Assessing the outcome of patients with liver cirrhosis during hospital stay: A comparison of lymphocyte/monocyte ratio with MELD and Child-Pugh scores

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ABSTRACT

Background/Aims: *Developing an easy and reliable score for evaluating the prognosis of patients with liver cirrhosis has always been challenging for hepatologists. This study aimed to assess the lymphocyte-to-monocyte ratio (LMR) in comparison with the Model for End-Stage Liver Disease (MELD) and Child-Pugh (CP) scores for determining the outcomes in these patients during hospital stay.*

Materials and Methods: *Receiver operator characteristic (ROC) curve was used to assess the efficacy of three parameters (LMR and MELD and CP scores) in determining the outcomes in 182 patients with cirrhosis. The cutoff values were calculated using Youden index, and the area under the curves (AUCs) was also compared. The associations of these scores between the survived and nonsurvived group was studied. The predictors of patient survival were determined using logistic regression analysis.*

Results: *The mean values for LMR and MELD and CP scores were 6.23, 11.62, and 9.32, respectively. MELD and CP were positively correlated with each other. LMR was negatively correlated to both MELD and CP scores (p=0.04). Pairwise comparison showed that the difference between the AUCs of MELD and LMR was not statistically significant (0.958 vs. 0.807; p>0.05). With the LMR cutoff value of <3.31 (sensitivity, 80%; specificity, 74.83%), patients were segregated into low and high LMR groups. MELD and CP scores were significantly higher in the low LMR group than in the high LMR group (p=0.000). Patients in the low LMR group showed decreased survival than those in the high LMR group (p=0.000). The nonsurvived group had lower LMR and higher MELD and CP scores than those of the survived group (p=0.000). Logistic regression model showed MELD (p=0.000), CP score (p=0.010), 1/LMR (p=0.004), alanine aminotransferase (ALT) level (p=0.010), and international normalized ratio (INR; p=0.043) as predictors of outcome of these patients.*

Conclusion: *LMR can be used to determine the outcome of patients during hospital stay, because it is easy to calculate and can be interpreted with efficacy nearly equal to those of MELD and CP scores.*

Keywords: *Liver cirrhosis, lymphocyte count, chronic Hepatitis C, ROC analysis, inflammation mediators, prognosis*

INTRODUCTION

Obtaining prognostic scores for liver cirrhosis has always been challenging for hepatologists. Hepatologists have been trying to scrutinize new scoring systems that can easily prognosticate the survival of patients with liver cirrhosis (1). Model for End-Stage Liver Disease (MELD) and Child-Pugh (CP) scores have a long-established role in predicting the survival of such patients and are widely used (2). However, each scoring system has certain limitations.

The presence of inflammation has been proven to play a pivotal role in the outcomes in patients affected by liver cirrhosis (3). Inflammation can suddenly deteriorate the stable and static condition of patients, thereby resulting in various complications, which can lead to early death (4,5). Monocytes are the key cells in the body's immune system and play a major role in the pathogenesis of liver fibrosis. Monocytes get activated by endotoxins and result in the release of large number of cytokines. These cytokines result in the recruitment of other blood cells. All these cells release further cytokines, which can result in circulatory changes and fibrosis in liver disease (6,7). Multiple studies have shown the presence of monocytosis in patients with liver cirrhosis and its positive relationship with disease progression (8,9). With many chronic diseases, the disruption of the immune system results in a decrease in the lymphocyte count. Lymphopenia has been documented in many diseases, such as malignancy, tuberculosis, viral infection, and peripheral vascular disease (10,11). Decrease in lymphocyte count has also been

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observed in patients with liver diseases (12). Thus, both monocytes and lymphocytes counts get disrupted during chronic liver disease (13).

Numerous studies have been accomplished to elaborate the role of various inflammatory markers in determining the survival of these patients. Among these markers, the ratio of neutrophils to monocytes, ratio of neutrophils to platelets, and distribution of red cell width (RDW) and its ratio with other blood cells are well studied (14,15). However, for the last few years, the most studied inflammatory marker has been the lymphocyte-to-monocyte ratio (LMR). This inflammatory marker has shown its absolute role in determining the survival of patients with various diseases, such as cancer, cardiovascular disease, gastrointestinal diseases (Crohn disease), and colorectal carcinoma (16-19). LMR has been shown to be a good prognostic marker for patients with hepatocellular carcinoma in many recent studies (20,21). This marker is extensively studied because it is cost-effective and easy to calculate and interpret.

Although MELD and CP scores are commonly used to determine the survival of patients with liver cirrhosis, MELD score is difficult to calculate without a personal digital assistant, whereas five parameters are required to interpret and calculate the CP score. This has led to the need for finding markers that are easy to obtain, calculate, and interpret. LMR has been widely used for predicting the outcomes in patients suffering from different chronic diseases, but its role in patients with liver cirrhosis is not well studied, and to date, only one study assessed its role in determining the outcomes in patients with chronic hepatitis B-related liver cirrhosis (22).

We conducted this study considering the increasing burden of liver cirrhosis and feasibility of LMR. The primary aim of this study was to focus on the role of LMR in predicting the outcome in patients with liver cirrhosis during their hospital stay. Additional aims included studying the relationship of LMR with MELD and CP scores, comparing these three variables in determining patient outcomes, and finding other independent predictors for outcomes in such patients.

MATERIALS AND METHODS

This study was designed and performed in Fauji Foundation Hospital from January 2016 to August 2017. Ethical approval was obtained from the relevant hospital before the study.

Study group

We analyzed all the patients admitted to the medical ward due to liver disease. Patients who had deranged liver function tests for >3 months with any one of the following features were included in the study group:

1. ±Ultrasound findings suggestive of chronic liver parenchymal disease;
2. ±Evidence of decompensated liver cirrhosis with ascites, hepatic encephalopathy, or coagulopathy;
3. ±Previous admissions due to these complications and availability of relevant medical records;
4. ±Liver biopsy findings suggestive of hepatic fibrosis.

Following criteria were designed to exclude the patients from the study:

a) Patients aged <13 years;
b) Patients diagnosed with liver cirrhosis, but admitted because of other medical illness, such as diabetes mellitus, ischemic heart disease, or cerebrovascular accident;
c) Patients with hepatocellular carcinoma;
d) Patients with any other concurrent ailment that could alter LMR, such as the presence of hematological malignancy, autoimmune disease, or chronic infection (tuberculosis);
e) Patients who were administered antibiotics in the last 14 days (because antibiotics can alter the blood counts in blood complete picture).

Study Method

At the time of admission, consent was obtained from patients or their relatives in case of critically ill patients. Blood samples were collected for complete blood count, prothrombin time (PT), international normalized ratio (INR), serum albumin, serum electrolytes, and liver function tests.

Lymphocyte and monocyte counts were obtained from complete blood count results, and LMR was calculated by dividing the lymphocyte count with the monocyte count. MELD score was calculated using a standard formula available online, and CP score was calculated using five variables (hepatic encephalopathy, INR, ascites, bilirubin, and albumin). At the time of admission, LMR and CP and MELD scores were calculated for each patient. The patients were followed up during their hospital stay. Patients who were successfully managed and discharged from hospitals regardless of their duration of hospital stay were included in the survived group, and those who died during the hospital stay due to complications of liver cirrhosis were included in the nonsurvived group. LMR

and MELD and CP scores were compared between the survived and nonsurvived groups. In addition, the relationship between these variables was determined. A similar number of age- and sex-matched healthy individuals were included in the control group. Their LMR was calculated and compared with the study groups.

Laboratory analysis

An automated hematology analyzer (Automated Hematology Analyzer XT-2000i, Sysmex Corporation, Japan) was used for lymphocyte and monocyte counts in peripheral blood after collecting 2 mL of blood sample in EDTA tubes. The normal lymphocyte count was 1.0×10^9-3.0×10^9 cells/L, and the normal monocyte count was 0.2×10^9-1.0×10^9 cells/L. An automated blood coagulation analyzer (CA-500 Coagulation Analyzer; Sysmex, Siemens Healthcare Diagnostics, Japan) was used to obtain PT using 3 mL of blood in 3.2% Na-citrate tubes. Chemistry analyzer (Max Chemistry Analyzer; Dimensions RxL, Siemens Healthineers Laboratories, USA) was used to perform all serum chemistry tests.

Statistical analysis

The data were analyzed using Statistical Package for Social Sciences version 20 (IBM Corp.; Armonk, NY, USA). Quantitative parameters were expressed in terms of range, mean, and standard deviation, whereas qualitative parameters in terms of percentages. The p-value of continuous parameters was calculated using sample t-tests, whereas categorical parameters were calculated using the contingency coefficient. Receiver operating characteristic (ROC) curve was used to evaluate the efficacy of the three variables (LMR and MELD and CP scores) in determining the outcome in patients with cirrhosis during hospital stay. Youden index was used to obtain the cut-off value of each variable, including its sensitivity, specificity, positive likelihood ratio (+LR), negative LR (-LR), positive predictive value (+PPV), and negative predictive value (-NPV). Hanley and McNeil's method was used to compare the AUCs of these three variables using MedCalc software. The Pearson correlation was also studied for these three variables. In addition, the statistical relation of these three variables in terms of the survived and nonsurvived groups was studied using the chi-square test and Pearson correlation. The binary logistic regression analysis was performed to express the predictors of outcomes in these patients.

RESULTS

We analyzed 205 patients admitted in the medical ward over a period of 18 months. Of these, 15 were excluded because of incomplete data and eight patients were excluded as they lost follow up due to transfer to other departments. Of the remaining 182 patients, 130 were females and 52 were males.

Baseline characteristics

The minimum and maximum age was 16 and 77 years, respectively, with the mean age of 53.14±12.02 years (mean±SD). A total of 163 patients (89.6%) were affected by chronic hepatitis C infection that led to liver cirrhosis. Other causes of liver cirrhosis were chronic hepatitis B in five patients (2.7%), Wilson's disease in four (2.2%), and unknown in 10 (5.5%). The baseline characteristics of the study group are shown in Table 1.

Relationship of LMR with MELD and CP scores

In 182 patients, the mean LMR was lower than that in the control group (6.23 vs. 12.28, p=0.006). The mean MELD score of 182 patients was 11.62±6.59 (mean±SD; range, 6-38). Four patients (2.2%) belonged to CP class A, 64 (34.2%) to class B, and 114 (62.6%) to class C. The mean CP score of the study group was 9.32±2.00 (mean±SD; range, 5-13). To determine the relationship between LMR and MELD and CP scores, Pearson correlation was performed. It was found that MELD and CP scores were

Table 1. Baseline characteristics of 182 patients in the study group. Mean, standard deviation, and range are used for the expression of variables

Variables	Minimum	Maximum	Mean±SD
Age (years)	16.00	77.00	53.14±12.02
Hemoglobin (g/dL)	3.47	16.00	9.75±2.29
WCC×10^9 cells/L	0.87	15.98	5.70±2.94
Platelets×10^3 cells/L	26.00	522.00	132.31±101.23
LMR	0.01	14.50	6.23±4.12
Bilirubin (umol/L)	7.00	189.00	24.87±26.68
ALT (IU/L)	18.00	279.00	54.53±43.62
ALP (IU/L)	105.00	675.00	226.45±108.33
PT (sec)	1.00	10.00	2.46±2.20
INR	1.00	4.50	1.15±0.39
Albumin (g/L)	2.20	4.40	3.51±0.52
Na (mEq/L)	132.00	144.00	138.23±2.46
K (mEq/L)	3.7	5.6	4.23±0.36
Cl (mEq/L)	90	106	99.57±2.75

WCC: white cell count; LMR: lymphocyte-to-monocyte ratio; ALT: alanine aminotransferase; PT: prothrombin time; ALP: alkaline phosphatase; INR: international normalized ratio; NA: sodium; K: potassium; Cl: chloride

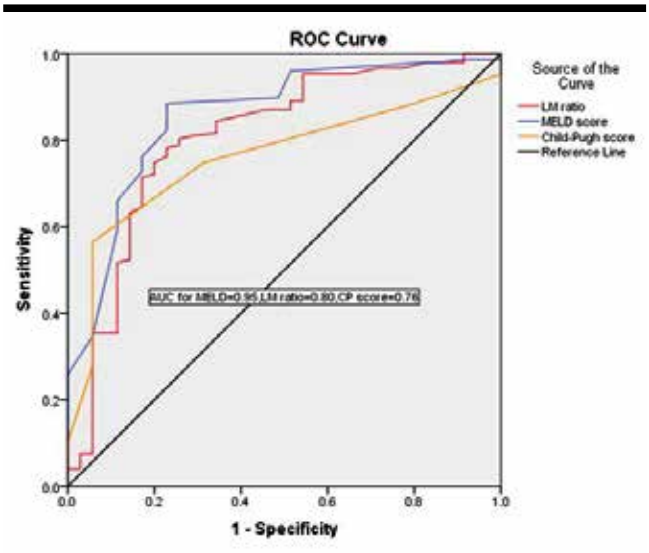

Figure 1. ROC curve showing the AUCs for LMR and MELD and CP scores in assessing the outcomes in patients with liver cirrhosis during hospital stay

AUC is the highest for MELD score (0.95) and lowest for CP score (0.76). The AUC for LMR is 0.80, which is similar to that of MELD score. It implies that both MELD score and LMR can be used with similar efficacy to assess the outcomes in patients with liver cirrhosis during hospital stay

positively correlated (r=0.103, p=0.16), whereas LMR was negatively correlated with both MELD and CP scores (r=-0.151, p=0.04)

ROC Curves of LMR and MELD and CP scores

ROC curve was used to calculate the AUCs of MELD and CP scores and LMR for determining the outcomes in patients in the survived and nonsurvived groups during their hospital stay. Among these three variables, the highest AUC was found for MELD score [AUC=0.958, 95% confidence interval (CI)=0.799-0.905, p<0.0001]. The cutoff value for MELD score was >15 (sensitivity: 77.14, 95% CI=59.9-89.6; specificity: 88.44%; 95% CI=82.1-93.1; +LR: 6.67; -LR: 0.26; +PPV: 61.4; -NPV: 94.2).

The AUC for LMR was also good at 0.807 with 95% CI ranging from 0.742 to 0.862 (p<0.0001). The cutoff value for LMR found using Youden index was ≤3.31 (sensitivity: 80%, 95% CI=63.1-91.6; specificity: 74.83%, 95% CI=67.0-81.6; +LR: 3.18; -LR: 0.27; +PPV: 43.1; -NPV: 94.0).

The AUC for CP score was 0.760 with 95% CI ranging from 0.691 to 0.820 (p<0.0001). The cutoff value for CP score was >9 (sensitivity: 94.29%, 95% CI=80.8-99.3; specificity: 56.46%, 95% CI=48.0-64.6; +LR: 2.17; -LR: 0.10; +PPV:34.0; -PPV: 97.6). The ROC curve showing AUC of the three variables (MELD and CP scores and LMR) is shown in Figure 1.

Table 2. Pairwise comparison to illustrate the differences between areas covered by ROC curve with their statistical significance

	Differences between areas	95% CI	p
CP score-LMR	0.0474	-0.0619-0.157	0.3953
CP score-MELD score	0.0983	0.00417-0.192	0.0407
LMR-MELD	0.0508	-0.0566 to 0.158	0.3536

CP: Child-Pugh; LMR: lymphocyte-to-monocyte ratio; MELD: Model of End-stage Liver Disease [MELD]; CI: confidence interval

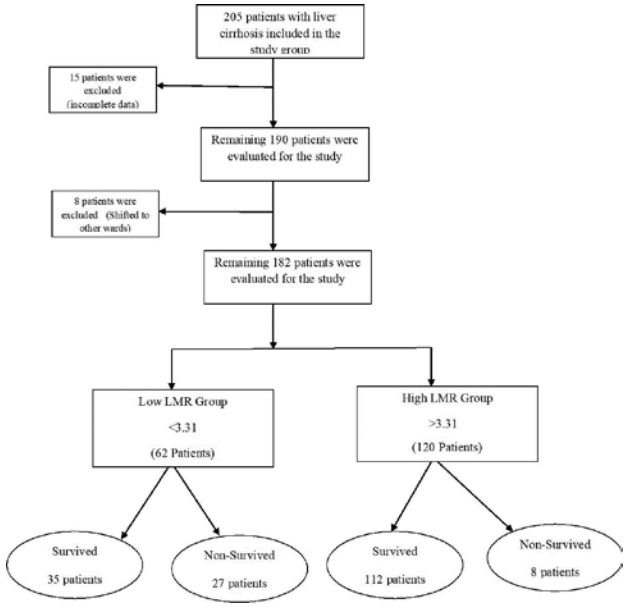

Figure 2. Flow chart showing the characteristics of the study group according to LMR (lymphocyte-monocyte ratio)

Pairwise comparison using Hanley & McNeil's method showed significant difference between the AUCs of CP and MELD scores (p<0.05). The AUC was not statistically different between MELD score and LMR, suggesting that both the variables can be used to assess the outcomes in patients with liver cirrhosis during their hospital stay. The comparison of areas under ROC curves of the three variables is shown in Table 2.

Low versus high LMR

The cutoff value for LMR calculated using Youden index was used to divide the patients into two groups: low (<3.31) and high (>3.31) LMR. A total of 62 patients (34.1%) had

low LMR, whereas 120 (65.9%) had high LMR. The MELD and CP scores were significantly higher in the low LMR group than in the high LMR group (p=0.000). Similarly, the low LMR group had decreased survival compared with the high LMR group (p=0.000). The characteristics of the two groups with statistical differences are shown in Table 3. It was also found that LMR was associated with CP class of liver cirrhosis. As the disease advances, LMR further decreases. As a result, many patients with CP class C had low LMR (Table 4). The Figure 2 is shown to illustrate the characteristics of the two groups.

Table 3. Characteristics of variables of the two groups (low vs. high LMR)

Variables	Low LMR (N=62)	High LMR (N=102)	p
Age (years)	52.98	53.45	0.804
Hemoglobin (g/dL)	9.13	10.08	0.008
WCC×109 cells/L	5.50	5.89	0.396
Platelets×103 cells/L	119.64	138.86	0.226
Bilirubin (umol/L)	25.66	24.47	0.777
ALT (IU/L)	52.61	55.53	0.670
ALP (IU/L)	286.56	195.40	0.000
PT (sec)	2.59	2.40	0.569
INR	1.14	1.16	0.721
Albumin (g/L)	3.417	3.568	0.065
Na (mEq/L)	137.98	138.35	0.332
K (mEq/L)	4.31	4.19	0.038
Cl (mEq/L)	99.30	99.71	0.342
MELD score	14.51	10.12	0.000
CP score	9.91	9.01	0.004
Survived	35 (N)	112 (N)	0.000
Nonsurvived	27 (N)	8 (N)	0.000

WCC: white cell count; L: lymphocyte; M: monocyte; ALT: alanine aminotransferase; PT: prothrombin time; ALP: alkaline phosphatase; INR: international normalized ratio; Na: sodium; K: potassium; Cl: chloride; LMR: lymphocyte-to-monocyte ratio; MELD: Model of End-stage Liver Disease

Table 4. Association of LMR with CP class of patients with liver cirrhosis

CP class	Low LMR	High LMR
A	0 (N)	4 (N)
B	16 (N)	48 (N)
C	46 (N)	68 (N)
Contingency Coefficient	C=0.184	p=0.04

LMR: lymphocyte-to-monocyte ratio; N: number of patients

Survived versus nonsurvived group

Of the 182 patients, 147 (80.8%) survived and 35 (19.2%) died during the hospital stay. Of the 35 patients who died, 11 died due to variceal bleeding leading to hypovolemic shock, seven due to hepatic encephalopathy, seven due to disease progression or acute on chronic insult, six due to septicemia, and four due to hepatorenal syndrome leading to metabolic acidosis and hyperkalemia. The nonsurvived group had lower LMR and higher MELD and CP scores than those of the survived group (p=0.000). The detailed characteristics between the survived and nonsurvived groups are shown in Table 5.

Predictors of survival in the study groups

Both correlation and logistic regression analyses were performed to define the relationship between the variables and outcomes in patients during hospital stay. Positive correlation was found between the three variables and patient outcomes [CP score (r=0.339, p=0.000), MELD score (r=0.537, p=0.000), and 1/LMR (r=0.441, p=0.000)]. Logistic regression was used to determine the independent predictors for survival in the study

Table 5. Mean differences of variables of the two groups (survived vs. nonsurvived)

Variables	Survived (N=147)	Nonsurvived (N=35)	p
Age (years)	53.16	53.05	0.963
Hemoglobin (g/dL)	9.96	8.87	0.011
WCC×10^9 cells/L	5.83	5.45	0.493
Platelets×10^3 cells/L	129.06	145.97	0.376
Bilirubin (umol/L)	24.53	26.34	0.719
ALT (IU/L)	51.78	66.11	0.081
ALP (IU/L)	216.03	270.22	0.007
PT (sec)	2.44	2.57	0.756
INR	1.15	1.14	0.853
Albumin (g/L)	3.56	3.33	0.019
Na (mEq/L)	138.37	137.62	0.107
K (mEq/L)	4.20	4.35	0.031
Cl (mEq/L)	99.69	99.08	0.241
LMR	11.54	4.26	0.02
MELD score	9.89	18.85	0.000
CP score	8.99	10.71	0.000

WCC: white cell count; L: lymphocyte; M: monocyte; ALT: alanine aminotransferase; PT: prothrombin time; ALP: alkaline phosphatase; INR: international normalized ratio; Na: sodium; K: potassium; Cl: chloride; LMR: lymphocyte-to-monocyte ratio; MELD: Model of End-stage Liver Disease

group. The regression model was statistically fit (Model chi-square=113.81, p=0.000). The model explained 46% (Cox and Snell R Square) to 74% (Nagelkerke R square) of variance in the tested parameters. The model classified 94.5% of cases. All the parameters were tested using logistic regression to find possible predictors for outcomes in patients during hospital stay. The positive predictors for outcome in these patients were MELD score (OR=1.578, 95% CI=1.276-1.951, p=0.000), CP score (OR=1.848, 95% CI=1.155-2.957, p=0.010), 1/LMR (OR=15.606, 95% CI=2.443-99.687, p=0.004), alanine aminotransferase (ALT) level (OR=1.024, 95% CI=1.006-1.044, p=0.010), and INR (OR=0.042, 95% CI=0.002-0.907, p=0.043).

DISCUSSION

Systemic inflammation is common in patients with hepatic cirrhosis (23). This inflammation adversely influences the survival of patients because of the development of numerous complications (24,25). This study was aimed to assess the role of inflammatory markers and LMR in predicting the outcome in these patients.

The most common cause of hepatic cirrhosis in our study population was chronic infection with hepatitis C. Many studies have suggested similar results and found that chronic hepatitis C is the leading cause of cirrhosis in most countries (26). The mean LMR in our study group was significantly lower than that in the control group (p=0.006). Similarly, Zhang et al. (22) also found that LMR was significantly lower in the disease group than in the control group.

The mean MELD score was 11.62, and the mean CP score was 9.32; both the parameters were positively correlated. As the disease progresses, these scores also increase. Many studies have suggested that the increasing scores predict the worse outcomes in patients with liver cirrhosis (2,27).

LMR has a negative correlation with both MELD and CP scores. As both the scores increase with disease progression, the ratio gets disrupted and hence, decreases. These findings were similar to those of Zhang et al. (22) that included patients with cirrhosis due to hepatitis B infection. They also found that MELD score and LMR were negatively correlated.

The predictive values of the three variables for determining the hospital outcomes in the patients were assessed using ROC curve analysis. It showed that the predictive value was higher for MELD score than for LMR and CP score (MELD=0.958; LMR=0.807; CP=0.760). Zhang et al. (22) also found the same AUC for MELD score, which was approximately 0.9, and for LMR was 0.8. The pairwise comparison showed that there was no statistically significant difference between the AUCs of MELD score and LMR (p>0.05), but those between CP and MELD scores were significant (p<0.05). Approximately similar AUCs without significant difference showed that both MELD score and LMR can be used with the same efficacy to determine the outcome in these patients during hospital stay.

The cutoff value for MELD score was > 15 (sensitivity: 77.14, 95% CI=59.9-89.6; specificity: 88.44%, 95% CI=82.1-93.1); Zhang et al. (22) found the cutoff value as 19. Although it was slightly higher than the value calculated by our study, the sensitivity was lower in their study than in our study (70% vs. 77%). The cutoff value for CP score was >9 (sensitivity: 94.29%, 95% CI=80.8-99.3; specificity: 56.46%, 95% CI=48.0-64.6). These results showed that CP score has a higher sensitivity than that of MELD score, whereas MELD score has a higher specificity than that of CP score. The higher sensitivity of CP score indicates that its predictive value in identifying patients with poor outcomes is higher than that of MELD score, whereas the higher specificity of MELD score indicates its predictive value in identifying patients with good outcomes is higher than that of CP score. A large meta-analysis conducted by Peng et al. (27) also found similar results.

The cutoff value for LMR was ≤3.31 (sensitivity: 80%, 95% CI=63.1-91.6; specificity: 74.83%, 95% CI=67.0-81.6). However, Zhang et al. (22) found a lower LMR cutoff value (2.1) with approximately similar sensitivity and specificity. Eo et al. (28) found approximately similar cutoff value in determining the prognosis of patients with endometrial carcinoma. Among the three variables, CP score was found to have the highest sensitivity in predicting the outcome of the patients, whereas MELD score had the highest specificity. The specificity of LMR was higher than that of CP score but lesser than that of MELD score. LRs of cutoff values of all the three variables were notable, with +LR of >1 and -LR of <1. This showed that at these cutoff values, the variables can accurately identify patients with favorable and unfavorable outcomes. PPV was highest for MELD score (61.4), suggesting that at this cutoff value, MELD score can positively predict the outcome of patients compared with LMR and CP score.

The patients were grouped according to low and high LMR (3.31). It was found that patients with low LMR had high

MELD and CP scores than those with high LMR (MELD: 14.51 vs. 10.12, p=0.000; CP: 9.91 vs. 9.01, p=0.004). Moreover, 27 of 62 patients did not survive in the low LMR group (p=0.000), whereas 112 of 120 survived in the high LMR group (p=0.000). Comparing survived group with the nonsurvived group, MELD and CP scores were significantly higher in the nonsurvived group than in the survived group (p=0.000), and LMR was significantly lower in the nonsurvived group than in the survived group (p=0.02). Similarly, in logistic regression analysis, all the variables were found to be independent predictors for outcomes in patients during hospital stay (OR>1, p<0.05). These results are consistent between our study and thay by Zhang et al. (22).

Many recent studies have shown that LMR can be used as an independent predictor for survival of patients with liver cirrhosis. Cai et al. (29) proposed a nomogram to predict the survival of patients with decompensated chronic liver disease. The nomogram, based on neutrophil-to-lymphocyte ratio and LMR, was found to be an accurate model in predicting the survival of these patients.

In the past few years, the role of LMR in predicting the survival of patients with hepatocellular carcinoma has been extensively studied. Many studies have proposed that LMR accurately predicts the prognosis of patients with hepatocellular carcinoma (30,31). Although its role in predicting hepatocellular carcinoma is well studied, the data on predicting the survival of patients with liver cirrhosis are very limited. Thus, more studies with larger cohorts and longer duration of follow-ups are required to further emphasize the importance of LMR in predicting the survival of patients with liver cirrhosis.

The main limitation of this study was that it was conducted on patients with liver cirrhosis who required hospital admission. They were followed up only during the hospital stay. Long-term follow-up of patients who survived was not performed. Further studies with long-term follow-ups may be required to further elaborate the results.

In conclusion, we found that in patients with liver cirrhosis, as the disease advances, LMR gets disrupted and decreases compared with MELD and CP scores, which increase with disease progression. During hospital stay, the efficacy of MELD score and LMR in assessing the patients' outcomes is almost similar and without statistical significance (MELD=0.958 vs. LMR =0.807, p between AUC of MELD vs. LMR >0.05). Thus, LMR has more advantages over MELD score; it is simple and easy to calculate and interpret.

Ethics Committee Approval: Ethics committee approval was received for this study from the Local Ethical Committee.

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

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - Z.J., A.A.D.; Design - Z.J.; Supervision - A.A.D.; Resources - Z.J., A.A.D.; Materials - Z.J.; Data Collection and/or Processing - Z.J.; Analysis and/or Interpretation - X.J.; Literature Search - A.A.D.; Writing Manuscript - Z.J.; Critical Review - A.A.D.

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