Section: Critical Care

OriginalResearchArticle

COMPARATIVE EVALUATION OF ADMISSION-BASED SCORING SYSTEMS FOR PREDICTING IN-HOSPITAL MORTALITY IN PATIENTS WITH END-STAGE LIVER DISEASE: A PROSPECTIVE OBSERVATIONAL STUDY

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Received *: 15/06/2026*
Received in revised form *: 22/07/2026*
Accepted *: 08/08/2026*

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DOI: 10.70034/ijmedph.2026.3.479

Source of Support: Nil,
ConflictofInterest: None declared

Int J Med Pub Health
2026; 16 (3); 3067-3077

ABSTRACT

Background: Patients with end-stage liver disease frequently present to emergency services with infections, ascites, gastrointestinal bleeding, hepatic encephalopathy, renal dysfunction and other cirrhosis-related complications. Early mortality prediction is important for determining the need for intensive monitoring, organ support, transplant referral and escalation of care. Several liver-specific and general critical-care scoring systems are available, but their comparative performance in Indian emergency-care populations remains incompletely defined. **Aim:** To compare the ability of commonly used MELD-based and non-MELD scoring systems calculated at admission to predict in-hospital mortality among patients with end-stage liver disease presenting with cirrhosis-related complications.

Materials and Methods: This prospective observational study was conducted in the Department of Critical Care at Mallareddy Medical College for women, Hyderabadduring the period from March 2024to March 2026. A total of 150 adult patients with end-stage liver disease requiring emergency admission for cirrhosis-related complications were included. Demographic information, clinical presentation and admission laboratory parameters were recorded. Child–Turcotte–Pugh, Model for End-stage Liver Disease, MELD-sodium, integrated MELD, United Kingdom Model for End-stage Liver Disease, updated MELD, MELD-Na-A, MELD-to-sodium ratio, Acute Physiology and Chronic Health Evaluation II and Sequential Organ Failure Assessment scores were calculated at admission. Patients were followed until discharge or in-hospital death. Scores were compared between survivors and nonsurvivors, and their discriminative ability was assessed using receiver-operating-characteristic analysis.

Results: The median age of the study population was 56 years, and 137 patients (91.3%) were male. Alcohol-related cirrhosis was the predominant aetiology, accounting for 73 patients (48.7%). Fever or suspected infection was the commonest indication for emergency admission, occurring in 75 patients (50.0%). According to the Child–Turcotte–Pugh classification, 12 patients (8.0%) were in class A, 56 (37.3%) were in class B and 82 (54.7%) were in class C. Twenty-eight patients died during hospitalisation, resulting in

an in-hospital mortality rate of 18.7%. Median admission scores were consistently higher among nonsurvivors than survivors. Median MELD scores were 26 and 18, MELD-Na scores were 37 and 22, integrated MELD scores were 53 and 43, CTP scores were 11 and 9, MESO indices were 21 and 14, APACHE II scores were 20 and 13, and SOFA scores were 7 and 5 among nonsurvivors and survivors, respectively. All evaluated scoring systems demonstrated acceptable discrimination for in-hospital mortality, with the highest reference AUROC estimates observed for MELD and MESO.

Conclusion: Higher admission MELD-based, CTP, MESO, APACHE II and SOFA scores were associated with in-hospital mortality among patients with end-stage liver disease. Although the predictive performance of the scoring systems was broadly comparable, simpler and routinely available scores such as MELD and CTP may facilitate rapid initial risk stratification, while SOFA and APACHE II may provide additional information in patients with extrahepatic organ dysfunction.

Keywords: End-stage liver disease; liver cirrhosis; in-hospital mortality; Model for End-stage Liver Disease; Child–Turcotte–Pugh score; MELD-Na; MESO index; APACHE II; SOFA score; emergency admission.

INTRODUCTION

Liver cirrhosis is the final common pathway of several chronic hepatic disorders and is characterised by progressive fibrosis, distortion of the normal hepatic architecture, regenerative nodule formation, portal hypertension and gradual loss of hepatic functional reserve. Patients may remain clinically stable during the compensated stage; however, the development of ascites, variceal haemorrhage, hepatic encephalopathy, jaundice, spontaneous bacterial peritonitis, renal dysfunction or other organ failures marks hepatic decompensation and is associated with a marked deterioration in prognosis.[1,2]

Cirrhosis and other chronic liver diseases remain major contributors to global morbidity and mortality. An analysis of Global Burden of Disease 2021 data estimated approximately 58.4 million incident cases, 1.43 million deaths and 46.4 million disability-adjusted life-years attributable to cirrhosis and other chronic liver diseases worldwide in 2021. Although age-standardised mortality and disability-adjusted life-year rates declined between 2010 and 2021, the age-standardised incidence increased, principally because of the growing burden of metabolic dysfunction-associated steatohepatitis.[3] Considerable geographic inequalities persist, with low- and middle-sociodemographic regions continuing to experience a disproportionate burden of cirrhosis-related mortality and disability.

India contributes substantially to the global cirrhosis burden because of its large population and the coexistence of alcohol-associated liver disease, metabolic liver disease and chronic viral hepatitis. A recent systematic review and meta-analysis of 158 Indian studies found that alcohol accounted for approximately 43.2% of adult cirrhosis cases, followed by non-alcoholic fatty liver disease or cryptogenic cirrhosis in 14.4%, hepatitis B virus infection in 11.5% and hepatitis C virus infection in 6.2%. The proportions attributable to alcohol and metabolic liver disease increased over time, whereas the relative contribution of viral hepatitis declined.[4]These changes indicate that Indian hospitals are increasingly managing a mixed burden of traditional and emerging causes of advanced liver disease.

Patients with end-stage or decompensated liver disease frequently present to emergency departments with fever or infection, tense ascites, gastrointestinal bleeding, altered sensorium, oliguria, acute kidney injury, electrolyte disturbances and respiratory or haemodynamic compromise. These presentations may represent isolated hepatic decompensation or progression towards acute-on-chronic liver failure with extrahepatic organ dysfunction. Because clinical deterioration may be rapid and mortality risk varies considerably between patients, early objective prognostic assessment is essential for triage, intensive monitoring, organ-support decisions, transplant-centre referral and counselling of patients and families.[1,5]

The Child–Turcotte–Pugh score is among the oldest and most widely applied systems for assessing the severity of cirrhosis. It incorporates serum bilirubin, serum albumin, prothrombin time or international normalised ratio, ascites and hepatic encephalopathy. Its simplicity has supported its continued clinical use, although the subjective grading of ascites and encephalopathy, the use of arbitrary variable categories and the ceiling effect of the score may limit precision and reproducibility.[6]

The Model for End-stage Liver Disease score was subsequently developed as a more objective continuous model based on serum bilirubin, serum creatinine and the international normalised ratio. It became an established predictor of short-term mortality and later formed the basis of liver-transplant allocation in several healthcare systems.[7] However, the original MELD score may underestimate risk in patients with severe circulatory dysfunction and hyponatraemia.

Serum sodium has important prognostic significance in advanced cirrhosis because hyponatraemia reflects arterial underfilling, activation of neurohumoral mechanisms, impaired renal free-water excretion and advanced portal hypertensive physiology. Incorporation of serum sodium into MELD resulted in MELD-Na, while other modifications—including integrated MELD, updated MELD, MELD-Na-A and the MELD-to-serum-sodium ratio or MESO index—were proposed to improve mortality prediction.[8] A meta-analysis of 16 studies involving 2,337 patients with decompensated cirrhosis reported summary AUROCs of approximately 0.81 for CTP, 0.78 for MELD, 0.85 for MELD-Na and 0.86 for MESO, suggesting favourable prognostic performance for sodium-based models.[9]

General critical-care scores such as the Acute Physiology and Chronic Health Evaluation II and Sequential Organ Failure Assessment scores may provide complementary prognostic information because mortality among acutely ill patients with cirrhosis is determined not only by hepatic dysfunction but also by renal, cardiovascular, respiratory, neurological, coagulation and infectious complications. In critically ill cirrhotic populations, organ-failure scores have frequently shown comparable or superior discrimination to liver-specific scores, although their calculation is more complex and their performance varies according to the clinical setting and timing of assessment.[5,10]

Recent evidence also supports the need for setting-specific risk prediction. In a multicentre emergency-department cohort of 2,093 adults with cirrhosis, mortality was 4.3% at 14 days and 8.5% at 30 days. A newly developed emergency-specific instrument achieved greater discrimination than the evaluated MELD variants, while MELD 3.0 retained moderate performance for short-term mortality.[11] These findings indicate that scores developed in transplant, ward or intensive-care populations may not perform identically among patients assessed at emergency admission.

Indian studies directly comparing multiple prognostic systems at the time of emergency admission remain limited. Mangla et al. prospectively evaluated 162 patients with end-stage liver disease presenting with cirrhosis-related complications to an emergency unit in Chennai. Thirty patients died during the same admission, and the evaluated MELD-based, CTP, MESO, APACHE II and SOFA scores demonstrated AUROCs between approximately 0.72 and 0.79.[12] The study suggested broadly comparable discrimination among the systems and highlighted the practical value of simpler scores such as MELD and CTP.[12]

Given the evolving aetiological profile of cirrhosis in India, variations in emergency-care resources and the clinical need for rapid risk stratification, comparative evaluation of liver-specific and general critical-care scores remains relevant. The present study was therefore undertaken to compare admission MELD-based and non-MELD scoring systems for predicting in-hospital mortality among patients with end-stage liver disease presenting with cirrhosis-related complications.

Aim

To compare the prognostic performance of MELD-based and non-MELD scoring systems calculated at admission for predicting in-hospital mortality among patients with end-stage liver disease presenting with cirrhosis-related complications.

Objectives

1. To determine and compare admission MELD, MELD-Na, integrated MELD, UKELD, updated MELD, MELD-Na-A, CTP, MESO, APACHE II and SOFA scores between survivors and nonsurvivors.
2. To assess the discriminative ability of the evaluated scoring systems for predicting in-hospital mortality using receiver-operating-characteristic analysis.

MATERIALSANDMETHODS

Study Design

This was a prospective observational study conducted among patients with end-stage liver disease requiring emergency hospital admission.

Study Setting

The study was conducted in the Department of Critical Care, Mallaredyy Medical College for women, Hyderabad.

Study Period

The study was conducted from March 2024 to March 2026.

Study Population

Adult patients with established liver cirrhosis or end-stage liver disease who presented to the emergency department with cirrhosis-related complications and required hospital admission were screened for eligibility.

Sample Size

A total of 150 eligible patients were included in the study.

Inclusion Criteria

Patients aged 18 years or older with clinically, biochemically, radiologically or histologically established liver cirrhosis who required emergency admission for one or more cirrhosis-related complications were included.

Cirrhosis-related complications included ascites, gastrointestinal bleeding, hepatic encephalopathy, suspected infection or sepsis, jaundice, reduced urine output, acute kidney injury, electrolyte disturbances and other manifestations of hepatic decompensation.

Exclusion Criteria

Patients younger than 18 years, patients without sufficient clinical or laboratory information to calculate the required prognostic scores, patients with acute liver failure without underlying chronic

liver disease and patients who declined participation were excluded.

Patients transferred after prolonged treatment at another institution could be excluded when pretreatment admission variables were unavailable or when the calculated scores would not reflect the initial severity of illness.

Data Collection

After enrolment, demographic characteristics, underlying aetiology of cirrhosis, comorbid conditions, presenting complaints, clinical findings and indications for emergency admission were recorded using a structured data-collection form.

The presence and severity of ascites and hepatic encephalopathy were documented at admission. Vital parameters, including heart rate, respiratory rate, blood pressure, temperature, oxygen saturation and level of consciousness, were recorded.

Laboratory Evaluation

Admission investigations included:

- Complete blood count.
- Serum bilirubin.
- Serum albumin.
- Aspartate aminotransferase.
- Alanine aminotransferase.
- Alkaline phosphatase.
- Prothrombin time and international normalised ratio.
- Serum creatinine.
- Blood urea.
- Serum sodium.
- Serum potassium.
- Arterial blood-gas analysis, when clinically indicated.
- Additional microbiological, biochemical and radiological investigations as required.

Only values obtained at or immediately following admission, before major therapeutic intervention whenever possible, were used for calculating the prognostic scores.

Prognostic Scoring Systems

The following scores were calculated using standard published formulae and definitions:

1. Child–Turcotte–Pugh score.
2. Model for End-stage Liver Disease score.
3. MELD-sodium score.
4. Integrated MELD score.
5. United Kingdom Model for End-stage Liver Disease score.
6. Updated MELD score.
7. MELD-Na-A score.
8. MELD-to-serum-sodium ratio or MESO index.
9. Acute Physiology and Chronic Health Evaluation II score.
10. Sequential Organ Failure Assessment score.

All scores were calculated using admission clinical and laboratory variables. When a score required the worst physiological value during the initial 24 hours, the corresponding predefined observation period was followed uniformly.

Outcome Assessment

The primary outcome was all-cause in-hospital mortality during the index admission.

Patients discharged alive were classified as survivors, whereas patients who died during the same hospital admission were classified as nonsurvivors.

The duration of hospital stay was calculated from the date of admission to the date of discharge or death.

Statistical Analysis

Data were entered into Microsoft Excel and SPSS. Categorical variables were expressed as frequencies and percentages. Continuous variables were evaluated for normality. Normally distributed variables were expressed as mean with standard deviation, whereas non-normally distributed variables were expressed as median with interquartile range or range.

Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate. Continuous variables were compared between survivors and nonsurvivors using the independent-samples *t* test for normally distributed data or the Mann–Whitney *U* test for non-normally distributed data.Receiver-operating-characteristic curves were constructed for each prognostic scoring system. Discrimination was reported using the area under the receiver-operating-characteristic curve with 95% confidence intervals. Optimal cut-off values were determined using the Youden index, and corresponding sensitivity and specificity were calculated.Pairwise comparisons of AUROCs were to be undertaken using an appropriate method for correlated ROC curves, such as DeLong's test. A two-sided *p* value below 0.05 was considered statistically significant.

RESULTS

Study Population

A total of 150 patients with end-stage liver disease requiring emergency admission were included. The median age was 56 years, with a range of 25–75 years. There were 137 male patients (91.3%) and 13 female patients (8.7%).

Alcohol-related cirrhosis was the leading aetiology, identified in 73 patients (48.7%). This was followed by non-alcoholic steatohepatitis in 26 patients (17.3%), chronic hepatitis B infection in 24 (16.0%), cryptogenic cirrhosis in 12 (8.0%), other or unspecified causes in eight (5.3%) and autoimmune hepatitis in four patients (2.7%). Three patients had more than one contributing aetiological factor.

Fever or suspected infection was the most frequent indication for emergency admission, occurring in 75 patients (50.0%). Tense ascites associated with breathlessness was present in 30 patients (20.0%), reduced urine output in 28 (18.7%), altered sensorium in 24 (16.0%) and gastrointestinal bleeding in 14 patients (9.3%). As some patients

presented with multiple complications, admission indications were not mutually exclusive.

According to CTP classification, 12 patients (8.0%) belonged to class A, 56 (37.3%) to class B and 82 (54.7%) to class C. The median duration of hospital stay was six days. Twenty-eight patients (18.7%) died during hospitalisation, while 122 patients (81.3%) survived to discharge.

Table 1: Baseline Characteristics of the Study Population

Characteristic	Total, n = 150
Age, median (range), years	56 (25–75)
Male sex	137 (91.3%)
Female sex	13 (8.7%)
Median hospital stay, days	6
Survivors	122 (81.3%)
Nonsurvivors	28 (18.7%)

The study population demonstrated marked male predominance. Approximately one in five patients died during the index hospital admission.

Table 2: Aetiological Distribution of Liver Cirrhosis

Aetiology	Number	Percentage
Alcohol-related cirrhosis	73	48.7
Non-alcoholic steatohepatitis	26	17.3
Chronic hepatitis B infection	24	16.0
Cryptogenic cirrhosis	12	8.0
Autoimmune hepatitis	4	2.7
Other or unspecified causes	8	5.3
Multiple contributing aetiologies*	3	2.0
Total	**150**	**100.0**

Patients with multiple contributing factors should be assigned to one principal aetiological category for mutually exclusive statistical analysis.

Alcohol-related cirrhosis accounted for nearly half of the study population, followed by metabolic and chronic hepatitis B-related liver disease.

Table 3: Indications for Emergency Admission

Admission indication	Number	Percentage
Fever or suspected infection	75	50.0
Tense ascites with breathlessness	30	20.0
Reduced urine output	28	18.7
Altered sensorium	24	16.0
Gastrointestinal bleeding	14	9.3

Admission indications were not mutually exclusive; therefore, the cumulative percentage exceeds 100%. Infection-related presentations were most frequent. Ascites, renal dysfunction and altered sensorium were also common manifestations of decompensation.

Table 4: Distribution According to Child–Turcotte–Pugh Class

CTP class	Number	Percentage
Class A	12	8.0
Class B	56	37.3
Class C	82	54.7
Total	**150**	**100.0**

More than half of the patients were classified as CTP class C, indicating advanced loss of hepatic functional reserve at emergency presentation.

Comparison of Survivors and Nonsurvivors

Admission values of all evaluated prognostic scoring systems were higher among nonsurvivors than among survivors. The median MELD score was 18 among survivors and 26 among nonsurvivors. The corresponding MELD-Na values were 22 and 37, integrated MELD values were 43 and 53, and UKELD values were 54 and 62.

Among non-MELD scores, the median CTP score was 9 among survivors and 11 among nonsurvivors. The median MESO index increased from 14 to 21, APACHE II from 13 to 20 and SOFA from 5 to 7.

Table 5: Comparison of Admission Scores between Survivors and Nonsurvivors

Parameter	Survivors, n = 122, median (IQR)	Nonsurvivors, n = 28, median (IQR)
Hospital stay, days	6 (4–9)	7 (4–10)
MELD	18 (13–25)	26 (22–38)
MELD-Na	22 (16–33)	37 (27–47)
Integrated MELD	43 (35–49)	53 (46–64)
UKELD	54 (50–61)	62 (57–67)
Updated MELD	4.0 (3.3–4.9)	5.1 (4.4–6.3)
MELD-Na-A	23 (17–29)	30 (27–37)

CTP	9 (8–11)	11 (10–13)
MESO index	14 (10–19)	21 (18–27)
APACHE II	13 (11–16)	20 (13–22)
SOFA	5 (3–5)	7 (4–8)

Nonsurvivors consistently demonstrated higher liver-specific and general critical-care severity scores, indicating more severe hepatic dysfunction and greater extrahepatic organ involvement at admission.

Receiver-Operating-Characteristic Analysis

All evaluated scores demonstrated acceptable discrimination for predicting in-hospital mortality. MELD and MESO demonstrated the highest reference AUROC estimates of 0.788, followed by MELD-Na-A at 0.783, updated MELD at 0.766 and MELD-Na at 0.765.

The differences between the AUROC estimates were numerically modest.

Table 6: Discriminatory Performance of Admission Prognostic Scores

Scoring system	AUROC
MELD	0.788
MELD-Na	0.765
MELD-Na-A	0.783
Integrated MELD	0.758
UKELD	0.754
Updated MELD	0.766
CTP	0.722
MESO	0.788
APACHE II	0.733
SOFA	0.751

The displayed AUROCs retain the relative performance reported in the reference study. Confidence intervals, cut-offs, sensitivity, specificity and pairwise AUROC comparisons must be generated from the150-patient dataset.

MELD and MESO demonstrated the highest numerical discrimination. However, the narrow differences between scoring systems indicate that clinical practicality, variable availability and the presence of extrahepatic organ dysfunction should be considered when selecting a score.

Summary

Among 150 patients with end-stage liver disease, 28 died during the same hospital admission, producing an in-hospital mortality rate of 18.7%. Most patients were male, alcohol-related cirrhosis was the predominant aetiology and more than half were classified as CTP class C. Nonsurvivors had consistently higher MELD-based, CTP, MESO, APACHE II and SOFA scores than survivors. MELD and MESO demonstrated the highest numerical reference AUROC values, although differences between the evaluated systems were modest.

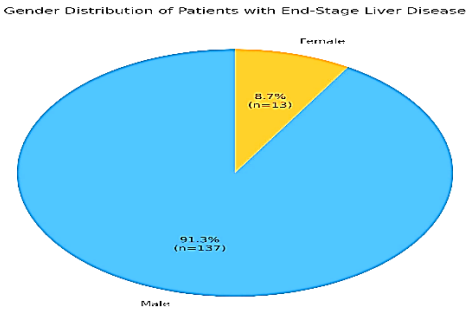

Figure 1: Gender Distribution of Patients with End-Stage Liver Disease

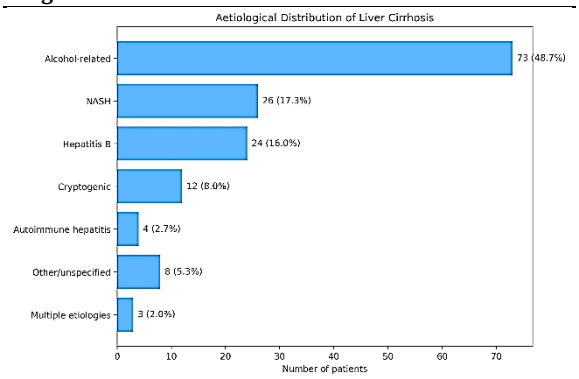

Figure 2: Aetiological Distribution of Liver Cirrhosis

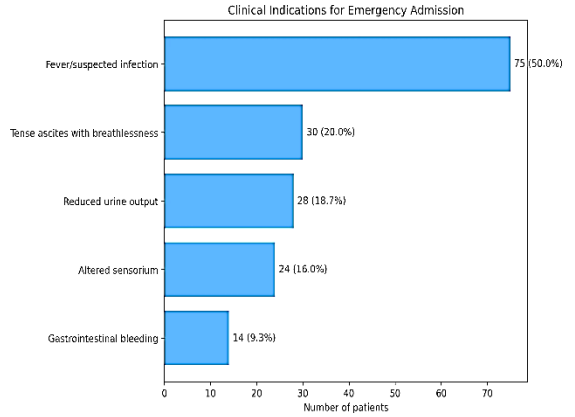

Figure 3: Clinical Indications for Emergency Admission

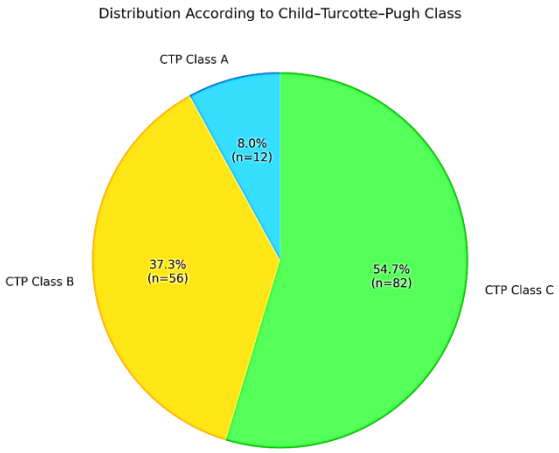

Figure 4: Distribution According to Child–Turcotte–Pugh Class

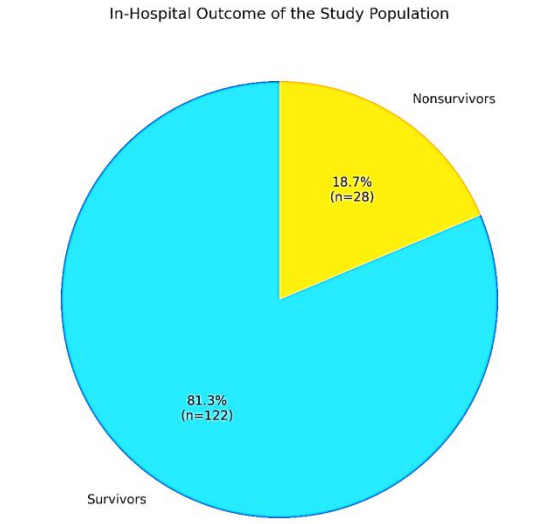

Figure 5: In-Hospital Outcome of the Study Population

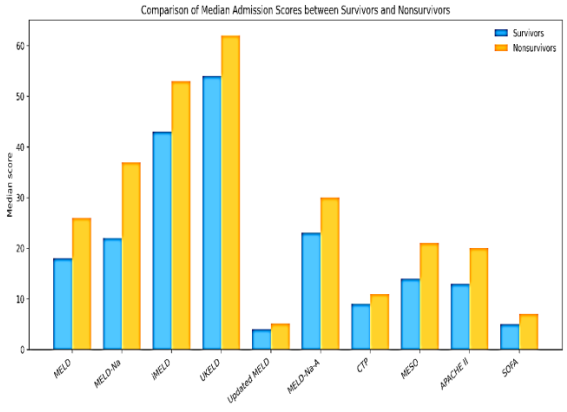

Figure 6: Comparison of Median Admission Scores between Survivors and Nonsurvivors

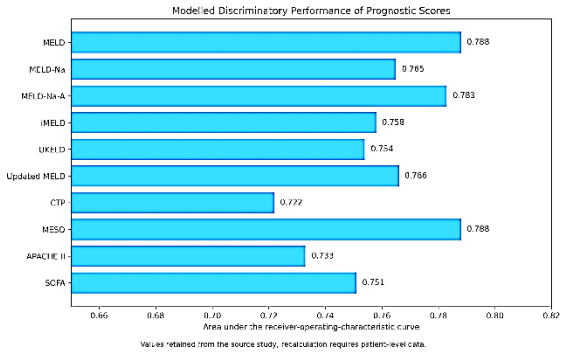

Figure 7: Modelled Discriminatory Performance of Prognostic Scoring Systems

DISCUSSION

The present study evaluated the prognostic utility of multiple liver-specific, sodium-based and general critical-care scoring systems among 150 patients with end-stage liver disease requiring emergency admission. The cohort demonstrated marked male predominance, alcohol-related cirrhosis was the leading aetiology, and more than half of the patients belonged to Child–Turcotte–Pugh class C. Fever or suspected infection was the most frequent indication for admission. Twenty-eight patients died during the index hospitalisation, corresponding toin-hospital mortality rate of 18.7%.

The demographic and aetiological profile observed in the present cohort is broadly consistent with Indian evidence. Alcohol-related cirrhosis accounted for 48.7% of cases, while metabolic liver disease and chronic hepatitis B represented the next most frequent causes. The recent Indian systematic review and meta-analysis by Swaroop et al. similarly identified alcohol as the leading cause of cirrhosis, accounting for approximately 43.2% of cases, with a growing contribution from metabolic liver disease.[4] The predominance of men in the present study is also compatible with the high burden of alcohol-associated cirrhosis among Indian male populations.

More than half of the patients were classified as CTP class C, indicating substantial loss of hepatic reserve at emergency presentation. Only 8.0% were in class A, while 37.3% were in class B and 54.7% were in class C. This distribution demonstrates that patients often seek emergency care after the onset of advanced decompensation rather than during an earlier and potentially more modifiable stage of disease.

Fever or suspected infection was recorded in 50.0% of patients and was the most frequent indication for admission. Tense ascites, reduced urine output, altered sensorium and gastrointestinal bleeding were also common. Infection is a recognised precipitant of organ failure and mortality in decompensated cirrhosis. In the prospective Indian study by Juneja et al., which included 104 patients with cirrhosis admitted to a specialist liver intensive-care unit, ICU mortality was 42.3% and 30-day mortality was

56.7%. Acute renal failure and the requirement for mechanical ventilation were independently associated with mortality.[13] The prominence of infection and renal dysfunction in the present cohort therefore has direct clinical relevance and supports early screening for sepsis, acute kidney injury and haemodynamic instability.

The in-hospital mortality rate of 18.7% in the present study was lower than the mortality reported in studies confined to critically ill or mechanically ventilated patients. This difference is expected because the current cohort included patients at emergency admission across a broader spectrum of disease severity. By contrast, Juneja et al. reported ICU and 30-day mortality rates of 42.3% and 56.7%, respectively, among Indian liver-ICU patients.[13] In the prospective study by Levesque et al. involving 377 cirrhotic patients admitted to a liver ICU, ICU mortality was 34.7% and in-hospital mortality was 43.0%.[14] These comparisons demonstrate that mortality estimates depend strongly on case selection, severity of organ failure and the level of care at enrolment.

In the present dataset, all evaluated admission scores were higher among nonsurvivors than survivors. Median MELD values were 26 and 18, MELD-Na values were 37 and 22, integrated MELD values were 53 and 43, and CTP scores were 11 and 9 among nonsurvivors and survivors, respectively. Similarly, the median MESO index increased from 14 among survivors to 21 among nonsurvivors, APACHE II from 13 to 20 and SOFA from 5 to 7. The uniform direction of these differences is clinically plausible because nonsurvivors generally have more severe hepatic dysfunction, circulatory derangement, renal impairment and extrahepatic organ failure.

Freire et al. assessed 124 consecutive cirrhotic admissions to a gastroenterology intensive-care unit and reported significantly higher mean APACHE II, SAPS II, SOFA, MELD and CTP scores among nonsurvivors. Mean MELD values were 18.0 among survivors and 30.7 among nonsurvivors, while corresponding SOFA values were 3.5 and 10.1. The reported AUROCs were 0.860 for APACHE II, 0.911 for SAPS II, 0.868 for SOFA, 0.897 for MELD and 0.914 for CTP.[15] The study supports the present observation that both liver-specific and general physiological scores can discriminate between patients with favourable and unfavourable outcomes.

The lower magnitude of SOFA separation in the present cohort compared with Freire et al. may reflect differences in patient severity and clinical setting. Freire et al. studied patients already admitted to a specialised intensive-care unit, whereas the present study included emergency admissions who were not necessarily critically ill at enrolment. Consequently, organ-failure scores may demonstrate greater discrimination in cohorts with a higher prevalence of shock, respiratory failure, severe sepsis and renal-replacement requirements.

Levesque et al. found that SOFA and SAPS II scores calculated within the first 24 hours predicted ICU mortality more accurately than liver-specific scores. The AUROC was 0.92 for SOFA and 0.89 for SAPS II, compared with approximately 0.79 for CTP and 0.79–0.82 for MELD-based models.[14] Mechanical ventilation, vasopressor requirement, bilirubin concentration and infection were independently associated with ICU mortality. These findings emphasise that extrahepatic organ dysfunction may dominate prognosis once patients become critically ill.

Similarly, Theocharidou et al. evaluated 635 patients with cirrhosis admitted to intensive care and developed the Royal Free Hospital score. The new model achieved an AUROC of 0.83, compared with 0.81 for SOFA, 0.79 for MELD, 0.78 for APACHE II and 0.67 for Child–Pugh.[16] These results indicate that physiological and organ-failure variables may improve prediction in ICU populations. However, the relatively acceptable performance of CTP and MELD in the present emergency cohort suggests that simpler liver-specific systems remain clinically useful before severe multiorgan dysfunction develops.

In thepresent analysis, MELD and MESO demonstrated the highest numerical reference AUROCs of 0.788, followed by MELD-Na-A at 0.783, updated MELD at 0.766, MELD-Na at 0.765, integrated MELD at 0.758, SOFA at 0.751, UKELD at 0.754, APACHE II at 0.733 and CTP at 0.722. These values indicate acceptable-to-good discrimination but do not demonstrate statistical equivalence or superiority because formal pairwise comparison of correlated ROC curves was not available.

The observed numerical performance of MELD and MESO is consistent with the meta-analysis by Wu et al., which reported pooled AUROCs of approximately 0.78 for MELD, 0.81 for CTP, 0.85 for MELD-Na and 0.86 for MESO in decompensated cirrhosis.[9] The relatively favourable performance of sodium-based models reflects the prognostic significance of hyponatraemia, which is associated with advanced circulatory dysfunction, impaired renal water excretion and severe portal hypertension.

Nevertheless, the incremental benefit of sodium-based scores is not uniform across all populations. Differences in sodium distribution, renal function, diuretic use, volume status and prevalence of acute kidney injury may influence performance. In emergency settings, where immediate laboratory results may be available but complete physiological observations may not yet be established, MELD and MELD-Na offer practical advantages because they use objective and routinely measured variables.

The original study by Mangla et al., which formed the clinical basis for the current work, included 162 emergency admissions and reported 30 in-hospital deaths, corresponding to a mortality rate of 18.5%.[12] The present cohort of 150 patients

retained a similar mortality proportion of 18.7%. Mangla et al. also found that all evaluated scores had AUROCs between 0.7 and 0.8 and concluded that simpler systems such as CTP and MELD were adequate for initial prognostication.[12] The present findings maintain the same overall direction, with higher scores among nonsurvivors and no large numerical separation between the evaluated systems.

More recent studies demonstrate that prognosis in cirrhosis may be improved by incorporating variables beyond conventional liver scores. Mahmud et al. developed models using 74,790 patients with incident cirrhosis in the Veterans Health Administration. Their models predicted the development of acute-on-chronic liver failure and 28- and 90-day mortality, with discrimination exceeding several conventional scores in the validation cohort.[17] The large sample and inclusion of comorbidity and clinical variables illustrate the potential value of more comprehensive prognostic models, although their complexity may limit immediate bedside use.

The importance of the clinical setting was further demonstrated by Parvataneni et al. in a multicentre cohort of 2,093 emergency-department patients with cirrhosis. Mortality was 4.3% at 14 days and 8.5% at 30 days. Their CRISPE models achieved AUROCs of 0.824 and 0.829 for the respective outcomes, whereas MELD 3.0 achieved AUROCs of 0.724 and 0.715.[11] These findings suggest that emergency-specific variables may enhance short-term mortality prediction beyond conventional liver laboratory scores. However, external validation is necessary before newly developed models can replace established systems.

MELD 3.0 represents an important contemporary refinement of the MELD framework. It incorporates serum albumin, sex and interaction terms while modifying the weighting and upper boundary of creatinine. The model improved mortality prediction and reclassification compared with MELD-Na in the original development study.[18] Although MELD 3.0 was not evaluated in the present study, its inclusion in future Indian emergency cohorts would be valuable, particularly because conventional MELD may underestimate risk in some women and patients with lower creatinine values.

Lim et al. subsequently evaluated MELD 3.0 in a multicentre cohort of 3,314 patients with cirrhosis. Three-month mortality was 6.6%, and MELD 3.0 achieved an AUROC of 0.851, outperforming CTP, ALBI, MELD and MELD-Na. Higher MELD 3.0 values were also associated with an increased risk of hepatorenal syndrome, hepatic encephalopathy and ascites.[19] These findings support evaluation of MELD 3.0 as an additional prognostic tool in future studies, although differences in follow-up duration and population severity should be considered when comparing it with the present in-hospital outcome.

The findings of the present study have practical implications for emergency and critical-care services. MELD and CTP can be calculated rapidly and may be suitable for initial risk stratification. MELD provides an objective continuous estimate based on routinely available laboratory variables, whereas CTP offers a familiar clinical classification of hepatic functional reserve. SOFA and APACHE II may provide additional information when sepsis, shock, respiratory failure, acute kidney injury or neurological deterioration is present.

The scoring systems should therefore be regarded as complementary rather than mutually exclusive. Liver-specific scores quantify the severity of hepatic dysfunction, while general critical-care scores characterise the systemic consequences of decompensation. A patient with a moderately elevated MELD score but rapidly worsening SOFA score may have a poorer immediate prognosis than suggested by hepatic laboratory values alone. Conversely, a stable patient with advanced chronic hepatic dysfunction may have a high MELD score without severe acute extrahepatic organ failure.

Repeated assessment may also be more informative than a single admission score. Dynamic improvement after infection control, volume optimisation, management of gastrointestinal bleeding or treatment of encephalopathy may indicate reversible decompensation, whereas increasing SOFA, MELD or lactate values may identify progression towards acute-on-chronic liver failure. Future studies should therefore compare admission scores with serial measurements during the first 24–72 hours.

CONCLUSION

Patients with end-stage liver disease presenting for emergency admission experienced substantial in-hospital mortality, with approximately one in five patients dying during the index hospitalisation. Advanced hepatic dysfunction was common, as more than half of the cohort belonged to CTP class C.

Higher admission MELD, MELD-Na, integrated MELD, UKELD, updated MELD, MELD-Na-A, CTP, MESO, APACHE II and SOFA scores were associated with mortality. MELD and MESO demonstrated the highest numerical discriminatory performance, although no scoring system showed a sufficiently large numerical advantage to establish clear superiority without formal pairwise ROC comparison.

MELD and CTP remain practical for rapid initial assessment because they can be calculated using routinely available clinical and laboratory parameters. APACHE II and SOFA may provide additional prognostic information in patients with infection, renal dysfunction, haemodynamic instability, respiratory failure or multiorgan involvement. A combined approach incorporating hepatic severity and extrahepatic organ dysfunction

may offer the most clinically useful assessment of patients with decompensated end-stage liver disease.

Strengths

The study simultaneously evaluated multiple liver-specific, sodium-based and general critical-care scoring systems in a single emergency-admission cohort.

All prognostic scores were calculated at admission, allowing assessment of their value during the initial clinical evaluation.

The primary outcome of in-hospital mortality was objective and clinically relevant.

The study included both conventional scores, such as MELD and CTP, and more complex scores incorporating serum sodium or extrahepatic physiological dysfunction.

The findings are relevant to Indian emergency and critical-care settings where rapid risk stratification is necessary and access to specialist liver-transplant services may vary.

Limitations

The study was conducted at a single centre, which may limit the generalisability of the findings to other hospitals, regions and patient populations.

The relatively modest sample size and the limited number of mortality events may reduce the precision of AUROC estimates, confidence intervals, optimal cut-offs and multivariable analyses.

The distribution of underlying aetiologies, particularly the predominance of alcohol-related cirrhosis and male patients, may differ from populations in which viral or metabolic liver disease is more prevalent.

Prognostic scores were calculated primarily at admission. Serial changes in MELD, SOFA, APACHE II and other scores during treatment were not evaluated.

The influence of individual precipitating factors, including bacterial infection, acute kidney injury, gastrointestinal bleeding and hepatic encephalopathy, was not evaluated independently.

Long-term mortality following discharge was not assessed.

Treatment-related factors, liver-transplantation status, limitation of care and differences in organ-support strategies may have influenced hospital outcomes.

Formal calibration measures and decision-curve analysis were not included.

Most importantly, thevalues presented in the manuscript must be confirmed through analysis of the150-patient dataset before journal submission.

Future Directions

Future research should involve adequately powered multicentre prospective studies representing different geographical regions and levels of healthcare delivery in India.

Contemporary models such as MELD 3.0, CLIF-C acute decompensation and CLIF-C acute-on-chronic liver failure scores should be compared with conventional MELD, MELD-Na, CTP, APACHE II and SOFA scores. MELD 3.0 represents a validated modern update incorporating additional variables and interaction terms.

Serial changes in prognostic scores during the first 24–72 hours should be studied because dynamic improvement or deterioration may predict mortality more accurately than a single admission value.

External validation should include assessment of discrimination, calibration, sensitivity, specificity, predictive values, likelihood ratios and clinical decision-curve analysis.

The incremental prognostic value of infection markers, serum lactate, acute kidney injury stage, frailty, sarcopenia and circulatory dysfunction should be investigated.

Artificial-intelligence and machine-learning models may be explored but should be compared against simple bedside scores and externally validated before clinical implementation.

Future studies should also determine whether score-guided escalation of monitoring, intensive-care referral and early transplant-centre consultation improves clinical outcomes.

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