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Red Blood Cell Distribution Width Level as Reliable Diagnostic and Prognostic Biomarker in Septic Patients: A Case-Control Study

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ABSTRACT

Background: Sepsis is one of the leading causes of death, with 40–50% mortality rates. The red blood cell distribution width (RDW) is an emerging, novel, and inexpensive marker for sepsis.

Objective: This study aimed to evaluate RDW levels as a reliable diagnostic and prognostic biomarker in septic patients.

Patients and Methods: A prospective case-control study was carried out in the Medical Intensive Care Unit (MICU), Zagazig University Hospitals on 46 patients, equally divided into two groups (n=23): the septic group and those who didn't develop sepsis (control group). All participants underwent a C-reactive protein (CRP, mg/ml) and a complete blood count (CBC) analysis, including RDW, on the first, third, and seventh days after admission. Procalcitonin (ng/ml) was determined using an enzyme-linked immunosorbent assay.

Results: Diabetes was the most common chronic disease, while lung infections were the most common source of sepsis. Septic patients had significantly higher RDW values compared to control patients on the first (18.9 vs. 13.8), third (20.4 vs. 14.3), and seventh day (25.7 vs. 16.0) after admission, p <0.05. RDW >14.8, CRP >38.7mg / l, or CRP >38.7mg/l, or procalcitonin >2.2 mg/l were correlated with development of sepsis. On the seventh day of admission to the ICU, the mortality rate was 43.5% and 13.1% in the septic and control groups, respectively. A positive correlation was detected between RDW and Sequential Organ Failure Assessment (SOFA) score on the seventh day of hospitalization (P<0.0001).

Conclusions: RDW is significantly higher in septic and dead patients; hence, it may be considered an effective biomarker for early sepsis detection and reliable predictor of mortality in septic patients.

Keywords: Sepsis, Red blood cell distribution width, CRP, RDW.

INTRODUCTION

Sepsis is a state of life-threatening organ dysfunction resulting from an improperly controlled host response to infection. Typically, a bacterial infection is a cause. Sepsis and septic shock are significant global health issues, affecting millions of people annually and causing deaths between one-third and one-sixth of those affected[(1)].

Sepsis continues to be the primary cause of death in non-coronary intensive care units (ICU) worldwide, with an estimated mortality rate of 30% in sepsis and 80% in septic shock in the United States[(2)] and 12.8% in sepsis and 45.7% in septic shock in Europe[(3)]. Unfortunately, data on the prevalence of sepsis in Egypt are limited.

Early diagnosis and effective treatment administered in the first few hours after the onset of sepsis development improve patient outcomes[(4)]. Prognostic factors such as age, sex, comorbidities, biomarkers (C-reactive protein and procalcitonin), and severity of the disease score [Acute Physiology and Chronic Health Evaluation (APACHE)] have been associated with the outcome of severe sepsis[(5)].

There are no gold standards for the diagnosis of infection; however, procalcitonin is regarded as one of the most potential sepsis indicators in critically ill patients[(6)], complementing clinical symptoms and routine laboratory variables that predict sepsis but remain costly[(7)].

The red blood cell distribution width (RDW) is a numerical measurement of the size, variability, and heterogeneity of the red blood cells (RBCs). In most patients with sepsis admitted to emergency rooms, automated analyzers perform a complete blood count (CBC), and RDW is routinely provided as part of the CBC. RDW is simple, cost-effective, frequently accessible, and quickly quantifiable[(8)]. RDW is calculated by dividing the standard deviation of the erythrocyte by the average corpuscular volume and multiplying the result by 100 to express as a percentage[(9)].

Any disease involving the breakdown or synthesis of RBCs could increase the variability of the size of RBCs and RDW. Both erythropoiesis and erythrocyte maturation can be altered by sepsis. A subsequent acute increase in RDW can reflect the severity of the underlying inflammatory state and provide important prognostic information on the intensity of resource use and the risk of mortality[(10)].

Although the mechanism of increased RDW in septic patients has not yet been determined, it has been postulated that inflammation and oxidative stress are associated with elevated RDW[(10)]. Electronic microscopy shows RBC shape changes during shock's refractory phase. Sepsis affects the morphology and function of RBC. Therefore, changes in RBC during sepsis and shock can contribute to multiple organ dysfunction syndromes. Septic shock bacteria endotoxins may reduce the elasticity of RBC, reduce the

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deformability of RBC, and increase the concentration of hidromiristic acid, a component of bacterial endotoxin[11].

Most RDW studies are used mainly to identify the type of anemia[6]. Research has found that, in addition to the evaluation of anemia, RDW is identified as a prognostic factor for disease severity and clinical outcomes in various diseases, including acute myocardial infarction (MI) [12], acquired pneumonia[13], and pulmonary embolism[14].

AIM OF THE STUDY

The current study aims to evaluate the diagnostic and prognostic reliability of RDW levels in septic patients admitted to the ICU to improve their prognosis.

PATIENTS AND METHODS

This prospective case-control cohort study was conducted in the medical intensive care unit (MICU) of the Zagazig University Hospitals, Zagazig City, Sharika Governorate, Egypt, for one year, from January 2021-2022. Forty-six patients from both sexes were divided into two groups of equal participants; 23 ICU patients who met the criteria for sepsis and septic shock after admission (septic group I) and 23 ICU patients who did not develop sepsis (control group II).

Before the beginning of the study, the suggested protocols were declared to all patients who accepted. At admission, a complete history of family, drug, and personal demographic data (name, sex, age, unique habits, height, and weight), the medical history of associated chronic diseases, and the current disease state of each participant were recorded. The general examination of vital signs involving pulse, blood pressure (BP), heart rate (HR), and temperature (°C) was conducted for all recruited subjects. Furthermore, sputum, urine, and blood cultures from a suspicious source were collected from all participants.

Inclusion Criteria:

Patients admitted to the ICU who met the criteria for septic shock and sepsis according to the 2013 Surviving Sepsis Campaign: International Guidelines[15] for treating sepsis and septic shock were included in our study.

Exclusion Criteria:

Patients younger than 18 years of age. Chronic use of drugs that alter the morphology and size of RBCs. Patients with diseases that primarily affect RBCs size and morphology include congestive heart failure (CHF), acute myocardial infarction (MI), or pulmonary embolism. Pregnant women, patients after cardiac arrest or with bleeding or blood loss > 10% of blood volume. Patients who underwent blood or blood product transfusion one week prior to ICU admission.

Methodology:

All patients were subjected to a daily CBC, including RDW. CBC tests were performed using microtubes containing the EDTA anticoagulant. RDW was evaluated using a Mindray BC-5500 autohematology analyzer, using Kt 6400 equipment, an automated hematology analyzer based on a combination of different principles of electrical impedance, light scatters, light absorption, and electrical conductivity. Additionally, a daily kidney function test including blood urea (mg/dl), serum creatinine (mg/dl) serum sodium (mg/dl) and serum potassium (mg/dl). A liver function test includes bilirubin, total and direct (mg/dl), alanine aminotransferase (ALT), and aspartate aminotransferase (AST) (μ/l). Arterial blood gases, sodium, potassium serum electrolytes, and Glasgow coma scale were performed.

CRP in mg/ml was measured on the first, third, and seventh days after admission by drawing a blood sample into green-topped vacutainer tubes containing lithium heparin as an anticoagulant. Procalcitonin levels in ng/ml were determined using a stat fax–2100 ELISA reader (Awareness Technology, Inc., New York, USA).

Ethical Consideration:

An approval of the study was obtained from Zagazig University Academic and Ethical Committee was obtained. Written informed consent of all the participants was obtained. This work has been carried out in accordance with The Code of Ethics of the World Medical Association[Ref] (Declaration of Helsinki) for studies involving humans.

Statistical analysis

The data obtained were performed using the Statistical Package for Social Sciences [SPSS version 22 (SPSS Inc., Chicago, IL, USA)]. Quantitative data were presented as mean ± standard deviation (SD), while qualitative data were represented as absolute frequencies (number) & relative frequencies (%). Chi-square (χ^2) and Fisher's exact were used to compare qualitative variables. The independent sample t-test was used to compare two independent groups of normally distributed variables. A paired sample t-test or Wilcoxon signed-rank test was employed to compare quantitative parameters at different time points. P value < 0.05 was considered significant.

RESULTS

Table (**1**) presented the demographic characteristics of 46 patients (47.8 % were females), with a mean age of 57.93 ± 8.67 and 55.13 ± 9.61, for the septic group (I) and control group (II), respectively. There were no statistically significant differences in age (P = 0.680) and sex (P = 0.163) between the two groups of the current research, as illustrated in Table (1). Regarding the associated chronic diseases and other risk factors, Table (1) showed a nonsignificant difference

between the two groups, p > 0.05. Diabetes mellitus (DM) was the most frequent associated chronic condition observed in 52.2% of sepsis cases and 43.5% of control cases, followed by smoking in 43.8% of sepsis cases and 52.2% of control cases. Some patients may have multiple comorbid conditions.

Table (1): Participants' demographic characteristics, risk factors, and comorbidities distribution in septic and control groups.

	Septic group (I) (n= 23)	Control group (II) (n= 23)	P-value
Age	57.93 ± 8.67	55.13 ± 9.61	0.680
Gender			0.163
Male	12 (52.1%)	13 (56.5%)	
Female	11 (47.9%)	10 (43.5%)	
Risk factors and comorbidities			
Smoking	10 (43.8%)	12 (52.2%)	0.148
DM	12 (52.2%)	10 (43.5%)	0.148
HTN	9 (39.1%)	12 (52.2%)	0.074
CHF	3 (13.1%)	5 (21.7%)	0.223
Other conditions	7 (30.4%)	7 (30.4%)	1

DM = Diabetes Mellitus; HTN = Hypertension; CHF = Congestive Heart Failure; Other conditions = include obesity, alcohol, and drugs intake.

There may be multiple origins of sepsis in some patients. Regarding the source of sepsis, according to the findings of our current study, Table (2) revealed that lung-related causes accounted for 39.1% of sepsis cases, followed by urinary tract infections (34.8%) and catheter-related bloodstream infections (30.4%). Other reasons included intra-abdominal infections (21.7%), skin and soft tissue infections (8.7%), and unclear causes (17.4%).

Table (2): Source of sepsis in the septic group (I).

Source of sepsis	Frequency	Percentage
Lung causes	7	39.1 %
CRBSI	2	30.4 %
Intra-abdominal	3	21.7 %
UTI	8	34.8 %
Skin and soft tissues	2	8.7 %
Unidentified causes	1	17.4%

CRBSI = Catheter Related Blood Stream Infection; **UTI** = Urinary Tract Infection

Table (3) reported the routine general examination at admission. Pulse, mean arterial pressure (MAP) and respiratory rate (RR) did not indicate significant differences between the two groups during the initial clinical examination at admission (p > 0.05); nevertheless, the median Glasgow coma scale (GCS) in the control group was (~ 13) significantly higher compared to the sepsis group (10), p= 0.016. In the sepsis group, the temperature was (39.09 ± 2.98 ° C) not significantly higher relative to the control group (37.5 ± 2.2 ° C).

Table (3): Analysis of items of general examination on admission in septic and control groups.

	Septic group (I) (n= 23)	Control group (II) (n= 23)	P-value
GCS	10 (3-14)	13(8-15)	0.016*
Pulse (b/min)	90.34 ± 19.48	87.14 ± 21.17	0.096
MAP (mm/hg)	91.64±22.09	94.33±22.68	0.362
RR (Br/min)	23 (15-34)	22(14-31)	0.127
Temperature (° C)	39.09 ± 2.98	37.5±2.2	0.068

GCS = Glasgow Coma Score; MAP = Mean Arterial Pressure; RR = Respiratory rate; *Statistically significant as p< 0.05.

The septic group had significantly higher median values of RDW compared to the control group; on admission (16.8 vs. 13.05, p = 0.039), on the first day (18.9 vs. 13.8, p = 0.015), on the third day (20.4 vs. 14.3, p < 0.001), and similarly on the seventh day following admission (25.7 vs. 16.0, p < 0.0001). The RDW values increased in both groups over time; however, they were significantly higher in the sepsis group only on the third (p=0.018) and seventh days (< 0.0001) after admission, Table (4).

Mean CRP values were significantly higher in the septic group on admission, the first, third, and seventh day after admission (P < 0.0001). Significant increase in CRP in the septic group with increased duration after admission (p < 0.0001), while CRP decreased significantly in the control group, Table (4). Furthermore, Table (4) demonstrated that at all periods, the septic group had significantly higher procalcitonin levels than the control group (p <0.0001). Procalcitonin levels decreased in both groups after admission but were significantly lower in the sepsis group on day three (p = 0.045) and seventh days (p= 0.003) compared to baseline levels.

Table (4): Red cell distribution width, CRP, and procalcitonin in study and control groups.

	Septic group (I) (n= 23)	Control group (II) (n= 23)	P-value
Basal (On admission)	16.8 (13.9-18.5)	13.05 (10.4-15.5)	0.039*
1st day	18.9 (16.77-20.5)	13.8 (11.3-15.9)	0.015*
P value (in relation to basal value)	0.065	0.547	
3rd day	20.4 (17.9-23.5)	14.3 (11.4-16.5)	0.001*
P value (in relation to basal value)	0.018*	0.273	
7th day	25.7 (18.7-29.5)	16.9 (12.4-18.1)	< 0.0001*
P value (in relation to basal value)	< 0.0001*	0.095	
C-Reactive Protein [CRP (mg/l)] in both studied groups			
Basal (On admission)	115.23 ± 22.76	89.41 ± 11.52	< 0.0001*
1st day	131.79 ± 19.69	66.33 ± 10.56	< 0.0001*
P value (in relation to basal value)	< 0.0001*	< 0.0001*	
3rd day	156.18 ± 15.07	54.61 ± 11.82	< 0.0001*
P value (in relation to basal value)	< 0.0001*	< 0.0001*	
7th day	183.86 ± 12.56	36.11 ± 8.54	< 0.0001*
P value (in relation to basal value)	< 0.0001*	< 0.0001*	
Procalcitonin (ng/ml) in both studied groups			
Basal (On admission)	12.27 ± 2.81	1.13 ± 0.18	< 0.0001*
1st day	8.56 ± 2.08	0.74 ± 0.16	< 0.0001*
P value (in relation to basal value)	0.121	0.854	
3rd day	7.74 ± 1.82	0.48 ± 0.11	< 0.0001*
P value (in relation to basal value)	0.045*	0.412	
7th day	5.37 ± 1.22	0.41 ± 0.10	< 0.0001*
P value (in relation to basal value)	0.003*	0.266	

Multiple regression analyses of the best diagnostic cut-off point of the RDW results to differentiate septic cases from controls showed that RDW > 14.8 was consistent with the development of sepsis after admission to the ICU (with AUC of 0.937, 97.8 % sensitivity and specificity of 95.7%), P < 0.001. Additionally, the CRP cut-off point (CRP > 38.7 mg/l) with 94.5% sensitivity and 90.4% specificity, and the procalcitonin > 2.2 mg/l with 98.8% sensitivity and 98.8% specificity was also correlated with sepsis development following admission to the ICU, as presented in Table (**5**).

Table (5): Predictive ability of RDW, CRP, and procalcitonin in differentiating septic from control cases.

	RDW	CRP	Procalcitonin
AUC	0.	0.	0.912
Cut	>	>	> 2.2
Sensiti	9	9	9
Specif	9	9	9
PPV	9	9	9
NPV	9	9	9
Accur	9	9	9
P	<	<	< 0.001

AUC = Area under curve; PPV = positive predictive value; NPV = Negative predictive value; P = Probability value

As shown in Table (**6**), the overall incidence of mortality on the seventh day of admission to the ICU was 43.5% and 13.1% in the septic and control groups, respectively, with a highly significant difference (p < 0.001) between both groups. Table (**6**) also showed the distribution of RDW, CRP, and procalcitonin according to survival in both studied groups; RDW was significantly higher in dead patients than in survived patients in the first (18.33 vs. 14.05), third (20.38 vs. 14.3), and seventh days after admission (26.65 vs. 17.11), p< 0.001.

Furthermore, CRP levels were substantially higher in the dead compared to survivors on the first day (96.70 ± 22.53 vs. 39.41 ± 9.62 mg/l), third (123.5 ± 30.17 vs. 26.88 ± 6.53 mg/l) (p 0.001), and seventh day after admission (158.51 ± 32.18 vs. 22.11 ± 5.43 mg/l), < 0.001. Whereas procalcitonin level was significantly higher in dead patients than in survivors on the first, third, and seventh days after admission, p < 0.0001, Table (**6**). On day 1 (r = 0.549, p < 0.0001) and day 3 (r = 0.586, p < 0.0001) post IUC-admit, the RDW and Sequential Organ Failure Assessment (SOFA) scores were moderately positively correlated. A strong positive correlation was detected between RDW and SOFA score on the seventh day of hospitalization (r = 0.617, p < 0.0001) was detected in Table (**6**).

Table (6): Incidence of mortality in study and control group at the end of the seventh day. RDW, CRP, and Procalcitonin distribution in both groups according to survival. Correlation between RDW and SOFA score in the septic cases of the study.

Items	Septic group (I) (n= 23)	Control group (II) (n= 23)	P-value
Survived	13 (56.5%)	20 (86.99%)	< 0.001*
Died	10 (43.5%)	3 (13.01%)	
Red Cell Distribution Width (RDW) in both studied groups according to survival			
	Died	Survived	P-value
1st day	18.33 (14.32-18.5)	14.05 (10.4-15.84)	0.001*
3rd day	20.38 (16.4-23.27)	14.3 (11.82-16.13)	< 0.0001*
7th day	26.65 (19.43-29.5)	17.11 (12.80-18.1)	< 0.0001*
C Reactive protein (CRP) in both studied groups according to survival			
1st day	116.70 ± 22.53	49.41 ± 11.74	< 0.0001*
3rd day	133.5 ± 30.17	36.88 ± 8.43	< 0.0001*
7th day	178.51 ± 32.18	42.11 ± 9.76	< 0.0001*
Procalcitonin in both studied groups according to survival			
1st day	9.23 ± 2.21	0.82 ± 0.20	< 0.0001*
3rd day	8.66 ± 2.11	0.52 ± 0.11	< 0.0001*
7th day	7.94 ± 1.84	0.46 ± 0.11	< 0.0001*
Correlation between RDW and SOFA score in the septic cases of the study			
	Red Cell Distribution Width		
	r (Spearman's correlation)	P (Probability)	
1st day	0.549	< 0.0001*	
3rd day	0.586	< 0.0001*	
7th day	0.617	< 0.0001*	

*statistically significant as p< 0.05.

DISCUSSION

Sepsis and septic shock are among the leading causes of death worldwide in non-coronary ICU patients, with mortality rates of 40-50%. Sepsis is a dysregulated host response to infection that results in organ failure that can be fatal. Elevation in RDW, a simple and commonly performed test, can detect variability in the size of the RBCs [(3)].

The present study is one of the first clinical trials conducted in the Zagazig hospital on the utility of RDW as a reliable prognostic biomarker in patients admitted to the ICU. In the current study, 46 patients were involved; 23 developed sepsis and septic shock after ICU admission (septic group), compared to 23 patients who did not develop sepsis after admission (control group), with a nonsignificant difference between both groups regarding demographic characteristics (age and gender).

Our findings revealed that DM was the most common associated chronic condition, reported in 52.2% of sepsis cases and 43.5% of control cases, followed by smoking in 43.8% of sepsis cases and 52.2% of control cases, with no statistically significant differences between the two groups; this was consistent with the findings of **Jandial *et al.*[(5)],** who demonstrated that DM was the most prevalent associated chronic condition occurring in ~ 31,4 % and 38.6 % of cases in control sepsis groups, respectively. Furthermore, in agreement with **Shaikh and Yadavalli's[(16)]** results, who revealed that DM (39.5%) and HTN (34.5%) were the most common comorbid conditions.

Contrary to our findings, **Kim *et al.*** [(17)] demonstrated that hypertension (64.6% of cases in the control group versus 52.3% of cases in the septic group) was more prevalent than DM in the patients included in their study. However, in our study, hypertension was the third most prevalent comorbidity among the cases.

The present study showed that lung-related causes accounted for 39.1% of sepsis cases, followed by UTI (34.8%) and CRBSI (30.4%). Intraabdominal infections (21.7%), skin and soft tissue infections (8.7%), and unexplained etiology were also factors (17.4 %). The increased risk of chest infections among ICU-admitted patients may be due to the increased prevalence of procedures such as endotracheal intubation and ventilator-associated pneumonia (VAP). Our results are consistent with early studies by **Kim *et al.*** [(17)], who found that respiratory causes were the most common source of infection (43.96% vs. 73.8%), followed by UTI (68.8% vs. 9.3%) in the control group relative to the septic group, respectively. Similarly, **Jandial *et al.*** [(5)], **Shaikh and Yadavalli**[(16)] demonstrated that respiratory tract infections (RTI), UTI, and intra-abdominal infections were the most common sources of infection among the cases included in their investigations.

Our study revealed that the septic group experienced significantly higher RDW value than the control group at all times. RDW values were also significantly higher in dead patients than survivors on the first, third, and seventh days after admission. Our results are consistent with early studies by **Razek *et al.*** [(18)] and **Lorente *et al.*** [(19)]. Furthermore, elevated RDW in septic patients coincides with **Carrillo *et al.*** [(20)], who showed that the mean RDW in the sepsis group (18.23 ± 2.01) was significantly higher than in the control group (12 ± 0.27).

The underlying mechanism that relates elevated RDW to mortality in septic patients is unclear; elucidating it could help us to understand the pathophysiology of sepsis and create advanced therapeutic approaches for septic patients. Numerous studies have associated elevated RDW with inflammatory markers (interleukin-6, CRP) and poor iron metabolism [(21)]. Furthermore, oxidative stress increases anisocytosis by interrupting erythropoiesis, alters RBC membrane deformability and circulation half-life, and increases RDW[(22)].

In our study, the mean CRP was significantly higher in the septic group compared to the control group. Our results are consistent with those of **Luzzani *et al.*** [(23)], who reported that non-septic patients had significantly lower plasma CRP values of 79.9 mg/l than septic patients 115.6 mg/l. These findings support Allen's 21 studies that related the elevation of RDW in sepsis to elevated inflammatory markers such as interleukin-6 and CRP.

Jain *et al.* [(24)]**,** found that patients' CRP levels reduced throughout their hospital stay; since CRP is an acute inflammatory reactant, its levels improve over time. In this study, mean CRP values were significantly higher in dead patients than in survivors on the first, third, and seventh days after admission. It is also consistent with the early report by **Devran *et al.*** [(25)] that non-survivors had higher CRP levels of 105 mg/l after 3 to 5 days of treatment versus 44 mg/l in survivors.

On admission, the first, third, and seventh day after admission, we found that procalcitonin levels were significantly higher in the septic group than in the control group. Procalcitonin levels decreased in both groups after admission, but the sepsis group showed statistically significant differences only on days 3 and 7; this coincided with **Mori *et al.*** [(26)], who found that the infected group had significantly higher serum procalcitonin (18.69 ± 2.06 mg/l) than the control group (15,75 ± 1.86). Furthermore, our results demonstrated that on the first, third, and seventh days after admission, procalcitonin was substantially higher in dead patients than in survivors, which is consistent with **Jain *et al.*** [(24)] and **Razek *et al.*** [(18)].

Regarding multiple regression analyzes of the best diagnostic cut-off point for the results of RDW in the separation of septic cases from controls, we found that RDW > 14.8, CRP > 38.7 mg / l, and procalcitonin > 2.2 mg/l were related to the development of sepsis after ICU-admission; this is in agreement with previous results reported by **Razek *et al.*** [(18)]**,** who found that at admission the best diagnostic cut-off point for RDW, CRP and procalcitonin was 15.3%, 39 mg/dl and 1.4 ng/ml, respectively; this showed that measurement RDW could be a valuable tool for the early diagnosis of sepsis.

Numerous associations were calculated between the results of the RDW test and all other variables to elucidate our outcomes. A moderate positive correlation between RDW and SOFA score was found on the first and third days following ICU admission. On the contrary, there was a strong positive correlation between RDW and the SOFA score on the seventh day of hospitalization; this agrees with **Megahed *et al.*** [(27)]**,** who found that within the first 24 h of admission, RDW was correlated with the SOFA score.

At the end of the seventh day of our study, the overall mortality rate in the septic was 43.5%, which was 3.3 times higher than the control group (13.1%), with a significant difference between the two groups. These findings agree with **Sakr *et al.*** [(28)], who reported that ICU mortality rates for patients with sepsis were 26%, twice as high as for non-septic patients.

CONCLUSIONS

Like traditionally utilized biomarkers (CRP and procalcitonin), RDW is a promising, simple, inexpensive, and easily accessible biomarker for the identification of sepsis, with sensitivity and specificity comparable to procalcitonin and superior to CRP. Furthermore, RDW is a reliable predictor of mortality in patients with sepsis, showing a moderate positive correlation with the SOFA score.

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