions accurately in these patients. Several factors contribute to this, such as decreased creatinine production due to a decreased hepatic synthesis of creatinine, decreased skeletal muscle mass, and increased tubular secretion of creatinine in cirrhotic patients. The calculated creatinine clearance may also overestimate the real glomerular filtration rate, due to the stated reasons (6,7).

RIFLE (Risk-Injury-Failure-Loss-End stage renal disease) and AKIN (Acute Kidney Injury Network) criteria were used to define and classify AKI (8-9). According to RIFLE criteria, AKI is defined as a rise in creatinine of more than 50% from its baseline value and/or a fall in the GFR by

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25% and/or a decrease in urine output below 0.5 mL/kg/h for 6 h or more. However, several studies have shown that small rises in creatinine may be important in terms of mortality rates (10,11).

In 2007, the AKIN criteria were published, which can be considered as a modification of the RIFLE criteria. The development of AKI in cirrhotic patients using these two criteria was shown to be a good predictor of morbidity and mortality (12,13). However, these criteria also are not perfect; each has its own limitations. Assuming normal renal baseline function, in the RIFLE criteria, the proportion of patients with AKI may be overestimated if preexisting chronic kidney disease is ignored. By taking the changes of serum creatinine values in the first 48 h into account, the sensitivity and specificity to detect AKI is increased in the AKIN criteria. But AKIN criteria still may underestimate AKI in patients for whom the increase in serum creatinine is slow. Recently, KDIGO (Kidney Disease: Improving Global Outcomes) proposed new AKI criteria, whereby AKI is defined by taking serum creatinine alterations within 7 days into account (14). KDIGO criteria evaluate baseline creatinine and also, therefore, can detect AKI in patients with a slow rise in creatinine. These criteria provide a standardized simple way of categorizing AKI and may be a better predictor of morbidity and mortality. The RIFLE, AKIN, and KDIGO criteria are summarized in Table 1.

KDIGO criteria of AKI were validated in a pediatric critical care population (15). Studies of AKI using KDIGO criteria in orthotopic lung transplant recipients, after cardiac surgery, and in septic patients in critical care units have been published recently, but, to the best of our knowledge, there is no study in the English literature investigating AKI in a cirrhotic population using KDIGO criteria (16-18). Therefore, in this study, we aimed to evaluate AKI in cirrhotic patients admitted to hospital using KDIGO criteria and to determine its relation with mortality. Not only was the presence of AKI evaluated but AKI stage and progression were also evaluated in terms of the potential effects on mortality rates.

MATERIALS AND METHODS

This is a retrospective study conducted in Necmettin Erbakan University, Meram School of Medicine, Turkey, which is a tertiary referral hospital for the treatment of liver diseases. Consecutive cirrhotic patients over the age of 18 years and who were admitted to the gastroenterology clinic or intensive care unit between 2008 and 2012 were evaluated retrospectively using a prospectively collected electronic database. The study protocol was approved by the Local Medical Ethics Committee of Necmettin Erbakan University.

The diagnosis of cirrhosis was based on a combination of physical signs and biochemical, endoscopic, or imaging findings compatible with the disease. Child Turcot Pugh (CTP) and Model For End-Stage Liver Disease (MELD) scores were calculated from the patient charts according to the United Network for Organ Sharing Formula (19). Deceased patients were determined, and the time-to-death was recorded from the hospital database.

The lowest serum creatinine value in the last 3 months was accepted as basal creatinine, and the criteria proposed by KDIGO were applied for the diagnosis of AKI. As data of urine output were not available, only serum creatinine was considered for these criteria. AKI is defined as any of the following:

Increase in SCr by ≥0.3 mg/dl within 48 hours; or increase in SCr to ≥1.5 times baseline which is known or presumed to have occurred within the prior 7 days.

AKI is staged for severity according to the following criteria:
Stage 1: SCr x1.5–1.9 times baseline or ≥0.3 mg/dl increase;
Stage 2: SCr x2.0–2.9 times baseline;
Stage 3: SCr x3.0 times baseline or an increase in serum creatinine to ≥4.0 mg/dl or an initiation of renal replacement therapy.

Patients were considered to have a worsening of AKI if they progressed to a higher AKI stage or, for patients initially pre-

Table 1. Diagnosis and staging of AKI, RIFLE, AKIN, and KDIGO criteria based on serum creatinine

Classification	Definition for AKI	Stage	Serum Creatinine Criteria for AKI Staging
RIFLE	Increase in SCr ≥50% within 7 d	Risk	To ≥1.5 times baseline
		Injury	To ≥2 times baseline
		Failure	To ≥3 times baseline or ≥0.5 mg/dL increase to at least 4.0 mg/dL
AKIN	Increase in SCr ≥0.3 mg/dL or ≥50% within 48 h	1	Increase of ≥0.3 mg/dL or to 1.5–1.9 times baseline
		2	To 2–2.9 times baseline
		3	To ≥3 times baseline or ≥0.5 mg/dL increase to at least 4.0 mg/dL or initiation of RRT
KDIGO	Increase in SCr ≥0.3 mg/dL within 48 h or ≥50% within 7 d	1	Increase in SCr ≥0.3 mg/dL within 48 h or to 1.5–1.9 times baseline
		2	To 2.0–2.9 times baseline
		3	To 3.0 times baseline or to at least 4.0 mg/dL or initiation of RRT

RIFLE: risk injury failure loss; ESRD:; AKIN: Acute Kidney Injury Network; KDIGO: Kidney Disease Improving Global Outcomes; SCr: serum creatinine; RRT: renal replacement therapy
Urine output was not used because records of hourly urine output were not available for the majority of patients.

sented in stage 3, if they subsequently required renal replacement therapy.

Patients with missing data, whom basal creatinine value could not be detected from electronic databases, patients with basal creatinine above 4 mg/dl, liver or kidney transplant recipients, pregnant patients, and patients hospitalized for less than 48 h were excluded from the study.

Statistical Analyses

Statistical analyses were performed using the Statistical Package for Social Sciences for Windows version 15.0 (SPSS; Chicago, IL, USA). In binary group analyses, the student's t-test was used for groups showing normal distribution and Mann-Whitney-U test for groups not showing normal distribution. Categorical variables were tested using the chi-square test. Logistic regression models were used to determine the independent predictors of mortality. Variables that could be related to mortality were assessed by univariate analysis. Multivariate analysis (backward stepwise regression analysis) of variables (with $p<0.05$) at baseline were performed. For the statistical analyses, the confidence interval was accepted as 95% and p values equal or smaller than 0.05 were accepted as statistically significant.

RESULTS

Cohort characteristics

Overall, 328 cirrhotic patients were found to be hospitalized between 2008 and 2012; 51 patients were excluded because they fulfilled exclusion criteria and the remaining 277 patients were included in the study. The mean age of the patients was 62.1 years, and 160 of them (57.8%) were males.

The most common etiology of cirrhosis were hepatitis B (30.7%), cryptogenic (28.8%), and hepatitis C (19.5%), and the most common reasons for hospitalization were refractory ascites (27.1%), hepatic encephalopathy (21.3%), gastrointestinal bleeding (18.4%), and spontaneous bacterial peritonitis (10.8%). Diabetes mellitus (36.1%), hypertension (19.1%), and hepatocellular carcinoma were the most common comorbid illnesses detected. Mean MELD and CTP scores on admission were 15.9 and 8.9, respectively. Demographic and clinic characteristics of the patients and laboratory studies on admission are summarized in Table 2.

Acute kidney injury

Using KDIGO criteria, 108 patients (39.0%) were found to have AKI. In 59 patients (21.3%), AKI was found to be already present on admission, and 49 patients (17.7%) developed AKI later in the course of hospitalization. The demographic characteristics of the patients with AKI were not different from those without AKI. Cirrhosis etiology also did not differ significantly between the two groups. When the hospitalization reason was taken into account, spontaneous bacterial peritonitis was found to

Table 2. Demographical and clinical characteristics of the patients and their relation with AKI

	Total	With AKI	Without AKI	p Value
N	277	108	169	
Age (years) mean±SD	62.1±13,3	62.7±12.4	61.7±13.9	0.576
Male, n (%)	160 (57.8)	65 (60.2)	95 (56.2)	0.299
Cirrhosis etiology, n (%)				
HBV	85 (30.7)	39 (36.1)	46 (27.2)	0.358
HCV	54 (19.5)	22 (20.4)	32 (18.9)	
Alcohol	13 (4.7)	5 (4.6)	8 (4.6)	
Autoimmune	12 (4.3)	3 (2.8)	9 (5.3)	
Cryptogenic	77 (27.8)	27 (25)	50 (29.6)	
PBS	16 (5.8)	6 (5.6)	10 (5.9)	
Other	20 (7.2)	6 (5.6)	14 (8.3)	
Reason for admission, n (%)				
Hepatic encephalopathy	59 (21.3)	25 (23.1)	34 (20.1)	0.551
Refractory ascites	75 (27.1)	33 (30.6)	42 (24.9)	0.333
GI bleed	51 (18.4)	19 (17.6)	32 (18.9)	0.874
SBP	16 (10.8)	9 (8.3)	7 (4.1)	0.001
Infection other than SBP	12 (4.3)	8 (7.4)	4 (2.4)	0.066
Other	64 (23.1)	14 (13.0)	50 (29.6)	0.001
Hospital admission				
Child Pugh Score	8.96±2.54	10.1±2.51	8.2±2.26	<0.001
Child-Pugh Class				
A	57 (20.6)	7 (6.5)	50 (29.6)	<0.001
B	108 (39)	39 (36.1)	69 (40.8)	
C	112 (40.4)	62 (57.4)	50 (29.6)	
MELD	15.97±6.57	19.8±7.7	13.4±4.1	<0.001
Hemoglobin (g/L)	10.6±2.06	10.4±2.1	10.7±1.97	0.197
Serum creatinine (mg/dL)	1.1±0.66	1.52±0.88	0.84±0.24	<0.001
Sodium (mEq/L)	135.4±4.6	133.9±5.1	136.4±3.9	<0.001
Albumin (g/dL)	2.91±0.54	2.75±0.51	3.02±0.54	<0.001
INR	1.58±0.49	1.73±0.63	1.49±0.34	<0.001
T. bilirubin (mg/dL)	3.57±4.52	5.37±,6.14	2.41±2.47	<0.001
Comorbidity, n (%)				
Diabetes mellitus	74 (26.7)	37 (34.3)	37 (21.9)	0.026
Hypertension	53 (19.1)	22 (20.4)	31 (18.3)	0.394
Hepatocellular carcinoma	45 (16.2)	19 (17.6)	26 (15.4)	0.621
MV requirement, n (%)	16 (5.8)	15 (13.9)	1 (0.6)	<0.001
Length of ICU stay, (days)	2.31±4.92	3.91±6.77	1.28±2.80	<0.001
Length of hospital stay, (days)	10.8±6.19	12.52±7.54	9.71±4.85	<0.001
In-hospital mortality, n (%)	43 (15.5)	39 (36.1)	4 (2.4)	<0.001

N: number; SD: standard deviation; HBV: hepatitis B virus; HCV: hepatitis C virus; PBS: primary biliary cirrhosis; GI: gastrointestinal; SBP: spontaneous bacterial peritonitis; MELD: model for end-stage liver disease; WBC: white blood cell; PLT: platelet count; INR: international normalized ratio; MV: mechanical ventilation; ICU: intensive care unit

be associated with AKI. Of the 12 patients with spontaneous bacterial peritonitis, AKI was present in 8 patients (66.7%). DM was also found to be more frequent in patients with AKI (34.3% vs. 21.9%, p=0.026).

As expected, patients with AKI were advanced stage cirrhotic patients, and therefore, the mean CTP and MELD scores of the patients with AKI were higher than those patients without AKI (10.1 vs. 8.2 and 19.8 vs. 13.4, respectively). When we consider the laboratory parameters, mean serum sodium and albumin concentrations were found to be significantly lower in patients with AKI (133.9 vs. 136.4 for sodium and 2.75 vs. 3.02 for albumin, respectively) on admission. The mean duration of hospitalization (12.52 vs. 9.71 days) and the mean duration of intensive care unit stay (3.91 vs. 1.28 days) were significantly higher for patients with AKI (p<0.01). A mechanic ventilation requirement was also more frequent in the AKI group (13.9% vs. 0.6%, p<0.01).

Mortality

Overall, 43 patients (15.5%) died during hospitalization. When survivor and deceased patients were compared for various parameters, it was seen that the demographic parameters were similar in the two groups. Statistical analyses showed that hepatic encephalopathy, spontaneous bacterial peritonitis, and refractory ascites were associated with mortality rates. Mortality rates were higher for patients hospitalized for hepatic encephalopathy and spontaneous bacterial peritonitis (30.5% and 43.8%, respectively, p<0.01), whereas patients hospitalized for refractory ascites were associated with significantly lower mortality rates (11.8%, p=0.014). CTP and MELD scores were also found to be significantly higher in the non-survivor group (p<0.001). The mean CTP and MELD scores of survivors and non-survivors were 8.4 vs. 11.8 and 14.5 vs. 23.8, respectively. Child stage was also found to be associated with mortality rates. None of the 57 patients with child stage A died during hospitalization, whereas the mortality rates for child B and C cirrhosis were 7.4% and 31.3%, respectively (p<0.001) (Table 3).

The effects of renal parameters on mortality are summarized in Table 4. Mean serum baseline creatinine did not differ between the survivors and non-survivors, but the mean serum creatinine concentration on admission was significantly higher in the non-survivor group (1.58 vs. 1.02, p<0.001). There was no difference between the two groups in terms of proteinuria. The mortality rate was found to be significantly higher in the AKI group than in patients without AKI (36.1% vs. 2.4%, p<0.01). The mortality rate for patients who already had AKI on admission was 54.2%, whereas for patients who developed AKI during hospitalization, the mortality rate was 14.2% and the difference between the two groups were statistically significant (p<0.001). When they first fulfilled KDIGO criteria, 75 patients (69.4%) were found to have stage 1, 22 patients (20.4%) stage 2, and 11 patients (10.2%) stage 3 AKI. The peak AKI stage detected during hospitalization was stage 1 for 58 patients (53.7%), stage 2 for 20 patients (18.5%), and stage 3 for 30 patients (27.7%). Tak-

Table 3. Demographical, laboratory and clinical characteristics of the patients and their relation with in-hospital mortality

	Total	Non-survivors	Survivors	p Value
N 277	43	234		
Age (years), mean±SD	62.1±13.3	62.2±13.5	62.1±13.3	0.959
Male, n (%)	160 (57.8)	28 (65.1)	132 (56.4)	0.317
Cirrhosis etiology, n (%)				
HBV	85 (30.7)	20 (46.5)	65 (27.8)	0.032
HCV	54 (19.5)	7 (16.3)	47 (20.1)	
Alcohol	13 (4.7)	0	13 (5.6)	
Autoimmune	12 (4.3)	1 (2.3)	11 (4.7)	
Cryptogenic	77 (27.8)	12 (27.9)	65 (27.8)	
PBS	16 (5.8)	1 (2.3)	15 (6.4)	
Other	20 (7.2)	2 (4.7)	18 (7.7)	
Reason for admission, n (%)				
Hepatic encephalopathy	59 (21.3)	18 (41.9)	41 (17.5)	<0.001
Refractory ascites	75 (27.1)	5 (11.6)	70 (29.9)	0.014
GI bleed	51 (18.4)	6 (14)	45 (19.2)	0.523
SBP	16 (10.8)	7 (34.9)	9 (6.4)	<0.001
Infection other than SBP	12 (4.3)	3 (7)	9 (3.8)	0.407
Other	64 (23.1)	4 (9.3)	60 (25.6)	0.018
Hospital admission				
Child-Pugh Score	8.96±2.54	11.81±2.12	8.44±2.25	<0.001
Child-Pugh Class				<0.001
A	57 (20.6)	0	57 (100)	
B	108 (39)	8 (7.4)	100 (92.6)	
C	112 (40.4)	35 (31.3)	77 (68.8)	
MELD	15.97±6.57	23.83±7.32	14.52±5.29	<0.001
Hemoglobin (g/L)	10.6±2.06	10.56±2.53	10.67±1.96	0.754
Serum creatinine (mg/dL)	1.1±0.66	1.58±0.95	1.02±0.56	<0.001
Sodium (mEq/L)	135.4±4.6	132.1±5.25	136±4.26	<0.001
Albumin (g/dL)	2.91±0.54	2.60±0.49	2.97±0.53	<0.001
INR	1.58±0.49	2.01±0.7	1.50±0.39	<0.001
T. bilirubin (mg/dL)	3.57±4.52	8.06±7.54	2.74±3.09	<0.001
Comorbidity, n (%)				
Diabetes mellitus	74 (26.7)	14 (32.6)	60 (25.6)	0.353
Hypertension	53 (19.1)	5 (11.6)	48 (20.5)	0.209
Hepatocellular carcinoma	45 (16.2)	13 (30.2)	32 (13.7)	0.012
MV requirement, n (%)	16 (5.8)	16 (37.2)	0	<0.001
Length of ICU stay, (days)	2.31±4.92	8.18±8.34	1.23±2.93	<0.001
Length of hospital stay, (days)	10.8±6.19	9.53±8.29	11.04±5.71	0.142

N: number; SD: standard deviation; HBV: hepatitis B virus; HCV: hepatitis C virus; PBS: primary biliary cirrhosis; GI: gastrointestinal; SBP: spontaneous bacterial peritonitis; MELD: model for end-stage liver disease; WBC: white blood cell; PLT: platelet count; INR: international normalized ratio; MV: mechanical ventilation; ICU: intensive care unit

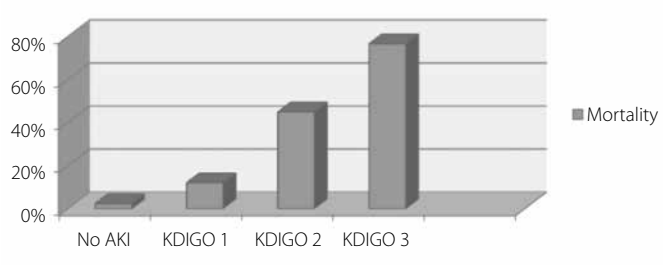

Figure 1. Mortality rates vs AKI stages.
Abbreviations: AKI, acute kidney injury; KDIGO: Kidney disease: improving global outcomes

Table 4. Renal parameters and their relation with AKI

	Total	Survivors	Non-Survivors	p
Baseline creatinine	0.82±0.32	0.82±0.31	0.82±0.39	0.999
Creatinine of admission	1.11±0.66	1.02±0.56	1.58±0.95	<0.001
Proteinuria, n (%)	25 (9)	19 (8.1)	6 (14)	0.245
Timing of AKI relative to admission, n (%)				
Outpatient	59 (54.6)	27 (39.1)	32 (82.1)	<0.001
Inpatient	49 (45.4)	42 (60.9)	7 (17.9)	
KDIGO stage at first meeting criteria				
Stage 1	75 (69.4)	51 (78.3)	21 (53.8)	
Stage 2	22 (20.4)	11 (15.9)	11 (28.2)	0.025
Stage 3	11 (10.2)	4 (5.8)	7 (17.9)	
KDIGO stage progressed				
Yes	30 (27.8)	5 (7.2)	25 (64.1)	<0.001
No	78 (72.2)	64 (92.8)	14 (35.9)	
Peak KDIGO stage				
Stage 1	58 (53.7)	51 (87.9)	7 (12)	
Stage 2	20 (18.5)	11 (55)	9 (45)	<0.001
Stage 3	30 (27.7)	7 (23.3)	23 (76.6)	

N: number; AKI: acute kidney injury; KDIGO: Kidney Disease: Improving Global Outcomes

Table 5. Independent predictors of in-hospital mortality in patients with cirrhosis using multivariate logistic regression analyses

	Odds Ratio	95% CI	P value
Peritonitis	5.85	2.044–16.774	P=0.001
MELD	1.16	1.085–1.242	P<0.001
AKI	9.18	2.890–29.193	P<0.001

N: number; MELD: model for end-stage liver disease; AKI: acute kidney injury

ing peak AKI stage into consideration, the mortality rates were 12.1%, 45.0%, and 76.7% for stage 1, 2, and 3 AKI, respectively. The relation between peak AKI stage and mortality rates were statistically significant (p<0.001) (Figure 1).

In 30 (28%) patients, progression of the AKI stage was detected according to KDIGO criteria. AKI stage progression was more prevalent among non-survivors than survivors (64.1% vs. 7.2%). Mortality rate for patients for whom the AKI stage had progressed was 83.3%, whereas for those with no progression, the mortality rate was 17.9%. In 14 patients, AKI had progressed one stage further, and 10 of them (71.4%) died during hospitalization. For those patients for whom AKI had progressed to stage 2, the mortality rate was 100%. The relation between mortality and AKI stage progression was also statistically significant. Multivariate logistic regression analysis yielded the MELD score, the presence of spontaneous bacterial peritonitis, and the presence of AKI as independent predictors of mortality (Table 5).

DISCUSSION

The present study was conducted to investigate AKI and its relation with in-hospital mortality in cirrhotic patients. To the best of our knowledge, this is the first study using the new KDIGO criteria. There are several studies in the literature investigating AKI in various patients using RIFLE and AKIN criteria. Cholongitas et al. (13) reported an AKI incidence of 50% in 412 intensive care unit patients using RIFLE criteria. The AKI stage was R in 22%, in 9%, and F in 19% of the patients. The mortality rate during or within 6 weeks of hospitalization was reported to be 61.2%. The mortality rate was 42.5% in patients without AKI, 71% for stage R, and 88% for patients with stage I and F AKI. In a study conducted by Carvalho et al. (20), AKI incidence within the first 48 h of hospitalization was 46% in cirrhotic patients with ascites, using AKIN criteria. In this study, 41.9% of the patients were stage 1, 2.5% stage 2, and 1.5% stage 3 AKI. The mortality rates for patients with and without AKI were 52.7% and 29.9%, respectively, and AKI was found to be independently associated with mortality.

In another study using AKIN criteria, Scott et al. (21) found that AKI prevalence was 48% in cirrhotic patients. The mortality rates according to AKI stages were 13.5% for stage 1, 37.8 for stage 2, and 43.2 for stage 3 AKI.

In a study conducted by Belcher et al. (22), AKIN criteria were used and 192 patients with AKI were analyzed. The total mortality rate was 26%. They found mortality rates of 22%, 23%, and 39.5% for stage 1, stage 2, and stage 3 AKI, respectively. In another study, Piano et al. (23) reported AKI prevalence as 26.2% in 233 cirrhotic patients with ascites. The mortality rates were 18.2%, 27.3%, and 54.5% for stage 1, 2, and 3 AKI, respectively.

Fede et al. (24) investigated the effect of renal failure on mortality rates in cirrhotic patients. In this study, a systematic review of 74 articles showed that renal insufficiency increased mortality rates in cirrhotic patients seven-fold. The presence of renal impairment was reported to be an independent prognostic factor in 59% of reviewed studies. Again, in this study, the evaluation of 2548 patients in 37 studies showed that age, child stage, CTP and MELD scores, hepatic encephalopathy, sepsis, and treatment with octreotid, mitodrin, and terlipressin were the most common independent factors associated with prognosis.

In our study, AKI prevalence was 38.9% when KDIGO criteria were used. Also, the AKI prevalence was lower than in the studies in the literature, most of which were done with ICU patients. Different mortality rates ranging from 11% to 81% are also reported in the literature (25,26), while in our study, the overall mortality rate was 15.5%.

One of the important findings in our study was the significant relation between AKI progression and mortality. The mortality for patients without AKI progression was 18%, whereas the mortality rate increased approximately four-fold for patients with progression of AKI, reaching as high as 83%. In a study conducted by Belcher et al. (22), similar to our results, a four-fold increase in mortality in patients with AKI progression was reported. The same study showed that there was a decrease in mortality rate for patients with an early recovery of AKI.

In our study, AKI was in stage I when KDIGO criteria were first met in 69.4% of the patients with AKI, and AKI progression was detected in 27.7% of them. Taking into account that AKI progression significantly increases mortality, it may be logical at this stage to take appropriate measures, such as the assessment of volume and cardiac status to preserve renal perfusion, the avoidance or discontinuation of drugs with potential nephrotoxicity, and the treatment of infections.

Another important point to focus is that AKI risk increases as the liver disease progresses. In this study, both mean CTP and MELD scores were found to be higher in patients with AKI. Considering the association between AKI and mortality, the correct timing of liver transplantation becomes more critical and early transplantation may be a reasonable strategy to prevent AKI-related deaths in patients with advanced liver disease.

AKI prevalence and mortality rate were both higher in patients with spontaneous bacterial peritonitis. Infections other than spontaneous bacterial peritonitis were also associated with the development of AKI. Similar results were also reported in the literature. Bagshaw et al. (27) showed that intraabdominal and genitourinary infections are associated with an increased risk of AKI. In another study, AKI were found to be associated with mortality in patients with spontaneous bacterial peritonitis (28). The mechanism underlying AKI development in intraabdominal infections may be the translocation of bacteria into blood triggering several mechanisms, such as various cytokines, resulting in the impairment of renal functions (18). In our study, statistical analysis showed that spontaneous bacterial peritonitis was also an independent predictor of mortality.

Our study has some limitations as well: first of all, this was a single center retrospective study. Hence, we could not assess all the potential risk factors that may be associated with the development of AKI during hospitalization. Also, it was not possible to detect the exact prevalence of hepatorenal syndrome from the retrospective analysis of hospital records. Again, only the serum creatinine criteria of KDIGO were used only because daily urinary volumetric recordings were not accessible for all the patients.

In conclusion, the results of this study showed that KDIGO criteria can be used to evaluate AKI in cirrhotic patients admitted to hospital for various reasons and AKI is associated with increased mortality rates. Mortality rates were also associated with the stage and progression of AKI. Advanced liver disease, AKI, and spontaneous bacterial peritonitis were found to be independent predictors of mortality. Further prospective studies comparing the old RIFLE and AKIN criteria with the newer KDIGO criteria would validate the sensitivity and specificity of these criteria sets to evaluate AKI in cirrhotic patients.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Necmettin Erbakan University, Meram School of Medicine

Informed Consent: Written informed consent was obtained from patients who participated in this study.

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