Platelet/Albumin Ratio, Fractional Excretion of Sodium, and Glomerular Filtration Rate as Novel Predictors for Hepatorenal Syndrome in Patients with Liver Cirrhosis

Amany Nabil Abbasy[1], Hesham Abdallah Elghoneimy [2], Marwa Ibrahim[1]

[1]Tropical Medicine Department, Faculty of Medicine, Alexandria University, Alexandria, Egypt.

[2]Nephrology Unit, Internal Medicine Department, Faculty of Medicine, Alexandria University, Alexandria, Egypt.

Corresponding Author
Amany Nabil Abbasy
E-mail:
amany.hasan@alexmed.edu.eg

Receive date:19/7/2025
Revise date:21/8/2025
Accept date:8/9/2025
Publish date:15/9/2025
Keywords: Hepatorenal syndrome; platelets/albumin ratio; fractional excretion of sodium; glomerular filtration rate.

Background and study aim: Hepatorenal Syndrome acute kidney injury (HRS-AKI) is an emergency complication occurring exclusively in patients with advanced liver cirrhosis (LC) and ascites, and a well-timed diagnosis is optimal. The KDIGO guidelines recently pointed out that HRS-AKI and terlipressin administration should not be postponed for 48 hours previously dictated as obligatory for exclusion of pre-renal azotemia. This study assessed the significance of certain albumin-related ratios, fractional excretion of sodium (FeNa), and estimated glomerular filtration rate (eGFR) and established a related equation that could predict the development of HRS-AKI in patients with LC.

Patients and Methods: The study design is cross sectional including 122 participants. Group 1: HRS (n=34), group 2: pre-renal azotemia (n=34), group 3: LC without renal impairment (n=36), while group 4: healthy controls (n=18). Certain albumin-related ratios, eGFR, Model of End Stage Disease (MELD), FeNa as well as the Child Pugh score were calculated. Receiver operating characteristic (ROC) curve analysis in addition to multivariate logistic regression were performed to identify the independent predictors of HRS.

Results: A multivariate logistic regression analysis identified platelets/albumin ratio, albumin-platelets product, eGFR and FeNa as independent predictors for HRS in patients with LC. Moreover, a predictive equation was derived showing that the probability of HRS = 1/ (1+e^-10.191 + 0.037 (platelet/albumin ratio) + 0.112 (GFR)+4.044 (albumin-platelets product) +4.73 (FeNa)), with a diagnostic sensitivity, specificity and accuracy of 85%, 83% and 83% respectively.

Conclusion: A multivariate logistic regression analysis identified platelets/albumin ratio, albumin-platelets product, eGFR and FeNa as independent predictors for HRS in patients with LC. Moreover, a predictive equation was derived showing that the probability of HRS = 1/ (1+e^-10.191 + 0.037 (platelet/albumin ratio) + 0.112 (GFR)+4.044 (albumin-platelets product) +4.73 (FeNa)), with a diagnostic sensitivity, specificity and accuracy of 85%, 83% and 83% respectively.

INTRODUCTION

Approximately, patients with end-stage liver disease (ESLD) might encounter incidences of kidney dysfunction during their course of illness [1]. The range of pathological conditions extends from potentially reversible disorders, including acute tubular necrosis (ATN) and prerenal azotemia, to progressive forms of kidney dysfunction, such as chronic kidney disease (CKD) and renal fibrosis [2].

Moreover, up to 60% of hospitalized patients with cirrhosis experience acute kidney injury (AKI) [3]. According to the Kidney Disease Improving Global Outcomes (KDIGO) guidelines for clinical practicing, AKI is operationally defined by one or more of the following parameters:

an elevation in serum creatinine of 0.3 mg/dL (26.5 mmol/L) within a 48-hour interval, an increase in serum creatinine to 1.5 times the baseline level over an estimated seven-day period, or a sustained diminished urine output decreasing below half mL/kg/h for a minimum of six consecutive hours.

In situations where a serum creatinine measurement from the preceding seven days is unobtainable, the most recent value available within the prior three months is considered the baseline reference for assessment [4].

Hepatorenal syndrome-associated AKI (HRS-AKI) depicts a distinct pathophysiological phenotype of AKI occurring solely in individuals with advanced liver cirrhosis (LC) and ascites. This condition may coexist with tubular injury, proteinuria, and/or pre-existing chronic kidney disease, further complicating the diagnosis and disease progression [4].

HRS-AKI is defined by a profound decline in eGFR, initially aggravated by profound constriction of the renal arterioles. Additionally, systemic inflammation, adrenal insufficiency, portal hypertension, and the hepatorenal reflex serve as pathophysiological contributors to the development and progression of renal impairment (RI) [5].

The classification of HRS is contingent upon the severity and duration of renal dysfunction, distinguishing two primary forms. HRS-AKI denotes an acute decline in renal function, whereas HRS–non-AKI describes a prolonged functional renal impairment exceeding seven days in individuals with LC, occurring in the absence of alternative etiologies of kidney disease [6].

Upon confirmation of diagnosis of HRS-AKI, prompt decision of initiation of vasoconstrictor therapy, with terlipressin as the recommended first-line agent, in conjunction with 20–25% albumin, is contingently advised. The Acute Disease Quality Initiative (ADQI) and the International Club of Ascites (ICA) joint multidisciplinary consensus currently detain the routine administration of intravenous albumin for 48 hours as a mandating step for HRS-AKI diagnosis and the exclusion of prerenal azotemia [4].

Conventional biomarkers employed in the clinical assessment of renal injury, such as serum creatinine and blood urea nitrogen (BUN), have proved to have plenty shortcomings, primarily due to their variability according to extrinsic physiological influences, including muscle mass, muscle metabolism, and dietary intake, all of which are factors that are particularly prevalent among individuals with LC [7]. Furthermore, accurate differentiation between prerenal azotemia and HRS is imperative to facilitate timely initiation of terlipressin therapy, thereby mitigating unnecessary treatment delays.

This study was designed to investigate the predictive value of novel albumin-related ratios, FeNa, eGFR in the early detection of HRS development. By integrating these innovative biomarkers, this research helps to promote diagnostic precision, optimize clinical decision-making, and facilitate timely therapeutic intervention for patients with advanced liver disease.

PATIENTS AND METHODS

This cross-sectional study encompassed all patients diagnosed with hepatitis C virus (HCV)-related LC and AKI who were admitted to the Tropical Medicine Department at Alexandria University during the period between December 2022 and December 2024. Ethical approval was obtained from the local institutional review board (IRB No: 00012098). The study was conducted in accordance with the principles outlined in the Declaration of Helsinki and its later amendments, with informed consent secured from all participants.

During the study period, 93 patients were diagnosed with AKI following the kidney disease: KDIGO clinical practice guidelines [4]. However, 7 patients were excluded due to unavailable baseline serum creatinine, and an additional 18 patients diagnosed with AKI attributed to sepsis, nephrotoxic drug intake, or ATN identified based on a fractional excretion of sodium (FeNa) >1% and patients with AKI on top of CKD were also excluded [8].

Among the remaining 68 patients, two distinct groups were classified based on serum creatinine response to intravenous IV albumin administration over 48 hours. Group 1 (n = 34) comprised patients with hepatorenal syndrome (HRS), evidenced by persistent serum creatinine elevation despite treatment. Group 2 (n = 34) included patients diagnosed with prerenal

azotemia, as confirmed by serum creatinine normalization following IV albumin administration.

Further diagnostic measures were undertaken to validate HRS, including urine analysis, which showed the absence of casts or dysmorphic red blood cells (RBCs). The urinary albumin-to-creatinine ratio (ACR) was calculated according to the following equation and was found to be within the normal reference range. Ultrasound (US) imaging revealed normal sonographic features of both kidneys.

ACR=Albumin (mg/dl) / Creatinine (g/dl) x 1000 [9]

Additionally, Group 3 (n = 36) consisted of patients with hepatitis C virus (HCV)-related liver cirrhosis (LC) and normal kidney functions, while Group 4 (n = 18) served as healthy controls. A summary of the patient classification studied is provided in the accompanying diagram (figure 1).

Detailed history and thorough clinical examinations were conducted on all patients. The diagnosis of hepatitis C virus (HCV) infection was established based on the detection of HCV-specific antibodies (Ab) using the Enzyme-Linked Immunosorbent Assay (ELISA), in accordance with standardized diagnostic protocols.[10] LC was identified through a comprehensive assessment incorporating clinical manifestations indicative of hepatic decompensation, corroborated by laboratory findings and characteristic US features suggestive of cirrhotic liver pathology [11].

Routine laboratory investigations were conducted including complete blood count (CBC), liver enzymes, renal function tests (RFTs), liver function tests (LFTs), fasting blood glucose (FBG) as well as a complete urine analysis were performed. The modified Child Pugh Grade [12], Model for End Stage Liver Disease sodium (MELD-Na) [13], eGFR by CKD-EPI equation (2021) [14], as well as FeNa which was calculated according to the following formula.

FeNa: [(urine sodium x serum creatinine)/(serum sodium x urine creatinine)] × 100 [15]

Finally, platelets/albumin ratio, serum creatinine/albumin ratio, blood urea nitrogen (BUN)/albumin ratio, bilirubin/albumin ratio, International normalized ratio (INR)/albumin ratio, leucocytes/albumin ratio, albumin platelet product (APP) [16] and albumin bilirubin index (ALBI) [17] were calculated from the laboratory tests obtained.

Statistical Analysis of Data

IBM SPSS version 20.0 was used for statistical analysis. Continuous variables were summarized by mean, median, and standard deviation, while categorical variables were described using frequency distributions. Relationships between categorical variables were assessed via Chi-Square, and continuous variables were compared using T-tests or ANOVA. Diagnostic accuracy was evaluated through ROC curve analysis, and multivariate logistic regression detected independent variables of HRS development.

RESULTS

FeNa and eGFR were found to be significantly less in patients with LC and RI than patients without. Moreover, they were found to be significantly less in patients with HRS than those with prerenal azotemia, as shown in table 1.

3.2. Value of studied albumin related ratios in diagnosing HRS and prerenal azotemia in patients with LC

Regarding the studied albumin related ratios, all ratios except for the albumin platelets product, were found to be significantly more in patients with LC and RI, compared to patients with LC without RI. The only ratio that was found to have a statistically significant difference between patients with HRS and prerenal azotemia was the platelets/albumin ratio as shown in table 2.

3.3. Regression analysis to identify the independent predictors for HRS in patients with LC

Multivariate logistic regression analysis identified platelets/albumin ratio (Odd's ratio (OR),95% confidence interval (CI): 0.95(0.93-0.99), p=0.023), eGFR (OR, 95% CI: 0.98(0.82-0.97), p=0.011), albumin-platelets product(OR, 95%CI: 0.018(0.001-0.22),p= 0.002) and FeNa (OR,95% CI: 0.009 (0.00 – 0.26) , p= 0.006) as independent predictors for HRS in cirrhotic patients, as shown in table 3.

3.4. Diagnostic accuracy of the derived model for prediction of development of HRS

DOI: 10.21608/aeji.2025.404471.1500

Based on these findings, a predictive equation was derived: Probability of HRS = 1/ (1+e^10.191 - 0.037(platelet/albumin ratio)-0.112(eGFR)-4.044(Albumin platelet product)-4.73(FeNa). ROC curve analysis demonstrated discriminative ability for the above combined model (AUC=0.91, 95% CI: 0.84-0.97, p=0.000) with sensitivity, specificity and accuracy of 85%, 83% and 83% respectively. The diagnostic performance of the predictive equation of probability of discriminating against patients with HRS from patients with pre-renal azotemia is shown in figure 2.

Table (1): Demographic and laboratory results of subjects studied.

	Group I (n = 34)		**Group II (n = 34)**		**Group III (n = 38)**		**Group IV (n = 18)**		**Test of Significance**	**P**
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**		
Sex										
Male	16	47.1	20	85.8	12	33.3	11	61.1	χ^2= 6.691	0.07
Female	18	52.9	14	41.2	24	66.7	7	38.9		
Age (years)										
Mean ± SD.	55.58 ± 8.95		58.02 ± 7.09		65.11 ± 5.45		55.66 ± 7.41		2.07	0.55
Child Pugh score										
Mean ± SD.	10.88 ± 1.25		10.17 ± 1.44		9.66 ± 1.12				H=15.57	0.000
	p_1=0.009*, p_2=0.000*, p_3=0.25									
MELD Na										
Mean ± SD.	27.76 – 5.73		24.00 ± 6.01		13.83 ± 4.34		7.94 ± 1.69		H=87.37	0.000
p_0	0.000*		0.000*		0.000*					
	p_1=0.007*, p_2=0.000*, p_3=0.001*									
Serum albumin (g/dl)										
Mean ± SD.	2.05 ± 0.45		1.98 ± 0.53		6.63 ± 0.67		4.75 ± 0.52		H=57.82	0.000
p_0	0.000*		0.000*		0.001*					
	p_1=0.74, p_2=0.001*, p_3=0.000*									
Serum bilirubin (mg/dl)										
Mean ± SD.	4.74 ± 4.85		3.58 ± 4.84		1.86 ± 2.37		0.76 ± 0.14		H=17.69	0.001
p_0	0.000*		0.000*		0.04*					
	$p_1$0.41, p_2=0.013*, p_3=0.04*									

INR						
Mean ± SD.	1.60 ± 0.39	1.62 ± 0.35	1.34 ± 0.18	1.06 ± 0.10	H=49.61	0.000
p_0	0.000*	0.000*	0.000*			
	p_1=0.82, p_2=0.003*, p_3=0.001*					
Platelet count (10^9/L)						
Mean ± SD.	108.64 ± 49.64	171.29 ± 115.02	107.77 ± 48.61	213.33 ± 36.78	H=34.20	0.000
p_0	0.000*	0.000*	0.000*			
	p_1=0.02*, p_2=0.88, p_3<0.013*					
Blood urea (mg/dl)						
Mean ± SD.	125.94±64.06	116.17 ± 51.77	33.55 ± 27.44	11.61 ± 2.42	H=85.58	0.000
p_0	0.000*	0.000*	0.000*			
	p_1=0.58, p_2=0.000*, p_3=0.000*					
Serum creatinine (mg/dl)						
Mean ± SD.	2.77 ± 0.92	2.11 ± 0.52	0.77 ± 0.21	0.65 ± 0.15	H=93.37	0.000
p_0	0.000*	0.000*	0.034*			
	p_1=0.004*, p_2=0.000*, p_3=0.000*					
eGFR (ml/min)						
Mean ± SD.	24.00 ± 8.98	31.70 ± 10.72	97.93 ± 40.48	126.20 ± 37.78	H=92.44	0.000
p_0	0.000*	0.000*	0.002*			
	p_1=0.01*, p_2=0.000*, p_3=0.000*					
FeNa (%)						
Mean ± SD.	0.57 ± 0.21	0.73 ± 0.21	0.93±0.25		U=303.50	0.000
p_0						
	p_1=0.000*, p_2=0.000*, p_3=0.001*					
Serum Na (mEq/L)						
Mean ± SD.	129.35 ± 6.43	132.35 ± 5.75	136.88 ± 3.41	140.05 ± 2.95	H=41.33	0.000
p_0	0.000*	0.000*	0.002*			
	p_1=0.05, p_2=0.000*, p_3=0.002*					

DOI: 10.21608/aeji.2025.404471.1500

Serum K (mEq/L)						
Mean ± SD.	4.44 ± 0.69	3.98 ± 0.58	4.10 ± 0.80	4.33 ± 0.45	H=9.74	0.021
p_0	0.32	0.009*	0.34			
	p_1=0.006*, p_2=0.07, p_3=0.5					
Serum Ca (mg/dl)						
Mean ± SD.	8.08 ± 0.87	7.76 ± 0.89	7.52 ± 0.72	8.86 ± 0.32	H=30.37	0.000
p_0	0.001*	0.000*	0.000*			
	P1=0.03*, p2=0.058, p3=0.7					
Serum Po4 (mg/dl)						
Mean ± SD.	4.70 ± 1.61	3.70 ± 0.59	3.73 ± 1.03	4.32 ± 0.52	H=13.39	0.004
p_0	0.39*	0.000*	0.000*			
	P1=0.009*	P2=0.03*	P3=0.9			

P0: significance between Groups I, II, III and group IV
P1: significance between I and II
P2: significance between I and III
P3: significance between II and III
MELD Na: Model for End Stage Liver Disease
mg/dl: milligram/deciliter
INR: International normalized ratio
eGFR: Estimated glomerular filtration rate
FeNa: Fractional excretion of sodium
K: Serum potassium.
Ca: Serum calcium
Po4: Serum Phosphorus
mEq/L: milliequivalent per liter

Table (2): Value of studied albumin related ratios in diagnosing HRS and prerenal azotemia in patients with LC.

	Group I (n = 34)	**Group II (n = 34)**	**Group III (n = 38)**	**Group IV (n = 20)**	**Kruskal Wallis test**	**p**
Creatinine/albumin ratio						
Mean ± SD.	1.41± 0.64	1.17 ± 0.48	0.33 ± 0.18	0.13 ± .03	92.13	0.000
p_0	0.000*	0.000*	0.000*			
	p_1=0.10, p_2=0.000*, p_3=0.000*					
Bilirubin /albumin ratio						
Mean ± SD.	2.33 ± 2.31	1.81 ± 2.43	0.85 ± 1.15	0.16 ± 0.03	48.18	0.000

p_0	0.000*	0.000*	0.000*			
	p_1=0.54, p_2=0.001*, p_3=0.000*					
INR/albumin ratio						
Mean ± SD.	0.82 ± 0.26	0.89 ± 0.36	0.57 ± 0.24	0.22 ± 0.03	62.30	0.000
p_0	0.000*	0.000*	0.000*			
	$p_1$0.58, p_2=0.000*, p_3=0.000*					
BUN/albumin ratio						
Mean ± SD.	28.95 ± 13.63	29.34 ± 16.20	5.94 ± 4.25	1.19 ± 0.28	90.14	0.000
p_0	0.000*	0.000*	0.000*			
	$p_1$0.44, p_2 =0.000*, p_3=0.000*					
Platelet/albumin ratio						
Mean ± SD.	55.49 ± 25.88	91.72 ± 61.04	41.85 ± 15.14	45.33 ± 8.59	23.18	0.000
p_0	0.000*	0.000*	0.48			
	$p_1$0.02*, p_2=0.02*, p_3=0.000*					
Leucocyte/albumin ratio						
Mean ± SD.	3.44 ± 1.50	3.53 ± 2.07	1.69 ± 0.77	1.09 ± 0.212	52.92	0.000
p_0	0.000*	0.000*	0.004*			
	$p_1$0.67, p_2 =0.000*, p_3=0.000*					
Albumin/bilirubin index						
Mean ± SD.	-0.67.40 ± 0.50	-0.68 ± 0.47	-1.38 ± 0.78	-3.27 ± 0.43	59.35	0.000
p_0	0.000*	0.000*	0.000*			
	P1=0.78, p2=0.000*, p3= 0.002*					
Albumin/platelet product					44.97	0.000
Mean ± SD.	0.22 ± 0.11	0.34 ± 0.27	0.87 ± 0.25	1.01 ± 0.21		
p_0	0.000*	0.000*	0.000*			
	P1= 0.059	P2=0.09	P3=0.5			

P0: significance between Groups I, II, III and group IV
P1: significance between I and II
P2: significance between I and III
P3: significance between II and III
INR: International normalized ratio.
BUN: Blood urea nitrogen
SD: Standard deviation.

DOI: 10.21608/aeji.2025.404471.1500

Table (3): Univariate and multivariate regression analysis for prediction of HRS. HRS patients versus patients with prerenal azotemia.

HRS vs Prerenal azotemia	Univariate		#Multivariate	
	P	OR (95%C. I)	p	OR (95%C. I)
Albumin platelet product	**0.03***	36.91 (1.39 – 974.29)	**0.002***	0.018(0.001-0.22)
Albumin- bilirubin index	**0.95**	0.97 (0.36 – 2.59)		
Platelet/albumin ratio	**0.009***	1.02 (1.005 – 1.03)	**0.023***	0.95(0.93-0.99)
BUN/albumin ratio	**0.91**	1.002 (0.97 – 1.02)		
INR/albumin ratio	**0.32**	2.15 (0.47 – 9.83)		
Bilirubin/albumin ratio	**0.36**	0.90 (0.73 – 1.11)		
Creatinine/albumin ratio	**0.09**	0.45 (0.18 – 1.13)		
Leucocyte/albumin ratio	**0.82**	1.03(0.78-1.34)		
FeNa	**0.000***	0.13(0.045-0.41)	**0.006***	0.009 (0.00 – 0.26)
eGFR	**0.01***	1.07(1.01-1.13)	**0.011***	0.98(0.82-0.97)
MELD-Na	**0.014***	0.89(0.82-0.97)		
Child Pugh score	**0.04***	0.67(0.46-0.98)		

P: significance.
OR: Odd's ratio
BUN: Blood urea nitrogen
INR: International normalized ratio
FeNa: Fractional excretion of sodium
eGFR:estimated glomerular filtration rate
MELD Na:Model for End Stage Liver Disease-Sodium

Figure 1: Flow chart of patient grouping into HRS and prerenal azotemia

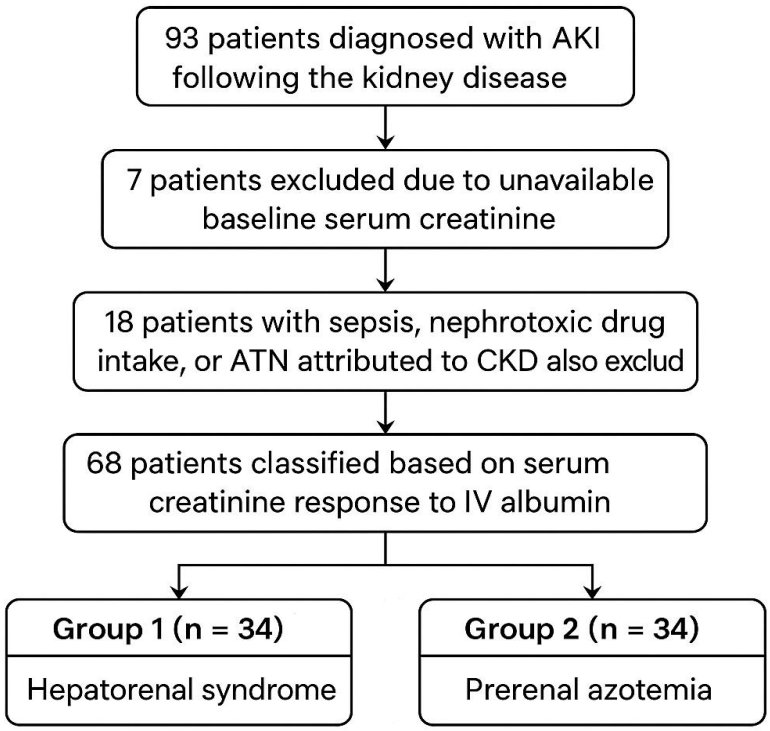
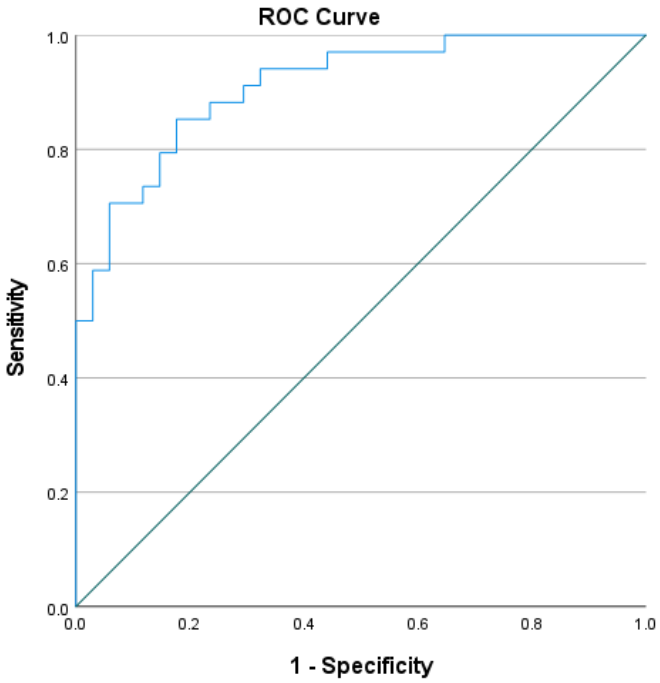


Figure 2: Roc curve of the predictive equation of HRS



DISCUSSION

AKI contributes crucially to morbidity and increased fatality among patients with LC. The pathophysiology of LC is inherently complex, characterized by substantial fluid redistribution and extensive vasodilation, both of which exacerbate disease progression and complications [6].

HRS-AKI is a predominantly functional and progressive form of RI that, while possibly curable, is most often lethal. Nearly 11%–20% of all incidences of AKI in patients with LC is attributed to HRS-AKI, posing significant diagnostic challenges in distinguishing it from prerenal azotemia or acute tubular necrosis (ATN). Furthermore, nearly 40% of cirrhotic patients complicated by ascites will develop HRS-AKI. Timely identification of HRS-AKI is mandatory, as well-timed intervention with terlipressin in combination with albumin, can demolish fatality risk and restore renal function in 40%–50% of affected individuals [18].

During the evaluation of patients with LC, multiple ratios derived from routine blood investigations may have prognostic implications. This study was undertaken to develop a predictive model for the occurrence of HRS-AKI in patients with LC. Findings revealed that the platelet-to-albumin ratio was significantly lower in patients with HRS-AKI compared to those with prerenal azotemia and cirrhotic individuals with preserved renal function ($p = 0.02$).

In alignment with our findings, Nghya N, et al. reported that a platelet-to-albumin ratio cut-off of ≥3.64 demonstrated a strong predictive capability in diagnosing AKI in patients with decompensated cirrhosis, yielding an AUC of 96.7% (95% CI: 95%–98%). Their analysis underscored that the predictive value of the platelet-to-albumin ratio for AKI in cirrhotic patients is driven primarily by two risk factors for RI, namely compromised microcirculation due to thrombocytopenia and abolished colloid osmotic pressure secondary to hypoalbuminemia. Given that renal performance is crucially dependent on adequate perfusion and colloid pressure, these alterations render the kidneys particularly susceptible to injury [19].

In our study, FeNA was significantly lower in HRS patients compared to those with prerenal azotemia, contradicting clinical trials on its diagnostic role [20]. While FeNA is typically 1% in acute tubular necrosis (ATN), its reliability is limited [21]. Factors such as initial low values in euvolemic glomerulonephritis (GN) and variability due to diuretic use prevent FeNA from being a sole indicator for AKI differentiation [21].

To our knowledge, the albumin-platelet product has not been previously studied in differentiating causes of LC related AKI. In this study, it was lower in LC patients, with or without AKI compared to controls. Although levels were also lower in HRS compared to prerenal azotemia and LC without RI, the differences were not statistically significant.

In recent years, scoring systems based on the ALBI model have emerged as promising alternatives to traditional tools like the Child-Turcotte-Pugh (CTP) and MELD scores for predicting outcomes in individuals with chronic liver conditions, liver failure, or hepatocellular carcinoma (HCC) [22]. Elevated INR levels indicates impaired liver function and an accelerated risk of bleeding due to coagulation dysfunction [23]. Likewise, an increased ratio of serum creatinine to albumin often indicates significant kidney dysfunction, which is frequently encountered in patients with advanced liver disease [24]. However, in the current study, it yielded no statistical diagnostic value.

The key outcome of the present study is the multivariate regression analysis which revealed that the platelet-to-albumin ratio, albumin-platelet product, estimated glomerular filtration rate (eGFR), and fractional excretion of sodium (FeNA) emerged as independent predictors of hepatorenal syndrome (HRS) in patients with LC, with p-values of 0.023, 0.002, 0.011 and 0.006, respectively. The predictive model demonstrated good performance, correctly identifying the absence of HRS in 27 of 34 cases (specificity of 83%) and the presence of HRS in 28 of 34 cases (sensitivity of 85%). The model achieved an overall classification accuracy of 83% and an area under the ROC curve of 0.91, suggesting it is a reliable tool for distinguishing HRS from prerenal azotemia in this patient population.

Predictive models for HRS development have been investigated for decades. Shouhao W. et al, deduced a model based on multivariate logistic

regression analysis identifying hemoglobin (OR = 0.938; 95% CI: 0.908–0.969), total bilirubin (OR = 1.014; 95% CI: 1.008–1.021), and serum creatinine (OR = 1.079; 95% CI: 1.043–1.117) as independent predictors of HRS. The model demonstrated excellent discriminative ability, with areas under the ROC curve of 0.968 in the training cohort and 0.980 in the validation cohort [25].

Another optimized predictive model designed involving five key clinical pillars—spontaneous bacterial peritonitis (SBP), erythrocyte count, serum creatinine, activated partial thromboplastin time (APTT), and total bilirubin—exhibited strong discriminatory capacity. The model achieved an area under the ROC curve of 0.832 (95% CI: 0.8069–0.8563) in the training dataset and 0.8415 (95% CI: 0.8042–0.8789) in the validation dataset, indicating high diagnostic accuracy and generalizability [26].

Limitations of the study

This study is limited by the small sample size owing to the declining number of patients with HCV related LC after clearance of HCV. Many patients is required to validate these findings and evaluate their impact on

clinical decision-making and patient outcomes. Moreover, follow up of patients after resolution of AKI with normalization of the studied parameters would further add to their diagnostic and prognostic potential.

CONCLUSION

In conclusion, the novel predictive equation incorporating these parameters provides a simple, reliable and readily available tool for early identification of HRS in clinical practice. Early detection of AKI-HRS using these parameters may facilitate prompt intervention, potentially improving outcomes in patient populations with historically poor prognosis.

Data Availability:

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request

Funding:

The authors did not receive support from any organization for the submitted work

Institutional Review Board Statement:

The study was conducted in accordance with the Declaration of Helsinki, and approved by the local Ethics Committee of the Faculty of medicine of Alexanderia University (IRB NO: 00012098)

Informed consent to participate:

Informed consent was obtained from all individual participants included in the study.

Authors'contributions:

Amany Nabil Abbasy; conceptualization, data collection, analysis and major writing of the manuscript, Marwa Ibrahim; conceptualization, writing and revision of manuscript and Hesham Abdallah Elghoneimy; conceptualization, writing and revision of manuscript. All authors approved the version of the manuscript to be published and agreed to be accountable for all aspects of the work.

Conflict of interest statement:

The authors declare no conflicts of interest

Acknowledgements

The authors of this article would like to express their deepest gratitude to the staff of Tropical medicine as well as Clinical and Chemical Pathology departments for their help accomplishing this work.

HIGHLIGHTS

- This study assessed the significance of certain albumin-related ratios, fractional excretion of sodium (FeNa), and estimated glomerular filtration rate (eGFR) and established a related equation that could predict the development of HRS-AKI in patients with LC.
- A predictive equation was derived showing that the probability of HRS = 1/ (1+e^-10.191 + 0.037 (platelet/albumin ratio) + 0.112 (GFR)+4.044 (albumin-platelets product) +4.73 (FeNa), with a diagnostic sensitivity, specificity and accuracy of 85%, 83% and 83% respectively.
- Timely initiation of terlipressin in patients with HRS can improve patient outcomes.

REFERENCES

1. Webster AC, Nagler EV, Morton RL, Masson P. Chronic kidney disease. *The lancet*. 2017;389(10075):1238-52.
2. Perazella MA, Shirali AC. Kidney disease caused by therapeutic agents. *National Kidney Foundation's Primer on Kidney Diseases: Elsevier;* 2018. p. 334-44.
3. Patidar KR, Naved MA, Grama A, Adibuzzaman M, Ali AA, Slaven JE, et al. Acute kidney disease is common and associated with poor outcomes in patients with cirrhosis and acute kidney injury. *Journal of hepatol*ogy. 2022;77(1):108-15.
4. Nadim MK, Kellum JA, Forni L, Francoz C, Asrani SK, Ostermann M, et al. Acute kidney injury in patients with cirrhosis: Acute Disease Quality Initiative (ADQI) and International Club of Ascites (ICA) joint multidisciplinary consensus meeting. Journal of hepatology. 2024.
5. Adebayo D, Wong F. Pathophysiology of hepatorenal syndrome–acute kidney injury. *Clinical Gastroenterology and Hepatology*. 2023;21(10):S1-S10.
6. Gupta K, Bhurwal A, Law C, Ventre S, Minacapelli CD, Kabaria S, et al. Acute kidney injury and hepatorenal syndrome in cirrhosis. *World journal of gastroenterology*. 2021;27(26):3984.
7. Lee HA, Seo YS. Current knowledge about biomarkers of acute kidney injury in liver cirrhosis. *Clinical and molecular hepatology*. 2021;28(1):31.
8. Bakry MA. Fractional Excretion of Sodium: A Simple Tool for the Differential Diagnosis of Acute Kidney Injury in ICU Patients. *Aswan University Medical Journal*. 2025.
9. Parveen N, Siddiqi E, Awan S, Abbasi M, Nigar R, Baloch M. Correlation of Spot Urine Albumin to Creatinine Ratio and 24-Hrs. Urinary Protein Excretion in Pregnancy Induced Hypertension Cases. Pakistan *Journal of Medical & Health Sciences.* 2022;16(05):1411-.
10. Irshad M, Dhar I, Singh S, Kapoor S. Comparison of serological and nucleic acid based assays used to diagnose hepatitis C virus (HCV) infection in acute and chronic liver diseases. *International Journal of Health Sciences*. 2007;1(1):3.
11. Bharti P, Mittal D, Ananthasivan R. Computer-aided characterization and diagnosis of diffuse liver diseases based on ultrasound imaging: a review. *Ultrasonic imaging*. 2017;39(1):33-61.
12. Pugh R, Murray-Lyon I, Dawson J, Pietroni M, Williams R. Transection of the oesophagus for bleeding oesophageal varices. *British journal of surgery*. 1973;60(8):646-9.
13. Freeman RB, Wiesner RH, Edwards E, Harper A, Merion R, Wolfe R. Results of the first year of the new liver allocation plan. *Liver Transplantation*. 2004;10(1):7-15.
14. Lesley A, Nwamaka D, Josef C, Hocine T, Dan W, Yingying S, et al., for the Chronic Kidney Disease Epidemiology Collaboration. New Creatinine- and Cystatin C-Based Equations to Estimate GFR without Race. *N Engl J Med*. 2021;385(19):1737- 49.
15. Alsaad AA, Wadei HM. Fractional excretion of sodium in hepatorenal syndrome: Clinical and pathological correlation. *World Journal of Hepatology*. 2016;8(34):1497.
16. Fujita K, Yamasaki K, Morishita A, Shi T, Tani J, Nishiyama N, et al. Albumin platelet product as a novel score for liver fibrosis stage and prognosis. *Scientific Reports.* 2021;11(1):5345.
17. Toyoda H, Johnson PJ. The ALBI score: From liver function in patients with HCC to a general measure of liver function. *JHEP Reports.* 2022;4(10):100557.
18. Arnold J, Avila E, Idalsoaga F, Diaz LA, Valverde MA, Ayares G, et al. Advances in the diagnosis and management of hepatorenal syndrome: insights into HRS-AKI and liver transplantation. *Gastroenterology*. 2023;1(2).
19. Nghia NN. Predictive value of platelet-to-albumin ratio for acute kidney injury in patients with decompensated cirrhosis: A double-center study. *Tạp chí Nghiên cứu Y học.* 2024;184(11E15):169-75.
20. Gowda YH, Jagtap N, Karyampudi A, Rao NP, Deepika G, Sharma M, et al. Fractional excretion of sodium and urea in differentiating acute kidney injury phenotypes in decompensated cirrhosis. *Journal of clinical and experimental hepatology*. 2022;12(3):899-907.
21. Nsengiyumva V, Igiraneza G, Lameire N. approach to the patient with presumed AKI. *Rwanda Medical Journal*. 2018;75(3):1-8.
22. Wang J, Zhang Z, Yan X, Li M, Xia J, Liu Y, et al. Albumin-Bilirubin (ALBI) as an accurate and simple prognostic score for chronic hepatitis B-related liver cirrhosis. *Digestive and Liver Disease*. 2019;51(8):1172-8.
23. Kim H-J, Lee H-K, Cho J-H. Factor analysis of the biochemical markers related to liver cirrhosis. Pakistan *Journal of Medical Sciences*. 2015;31(5):1043.
24. Li F, Wang T, Liang J, Qian B, Tang F, Gao Y, et al. Albumin‐bilirubin grade and INR

for the prediction of esophagogastric variceal rebleeding after endoscopic treatment in cirrhosis. *Experimental and Therapeutic Medicine*. 2023;26(5):501.

25. Wang S, Zhou Z, Xu C, Chen H, Ren W, Yang X, Yin Q, Zheng W, Pan H. Establishment and evaluation of an early prediction model of hepatorenal syndrome in patients with decompensated hepatitis B cirrhosis. *BMC gastroenterology*. 2023 Jan 2;23(1):1.
26. Yao F, Luo J, Zhou Q, Wang L, He Z. Development and validation of a machine learning-based prediction model for hepatorenal syndrome in liver cirrhosis patients using MIMIC-IV and eICU databases. *Scientific Reports.* 2025 Jan 22;15(1):2743.

Cite as: Abbasy, A., El ghoneimy, H., Ibrahim, M. Platelet/Albumin Ratio, Fractional Excretion of Sodium, and Glomerular Filtration Rate as Novel Predictors for Hepatorenal Syndrome in Patients with Liver Cirrhosis. *Afro-Egyptian Journal of Infectious and Endemic Diseases,* 2025; (): -. doi: 10.21608/aeji.2025.404471.1500