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Original Research Article

EVALUATION OF RED CELL DISTRIBUTION WIDTH IN DECOMPENSATED CHRONIC LIVER DISEASE PATIENTS AND ITS CORRELATION WITH MELD-NA SCORE: A CROSS-SECTIONAL STUDY

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Abstract

Background: Cirrhosis is a major cause of morbidity and mortality in developing countries, it is the 14th most common cause of death worldwide .Red Cell Distribution Width (RDW) is a routinely measured haematological parameter that reflects the variability in the size of circulating erythrocytes. The Model for End-Stage Liver Disease incorporating Serum Sodium (MELD-Na) score is a well-established tool used to assess the severity of liver disease. Decompensated cirrhosis, characterized by complications such as ascites, hepatic encephalopathy, variceal bleeding, and jaundice, represents a critical stage in chronic liver disease where prognosis and survival are markedly reduced. This literature review aims to explore the correlation between RDW and MELD-Na in patients with decompensated cirrhosis in the previous studies. **Materials and Methods:** This is a Hospital based Cross-Sectional analytical Study conducted in Regional Institute of Medical Sciences (RIMS), Imphal for 2 years (May2022 to June 2024). All the patients attending Medicine OPD, Liver and Gastroenterology Clinic and those admitted in the medicine ward with a history of decompensated chronic liver disease (DCLD) were included in the study. Diagnosis of CLD is done by clinical, laboratory parameters & ultrasonography of the abdomen. Complete blood counts, prothrombin time(PT), international normalized ratio (INR), kidney function test, liver function test and USG whole abdomen were collected for every patients. IBM SPSS (Statistical Package for the Social Sciences) software, version 27 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. A significance level of $p = 0.05$ was considered statistically significant. Descriptive and inferential statistical techniques were used in combination to evaluate red cell distribution width in decompensated CLD patients and its correlation with the MELD-Na score. **Result:** A total 200 DCLD patients were enrolled in the study with mean age of 61.5 years and majority of them (181, 90.5%) were males. The mean RDW-SD was 48 and the abnormal range of RDW-SD was in between 46 to 70.94. RDW-SD was above normal in 174(87%) patients. MELD-Na score was moderately high at 10-19% in 80(40%) patients, while high to extremely high was seen in 106(53%) patients. The present study showed statistically significant correlation of RDW ($P < 0.05$) with laboratory parameters of haemoglobin, platelet, bilirubin, albumin, PT/INR, creatinine & sodium, when correlated with RDW. Similarly, there was statistically significant ($p< 0.001$) in predicting 3-month mortality by RDW-SD against MELD-Na scores with predicted mortality increasing from 1.9% to 71.3%.The higher mean RDW patients had higher MELD-Na score values which indicate more severe DCLD patients. **Conclusion:** This study concluded that red cell distribution width (RDW) had a significant association with the severity of DCLD. There is statistically significant correlation between RDW-SD values with MELD-Na thereby indicating that more severe liver dysfunction had higher MELD-Na score and a higher RDW-SD value. Thus, we speculate that this is an important factor influencing disease progression and may present as an important predictor for mortality in DCLD.

INTRODUCTION

Cirrhosis results in 1.03 million deaths per year worldwide.[1] Liver biopsy is the gold standard in diagnosing liver cirrhosis, but the nature of liver biopsy, such as invasiveness, cost, poor compliance, and contraindications, restrict the widespread utilization, particularly in the follow-up.[2] One of the most common and serious complications of Cirrhosis is portal hypertension. Portal hypertension is a harmful consequence of portal blood flow restriction from cirrhosis or portal vein (PV) thrombosis.[3,4]

Red cell distribution width (RDW) is an automated measure of the variation in red blood cell (RBC) sizes (such as anisocytosis).It is routinely performed as part of complete blood cell counts.[5-7] RDW is used in the differential diagnosis of anaemia.[8] Recently, a series of studies have demonstrated that for individuals suffering from cardiovascular conditions such as heart failure, stable coronary disease, acute myocardial infarction, strokes, and pulmonary hypertension, RDW may be a new and independent prognostic factor.[9-15] Elevated RDW values were also shown to be associated with an increased risk of mortality in the general population.[16-18] Impaired iron mobilisation, inflammatory stress, and various other factors lead to increased RDW. It has been found that ferritin regulates the expression of pro-inflammatory cytokines in hepatic cirrhosis. These cytokines increase the heterogenicity of RBC maturation and further impairment, which leads to an increase in RDW.[19]

MELD-Na score is the best scoring method for predicting the clinical prognosis of cirrhosis patients. It was created by the Mayo Clinic in 2000 and implemented as a criterion for patient prioritization on the waiting list for liver transplants in 2002.Three easily obtained, repeatable, and objective biochemical variables form the foundation of the MELD. These include the international normalized ratio (INR) of prothrombin time, serum creatinine, and serum bilirubin. When considering orthotopic liver transplantation (OLT) for cirrhotic patients, MELD is a highly reliable indicator of 3-month mortality. Research has demonstrated that when it comes to predicting short-term mortality in individuals with chronic liver disease (CLD), the MELD scoring system has high accuracy20.To our knowledge, the severity of decompensated chronic liver disease (CLD) prediction by RDW and its correlation with MELD-Na scoring has not been well defined. The present study was designed to investigate the role of RDW as an index for predicting severity in DCLD by correlating with MELD Na scoring.[20]

MATERIALS AND METHODS

This is a Hospital based Cross-Sectional analytical Study conducted in Regional Institute of Medical Sciences (RIMS), Imphal for 2 years (May2022 to June 2024). All the patients attending Medicine OPD, Liver and Gastroenterology Clinic and those admitted in the medicine ward with a history of decompensated CLD were enrolled.

Inclusion criteria

Included all patients with decompensated cirrhosis above 18 years of age who were willing to participate in the study.

Exclusion criteria

Included those patients with iron deficiency anaemia, those who were on medications that impair red cell production or cause destruction (haemolysis) and those who did not give consent for the study.

Sample Size: Based on Etiology and Mode of Presentation of CLD in India, a study conducted by Mukherjee PS[21],

Sample size $=\frac{4p(100-p)}{L^2}= 4 \times 33.9 \times \frac{(100-33.9)}{6.7\times6.7}$=200 (approx.)

Where, p = prevalance,[21] L= allowable absolute error. Therefore, the sample size is 200 patients.

Independent variables included age, sex, Alcohol-related CLD, Hepatitis B and Hepatitis C related CLD and Non-alcoholic fatty liver disease.

Dependent variables included RDW, Serum bilirubin, Prothombin time (PT/INR), S. creatinine (S.Cr) and S. sodium.

Working Definition: Chronic liver disease is the progressive decline of liver functions. Liver functions include bile excretion, detoxifying harmful metabolism products and producing clotting factors and other proteins. Fibrosis and cirrhosis are results of the ongoing process of inflammation, destruction, and regeneration of liver parenchyma. Cirrhosis is a final stage of chronic liver disease that disrupts liver architecture, the formation of widespread nodules, vascular reorganization, neo-angiogenesis, and deposition of an extracellular matrix. Hepatocellular stem cells are necessary for parenchymal regeneration, whereas stellate cells and fibroblasts are the fundamental cause of fibrosis and cirrhosis at the cellular level.[22] Decompensated cirrhosis is defined as an acute deterioration in liver function in a patient with cirrhosis and is characterised by jaundice, ascites, hepatic encephalopathy, hepatorenal syndrome or variceal haemorrhage.[23]

MELD-Na: calculated through the formula "MELD-Na= MELD + 1.32 x (137 - Na) - [0.033 x MELD*(137 – Na))]". According to criteria by UNOS (United Network for Organ Sha

Working range: 6 to 40

MELD-Na and predicted 3-month mortality.[24]

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Score	Mortality (%)
MELD /Na score >40	71.3
MELD/Na score 30-39	52.6
MELD /Na score 20-29	19.6
MELD /Na score 10-19	6
MELD /Na score <9	1.9

Ultrasonography (USG) for diagnosing liver cirrhosis

LIVER: coarse appearance or nodularity of liver parenchyma, hepatomegaly, hypertrophy of caudate lobe (which is the ratio of caudate lobe to right lobe) Characteristics of normal spleen – The average length of the adult spleen is 12cm. Parenchyma is homogeneous with uniform mid to low echogenicity. In Portal hypertension Spleen size is >13cm in cephalocaudal measurement and more echogenic than normal.[19]

RDW

RDW CV is the measure of the deviation of the RBC volume width, usually referring to the width of the volume curve; measurement is derived from 1 standard deviation (SD) divided by Mean corpuscular volume (MCV) times 100%.So it is affected by RBC size.

The width of RBC size distribution histogram was measured using RDW-SD 19.

Reference range:

RDW-SD 39-46 fL.[25]

RDW-CV 11.6-14.6%.[26]

Procedure: The patients who fulfilled the inclusion criteria are included after obtaining written consent. These cases underwent a thorough comprehensive history taking, clinical examinations and necessary investigations as per the predesigned proforma. Diagnosis of CLD is done by clinical, laboratory parameters &usg abdomen. Routine Examinations: Complete blood counts, prothrombin time (PT), INR, total bilirubin, serum albumin, serum creatinine and serum sodium were done.

Approval of research ethics board: Ethical approval for this study was obtained from the Research Ethics Board, Regional Institute of Medical Sciences, Imphal [No.A/206/REB-Comm(SP)/RIMS/2015/859/197/2022].

Statistical analysis

IBM SPSS (Statistical Package for the Social Sciences) software, version,[27] (IBM Corp., Armonk, NY, USA) was used for statistical analysis. A significance level of p value = 0.05 was considered statistically significant. The methodology employed a combination of descriptive and inferential statistical techniques to evaluate RDW in DCLD patients and its correlation with the MELD-Na score. Descriptive statistics summarized the characteristics of the study population, encompassing demographic variables (age, gender), clinical parameters, and MELD-Na scores. Continuous variables were described using mean and standard deviation (SD), while categorical variables were presented as frequencies and percentages. Inferential statistics encompass various analytical methods. The analysis of various clinical parameters using ANOVA with RDW-SD as the dependent variable revealed significant differences among the sample population.

RESULTS

A total of 200 DCLD patients were included in the study. The baseline characteristics of the study subjects were shown in [Table 1].The mean age of the patients studied was 61.5 years, with majority of the patients 78 (39%)in the age group 41-60 years. There were a predominant proportion of males, 181(90.5%) patients compared to 19(9.5%) female patients. RDW-SD was above normal in 174(87%) patients. The mean RDW-SD was 48.94.

The distribution of haemoglobin (Hb) levels within the sampled population reveals a diverse spectrum of values, ranging from 3.70 g/dL to 16.70 g/dL. Delving into distinct Hb ranges, approximately half of the individuals (50.5%) exhibit levels within the normal range of 11.01 to 15.00 g/dL, indicating typical hematological health. Notably, a significant portion (23.0%) falls below the normal range, suggesting potential mild anemia or underlying health concerns. Conversely, 14.0% showcases Hb levels exceeding 15.00 g/dL, possibly indicating conditions like polycythemia. A smaller subset (12.5%) presents with Hb levels ranging from 3.00 to 7.00 g/dL, potentially indicative of more severe anemia. The mean Hb was 10.95 ± 3.17g/dl, reflecting variability within the population. The mean platelet count of 115,380 cells/mcL ± 44,345 A significant majority (39.5%) demonstrates platelet counts ranging from 100,001 to 150,000, indicating typical and healthy levels, a minority (5.0%) showcases platelet counts below 50,000, indicating thrombocytopenia while 2.0% surpass 200,000 platelets, indicative of thrombocytosis. The majority of individuals (33.0%) have albumin levels ranging from 2.0 to 2.3, suggesting a typical and healthy range of albumin concentrations while a minority of individuals (2.5%) exhibit albumin levels below 2.0, indicating a potential deficiency. The mean albumin level for the sample is 2.57± 0.36g/dl. A majority (42.5%) demonstrate INR values ranging from 1.1 to 1.5, falling within the typical and desired range for most individuals. Significantly, a quarter of the sample (25.0%) exhibits INR values surpassing 2.0, indicating potential coagulation issues and a heightened risk of bleeding while a subset (11.0%) presents INR values below 1.1, implying enhanced coagulation and a potential increased risk of thrombosis. It's noteworthy that the typical normal range for INR is 0.8-1.1. The mean INR value for the sample is 1.52 ± 0.296.

The majority of individuals (46.0%) have S.Cr levels < 1.0 mg/dL, indicating normal kidney function while 5.5% of patients exhibit S.Cr levels > 2.0 mg/dL, indicating potentially severe kidney dysfunction or renal failure. The mean S.Cr level for

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the sample is 1.35± 0.88 mg/dL. A significant majority (44%) have bilirubin levels between 1.3 and 3.0 mg/dL, indicating mild to moderate elevation. Additionally, 17.5% of the patients have levels between 3.1 and 6.0 mg/dL, while 8.5% have levels ranging from 6.1 to 9.0 mg/dL. Notably, 20.5% of the patients have bilirubin levels exceeding 9.0 mg/dL, reflecting a higher severity of hyperbilirubinemia. The mean total bilirubin level is 8.346 + 7.810 mg/dL. MELD-Na score was moderately high at 10-19% in 80(40%) patients, while high to extremely high were seen in 106(53%) patients.

The distribution of Red Cell Distribution Width-Standard Deviation (RDW-SD) within the sample population reveals varying levels of erythrocyte size heterogeneity. Most individuals (69.0%) fall within the range of 46.1 to 50.0, indicating a relatively normal distribution of erythrocyte sizes, 13.0% subjects exhibit RDW-SD levels <46, suggesting a more homogeneous population of erythrocytes. Conversely, a smaller but notable portion of the sample (14.0%) demonstrates slightly elevated RDW-SD levels falling within the range of 50.1 to 60.0, indicative of increased erythrocyte size heterogeneity. A minority of individuals (3.0%) present with even higher RDW-SD levels, ranging from 60.1 to 70.0, while a very small proportion (1.0%) exhibits RDW-SD levels exceeding 70, suggesting severe erythrocyte size heterogeneity. The mean RDW-SD level for the sample is 48.94, with a median of 47.80 and a mode of 46.10, indicating a central tendency around the mid-40s.The variability in RDW-SD levels, as demonstrated by the standard deviation and range, highlights the diversity in erythrocyte size distribution within the population. Overall, this distribution provides valuable insights into the erythrocyte morphology and potential hematological abnormalities present within the sample population. Inferential statistics of RDW-SD Vs other parameters was given in [Table 2]. Laboratory parameters of haemoglobin, platelet, bilirubin, albumin, PT/INR, creatinine & sodium, when correlated with RDW (Red Cell Distribution Width), showed statistical significance, with p-values;<0.001, <0.001, <0.001, 0.001, 0.001, <0.016, <0.001 respectively. RDW-SD is correlated with MELD-Na to predict 3-month mortality were shown in [Table 3].Patients grouped by MELD-Na scores against RDW-SD to predict 3-month mortality showed statistical significance p-value (<0.001), with predicted mortality increasing from 1.9% to 71.3%. Higher the MELD-Na score value higher was the mean RDW of the patients. This significant correlation p-value (<0.001) between RDW-SD values with MELD-Na suggests that RDW-SD may be used.

Table 1: Baseline characteristics of study subjects (N = 200).

Characteristics	Study patients (N = 200), n (%)
Age (in years)	
0-20	1(0.5%)
21-40	17(8.5%)
41-60	78(39%)
61-80	84(42%)
81-100	20(10%)
Gender	
Male	181(90.5%)
female	19(9.5%)
Hb range(g/dl)	
3.00-7.00	25(0%)
7.01-11.00	46(%)
11.01-15.00	101(%)
>15.00	28(%)
RDW -SD Range	
<46	26(13%)
46.1-50	138(69%)
50.1-60	28(14%)
60.1-70	6(3%)
>70	2(1%)
Platelet count (per microlitre)	
<50000	10(5%)
50001-100000	76(38%)
100001-150000	79(39.5%)
150001-200000	31(15.5%)
>200000	4(2%)
Serum albumin (g/dl)	
<2.0	5(2.5%)
2.0-2.3	66(33%)
2.31-2.6	39(19.5%)
2.61-3.0	52(26%)
>3.0	38(19%)
Prothrombin time (seconds)	
Normal (<13.5)	25(12.5%)
13.51-18.00	108(54%)
18.01-24.00	56(28%)
24.01-26.00	11(5.5%)

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INR Range	
<1.1	22(11%)
1.1-1.5	85(42.5%)
1.51-2.0	43(21.5%)
>2.0	50(25%)
Serum creatinine(mg/dl)	
<1.0	92(46%)
1.0-1.9	97(48.5%)
>2.0	11(5.5%)
Serum sodium (mg/dl)	
Low (<134)	96(48%)
Normal(135-145)	93(46.5%)
High(>145	11(5.5%)
Total bilirubin (mg/dl)	
Normal (<1.2)	19(9.5%)
1.3-3.0	88(44%)
3.1-6.0	35(17.5%)
6.1-9.0	17(8.5%)
>9.0	41(20.5%)
MELD Na Score	
Low (<9)	14(7%)
Moderate (10-19)	80(40%)
High (20-29)	68(34%)
Very high (30-39)	37(18.5%)
Extremely high (>40)	1(0.5%)

Inferential Statistics

Table 2: Inferential statistics of RDW-SD Vs other parameters (n = 200).

RDW-SD	Mean ± SD	F	p-value
Age	61.5±13.48	1.658	0.006
Haemoglobin	10.95±3.17	6.451	<0.001
Platelet Count	115380±44345.67	2.792	<0.001
Serum Albumin	2.58±0.36	1.917	0.001
International Normalised Ratio	1.53±0.3	2.286	<0.001
Serum Creatinine	1.36±0.89	1.542	0.016
Total bilirubin	8.35±7.82	2.737	<0.001
Prothrombin time	18.19±3.82	3.522	<0.001
Sodium	136.24±6.27	2.737	<0.001
MELD-Na Score	21.17±8.6	2.885	<0.001

Table 3: RDW-SD is correlated with MELD-Na to predict 3-month mortality (n = 200).

MELD-Na Score		No. of Patients	Mean	Std. Deviation	Mortality (%)	F	p-Value
RDW-SD	Low (<9)	14	46.7286	4.19568	1.90	10.9	<0.001
	Moderate (10-19)	80	47.1113	3.14715	6.00		
	High (20-29)	68	50.1279	4.92368	19.60		
	Very high (30-39)	37	51.5622	3.44636	52.60		
	Extremely high (>40)	1	49.1000	4.34073	71.3		

DISCUSSION

RDW reflects the variability in circulating RBC size. It is based on the width of the RBC volume distribution curve, with larger values indicating greater variability.[27] The liver is the largest organ in the body and is responsible for filtering harmful chemical substances; accumulation of toxins may affect the size of RBCs and, therefore, the RDW values. Yang K et al,[28] concluded that RDW-SD is considered a more accurate indicator of variations in RBC size than RDW-CV. Hence, RDW-SD is considered for correlation with MELD-Na in our study.

A cohort of 200 patients with DCLD were included in this study. The mean age of the patients was 61.5 years, and the majority, 78(39%) belonged to the age group 41-60 years. Males 181(90.5%) were predominant, compared to females 19(9.5%), which were comparable to study by Kalairajan S et al,[29] with a majority of 19(38%) patients in the 41-50 years age group, and the male-to-female ratio was 86:14. Such a skewed distribution could suggest a sex-specific prevalence of the medical condition being studied or possible sampling bias.

Anaemia is a common complication in patients with advanced liver diseases. When portal hypertension occurs in patients with CLD, the spleen frequently enlarges and, due to pooling, reduces the number of RBCs in the blood. As represented in our study, half of the patients, 99(49.5%), had anaemia, of which 28(12.5%) patients presented with very low Hb levels ranging from 3.00 to 7.00 g/dL.

In hepatic cirrhosis, the expression of pro-inflammatory cytokines increases the heterogenicity of RBC maturation which further impairs RBC production, leading to an increase in RDW. In our study most patients 174(87.0%) had high RDW-SD>46, which indicates variability in the

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erythrocyte sizes. In contrast, the study by Nafady HA et al showed that only 45(17%) had high RDW-SD.[30]

The platelet count in the study population was less than the normal range (150000/mcL) in 165 (82.5%) patients. Similarly, Afdhal N et al,[31]showed thrombocytopenia in 76% of CLD patients, confirming that most CLD patients are thrombocytopenic.

Bilirubin is a marker of hepatic excretory function; most 88(44%) patients had bilirubin levels between 1.3 and 3 mg/dL, indicating mild elevation, while 41(20.5%) patients had bilirubin levels more than 9 mg/dL in our study. Albumin is a measure of the synthetic function of the liver; supporting this, 181(89%) patients had low albumin <3.5mg/dl in our study which was similar to a study by Khattak AA et al,[32] with serum albumin levels <3.5 in all of his study population. The majority, 108(54.0%) of patients, had slightly raised prothrombin time between 13.5 to 18.00 seconds, while 56(28.0%) patients had PT ranging from 18.01 to 24.00 seconds, but only 11(5.5%)patients had raised levels above 24 seconds. This trend of coagulopathy was similarly reflected in the INR of patients. Most individuals 140(70%) had creatinine levels below 1.2 mg/dL, but a substantial portion 60 (30%), had increased creatinine levels, suggesting varying degrees of kidney impairment. Similarly, Das N et al.[33] showed that 10% of patients with CLD had acute kidney injury (AKI). Hepatorenal syndrome (HRS) developed in about 20% and 40% of the patients at 1 and 5 years.

The distribution of patients based on the MELD-Na score showed a diverse range. The low category with a MELD-Na score of less than 9 had 14 (7%) patients. The moderate category, with scores between 10 and 19, was the largest group, encompassing 80(40%). High scores from 20 to 29 were 68(34%). Very high and extremely high scores between 30 to 39 and above 40 were seen in 37(18.5%) and 1(0.5%), respectively.

In this study, various laboratory parameters were also considered and looked for association with RDW-SD. The mean values for haemoglobin was 10.95 ± 3.17, platelet count was 115,380 ± 44,345 cells/mcL, serum albumin was 2.58 ± 0.36mg/dl, prothrombin time was 18.19 ± 3.82 ,INR 1.53 ± 0.3 ,serum creatinine levels was 1.36 ± 0.89, serum sodium levels of 136.24 ± 6.27 and bilirubin levels was 8.35 ± 7.82. The studied parameters showed statistically significant association (p value <0.001) with RDW-SD, however no particular study was available for RDW association with platelet count, bilirubin, PT/INR and sodium.

Puentes JC et al,[24]did a study correlating MELD-Na scores and the corresponding mortality percentages for patients with liver disease. The increasing MELD-Na score indicating more severe liver dysfunction showed a rise in the mortality rate of CLD patients. However, the present study was done on CLD patients in decompensation.

A MELD-Na score of less than 9 was seen in 14(7%) patients, with a mean RDW-SD of 46.72, with a predicted mortality rate of 1.9%. A MELD-Na score between 10-19 was seen in 80(40%) patients, with a mean RDW-SD of 47.10, correlating with a predicted mortality rate of 6%. A MELD-Na score between 20-29 was seen in 68(34%) patients, with a mean RDW-SD of 50.12, correlating with a predicted mortality rate of 19.60%. A MELD-Na score between 30-39 was seen in 37(18.5%) patients, with a mean RDW-SD of 51.16, correlating with a predicted mortality rate of 52.60%. A MELD-Na score greater than 40 was seen in one patient (0.5%), with a mean RDW-SD of 49.1, correlating with a predicted mortality rate of 71.3%. The p-value on the statistical correlation between RDW-SD and MELD-Na was<0.001, which is statistically significant.

This study showed a significant correlation of RDW-SD values with the worsening of MELD-Na, suggesting that RDW-SD can be used to predict the 3-month mortality in patients with decompensated CLD which was consistent with then finding by Kalairajan S et al,[29] in his study.

Limitations: This was a single-centre study, so a multi-centric study covering a larger population is required. The causes of elevated RDW values, such as folate and vitamin B12 deficiency, which could confound the findings of the present study were not investigated. RDW values were not dynamically observed thus, whether RDW values elevated stepwise when the patient's condition progressively deteriorated or it improved, when the patient received treatment needs to be seen. So, a prospective study is more appropriate. Patients were not followed up for mortality, so predicted 3-month mortality derived from the MELD-Na score was not compared with actual mortality in study patients.

CONCLUSION

This study highlights the significant association between red cell distribution width (RDW) and the severity of decompensated chronic liver disease (DCLD). Those with higher MELD-Na score with more severe liver dysfunction had a corresponding higher RDW-SD value. So, RDW-SD, a readily available biomarker, can aid clinicians in assessing disease severity and predicting outcomes in patients with DCLD.

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