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# Red Cell Distribution Width (RDW) as a New Modality in Diagnosis and Prognosis of Ventilator-Associated Pneumonia (VAP)

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## Abstract

**Background:** Ventilator-associated pneumonia (VAP) is a prevalent nosocomial infection in intensive care units (ICUs), with a high death rate, a prolonged stay in the ICU, and an increased health care expense. The goal of this study was to assess the diagnostic and prognostic value of RDW in VAP.

**Methods:** This prospective cohort observational study was established on on 106 critically ill mechanically ventilated patients who referred to ICU. They were classified into two groups: VAP (31 patients) and non VAP (75 patients) group. clinical pulmonary infection score(CPIS), sputum culture results, ICU stay period, incidence of 28th day morality, acute physiology and chronic health evaluation (APACHE) II score, antibiotics and laboratory test including ( PCT: at day of admission, within 7 days after admission in suspected VAP cases, RDW: was analysed daily from admission until VAP diagnosis within 7 days from the day of admission and CRP: was analysed daily from admission until VAP diagnosis within 7 days from the day of entrance)

**Results:** There was a positive significant correlation between RDW at time of diagnosis and CPIS (r = 0.247, P =0.04) and between RDW at time of diagnosis and APACHE (r = 0.476, P <0.001). RDW at time of diagnosis and Delta RDW was significantly higher in non-survivors group than survivors group (P = 0.020, p=0.021 respectively). RDW was at cut-off >16.3 significantly predict mortality with sensitivity of 84.62, specificity was 52.69, PPV was 20, NPV was 96.1, AUC was 0.806 and P value was <0.001 There was a positive significant correlation between RDW and delta RDW at time of diagnosis and duration of MV (r = 0.317, r = 0.398 respectively and P <0.001) and between delta RDW and ICU stay (r = 0.279, P = 0.004).

**Conclusions:** RDW at time of diagnosis and delta RDW are good diagnostic and prognostic markers of (VAP) and better than CRP and procalcitonin. RDW is correlated to duration of mechanical ventilation, CPIS, APACHE and 28th day mortality.

**Keywords:** Red Cell Distribution Width, Ventilator-Associated Pneumonia, New Modality.

## Introduction:

Ventilator-associated pneumonia (VAP) is a kind of pneumonia that occurs at least 48 hours after invasive mechanical ventilation in individuals who do not have clinical evidence of pneumonia developing during or prior to intubation [1].

VAP is a prevalent nosocomial infection in intensive care units (ICUs), with linked complications including higher mortality, longer ICU stay, and increased health care costs [2]. While the frequency varies by diagnostic criteria and patient demographic, It complicates the hospital stay of around 20% of patients on mechanical breathing, or approximately five incidents every 1,000 ventilator days. According

to another study, an occurance rate of 1.33 per 1,000 ventilator days was reported. [3].

As a result of these factors, early detection and therapy of VAP are critical. However,its high prevalence, diagnosis is extremely challenging since many patients in the ICU have comparable clinical symptoms [4].

A simple diagnostic tool for VAP was required, and therefore a scoring system was established in 1991, named as Clinical Pulmonary Infection Score (CPIS) [5]

This score system is used to compare the findings of radiographic and endotracheal aspirate (ETA) cultures. Body temperature, leucocyte count and morphology, tracheal secretion volume and character, arterial oxygen tension (PaO2) / fraction of inspired oxygen (FiO2) ratio, presence and development of pulmonary infiltration, and microbiological culture findings were used to diagnose VAP. A score of 6 or greater indicates VAP.

In automated complete blood counts, the red cell distribution width (RDW) is frequently recorded. It is a commonly accessible, low-cost test that reflects the size range of circulating red blood cells [5]. Additionally, a laboratory index that is used to aid in the differential diagnosis of anaemia. It is routinely conducted during the admission examination of practically all patients. Any procedure This leads in Increased RDW is caused by the release of reticulocytes into the circulation [6].

RDW may be utilized as an independent predictor of death, potentially augmenting existing prognostic scores such as the simplified Acute Physiology Score (SAPS) and APACHE-II scores [7].

The pathophysiologic processes via which RDW is related with VAP-associated mortality [8, 9] are unclear. However, that its association with inflammation and oxidative stress contributes to VAP-related mortality.[10, 11].

The goal of this trial was to assess the diagnostic and prognostic value of RDW in VAP.

## Patients and Methods:

This prospective cohort observational trial was established on 106 critically ill mechanically ventilated patients aged from 18 to 60 years old from both sex who referred to intensive care unit (ICU) and classified into two groups : VAP and non VAP group.

Exclusion criteria were patients with pneumonia diagnosed before ventilation, were suspected incubating pneumonia at time of intubation, had any other sites of infection, had previous history of diseases primarily affecting RBCS, Blood loss >10% of blood volume, blood product transfusion one week prior to admission, Utilization of medicines known to alter the morphology of RBCS(e.g. Acetylsalicylic acid), pregnant patients, HIV-positive, on steroid therapy, with known hematologic malignancy, admitted to ICU for less than 48 hours, cardiogenic shock, burns covering more than 20% of total body area, postoperative patients undergoing bone marrow transplantation (within the past six months), coronary artery bypass grafts (within the last seven days), or solid organ transplantation (within the last 14 days).

## VAP diagnosis:

At ICU admission, until gram staining and culture findings were acquired, VAP was diagnosed using the CPIS (using the first five parameters of CPIS (body temperature, leukocyte count and morphology, tracheal secretion volume and character, PaO2/FiO2 ratios, and presence of pulmonary infiltrate). The CPIS values were determined 48 hours after intubation using seven parameters (body temperature, leukocyte count and morphology, tracheal secretion volume and character, PaO2/FiO2 values, presence of pulmonary infiltration, advancement of pulmonary infiltration, microbiological culture findings). A CPIS value greater than 6 is indicative of VAP. Three-day intervals were used to monitor patients (1st day, 4th day and 7th day).

**Measurement of serum procalcitonin levels:** On day 1 of ICU admission, a sample of peripheral blood was collected from each patient in heparinized tubes and centrifuged for 10 minutes. Plasma aliquots were then maintained at -80°C until analysis.

**Measurement of RDW :** No special preparation was required for the RDW test. If additional factors are being examined at the same time, a

person may need to fast for several hours prior to the test.

**C-reactive protein** was measured in milligrams of CRP per litter of blood (mg/L). No special preparation was necessary for this test.

**Microbiological tests :** ETA

**Each patient was underwent to the following:**

Demographic data as age, gender, comorbidities and cause of ICU admission, history taking (previous history of Mechanical Ventilation), indication of MV, duration of mechanical ventilation, CPIS, sputum culture results, ICU stay period, incidence of 28$^{th}$ day morality, acute physiology and chronic health evaluation (APACHE) II score, antibiotics and laboratory test including ( PCT: at day of admission, within 7 days after admission in suspected VAP cases, RDW: was analysed daily from admission until VAP diagnosis within 7 days from the day of admission and CRP: was analysed daily from admission until VAP diagnosis within 7 days from the day of admission).

**Sample size calculation:**

G*Power 3.1.9.2 was used to calculate the sample size (Universitat Kiel, Germany).Sample size calculation based on alpha 0.05 and power 95% and in a previous study [12], AUC 0.8 for diagnosis of sepsis (null =0.6). Prevalence of VAP was 38.4% in our hospital [13]. Therefore, 106 patients were recruited.

**Statistical analysis**

SPSS v25 (IBM, Chicago, IL, USA) was used for statistical analysis. The Shapiro-Wilks test and histograms were employed to determine if the data distribution was normal. The mean and standard deviation of quantitative parametric variables were calculated (SD).They were compared using an unpaired student's t-test between the two groups and a paired T-test within the same group. The median and range of quantitative non-parametric variables were calculated and compared between the two groups using the Mann Whitney (U) test and within the same group using the Wilcoxon test. Qualitative variables were expressed as a frequency or a percentage and analysed using the Chi-square or Fisher's exact test as applicable. Pearson correlation was used to determine the degree to which two quantitative variables are correlated. To assess the predictive value of several markers for VAP and mortality, a receiver operating characteristic (ROC) curve was utilised. Additionally, logistic regression was used to analyse different laboratory data in order to determine VAP predictors, and a mortality value of 0.05 was regarded statistically significant.

**Results:**

Past history of comorbidities as diabetes mellitus, hypertension and previous mechanical ventilation were insignificantly different between both groups (P = 0.518, 0.253 and 1 respectively). COPD exacerbation in The VAP group had considerably greater rates of infection than the non-VAP group (P = 0.002). Patients ventilated due to intracranial hemorrhage were significantly higher in non VAP group (P = 0.015) . Duration of mechanical ventilation and ICU stay significantly prolonged in VAP group than non VAP group (P < 0.001 and 0.048 respectively). Twenty-eight-day mortality was significant higher in VAP group than non VAP group (22.6% vs 8%, P = 0.037). **[**Error! Not a valid bookmark self-reference.**]**

**Table 1: Patients' characteristics, cause of mechanical ventilation, duration of mechanical ventilation, ICU stay and 28th day mortality in both groups and sputum culture in VAP group**

| | | **VAP group (n = 31)** | **Non VAP group (n = 75)** | **P value** |
|---|---|---|---|---|
| **Age (years)** | **Mean ± SD** | 50.35 ± 12.34 | 47.67 ± 10.34 | 0.253 |
| | **Range** | 29-69 | 29-62 | |

| | | | | |
|---|---|---|---|---|
| **Sex** | **Male** | 17 (54.8%) | 36 (48%) | 0.522 |
| | **Female** | 14 (45.2%) | 39 (52%) | |
| **Past history** | **DM** | 5 (16.1%) | 8 (10.7%) | 0.518 |
| | **Hypertension** | 10 (32.3%) | 18 (24%) | 0.263 |
| | **Previous mechanical ventilation** | 2 (6.5%) | 5 (6.7%) | 1 |
| **Cause of mechanical ventilation** | **COPD Exacerbation** | 16 (51.6%) | 16 (21.3%) | **0.002*** |
| | **Intracranial hemorrhage** | 11 (35.5%) | 46 (61.3%) | **0.015*** |
| | **Trauma** | 4 (12.9%) | 13 (17.3%) | 0.572 |
| **Duration of mechanical ventilation (days)** | **Median** | 6 | 3 | **<0.001*** |
| | **IQR** | 4-8 | 2-5 | |
| **ICU-stay (days)** | **Median** | 10 | 8 | **0.048*** |
| | **IQR** | 7-16 | 5-13 | |
| **Mortality** | **Died** | 7 (22.6%) | 6 (8%) | **0.037*** |
| | **Alive** | 24 (77.4%) | 69 (92%) | |
| | | **VAP group (n = 31)** | | |
| **Sputum culture** | **Klebsiella pneumonia** | 10 (32.3%) | | |
| | **Streptococcus pneumoniae** | 9 (29%) | | |
| | **MRSA** | 5 (16.1%) | | |
| | **Pseudomonas** | 4 (12.9%) | | |
| | **Escherichia coli** | 3 (9.7%) | | |

*: Significant as p value < 0.05, ICU: intensive care unit, IQR: interquartile range, VAP: ventilator-associated pneumonia, DM: diabetes mellitus, COPD: cardiac obstructive pulmonary disease. MRSA: Methicillin-resistant Staphylococcus aureus

In VAP group, RDW significantly increased at the 3rd, 4th, 5th, 6th and 7th day compared to 1st day (P = 0.002, 0.003, 0.002, 0.026 and 0.028 respectively). In non VAP group, RDW increased insignificantly at the 2nd, 3rd, 4th, 5th, 6th and 7th day as compared to 1st day (P = 0.125, 0.169, 0.407, 0.526, 0.783 and 0.949 respectively). RDW showed a significant increase in VAP group at 1st, 2nd, 3rd, 4th, 5th, 6th, 7th days and delta RDW compared to non VAP group (P = 0.004, <0.001, <0.001, <0.001, <0.001, <0.001, 0.001 and <0.001 respectively). CRP was a significant decrease in non VAP group than VAP group at 5th, 6th and 7th day (P

= 0.007, 0.013 and 0.022 respectively). **[**Error! Reference source not found.**]**

**Table 2: RDW and CRP in both groups**

| | | 1 day | 2 days | 3 days | 4 days | 5 days | 6 days | 7 days | Delta |
|---|---|---|---|---|---|---|---|---|---|
| **RDW** | | | | | | | | | |
| **VAP group (n = 31)** | **Mean** | 16.50 | 17.08 | 17.96 | 17.83 | 17.92 | 17.52 | 17.51 | 1.46 |
| | **± SD** | 1.63 | 1.75 | 1.83 | 1.66 | 1.66 | 1.72 | 1.70 | 0.69 |
| | **P 1** | | 0.182 | **0.002*** | **0.003*** | **0.002*** | **0.026*** | **0.028*** | ---- |
| **Non VAP group (n = 75)** | **Mean** | 15.61 | 15.72 | 15.87 | 16.02 | 15.99 | 16.16 | 16.29 | 0.26 |
| | **± SD** | 1.29 | 1.28 | 1.24 | 1.20 | 1.27 | 1.28 | 1.31 | 0.49 |
| | **P 2** | | 0.125 | 0.169 | 0.407 | 0.526 | 0.783 | 0.949 | ---- |
| **P value** | | **0.004*** | **<0.001*** | **<0.001*** | **<0.001*** | **<0.001*** | **<0.001*** | **0.001*** | **<0.001*** |
| **CRP** | | | | | | | | | |
| **VAP group (n = 31)** | **Median** | 69.5 | 72.7 | 85.2 | 75.7 | 75.7 | 72.85 | 73.2 | 15.1 |
| | **Range** | 6.2-141.3 | 10-143 | 30-142 | 10-141 | 10-148.9 | 10-132.9 | 10-141.7 | -7.6:31.1 |
| | **P 1** | | 0.124 | **<0.001*** | 0.290 | 0.290 | 0.094 | 0.173 | ---- |
| **Non VAP group (n = 75)** | **Median** | 88.8 | 83.4 | 95.4 | 55.35 | 41.6 | 41.6 | 48.4 | 11 |
| | **Range** | 10.8-159.3 | 10-158.3 | 30-172.9 | 3-145.5 | 1-120.8 | 3.3-128.3 | 2.9-131 | -14.1:19.2 |
| | **P 2** | | **<0.001*** | **<0.001*** | **<0.001*** | **<0.001*** | **<0.001*** | **<0.001*** | ---- |
| **P value** | | 0.153 | 0.496 | 0.249 | 0.126 | **0.007*** | **0.013*** | **0.022*** | 0.154 |

*: Significant as p value < 0.05, P1: comparison of measurements in VAP group, P2: comparison of measurements in Non VAP group, Delta: between value at time of diagnosis and value of first day, RDW: red cell distribution width, CRP: c reactive protein.

In both groups, procalcitonin increased significantly at the 4th and 7th day compared to the 1st day (P <0.001). Procalcitonin levels considerably increased in the VAP group as compared to the non-VAP group at the 4th and 7th days and delta (P = <0.001). CPIS showed significant increase in VAP group than non VAP group at the 4th and 7th day (P <0.001). APACHE showed an insignificant change between two groups. **[**Error! Reference source not found.

**Table 3: Procalcitonin, CPIS and APACHE in both groups**

| | | 1 day | 3 days | 7 days | Delta |
|---|---|---|---|---|---|
| **VAP group (n = 31)** | **Median** | 0.9 | 3.6 | 2.9 | 2.9 |
| | **Range** | 0.3-1.9 | 0.4-12.9 | 0.1-12.4 | -1.3:12.6 |
| | **P 1** | | **<0.001*** | **<0.001*** | ---- |

| | | | | | |
|---|---|---|---|---|---|
| **Non VAP group (n = 75)** | **Median** | 0.8 | 1.8 | 0.9 | 0.9 |
| | **Range** | 0.2-1.5 | 0.2-4.1 | 0.1-2.8 | -1:2.8 |
| | **P 2** | | **<0.001*** | **<0.001*** | ---- |
| **P value** | | 0.481 | **<0.001*** | **<0.001*** | **<0.001*** |
| | | **1 day** | **4 days** | | **7 days** |
| **CPIS** | | | | | |
| **VAP group (n = 31)** | **Mean** | 3.81 | 8.61 | | 10.56 |
| | **± SD** | 1.35 | 0.57 | | 1.45 |
| **Non VAP group (n = 75)** | **Mean** | 3.57 | 2.42 | | 2.24 |
| | **± SD** | 0.93 | 0.93 | | 0.80 |
| **P value** | | 0.310 | **<0.001*** | | **<0.001*** |
| **APACHE** | | | | | |
| **VAP group (n = 31)** | **Mean** | 51.03 | 51.50 | | 52.08 |
| | **± SD** | 11.58 | 11.21 | | 10.63 |
| | **P 1** | | 0.876 | | 0.728 |
| **Non VAP group (n = 75)** | **Mean** | 48.01 | 47.25 | | 48.47 |
| | **± SD** | 10.10 | 10.31 | | 9.17 |
| | **P 2** | | 0.300 | | 0.418 |
| **P value** | | 0.183 | 0.079 | | 0.140 |

*: Significant as p value < 0.05, P1: comparison of measurements in VAP group, P2: comparison of measurements in Non VAP group, Delta: between value at time of diagnosis and value of first day, VAP: ventilator-associated pneumonia, CPIS: clinical pulmonary infection score, APACHE: acute physiology and chronic health evaluation.

There was a positive moderate significant correlation between RDW and delta RDW at time of diagnosis and duration of MV (r = 0.317, r = 0.398 respectively and P <0.001) and between delta RDW and ICU stay (r = 0.279, P = 0.004). There was a positive mild significant correlation between RDW at time of diagnosis and CPIS (r = 0.247, P =0.04) and between RDW at time of diagnosis and APACHE (r = 0.476, P <0.001). There was a positive moderate significant correlation between delta RDW and CPIS (r = 0.587, P <0.001) and between delta RDW and APACHE (r = 0.485, P <0.001). **[Table** 4**]**

**Table 4: Correlation between RDW at time of diagnosis and duration of MV, ICU stay, CPIS and APACHE**

| | **RDW** | |
|---|---|---|
| | **r** | **P value** |
| **Duration of MV** | 0.317 | **<0.001*** |
| **ICU stay** | 0.141 | 0.15 |
| **CPIS** | 0.247 | **0.04*** |
| **APACHE** | 0.476 | **<0.001*** |
| | **Delta RDW** | |
| | **r** | **P value** |
| **Duration of MV** | 0.398 | **<0.001*** |
| **ICU stay** | 0.279 | **0.004*** |
| **CPIS** | 0.587 | **<0.001*** |
| **APACHE** | 0.485 | **<0.001*** |

r: Pearson correlation coefficient *Significant as p value < 0.05, VAP: ventilator-associated pneumonia, CPIS: clinical pulmonary infection score, APACHE: acute physiology and chronic health evaluation, RDW: red cell distribution width, ICU: intensive care unit, MV: mechanical ventilation.

RDW at time of diagnosis and Delta RDW was Significantly greater in the group of non-survivors than in the group of survivors (P = 0.020, p=0.021 respectively) **[**Error! Reference source not found.**]**.

**Table 5: Relationship between RDW at time of diagnosis and Mortality and between Delta RDW and Mortality**

| | | **Non-survivors (n = 13)** | **Survivors (n = 93)** | **P value** |
|---|---|---|---|---|
| **RDW** | **Mean ± SD** | 17.52 ± 3.1 | 16.34 ± 1.39 | **0.020*** |
| | **Range** | 13.8-22.9 | 13.4-19.6 | |
| **Delta RDW** | **Median** | 1.1 | 0.2 | **0.021*** |
| | **IQR** | 0.1-2.1 | 0.1-1 | |

*Significant as p value < 0.05

In multivariate regression analysis, delta RDW was the only independent predictor for mortality (P =0.017) **[Table** 6**].**

**Table 6: Logistic regression of factors predicting mortality**

| Variable | Coefficient | Std. Error | Wald | P | Odds ratio | 95% CI |
|---|---|---|---|---|---|---|
| **RDW** | 0.331 | 0.250 | 1.749 | 0.186 | 1.39 | 0.85 - 2.27 |
| **CRP** | -0.001 | 0.011 | 0.292 | 0.589 | 0.99 | 0.97 - 1.02 |
| **Procalcitonin** | 0.049 | 0.189 | 0.066 | 0.797 | 1.05 | 0.72 - 1.52 |
| **Delta RDW** | 1.168 | 0.493 | 5.628 | **0.017*** | 3.21 | 1.22 - 8.44 |
| **Delta CRP** | 0.026 | 0.049 | 0.271 | 0.603 | 1.03 | 0.93 - 1.13 |
| **Delta procalcitonin** | 0.088 | 0.299 | 0.087 | 0.768 | 1.09 | 0.61 - 1.96 |
| **Constant** | -8.907 | 4.504 | 3.911 | 0.048 | ----- | ---- |

RDW was at cut-off >16.3 significantly predict mortality with sensitivity of 84.62, specificity was 52.69, PPV was 20, NPV was 96.1, AUC was 0.806 and P value was <0.001. CRP was at cut-off >70 insignificantly predict mortality with sensitivity of 53.85, specificity was 33.33, PPV was 83.8, NPV was 10.1, and AUC was 0.557 (P value = 0.552). procalcitonin was at cut-off >2.5 significantly predict mortality with sensitivity of 84.62, specificity was 69.89, PPV was 28.2, NPV was 97, AUC was 0.799 (P value= <0.001). **[**Error! Reference source not found.**]**

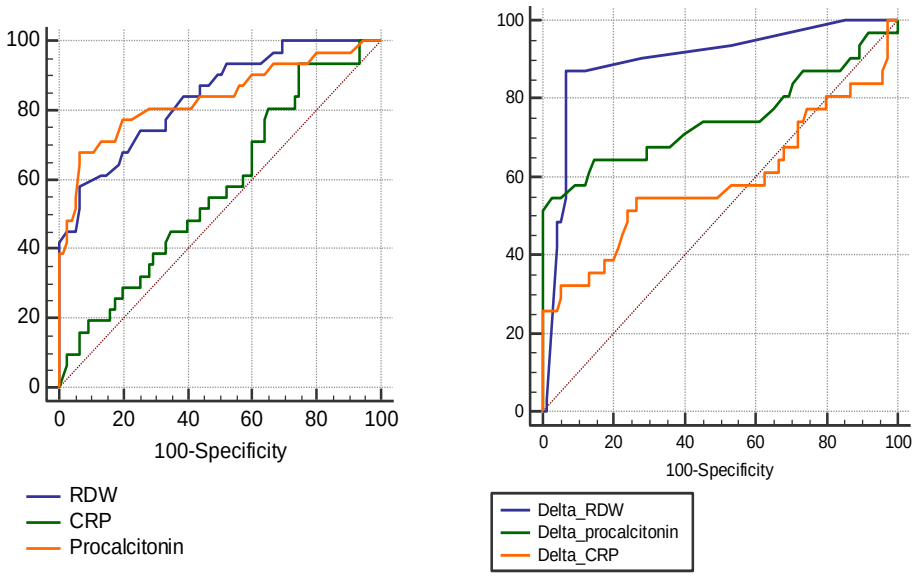


**Figure 1: ROC curves of RDW, CRP, procalcitonin in and of delta RDW, delta CRP, delta procalcitonin diagnosis of VAP**

Delate RDW was at cut-off >0.4 can significantly predict mortality at sensitivity was 84.62, specificity was 77.42, PPV was 34.4, NPV was 97.3, AUC was 0.810 and (P <0.001). Delate CRP, at cut-off >17.7 non-significantly predict mortality at sensitivity was 38.46, specificity was 90.32, PPV was 35.7, NPV was 91.3, AUC was 0.574 and (P =0.469). Delate procalcitonin was at cut-off >2 can insignificantly predict mortality at sensitivity was 61.54, specificity was 75.27, PPV was 25.8, NPV was 93.3, AUC was 0.665 and (P =0.085). **[**Error! Reference source not found.**]**

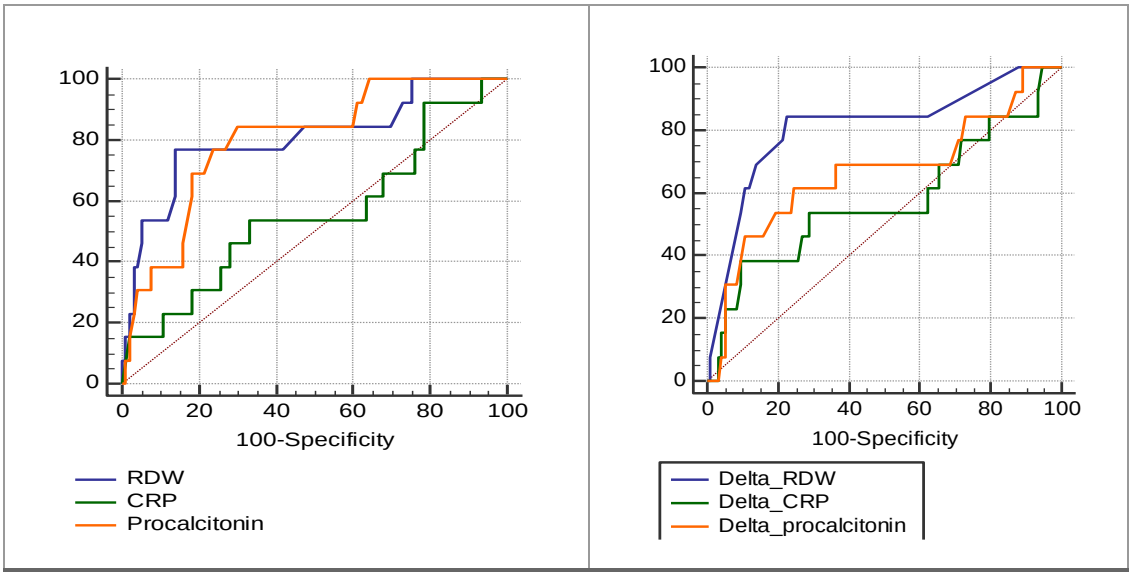


**Figure 2: ROC curves of RDW, CRP, procalcitonin and of delta RDW, delta CRP, delta procalcitonin to predict mortality**

## Discussion

(VAP) is a common complication in the ICU and is related with extended mechanical ventilation (MV), an increased length of stay in the ICU, and worse outcomes [14].Ventilator-associated Pneumonia is diagnosed using a combination of clinical and radiological symptoms, which is often accompanied by a quantitative examination.

In the current study, CRP showed an insignificant difference between both groups at the 1st, 2nd, 3rd, 4th and delta and a significant decrease in non VAP group than VAP group at 5th, 6th and 7th day. This agreed with **Othman et al** [15] who presented that CRP was insignificantly different between VAP group and non VAP group.

In the present study, Procalcitonin was significantly higher in VAP group compared to non VAP group at the 3rd days and delta and was insignificantly different in both groups at the 1st day. This was in line with **Luyt et al** [16] showed that median serum PCT levels on day 1 did not differ between patients with and without VAP. In the recent study, RDW showed a significant increase in VAP group at 1st, 2nd, 3rd, 4th, 5th, 6th, 7th days and delta RDW compared to non VAP group.

In the present study, at cut-off >16.3, RDW at time of diagnosis can significantly diagnose VAP with 83.87 sensitivity, 61.33 specificity, PPV was 47.3, NPV was 90.2, AUC was 0.818 (P value <0.001). At cut-off >2.2, procalcitonin at time of diagnosis can significantly diagnose VAP with sensitivity of 80.65, specificity was 72, PPV was 54.3, NPV was 90, AUC was 0.835 (P value <0.001). This was not in line with **Luyt et al** [16] who found Procalcitonin levels were 1.89 ng/ml (interquartile range 0.18–6.01) and 2.14 (0.76–5.75) in patients with and without VAP, respectively, and the procalcitonin threshold had a sensitivity of 72 percent but a specificity of only 24 percent for diagnosing VAP, indicating that procalcitonin rise had limited diagnostic value for VAP. This difference can be owed to the small recruited sample size.

In the current study, APACHE showed an insignificant difference in VAP group compared to non VAP group at the 1st, 4th and 7th. This agreed with **Mathai et al** [17] who showed that APACHE was insignificantly different in VAP group compared to non VAP group.

In the present study, duration of MV and ICU stay significantly prolonged in VAP group than non VAP group. This was in line with **Mathai et al** [17] who showed that patients with VAP experienced a significantly longer duration of mechanical ventilation ICU stay and total hospital stay.

The present research examines, there was a positive moderate significant correlation between RDW at time of diagnosis and duration

of MV (r = 0.317, P <0.001) but an insignificant correlation between RDW at time of diagnosis and ICU stay (r = 0.141, P = 0.15). There was a positive mild significant correlation between RDW at time of diagnosis and CPIS (r = 0.247, P =0.04) and between RDW at time of diagnosis and APACHE (r = 0.476, P <0.001). This was in line with **Yousef et al** [18]. They showed that a significant positive relationship was found between RDW level and CPIS in CAP patients (r=0.664; P<0.001).

In the current study, as regard to RDW at time of diagnosis, at cut-off >16.3 significantly predict mortality with sensitivity of 84.62%, specificity was 52.69%, PPV was 20%, NPV was 96.1%, AUC was 0.806 and P value was <0.001. This wasn't in line with **Yousef et al** [18] who The RDW test's diagnostic performance was examined, and it was discovered that an RDW level more than 16.1 % at the cut-off point had a sensitivity of 94.12 % and a specificity of 98.70 % for predicting in-hospital death in patients with CAP.

In the recent study, RDW was substantially greater in the non-survivor group than in the survivor group at the time of diagnosis (P = 0.020).This was in line with **Fawzi et al** [19] who showed that RDW is significantly higher in poor outcome. In agreement with **Yousef et al** [18]who presented that The level of RDW was substantially greater in non-survivors than in survivors (18.52±3.07 vs. 12.76±2.08; P=0.022).

Patients with a low RDW at baseline and a decreasing RDW had the longest survival time. This observation might be explained by the reduction of inflammation and oxidative stress associated with early therapy of pneumonia [20]. According to reports, proinflammatory cytokines decrease erythropoietin-induced erythrocyte maturation [21], systemic inflammation-bone marrow function and iron metabolism were impacted [22], whereas oxidative stress decreased the lifespan of red blood cells and increased the discharge of premature red blood cells [11]. Thus, during early therapy, resolution of inflammatory and oxidative stress may result in a decrease in RDW, and baseline RDW levels may represent the inflammatory and oxidative stress that existed initially.

Also, **Lee et al** [20] showed that $\Delta RDW_{4-1}$ was significantly higher in non-survivors compared with survivors. However, $\Delta RDW_{3-1}$ and $\Delta RDW_{2-1}$ were insignificantly different between non-survivors and survivors. **Braun et al** [23] showed that RDW > 15% was correlated with 90-day mortality in patients with CAP. This difference may be due to the differences in age (mean age of 69.9 years) and comorbidities. Also, **Bello et al** [24] showed that RDW > 14 was an independent risk factor in CAP patients for 30-day but CRP and procalcitonin wasn't.

**Hunziker et al** [7] RDW significantly improves risk stratification for the simplified acute physiological score in terms of predicting short- and long-term mortality rates in a large, unselected cohort of ICU patients.

## Conclusions:

RDW at time of diagnosis and delta RDW are good diagnostic and prognostic markers of (VAP) and better than CRP and procalcitonin. RDW is correlated to mechanical ventilation duration, CPIS, APACHE and 28th day mortality.

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