Section: General Medicine

Original Research Article

RED CELL DISTRIBUTION WIDTH UNVEILED: A NEW LENS ON ICU PATIENT MORTALITY AND MORBIDITY

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ABSTRACT

Background: In the MICU high mortality rates highlight the need for effective treatment planning. Red Cell Distribution Width (RDW) is a crucial marker, reflecting red blood cell size variability. Elevated RDW is linked to poor outcomes in acute conditions such as heart failure, pancreatitis, pulmonary embolism, and sepsis. Monitoring RDW can help in prognosis and guiding treatment decisions.

Materials and Methods: This study aims to access the prognosis of patients admitted in medical intensive care unit based on RDW values. Conducted at GIMS Hospital Kalaburgi, this a Prospective Interventional Study from August 2022 to January 2024. A total of 161 patients were included, via simple random sampling method.

Results: In a study of 161 MICU patients (103 males, 58 females), 57.7% died and 42.2% survived. Higher RDW levels at admission and day 1 were associated with increased mortality. Prolonged hospital stay also correlated with elevated RDW values, indicating RDW as a significant prognostic marker.

Conclusion: The study shows that RDW is a strong predictor of prognosis and hospital stay duration in MICU patients. Higher RDW levels correlate with poorer outcomes and longer stays. This can guide appropriate care and enable better prognostic counseling for patient attendants, improving overall treatment management.

Keywords: Medical Intensive Care Unit, Red Ccell Distribution Width (RDW), Prognosis, Acute heart failure, Sepsis, Pancreatitis, Pulmonary embolism, Acute renal failure, Stroke, Influenza.

INTRODUCTION

The red cell distribution width (RDW) test measures variation in red blood cell size or red blood cell volume as a part of a complete blood count (CBC). It is used along with other red blood cell (RBC) indices, especially mean corpuscular volume (MCV), to help determine the causes of anemia.

RDW is elevated in accordance with variation in red cell size (anisocytosis); that is, when elevated RDW is reported on complete blood count, marked anisocytosis (increased variation in red cell size) is expected on peripheral blood smear review.

Red Cell Distribution Width (RDW) traditionally found its application in the diagnostic workup of anemia, where it quantifies the variation in red blood cell size.[1] However, recent times have seen a widening of its clinical relevance. Elevated RDW values have now been correlated with inflammation, malnutrition, and oxidative stress.[2] Such values are of paramount importance in the MICU, where inflammation and oxidative stress are commonly encountered adversaries.[3] Indeed, a mounting body of evidence suggests that RDW might be a surrogate for severity in conditions like sepsis, chronic obstructive pulmonary disease exacerbations, and even cardiovascular diseases.[4,5]

The reference range for RDW is as follows

- RDW-SD 39-46 fL 6
- RDW-CV 11.6-14.6% in adult 7

A study by Safdar et al. (2017),[8] examined the role of Red Cell Distribution Width (RDW) as a predictor of 30-day mortality in ICU patients. Among 156 patients, those who didn't survive had a median RDW of 17.20, significantly higher than

survivors (P = 0.007). With an RDW cutoff of 15.75, the sensitivity and specificity for predicting mortality were 71% and 89%, respectively. The study concluded that RDW is an independent and cost-effective predictor of 30-day mortality in critically ill patients.

A study by Sarkar et al. (2021),[9] analyzed the prognostic value of Red Blood Cell Distribution Width (RDW) in COVID-19 patients. Reviewing 25 studies with 18,392 patients for mortality and 3,446 for disease severity, they found that higher RDW levels on admission were associated with increased mortality and severity (SMD = 0.46). In a subgroup of 2,980 patients, RDW over 14.5 indicated a higher mortality risk (OR = 2.73). The study suggests elevated RDW correlates with worse outcomes in COVID-19 but calls for further research on optimal cut-off values.

MATERIALS AND METHODS

Source of Data: Data was procured from patients aged 18 or above who were admitted to the Medical Intensive Care Unit (MICU) at the GIMS Hospital, Gulbarga Institute of Medical Sciences College and Hospital, Kalaburgi.

Method of Collection of Data

Study Design: This was a prospective interventional study.

Study Area: The study was conducted at GIMS Hospital, Gulbarga Institute of Medical Sciences College and Hospital, Kalaburgi.

Study Population: Patients aged 18 or above who were admitted to the Medical Intensive Care Unit (MICU) at GIMS Hospital, Gulbarga Institute of Medical Sciences College and Hospital, Kalaburgi were included.

Study Duration: The study spanned 18 months.

Sample Size: A total of 161 patients were included. The sample size was limited due to the high costs associated with the investigations.

Sampling Technique: Simple Random Sampling was employed.

Inclusion Criteria

- Patients treated in ICU aged >18 years.
- Patients requiring MICU admissions on the 1st day of hospitalization.
- Presence RDW abnormalities upon MICU admission.

Exclusion Criteria

- Patients who declined formal consent.
- Patients readmitted to MICU.
- Recent trauma history.
- Pregnant females.
- History of packed cell transfusion.
- Known hematological disorders.
- Recent chemotherapy.
- Patients on immunosuppression therapy.
- Post solid organ transplantation patients.
- Post splenectomy patients.
- All surgical patients.
- All obstetrics and gynecological patients.

Methodology

A total of 161 patients were selected based on the inclusion criteria and after obtaining valid written consent. This prospective interventional study was conducted in the MICU of the GIMS hospital, Gulbarga Institute of Medical Sciences College and Hospital, Kalaburgi.

Methods

Venous sample drawn from the patient after informed consent under aseptic precautions. The sample is then transferred to purple caped (EDTA – Ethylenediamine tetraacetic acid) vacutainer.

For measuring RDW, either the Sysmex XP 300 (3 Part machine) or the Erba H 360 (3 Part machine) was used, both of which determine RDW using Coulter's Principles.

Patients were then categorized based on their RDW values, and clinical investigations, severity of illness, hospital stay duration, and the requirement of vasoactive agents were compared between the two groups.

RDW readings were assessed on the day of admission, and then at 24 and 48 hours post-admission. This was done to understand the prognosis and outcome of patients in the MICU at the GIMS Hospital, Gulbarga Institute of Medical Sciences College and Hospital, Kalaburgi.

Lastly, an assessment was made of the number of patients who passed away having either high/normal RDW values, in contrast to their acute physiological and chronic health statuses.

Statistical Analysis: Data collected was analyzed using IBM SPSS statistics software 16.0 and MS Office. Quantitative data was represented through mean and standard deviation, while chi-square tests were applied for qualitative data.

RESULTS

The study involved 161 patients, with variable diagnosis of different systems and different age groups. The study using RDW predicting the morbidity and mortality in MICU admitted patients. Analysis of the end results are as follows. [Table 1]

In the above study, mean age amomg death 50.9 ± 16.02 and survival 44.3 ± 17.2. mean values of RDW among deaths are 19.5 ± 4.07, 19.4 ± 3.8 and 19.16 ± 3.47 on day of admission, day 1 and day 2 respectively with significant p value <.0.0001. [Table 2]

The Positive Predictive Value (PPV) and Negative Predictive Value (NPV) are included for the above study. [Table 3]

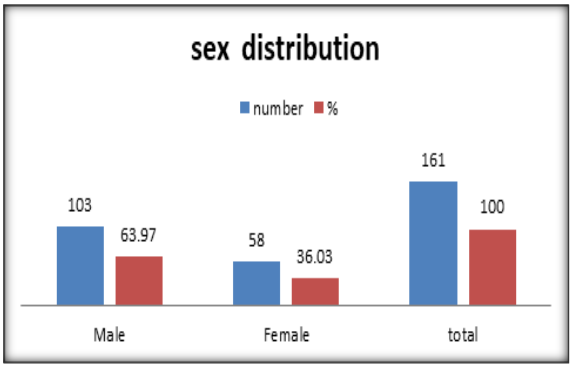

Figure 1: Sex Distribution

A total of 161 patients were included in the study, of them 63.97% (103) were males and 36.03% (58) were females.

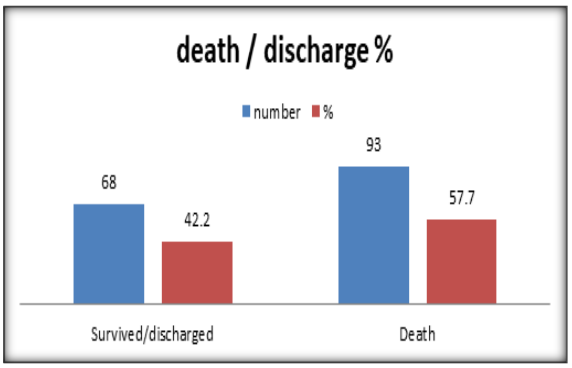

Figure 2: Death / Discharge Percentage

Among 161 patients included in the study, survival rate was seen in about 42.2% population that is 68 members survived or discharged from the hospital. Death rate was seen in around 57.7 % population which says 93 members died with significant p value (<0.01).

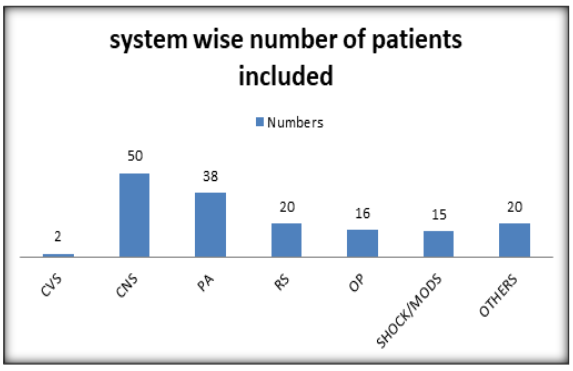

Figure 3: System Wise Number of Patients Involved

Among the study population 50 cases of nervous system, 38 cases of abdomen (Gastrointestinal tract and renal system), 20 cases of respiratory 16 Organoposphorus poisoning, 15 cases involving multiple systems others being 20 cases and lowest in the study population included cardiovascular system.

75 % of death rate was seen in age >70 years with 25% survival in same age group. Followed by 73.07% and 26.9 % of death and survival among 60 – 69 years age. With lowest percentage of death (28.5%) and highest survival rate (71.4%) was seen in <30 years of age. Indicates lesser the age groups higher the survival rate. [Table 4]

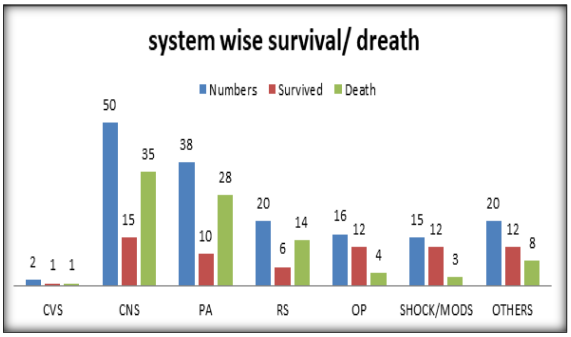

Figure 4: Survival/Death Percentage of Systemic Involvement

2 cases of cardiovascular system involved in the study population of them 1 patient survived. 6 survived in respiratory diseased patients. 35 patients with nervous system disorders recovered and discharged from the hospital.

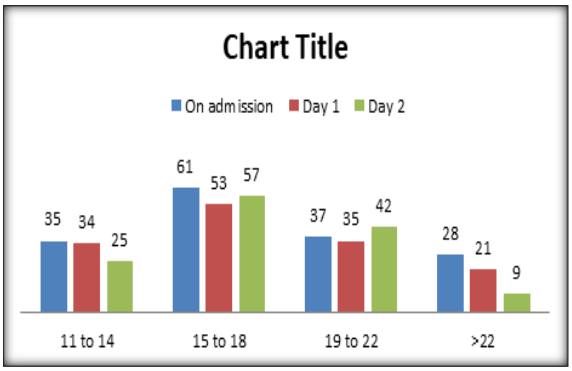

Figure 5: RDW Values at Different Intervals

RDW values between 15 – 18 are seem to be higher in the study population followed by RDW values between 19 – 22.

35, 34 and 25 number of patients found to be within normal limits of RDW, On admission, day 1 and day 2 respectively. [Table 5]

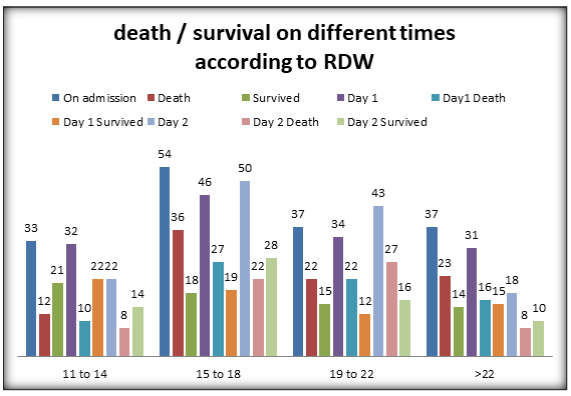

Figure 6: Number of Death/Survival with RDW Values

Death numbers and survival numbers, increases with the RDW values and decreases if maintained within the normal ranges. RDW predicts the mortality in the MICU with significant p values < 0.001.

Table 1: Baseline characteristics and outcome

Variable	Death (Mean ± SD or %)	Survival (Mean ± SD or %)
Age	50.9 ± 16.02	44.3 ± 17.2
Sex (Male/Female)	61.1% / 51.7%	38.8% / 41.5%
Diagnosis	Various	Various

Table 2: Clinical Parameters and Outcome

Variable	Death (Mean ± SD or %)	Survival (Mean ± SD or %)	p-value
RDW on Admission (RDW OA)	19.5 ± 4.07	16.96 ± 3.32	<0.0001
RDW on Day 1 (RDW D1)	19.4 ± 3.8	16.98 ± 3.36	<0.0001
RDW on Day 2 (RDW D2)	19.16 ± 3.47	17.05 ± 3.21	<0.0001

Table 3: ROC Analysis (RDW Vs Death or Survival)

Variable	AUC	95% CI	Sensitivity	Specificity	Cut-off Value	PPV	NPV
RDW on Admission (RDW OA)	0.68	0.61 - 0.75	75%	60%	18.5	70%	65%

Table 4: Percentage of Deaths / Survival in Different Age Groups

Age group	Numbers	Survived	%	Death	%
<30 years	28	20	71.4	8	28.5
30-39	19	6	31.5	13	68
40-49	33	14	42.4	19	57.5
50-59	31	15	48.3	16	51.6
60-69	26	7	26.9	19	73.07
>70	24	6	25	18	75

Table 5: RDW Values at Different Intervals

RDW	On admission	Day 1	Day 2
11- 14	35	34	25
15 - 18	61	53	57
19 - 22	37	35	42
>22	28	21	9

Table 6: Number of Death/Survival with RDW Values

RDW	On admission	Death	Survived	Day 1	Day1 Death	Day 1 Survived	Day 2	Day 2 Death	Day 2 Survived
11 to14	33	12	21	32	10	22	22	8	14
15 to 18	54	36	18	46	27	19	50	22	28
19 to 22	37	22	15	34	22	12	43	27	16
>22	37	23	14	31	16	15	18	8	10

Table 7: Death/ Discharge with Duration of Hospital Stay

Duration of hospital stay	Numbers	Death	Death %	discharged	discharged%
<24 hours	18	18	100	0	
24-48 hours	10	10	100	0	
2-5 days	74	49	66	25	33.78
5-10 days	41	9	21.95	32	78
>10 days	18	7	38.88	11	61.11

DISCUSSION

Red Cell Distribution Width (RDW) is a parameter in a hemogram that reflects the variation in red blood cell size. RDW levels typically rise in situations where red blood cell production is insufficient or there is an increased rate of red blood cell destruction.

Recent studies have highlighted RDW's emerging role as a prognostic marker in various conditions, including sepsis, acute and chronic inflammatory diseases, neurological disorders, cardiovascular conditions, and thromboembolic diseases.[10-16]

Furthermore, studies have shown a link between elevated RDW levels and higher fatality rates following admission to an intensive care unit.[17,18,19,20] RDW is a strong and accurate predictor of morbidity and death in ICU patients.[21,22,23] Circulatory failure, respiratory failure, renal failure, neurological failure, and sepsis are the main symptoms of critically ill patients. The majority of patients admitted to the MICU have sepsis, cardiovascular illness, neurological disorders, and respiratory diseases, according to admission data.

The association between RDW and clinical outcomes in patients with severe illness was confirmed by our analysis. More precisely, our findings showed a relationship between increased RDW and in-hospital mortality and longer hospitalisations in the intensive care unit. In the first publication on the association between RDW and clinical outcome in critically sick patients, ICU mortality served as the key study end point. As a result, patients were deemed to have had a good

outcome if they were able to be successfully discharged from the ICU.[19]

COMPARISION OF RDW AND OTHER STDUIES

Comparative studies related Age distribution

In this study, patient ages ranged from under 30 to over 70 years, with most patients (20.4%) between 40-49 years old, followed by those aged 50-59 (19.2%). The average age was 49.2 ± 2.2 years. A significant age difference was noted between survivors and non-survivors ($p < 0.01$). In Kader et al.'s,[24] study, ages spanned 18–86 years, with 50% of severely ill patients over 60 years, while 65.6% of less severe cases were aged 31-60. The mean age difference was also statistically significant ($p < 0.05$). Similar findings were reported in studies by Ergoden, Bazick, and Huzicker.[25,26,27]

Comparative studies related Sex distribution

Males made up more of the study's participants (63.97%) than females (36.03%). Previous research also revealed that the majority of ICU patients were male. Bazick et al., Ergoden et al., Kader et al., Hunziker et al.[24,25,26,27] These results were almost in line with what we had investigated.

Comparative studies related to distribution of clinical diagnosis

The current study includes 50 cases (31.05%) of cerebral vascular disease, 38 cases (23.6%) of Per abdomen, 38 cases (23.5%) of cardiovascular disease, 20 cases (23.5%) of Respiratory system, 16 cases (9.9%) of organophosphorous poisoning, and 20 cases (9.3%) of shock/MODS. The study by Ergoden et al,[25] included various conditions among ICU patients who were admitted for more than 24 hours following emergency or elective surgery. These conditions included 16 cases of cerebral vascular disease (14.7%), 11 cases of pneumonia (10.1%), 7 cases of sepsis (6.4%), 4 cases of drug intoxication (3.7%), 5 cases of acute renal failure (4.6%), 5 cases of malignancy (4.6%), 8 cases of chronic obstructive pulmonary disease (7.3%), 3 cases of cardiovascular disorders (2.7%), 15 patients with poor general condition (13.8%), and 35 postoperative cases (32.1%). In the Kader et al. study,[24] patients had sepsis in 10 (16%), neurological disorders in 21 (35%), cardiovascular diseases in 18 (30%), and trauma patients in 11 (18.3%) cases.

Comparative studies related to length stay in MICU

In Present study 74 cases stay for 2-5 days and 41 cases for 6-10 days .There were significant positive correlations between survivors and deaths (p value <0.001). In Ergoden et al study.[25] The median duration of ICU stays was 6 days, with a range of 2 to 82 days. Among the ICU patients, 37 (33.9%) died. RDW showed significant positive correlations with APACHE II, SOFA, and SAPS II scores. Zhang et al,[28] RDW measurements did not provide extra clinical benefit for outcome prediction. Although a longer ICU stay was associated with higher RDW levels, RDW alone was not effective in identifying patients with a better chance of survival. Furthermore, taking multiple RDW measurements did not enhance the accuracy of outcome predictions.

Comparative studies related to RDW distribution between survivors and Deaths

In the present study RDWs were significantly higher in deaths (19.5 ± 4.07versus survivours 16.96 ± 3.32, p<0.01) showing significant correlation with p value <0.01). In Ergoden et al study.[25] RDWs were significantly higher in non-survivors (16.94±3.05 versus survivours (15.62±2.82, p<0.001). In Zhongheng Zhang et al study,[28] the results showed that RDW was significantly higher in nonsurvivors .In kader et al.[24] The study found that the mean RDW was 19.75 ± 1.90 in the more severe group and 16.04 ± 0.70 in the less severe group. An unpaired t-test showed a statistically significant difference ($p < 0.001$) in mean RDW between the two groups, indicating that higher RDW is associated with greater illness severity. Additionally, important findings from other studies were also observed.

Sadaka et al,[29] Bazick et al,[26] Ani et al,[9] and Hunzicker et al.[27] According to earlier research, higher RDW was linked to higher death rates than lower RDW. This result aligned with what we had investigated.

Comparative studies related distribution of other Hematology parameters

In Present study Hb and Platelet count showed significant statistical correlation between survivors and death cases with p value <0.01. However, Lorente et al and Meynaar et al could not find a correlation between RDW and WBC count.[8,30]

CONCLUSION

The study found that RDW, a common and cost-effective measure found in a CBC, is a strong independent predictor of mortality and early clinical decline in MICU patients. It revealed a positive association between RDW and mortality in the MICU. This suggests that RDW alone could be used to predict mortality in MICU patients, potentially offering a simpler alternative to complex scoring systems that require multiple factors.

In MICU patients, acidosis is commonly associated with various causes and negative outcomes. Survivors typically experience a greater resolution of acidosis compared to those who die. Early correction of pH levels is a better predictor of survival in the MICU. Longer hospital and ICU stays, as well as both alkalosis and acidosis, are linked to higher mortality rates. Monitoring pH levels seems essential and could serve as a valuable indicator of mortality for ICU patients.

Ethical Clearance

Approved by the Institute of Ethical Committee.

Consent: Informed and written consent from all patients

Funding: None

Authors Contribution

Dr Praveen kumar: study concept, principle investigator, writing the paper

Dr G B Doddamani: study concept and writing the paper, co-investigator and correction of paper.

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