



ORIGINAL ARTICLE

Association between Red Cell Distribution Width and Mortality in Pediatric Patients Admitted to Intensive Care Units

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ABSTRACT

Background: Red cell distribution width (RDW) is a routine laboratory measure that could be used as a predictor of mortality in critically ill patients. Identification of patients at risk for mortality early in the course of PICU admission is an important step in improving the outcome. We aimed to assess the use of RDW as an early biomarker for outcome in pediatric critical illnesses. **Methods:** A retrospective study by extracting administrative and laboratory data from patients admitted to PICU of an academic pediatric teaching hospital was accomplished. After exclusion of 64 patients according to our exclusion criteria, 304 pediatric patients with PICU admissions over the 6 months of study period were included in the study.

Results: The mean RDW for all patients was $14.9\% \pm 2.5\%$. PICU mortality was 13.3%. The rate of mortality in the quartile of $RDW > 15.7\%$ was 20.1%. Elevated RDW was associated with longer duration of PICU admission ($P < 0.001$). Tracheal intubation and ventilator support was needed in 34.2% of the patients. This was also correlated with elevated RDW ($P = 0.043$).

Conclusion: We observed that higher RDW was strongly linked to higher mortality risk in pediatric patients admitted in PICU. Higher RDW was associated with longer duration of PICU admission.

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Introduction

Pediatric intensive care units (PICU) with growing life-sustaining technologies have resulted in advanced care for children and adolescents. Moreover, characterizing the disease severity at admission and assessing risk factors correlating with mortality can help improve the quality of patient care. By means of simple laboratory values this goal seems to be attainable.

Red cell distribution width (RDW) is a laboratory parameter which expresses the variability in red blood cell size and is calculated as the standard deviation in red blood cell (RBC) size divided by the mean corpuscular volume (MCV). Clinically, it is a widely available and

low-cost test. Its normal range is between 11.5–14.5%. Reference ranges may vary depending on the individual laboratory and patient's age. Elevated RDW on complete blood count reflects marked anisocytosis on peripheral blood smear review, which can be caused by any disease involving red blood cell (RBC) destruction or production.¹

Studies have revealed that RDW could be used as a predictor of mortality in critically ill patients.^{2,3} Although the mechanism of this relationship is not fully apparent, it seems that in critical illnesses, the acute systemic inflammatory response can alter both erythropoiesis and erythrocyte maturation.⁴⁻⁹ In different contexts including sepsis, cardiovascular disease, cancer, and

chronic lower respiratory tract disease, RDW has shown to have association with increased risk of mortality.^{4,10-15} In patients admitted to PICU, RDW is associated with risk of death and is suggested as an independent prognostic marker.^{14,16-18} The prognostic value of RDW in adult patients with medical conditions such as heart failure admitted to ICU has been studied previously,^{19,20} however, information about the value of RDW as a predictor of clinical outcomes in pediatric patients is more limited. We aimed to study the association between RDW parameter in pediatric patients admitted to PICU with mortality.

Materials and Methods

A retrospective study by extracting administrative and laboratory data from patients admitted to PICU of an academic pediatric teaching hospital between September 2015 and February, 2016 was accomplished. Approval for the study was obtained from the Institutional Review Board of Mofid Children's Hospital.

The medical records of all patients were reviewed for the following data: Demographic data, vital signs including body temperature, blood pressure, respiratory rate and pulse rate, a CBC, including RDW, measured within 24 hours of PICU admission, blood gas results, blood bank reports, microbiology reports, mortality, and duration of PICU admission.

RDW is reported as a coefficient of variation (percentage) of red blood cell volume. The normal reference range for RDW in this hospital laboratory was 11.5-14.5%. Patients were categorized into four RDW quartiles based on previously published studies as a priori cut-points (RDW<13.4%, 13.4-14.3%, 14.4-15.7%, and >15.7%).^{4,13,14} Anemia was defined in accordance with World Health Organization (WHO) recommendations.²¹

Exclusion criteria were: Age more than 16 years, chronic renal failure, chronic metabolic disease, cancer, chronic hematologic diseases with the potential to change RDW, history of RBC transfusion within previous 72 hours.

SPSS software, version 16.0, was adopted for statistical analysis. The obtained measurement data in line with the normal distribution were expressed as mean±standard deviation. Univariate analysis was performed using Mann-Whitney U and Chi-square tests when appropriate. P<0.05 was considered statistically significant.

Results

After exclusion of 64 patients according to our exclusion criteria, 304 pediatric patients with PICU admissions over the 6 months of study period were included in the study. Demographic, clinical, and laboratory characteristics of the patients are summarized in Table 1. The mean age of the patients was 2.9±3.6 years and 42.9% were female. Nonsurgical, surgical and neurosurgical diseases were recorded in 50.5%, 29.3% and 20.1% of the cases, respectively. The mean RDW for all patients was 14.9%±2.5%. The RDW range was between 11.6%-25%.

Overall PICU mortality was 13.3%. However, the rate of mortality in the quartile of RDW>15.7% was 20.1%. Elevated RDW was significantly more encountered in nonsurgical patients (P=0.046).

The median length of PICU stay was 7.2 days. Elevated RDW was associated with longer duration of PICU admission (P<0.001). Tracheal intubation and ventilator support was needed in 34.2% of patients. This was also correlated with elevated RDW (P=0.043).

Anemia was detected in 52.7% of the patients; it was more frequent in patients with elevated RDW (P=0.048). Thrombocytopenia and thrombocytosis was observed in 13.1% and 19.6% of the patients, respectively. Abnormal platelet counts significantly correlated with elevated RDW (P=0.001).

Leukocyte counts lower than $5 \times 10^3 / \mu\text{L}$ was reported in 9.3% of patients and leukocyte counts more than $15 \times 10^3 / \mu\text{L}$ in 24%. There was no correlation between RDW and leukocyte counts.

The patients in the quartile of RDW>15.7% had significantly more hypotension according to their age, but RDW did not correlate with body temperature and pulse rate at the time of PICU admission.

Discussion

Elevated RDW reflects anisocytosis and higher variability in size of circulating RBCs. The results of our study was compatible with the literature that elevated RDW in pediatric patients admitted in PICU is associated with a higher risk for mortality in critically ill pediatric patients.^{2,3}

Many studies have evaluated diverse prognostic markers for early recognition of ICU patients who have high morbidity and mortality risk. A variety of approaches including clinical scoring systems such as the Pediatric Risk of Mortality (PRISM) score, and Pediatric Index of Mortality score and also specific routine laboratory tests have been evaluated in former studies for identifying their potential role in prediction of outcome in critically ill pediatric patients.^{22,23}

RDW has been proposed to be a prognostic factor influencing mortality in a spectrum of diseases including cardiovascular, pulmonary, renal, infectious and oncologic diseases and also in critically ill patients.²⁴⁻²⁷ Studies have shown that RDW is an independent predictor of mortality and its addition to the "Acute Physiologic and Chronic Health Evaluation (APACHE)" score; which is one of the most commonly used ICU scoring systems, has improved its power for mortality prediction.²⁸

Although the precise pathophysiological mechanism of the correlation between higher RDW and mortality is vague, it seems that chronic subclinical inflammation affects iron metabolism as well as bone marrow function and its response to erythropoietin. On the other hand, erythrocyte maturation is suppressed by the inflammatory cytokines and high oxidative stress leading to the entry of newer, larger reticulocytes into the circulation and elevation of RDW.¹⁰ Additionally, RBC membrane glycoproteins and ion channels are altered by inflammation contributing to the change of RBC morphology.^{29,30}

Previous studies have established that RDW values increased with age.¹⁷ This relationship; although not fully defined, could depend on several factors

Table 1: Patient characteristics

Characteristic	All patients	RDW Quartile <13.4	RDW Quartile 13.4-14.3	RDW Quartile 14.4-15.7	RDW Quartile >15.7	P value
Number (%)	304	85(28)	75(24)	68(22)	76(25)	
Age(years)	2.9(0.1-16)	3.4(0.15-16)	2.13(0.1-14)	2.1(0.1-13)	3.1(0.1-16)	0.046
Gender (%)						0.9
Male	169(55.)	50(58.8)	41(54.7)	36(52.9)	42(55.3)	
Female	135(44.)	35(41.2)	34(45.3)	32(47.1)	34(44.7)	
Admit category (%)						0.004
Nonsurgical	140(46.)	37(43.5)	26(34.7)	31(45.6)	46(60.5)	
Surgical	94(30.9)	20(23.5)	28(37.3)	23(33.8)	23(30.3)	
Neurosurgical	70(23)	28(32.9)	21(28)	14(20.6)	7(9.2)	
CRP						0.01
<10	68(58.6)	22(73.3)	12(66.7)	23(63.9)	11(34.4)	
>10	48(41.4)	8(26.7)	6(33.3)	13(36.1)	21(65.6)	
Anemia (%)	159(52.)	39(45.9)	35(46.7)	35(51.5)	50(65.8)	0.048
WBC						0.128
<5000/mm3	25(8.2)	8(9.4)	5(6.4)	3(4.4)	9(11.8)	
5000-15000/mm3	205(67.4)	61(71.8)	54(72)	49(72.1)	41(53.9)	
>15000/mm3	74(24.3)	16(18.8)	16(21.3)	16(23.5)	26(34.2)	
Platelet						0.001
<150000/mm3	35(11.6)	3(3.6)	4(5.3)	13(19.1)	15(19.7)	
150000-450000/mm3	207(68.5)	67(79.8)	61(80.6)	38(55.9)	41(53.9)	
>450000/mm3	61(20.1)	14(16.7)	10(13.3)	17(25)	20(26.3)	
PICU Length of stay mean (days)	7.2(0.1-90)	5.39(0.5-60)	6.4(0.5-56)	9.1(1-51)	8.45(0.1-90)	<0.001
PICU Length of stay >48 hrs	164(53.9)	45(52.9)	30(40)	41(60.3)	48(63.2)	0.022
Mortality(%)	34(11.1)	8(9.4)	5(6.6)	5(7.3)	16(21.1)	0.016
Respiration						0.043
Normal	153(50.3)	46(54.1)	45(60)	34(50)	28(36.8)	
Tachypnea	51(16.8)	17(20)	12(16)	8(11.8)	14(18.4)	
Intubation	100(32.9)	22(25.9)	18(24)	26(38.2)	34(44.7)	
Tachycardia(%)	185(60.9)	53(62.4)	45(60)	42(61.8)	45(59.2)	0.975
Temperature	37.36(35-40.5)	37.36(36.39-4)	37.22(35-40)	37.43(35-40)	37.44(35.4-40.5)	0.7
Blood pressure						0.017
Normal	267(87.8)	79(92.9)	67(89.3)	59(86.8)	62(81.6)	
Hypotention	11(3.6)	0(0)	1(1.3)	2(2.9)	8(10.5)	
Hypertention	28(8.6)	6(7.1)	7(9.3)	7(10.3)	6(7.9)	
PTT						0.017
<35 sec	134(76.6)	42(89.4)	33(78.6)	30(76.9)	29(61.7)	
>35 sec	41(23.4)	5(10.6)	9(21.4)	9(23.1)	18(38.3)	
INR						0.017
<1.5	167(91.3)	49(98)	45(95.7)	34(89.5)	39(81.3)	
>1.5	16(8.7)	1(2)	2(4.3)	4(10.5)	9(10.8)	
Albumin						0.003
<3.5 gr	47(44.3)	7(28)	13(56.5)	5(21.7)	22(62.9)	
>3.5 gr	59(55.7)	18(72)	10(43.5)	18(78.3)	13(37.1)	

including inflammation, anemia, nutritional status and age associated diseases.^{31,32} In a study by Buyukkocak and colleagues, the correlation between RDW and age in patients admitted in ICU was significant especially among the patients who had expired.¹⁶ In our study, age correlated positively with RDW and the mean age of patients in the quartile of RDW>15.7% was significantly higher.

An association between increasing levels of acute phase reactants such as erythrocyte sedimentation rate (ESR), C-reactive protein (CRP) and interleukin-6 with elevated

RDW has been confirmed in adults.^{4-6,33,34} In our study, elevated RDW was correlated positively with raised CRP but not with ESR.

In the study by Ramby et al. AI in Italy the Overall PICU mortality was 6.5% which was much less than what we had in our hospital. They also found that there was a significant increase in mortality rate across all RDW quartiles and RDW measured within 24 hours of PICU admission was independently associated with PICU duration of admission >48 hours and higher mortality

in a general PICU population.³⁵ In our patients, elevated RDW was also associated with longer duration of PICU admission more than 48 hours.

Increase in RDW may be a sign of cytomembrane instability which may cause multiple organ dysfunction, consequently leading to a poorer prognosis and increase in mortality.³⁶ Instability of cell membrane could be due to lack of some materials such as blood albumin and cholesterol.^{19,39} In our study hypoalbuminemia was associated with elevated RDW ($P=0.003$).

Different cohorts reveal that poor medical conditions requiring mechanical ventilation is one of the most important risk factors of mortality in PICU patients.³⁸ In our study, tracheal intubation and mechanical ventilation was associated with elevated RDW ($P=0.043$).

In summary, we observed that higher RDW was associated with higher mortality rate in pediatric patients admitted to PICU. This study should prompt further prospective evaluation of the association between high RDW and prediction of mortality in pediatric patients in order to improve risk-stratification of the ill patients.

There is no citation for ref #37 and the order of 38 and 39 is wrong

Conflict of Interest: None declared.

References

- Qurtom HA, Al-Saleh QA, Lubani MM, Hassanein A, Kaddoorah N, Qurtom MA, et al. The value of red cell distribution width in the diagnosis of anaemia in children. *Eur J Pediatr.* 1998; 148(8):745-8. PubMed PMID: 2792125.
- Kim CH, Park JT, Kim EJ, Han JH, Han JS, Choi JY, et al. An increase in red blood cell distribution width from baseline predicts mortality in patients with severe sepsis or septic shock. *Crit Care.* 2013; 17(6):R282. doi: 10.1186/cc13145. PubMed PMID: 24321201. PubMed Central PMCID: PMC4056357.
- Hunziker S, Stevens J, Howell MD. Red cell distribution width and mortality in newly hospitalized patients. *Am J Med* 2012; 125(3): 283-91. doi: 10.1016/j.amjmed.2011.08.021. PubMed PMID: 22340927.
- Forhecz Z, Gombos T, Borgulya G, Pozsonyi Z, Prohászka Z, Jánoskúti L. Red cell distribution width in heart failure: Prediction of clinical events and relationship with markers of ineffective erythropoiesis, inflammation, renal function, and nutritional state. *Am Heart J.* 2009; 158(4):659-66. doi: 10.1016/j.ahj. 2009.07.024 PubMed PMID: 19781428.
- Lippi G, Targher G, Montagnana M, Salvagno GL, Zoppini G, Guidi GC. Relation between red cell distribution width and inflammatory biomarkers in a large cohort of unselected outpatients. *Arch Pathol Lab Med.* 2009; 133(4): 628-32. doi: 10.1043/1543-2165-133.4.628 PubMed PMID: 19391664
- Scharte M, Fink MP. Red blood cell physiology in critical illness. *Crit Care Med.* 2003; 31(12 Suppl):S651-7. doi: 10.1097/01.CCM.0000098036.90796.ED. PubMed PMID: 14724462.
- Brody JS, Spira A. State of the art. Chronic obstructive pulmonary disease, inflammation, and lung cancer. *Proc Am Thorac Soc.* 2006; 3(6):535-7. doi: 10.1513/pats.200603-089MS. PubMed PMID: 16921139.
- Libby P. Inflammation in atherosclerosis. *Nature.* 2002; 420: 420(6917):868-74. doi: 10.1038/nature01323. PubMed PMID: 12490960.
- Morrow DA, de Lemos JA. Benchmarks for the assessment of novel cardiovascular biomarkers. *Circulation.* 2007; 115(8):949-52. doi: 10.1161/CIRCULATIONAHA.106.683110. PubMed PMID: 17325253.
- Ku NS, Kim H, Oh HJ, Kim YC, Kim MH, Song JE, et al. Red cell distribution width is an independent predictor of mortality in patients with Gram-negative bacteremia. *Shock.* 2012; 38(2):123-7. doi: 10.1097/SHK.0b013e31825e2a85. PubMed PMID: 22683729.
- Jo YH, Kim K, Lee JH, Kang C, Kim T, Park HM, et al. Red cell distribution width is a prognostic factor in severe sepsis and septic shock. *Am J Emerg Med.* 2013; 31(3): 545-8. doi: 10.1016/j.ajem.2012.10. 017. PubMed PMID: 23380094.
- Felker GM, Allen LA, Pocock SJ, Shaw LK, McMurray JJ, Pfeffer MA, et al. Red cell distribution width as a novel prognostic marker in heart failure. Data from the CHARM Program and the Duke Databank. *J Am Coll Cardiol.* 2007; 50(1): 40-7. doi: 10.1016/j.jacc.2007.02.067. PubMed PMID: 17601544.
- Al-Najjar Y, Goode JM, Zhang J, Cleland JG, Clark AL. Red cell distribution width: an inexpensive and powerful prognostic marker in heart failure. *Eur J Heart Failure.* 2009; 11(12): 1155-62. doi: 10.1093/eurjhf/hfp147. PubMed PMID: 19926599.
- Bazick HS, Chang D, Mahadevappa K, Gibbons FK, Christopher KB. Red cell distribution width and all cause mortality in critically ill patients. *Crit Care Med.* 2011; 39(8): 1913-21. doi: 10.1097/CCM.0b013e31821b85c6. PubMed PMID: 21532476.
- van Kimmenade RR, Mohammed AA, Uthamalingam S, van der Meer P, Felker GM, Januzzi JL Jr. Red blood cell distribution width and 1-year mortality in acute heart failure. *Eur J Heart Fail.* 2010; 12(2):129-36. doi: 10.1093/eurjhf/hfp179. PubMed PMID: 20026456.
- Büyükkoçak U, Gencay I, Ates G, Çağlayan O. Red Blood Cell Distribution Width and Mortality in ICU Patients; A Cross Sectional Retrospective Analysis Red Blood Cell Distribution Width and Mortality in ICU Patients. *Enliven: J Anesthesiol Crit Care Med.* 2014; 1(4): 1-4.
- Wang F, Pan W, Shuming P, Ge Junbo, Wang S, Chen M. Red cell distribution width as a novel predictor of mortality in ICU patients. *Ann Med.* 2011; 43(1):40-6. doi: 10.3109/07853890.2010.521766. PubMed PMID: 20961272.
- Hunziker S, Celi LA, Lee J, Howell MD. Red cell distribution width improves the simplified acute physiology score for risk prediction in unselected critically ill patients. *Crit Care.* 2012; 16(3):R89. doi: 10.1186/cc11351. PubMed PMID: 22607685. PubMed

- Central PMCID: PMC3580634.
19. Pascual-Figal DA, Bonaque JC, Redondo B, Caro C, Manzano-Fernandez S, Sánchez-Mas J, et al. Red blood cell distribution width predicts long term outcome regardless of anemia status in acute heart failure patients. *Eur J Heart Fail* 2009; 11(9):840-6. doi: 10.1093/eurjhf/hfp109. PubMed PMID: 19696056.
 20. Nishizaki Y, Yamagami S, Suzuki H, Joki Y, Takahashi S, Sesoko M, et al. Red blood cell distribution width as an effective tool for detecting fatal heart failure in super elderly patients. *Intern Med*. 2012; 51(17): 2271-6. doi: 10.2169/internalmedicine.51.7938.
 21. World Health Organization. "Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity." 2011. **WHO reference number:** WHO/NMH/NHD/MNM/11.1
 22. Slater A, Shann F, ANZICS Paediatric Study Group. The suitability of the Pediatric Index of Mortality (PIM), PIM2, the Pediatric Risk of Mortality (PRISM), and PRISM III for monitoring the quality of pediatric intensive care in Australia and New Zealand. *Pediatr Crit Care Med*. 2004; 5(5):447-54. doi: 10.1097/01.PCC.0000138557.31831.65. PubMed PMID: 15329160.
 23. Thukral A, Lodha R, Irshad M, Arora NK. Performance of Pediatric Risk of Mortality (PRISM), Pediatric Index of Mortality (PIM), and PIM2 in a pediatric intensive care unit in a developing country. *Pediatr Crit Care Med*. 2006; 7(4):356-61. doi: 10.1097/01.PCC.0000227105.20897.89. PubMed PMID: 16738502.
 24. Makhoul BF, Khourieh A, Kaplan M, Bahouth F, Aronson D, Azzam ZS. Relation between changes in red cell distribution width and clinical outcomes in acute decompensated heart failure. *Int J Cardiol*. 2013; 167(4):1412-6. doi: 10.1016/j.ijcard.2012.04.065. PubMed PMID: 22560496.
 25. Hong N, Oh J, Kang SM, Kim SY, Won H, Youn JC, et al. Red blood cell distribution width predicts early mortality in patients with acute dyspnea. *Clin Chim Acta*. 2012; 413(11-12):992-7. doi: 10.1016/j.cca.2012.02.024. PubMed PMID: 22406179.
 26. Braun E, Domany E, Kenig Y, Mazor Y, Makhoul BF, Azzam ZS. Elevated red cell distribution width predicts poor outcome in young patients with community acquired pneumonia. *Crit Care*. 2011; 15(4):R194. doi: 10.1186/cc10355. PubMed PMID: 21835005. PubMed Central PMCID: PMC3387636.
 27. Şenol K, Saylam B, Kocaay F, Tez M. Red cell distribution width as a predictor of mortality in acute pancreatitis. *Am J Emerg Med*. 2013; 31(4):687-9. doi: 10.1016/j.ajem.2012.12.015. PubMed PMID: 23399348.
 28. Loveday S, Sinclair L, Badrick T. Does the addition of RDW improve current ICU scoring systems? *Clin Biochem*. 2015; 48(9):569-74. doi: 10.1016/j.clinbiochem.2015.04.002. PubMed PMID: 25869493.
 29. Ghaffari S. Oxidative stress in the regulation of normal and neoplastic hematopoiesis. *Antioxid Redox Signal*. 2008; 10(11):1923-40. doi: 10.1089/ars.2008.2142. PubMed PMID: 18707226. PubMed Central PMCID: PMC2932538.
 30. Song CS, Park DI, Yoon MY, Seok HS, Park JH, Kim HJ, et al. Association between red cell distribution width and disease activity in patients with inflammatory bowel disease. *Dig Dis Sci*. 2012; 57(4):1033-8. doi: 10.1007/s10620-011-1978-2. PubMed PMID: 22147246.
 31. Sánchez-Chaparro MA, Calvo-Bonacho E, González-Quintela A, Cabrera M, Sáinz JC, Fernández-Labandera C, et al. Higher red blood cell distribution width is associated with the metabolic syndrome. *Diabetes Care*. 2010; 33(3):e40. doi: 10.2337/dc09-1707. PubMed PMID: 20190288.
 32. Perlstein TS, Weuve J, Pfeffer MA, Beckman JA. Red cell distribution width and mortality risk in a community based prospective cohort. *Arch Intern Med*. 2009;169(6): 588-94.
 33. Sipahi T, Koksal T, Tavil B, Akar N. The effects of acute infection on hematologic parameters. *Pediatr Hematol Oncol*. 2004; 21(6):513-20. PubMed PMID: 15552815.
 34. Pierce CN, Larson DF. Inflammatory cytokine inhibition of erythropoiesis in patients implanted with a mechanical circulatory assist device. *Perfusion*. 2005; 20(2):83-90. doi: 10.1191/0267659105pf793oa. PubMed PMID: 15918445.
 35. Ramby AL, Goodman DM, Wald EL, Weiss SL. Red Blood Cell Distribution Width as a Pragmatic Marker for Outcome in Pediatric Critical Illness. *PLoS One*. 2015; 10(6):e0129258. doi: 10.1371/journal.pone.0129258. PubMed PMID: 26057629. PubMed Central PMCID: PMC4461244.
 36. Chen J, Jin L, Yang T. Clinical study of RDW and prognosis in sepsis new borns. *Biomedical Research*. 2014;
 37. Chen PC, Sung FC, Chien KL, Hsu HC, Su TC, Lee YT. Red blood cell distribution width and risk of cardiovascular events and mortality in a community cohort in Taiwan. *Am J Epidemiol*. 2010; 171(2):214-20. doi: 10.1093/aje/kwp360. PubMed PMID: 20008450.
 38. Tan GH, Tan TH, Goh DY, Yap HK. Risk factors for predicting mortality in a paediatric intensive care unit. *Ann Acad Med Singapore*. 1998; 27(6):813-8. PubMed PMID: 10101556.