The relationship between level of the red cell distribution width and the outcomes of patients who acquired pneumonia from community

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**Background** Inflammatory and oxidative stress caused by infection has recently been proposed as a mechanism of association between the red cell distribution width (RDW) and infectious diseases, such as community-acquired pneumonia (CAP).

**Objective** The present goal was to assess the prognostic importance of the RDW test in patients with CAP.

**Patients and methods** The present research was a descriptive and prospective study of patients diagnosed with CAP. All were admitted to Chest Department of Assiut University Hospital between April 2017 and July 2018. Assessment of CAP severity at time of hospital admission using Pneumonia Severity Index was done for all enrolled patients. Complete blood count was measured by automated hematology analyzer, and RDW was reported as a part of the complete blood count result. Normal reference range of RDW was 11.5–14.5%. All of the patients were followed up until being discharged. The outcome variable was in-hospital mortality.

**Results** The current study involved 94 patients with CAP: 77 (82%) survived and 17 (18%) died. RDW level was significantly higher in nonsurvivors compared with survivors (18.52±3.07 vs. 12.76±2.08; P=0.022). A significant positive relationship was found between RDW level and Pneumonia Severity Index points (r=0.664; P=0.000). Regarding the diagnostic performance of the RDW test, it was observed that RDW level at cutoff point more than 16.1% had 94.12% sensitivity and 98.70% specificity for the prediction of in-hospital mortality in patients with CAP.

**Conclusion** The present data indicated that the measurement of RDW on admission may provide the physician with a tool to predict the outcomes of patients with CAP and thus assist in decision making and management in such cases either alone or alongside the other well-established means, taking into account that RDW testing is simple, cheaper, and readily available.

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**Introduction** Community-acquired pneumonia (CAP) is a common infectious disease, and it is a major cause of morbidity and mortality worldwide [1,2]. Scoring systems, including CURB-65 and Pneumonia Severity Index (PSI), and novel biomarkers, including procalcitonin (PCT) and C-reactive protein (CRP), are useful for predicting CAP outcomes, but all have their own strengths and weaknesses [3–5]. PSI and CURB-65 scoring systems have been evidenced to have positive correlations with mortality in patients with severe CAP. The PSI scoring system is time intensive owing to more than 20 elements in its questionnaire. The CURB-65 scoring system was controversial in elderly patients [5–8]. Serum PCT, as a novel biomarker, is a valuable single predictor in the assessment of severe CAP, the same as CRP [8]. In developing countries, PCT and CRP tests are not promptly available for every patient [9–12]. On the contrary, complete blood count (CBC) test is a simple, valuable, inexpensive, and readily available measurement. White blood cell (WBC) count is one of the CBC components that traditionally is used as a biomarker in assessment of CAP severity; however, it has become less relied upon owing to its lower sensitivity and specificity compared with the more promising CRP and PCT [13]. Red cell distribution width (RDW) is also reported as one of parameters routinely analyzed in peripheral blood counts that reflects the heterogeneity of red cell size and has been traditionally used in diagnosing certain anemias. Inflammatory and oxidative stress caused by infection has recently been proposed as a mechanism of association between RDW and infectious diseases such as CAP [14–16]. In this context, some studies on patients with CAP focused on single RDW measurements at hospital admission [17–19]. Others have considered RDW as a dynamic parameter, with rapid changes during the course of the disease that requires repeated measurement during...
hospitalization to improve the prognostic performance [20]. As we belong to a developing country, that is, Egypt, the present goal was to assess the prognostic importance of the RDW test as a simple, cheap, and presumably useful measure in patients with CAP.

Patients and methods
This is a prospective descriptive study of 94 patients aged 18 years or older diagnosed to have CAP. All were admitted to Chest Department, Assiut University Hospital, between April 2017 and July 2018. The study protocol was approved by the Local Ethics Committee, and informed consent was obtained from all patients or those responsible for them. CAP was defined as the presence of a new pulmonary infiltrate on chest radiography and symptoms corresponding to pneumonia such as cough, breathlessness, rising body temperature, and/or chest pain, which were not acquired in a hospital. The exclusion criteria included patients under the age of 18 years, as well as those with previous use of oral steroids (>10 mg prednisone equivalent per day for at least 2 weeks); taking medications that suppress the immune system; had tuberculosis; had human immunodeficiency virus infection; had active malignancy; had primary hematological disorders; and were hospitalized within the preceding 21 days.

Basic clinical information was obtained, and a bedside assessment was performed for each patient. The laboratory data and the chest radiographic findings were also collected. Assessment of CAP severity at time of hospital admission using PSI was done for all enrolled patients. CBCs were measured by an automated hematology analyzer (ADVIA 2120i Hematology Systems; Siemens Healthcare Diagnostics, Ballina, Ireland) during the first day of hospitalization, and RDW was reported as a part of the CBC results. Normal reference range of RDW was 11.5–14.5%. All of the patients were followed up until being discharged. The outcome variable was in-hospital mortality.

Statistical analysis
Data were collected and analyzed using SPSS (Statistical Package for the Social Science, version 20; IBM, Armonk, New York, USA). Continuous data were expressed in the form of mean±SD, whereas nominal data were expressed in the form of frequency (percentage). $\chi^2$ test was used to compare the nominal data of different groups in the study, whereas Student $t$ test was used to compare mean of two different groups. Pearson correlation was used to determine the correlation between RDW with PSI. Diagnostic performance of RDW in predicting the outcome in patients with CAP was determined by receiver operating characteristic curve. Level of confidence was kept at 95%, and $P$ value was significant if less than 0.05.

Results
The characterized data of the included patients are summarized in Table 1. The current study enrolled 94 patients with CAP, and of them, 77 (82%) patients survived, whereas 17 (18%) patients’ health deteriorated and they died. Mean age of survivors was 57.73±13.61 years whereas the mean age of nonsurvivors was 60.29±7.66 years. Most patients in both survivors and nonsurvivors were male (57.1 and 52.9%, respectively). Both survivors and nonsurvivors had insignificant differences regarding smoking status, presence of comorbidities, and history of previous antibiotics treatment. On the contrary, both groups had a significant difference regarding the chest radiographic findings.

Table 1 Characteristics of 94 patients with community-acquired pneumonia enrolled in this study

|                          | Survivors (N=77) | Nonsurvivors (N=17) | P value |
|--------------------------|------------------|---------------------|---------|
| Sex                      | [n (%)]          | [n (%)]             |         |
| Male                     | 44 (57.1)        | 9 (52.9)            | 0.752   |
| Female                   | 33 (42.9)        | 8 (47.1)            |         |
| Age (years) (mean±SD)    | 57.73±13.61      | 60.29±7.66          | 0.455   |
| Smoking status           |                  |                     |         |
| Current smoker           | 4 (5.2)          | 0                   |         |
| Exsmoker                 | 18 (23.4)        | 3 (17.6)            | 0.518   |
| Nonsmoker                | 55 (71.4)        | 14 (82.4)           |         |
| Comorbidity              |                  |                     |         |
| Heart disease            | 14 (18.2)        | 3 (17.6)            | 1.000   |
| Pulmonary disease        | 43 (55.8)        | 7 (41.2)            | 0.273   |
| Renal disease            | 5 (6.5)          | 3 (17.6)            | 0.154   |
| Liver disease            | 8 (10.4)         | 3 (17.6)            | 0.412   |
| Diabetes                 | 17 (22.1)        | 7 (41.2)            | 0.127   |
| Previous antibiotic      | 2 (2.6)          | 0                   | 1.000   |
| Multilobar CXR infiltrate| 15 (15.1)        | 9 (52.9)            | 0.029*  |
| Hospital stay (days)     | 8.33±4.35        | 14.14±4.38          | 0.045*  |
| Pneumonia Severity Index score | 110.74 | 140.47±30.09 | 0.017*  |
| RDW (%)                  |                  |                     |         |

CXR, chest radiography; RDW, red cell distribution width.

*Significant $P$ value.
radiology infiltration and length of hospital stay. Mean PSI was also significantly higher in nonsurvivors in comparison with survivor (140.47±30.09 vs. 110.74 ±45.56; \( P = 0.017 \)). Most nonsurvivors had PSI class V (70.6%), but only 31.2% of survivors had PSI class V. Statistical analysis of the CBC parameters among nonsurvivors and survivors showed insignificant differences as regarding WBCs and platelets counts, whereas RDW level was significantly higher in nonsurvivors compared with survivors (18.52±3.07 vs. 12.76±2.08; \( P = 0.022 \)). A significant positive relationship was found between RDW level and PSI points (\( r = 0.664, P = 0.000 \)), as shown in Fig. 1. Of the study population, 67 (71.3%) patients had normal RDW level in the CBC test whereas 27 (28.7%) patients had high RDW level, and majority of them (70.4%) had PSI class V, as shown in Table 2. The diagnostic performance of the RDW test in predicting deaths in patients with CAP is illustrated in Table 3 and Fig. 2. It was noticed that RDW level at cutoff point more than 16.1% had 94.12% sensitivity and 98.70% specificity for the prediction of in-hospital mortality in patients with CAP.

### Table 2 Distribution of red cell distribution width based on Pneumonia Severity Index class

| PSI class | Normal RDW (\( N = 67 \)) [\( n (\% ) \)] | High RDW (\( N = 27 \)) [\( n (\% ) \)] | \( P \) value |
|-----------|---------------------------------|-----------------|-------------|
| II        | 13 (19.4)                       | 0               | 0.003       |
| III       | 7 (10.5)                        | 2 (7.4)         |             |
| IV        | 30 (44.8)                       | 6 (22.2)        |             |
| V         | 17 (25.3)                       | 19 (70.4)       |             |

PSI, Pneumonia Severity Index; RDW, red cell distribution width.

### Discussion

The relation between RDW levels and CAP is vague. However, different mechanisms have been suggested to explicate the association between RDW and the mortality. Weiss and Goodnough [21] reported that inflammation may increase RDW by compromising erythrocyte half-life, erythropoiesis, and the red cell membrane. Patel et al. [22] showed that decreased serum antioxidant levels and exposure to oxidative stress causes erythrocyte destruction and reduced life span. Katsoulis et al. [23] showed significantly lower total antioxidant status in patients with CAP compared with a control group.
To our knowledge, this is the first study looking at the relation between the basal RDW level and the outcomes of patients with CAP who were admitted to Assiut University Hospitals. Our study was conducted upon 94 patients. The main results of our study showed that the RDW level was significantly higher in nonsurvivors than survivors. RDW had a significant positive relationship with the PSI score. Regarding the diagnostic performance of the RDW test, it was observed that RDW level at cutoff point more than 16.1% had 94.12% sensitivity and 98.70% specificity for the prediction of in-hospital mortality in patients with CAP.

Lee et al. [16] showed that high RDW more than 15.2% was associated with high mortality in 744 patients with CAP, and the patients had a mean age of 70.1 years. Braun and colleagues reported that high RDW more than 14.5% was associated with higher mortality and severe morbidity, independently of blood WBC and hemoglobin levels at time of presentation to hospital, in 637 patients with CAP, and the patients had a mean age of 46 years [16]. Braun et al. [17] reported that RDW more than 15% was correlated

### Table 3 Diagnostic performance of red cell distribution width in prediction of mortality in patients with community-acquired pneumonia

| Indices                        | Value (%) |
|--------------------------------|-----------|
| Sensitivity                    | 94.12     |
| Specificity                    | 98.70     |
| Positive predictive value      | 94.1      |
| Negative predictive value      | 98.7      |
| Accuracy                       | 97.87     |
| Cutoff point                   | >16.1     |
| Area under curve               | 0.974     |

Figure 2

Receiver operating characteristic (ROC) curve for RDW in predicting in-hospital mortality of 94 patients with CAP. CAP, community-acquired pneumonia; RDW, red cell distribution width.
with mortality in patients with CAP, who had a mean age of 69.9 years.

The reduction in the number of patients enrolled in our study compared with the aforementioned study is evident. Moreover, what can be considered as a limitation that should be noted is that the RDW level was recorded once upon admission, and it may be better to register it several times during the course of the disease and to determine any change in its level and relation to the outcome of the disease as described in the study by Lee et al. [20]. This may be more accurate, and on the contrary may help modify treatment.

**Conclusion**

In conclusion, the present data indicated that the measurement of RDW on admission may provide the physician with a tool to predict the outcomes of patients with CAP and thus assist in decision making and management in such cases either alone or alongside other well-established means, taking into account that RDW testing is simple, cheaper, and readily available.

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Nil.

**Conflicts of interest**

There are no conflicts of interest.

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