Red cell distribution width as a new prognostic marker in patients with acute heart failure

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ABSTRACT

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Background: Red cell distribution width (RDW) is discovered to be a novel prognostic and predictive marker in heart failure patients. We tested whether serial measurements of RDW would have prognostic importance in patients with acute heart failure (AHF).

Methods: We analyzed laboratory findings and echocardiographic parameters in 140 hospitalized AHF patients (71 males, 62.8 ± 14.0 years old). RDW was measured on admission, at discharge and at 1-month after discharge. We assessed cardiovascular (CV) events, defined as CV mortality and HF rehospitalization during 1-year.

Results: Mean RDW change between admission and discharge ($RDW\Delta_{adm\text{-}dis}$) and 1-month after discharge ($RDW\Delta_{adm\text{-}1Mdis}$) were -0.77 ± 1.58 % and -0.06 ± 1.19 %. The Kaplan-Meier analysis showed that patients with positive $RDW\Delta_{adm\text{-}1Mdis}$ (n = 62) had a significantly higher CV events compared with patients with negative or no $RDW\Delta_{adm\text{-}1Mdis}$ (n = 78) (51.6 % vs 28.2 %, log-rank: p = 0.005) but there were no significant differences in CV events between positive $RDW\Delta_{adm\text{-}dis}$ and negative or no $RDW\Delta_{adm\text{-}dis}$ (38.8 % vs 33.3 %, p = 0.41). The positive $RDW\Delta_{adm\text{-}1Mdis}$ was an independent predictor of CV events after adjusting other CV risk factors (hazard ratio : 4.61, 95 % CI 2.05 - 10.37, p < 0.001) in Cox proportional hazards regression analysis.

Conclusion: These findings suggest that positive $RDW\Delta_{adm\text{-}1Mdis}$ is an independent prognostic marker in AHF patients. Therefore, the serial

measurements of RDW, its simple, inexpensive method may help risk stratification in patients with AHF.

Key words : red cell distribution width, prognosis, acute heart failure

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I. INTRODUCTION

Red cell distribution width (RDW) is a measurement of size variability of red blood cell population, easily measured by modern cell counters. Generally, high RDW level may reflect reticulocytosis due to iron deficiency anemia and hemolytic disorders. Recently, RDW has been known to be a novel prognostic and predictive marker in patients with heart failure (HF) and prior myocardial infarction without HF. [1, 2] Two large epidemiologic studies further suggested that RDW was associated with all-cause mortality including cardiovascular (CV) disease even if in cohort without anemia, iron, folate and vitamin B deficiency, [3, 4] and known to be a prognostic marker in patients with acute and chronic HF, myocardiac infarction and pulmonary hypertension. [5-11]

Acute heart failure (AHF) is the most common cause for hospitalization among patients over 65 years of age. [12] Therefore, an accurate prognostic prediction of AHF is needed and many approaches for this have been done. To date, B-type natriuretic peptide (BNP), N-terminal pro-B-type natriuretic peptide (NT-proBNP), cardiac troponins and their combinations have been known to be related to the severity and prognosis of patients with AHF. [13, 14] The serial monitoring and interval change value as well as initial value also have been known to be well associated with prognosis in CV disease patients including HF. [15-18] Recent studies reported that RDW levels at admission and discharge is a prognostic marker independent of NT-proBNP in AHF patients. [7, 8, 11] However,

there have not been any studies about the serial measurement of RDW and its prognostic value in AHF patients. We examined the hypothesis that serial measurements of RDW would have a prognostic importance in patients with AHF.

II. MATERIALS AND METHODS

1. Study population

Two hundred fifty consecutive patients who visited the emergency room of our hospital from Sep. 2006 to Jan. 2009 with clinical diagnosis (rale or generalized edema or pulmonary congestion) of AHF were included in this study. Patients with known hematologic diseases such as hemolytic anemia, neoplastic metastases to bone marrow, pregnancy, severe arthritis and inflammatory bowel diseases which can increase plasma RDW levels and other extracellular fluid–increasing diseases, such as hypothyroidism and liver cirrhosis, were excluded in this study.

RDW levels were measured at discharge and at 1-month after discharge in 140 (56.0 %) pts. RDW_{adm} was defined as RDW at admission and RDW_{dis} as RDW at discharge, RDW_{1Mdis} as RDW at 1-month after discharge, respectively. RDW change between admission and discharge ($RDW\Delta_{adm\text{-}dis}$) was calculated from RDW_{dis} - RDW_{adm}, RDW change between admission and 1-month after discharge ($RDW\Delta_{adm\text{-}1Mdis}$) from RDW_{1Mdis} - RDW_{adm}, hemoglobin (Hb) change between admission and discharge ($Hb\Delta_{adm\text{-}dis}$) from Hb_{dis} - Hb_{adm}, Hb change between admission and 1-month after discharge ($Hb\Delta_{adm\text{-}1Mdis}$) from Hb_{1Mdis} - Hb_{adm}, respectively. Study approval was obtained from the internal review board of Yonsei University College of Medicine.

2. Study endpoints

Patients were recruited between Sep. 2006 and Jan. 2009 and followed-up until 15 May. 2009. The primary endpoint was the composite of CV mortality and HF rehospitalization which were assessed by reviewing medical

records or contacting the general practitioner or the heart failure clinic. There was no loss in the follow-up.

3. Echocardiographic and laboratory measurements

Within 24 hours, two-dimensional echocardiography was performed and analyzed blindly in all patients. Left ventricular ejection fraction (LVEF) was measured using the modified Quinones method. Blood was sampled for the measurements of routine chemistry including NT-proBNP. The NT-proBNP was kept at 4℃, and analyzed by the electrochemiluminescence immunoassay method (Elecsys proBNP; Roche Diagnostics GmbH, Basel, Switzerland) within 2 hours of ER visit. Since the NT-proBNP distribution was positively skewed, we used log-transformed NT-proBNP values in statistical analysis. RDW levels were measured with the use of the Coulter STK-S analyzer (Coulter, FL., USA) at our hospital laboratory. We estimated glomerular filtration rate (eGFR) using the Modification of Diet in Renal Disease formula following equation: $170 \times (SCr)^{-0.999} \times (age)^{-0.176} \times (BUN)^{-0.170} \times (albumin)^{0.318} \times 0.762$ (if female), where SCr is serum creatinine in mg/dL. [19]

4. Statistical analysis

SPSS version 17.0 (SPSS Inc., Chicago, Illinois, USA) was used for statistical analysis. Continuous variables were described using means and standard deviations (SD) except NT-proBNP which used median and interquartile range (IQR) when skewed, categorical variables were described using numbers or percentages. We compared differences between groups with the Mann–Whitney U test, Kruskall–Wallis test, student t-test, ANOVA with Bonferroni post hoc testing when appropriate. Correlations of RDW change with the change of other variables were examined by Pearson correlation analysis. Kaplan–Meier method was used to test the influence of RDW and the change of RDW levels on CV events, with log-rank testing. Regarding the limited sample size, in Cox proportional hazards regression analysis, we assessed the association between the change of RDW levels and CV events after adjusting

age, sex, LVEF, log NT-proBNP, eGFR, RDW, Hb_{adm} and $Hb\Delta_{adm\text{-}1Mdis}$. Hazard ratio (HR) with 95% confidence interval (CI) demonstrated the risk of CV events. A value of $p < 0.05$ was considered statistically significant and all reported probability values were two-tailed.

III. RESULTS

1. Baseline clinical characteristics and laboratory findings

Total study group consisted of 250 patients (129 males, 65.4 ± 14.2 year-old) and RDW was measured at discharge and 1-month after discharge in 140 patients (56 %). In this group (n = 140), mean RDW was 14.4 ± 2.2 % and median NT-proBNP was 5032.5 (IQR 1881.5-12425.5) pg/ml and mean LVEF was 33.2 ± 14.9 %, respectively. The baseline characteristics of patients with AHF by subgroups of $RDW\Delta_{adm\text{-}1Mdis}$ are shown in Table 1. Mean $RDW\Delta_{adm\text{-}dis}$ was -0.08 ± 1.14 % and $RDW\Delta_{adm\text{-}1Mdis}$ was -0.04 ± 1.19 %. There were 42 diabetic (30 %), 75 hypertensive (53.6 %) patients and 71 male (50.7 %) patients. The etiology of heart failure included 45 ischemic heart diseases (32.1 %). All patients were on medical therapy including diuretics (82.1 %), angiotensin converting enzyme inhibitors/angiotensin Ⅱ receptor blockers (81.4 %), and beta-blockers (37.9 %). There were no significant differences in baseline characteristics between positive and negative or no $RDW\Delta_{adm\text{-}1Mdis}$ except for RDW_{adm} (13.6 ± 1.2 % vs. 15.0 ± 2.5 %, $p < 0.001$). In addition, RDW_{adm} was not different between measured and unmeasured group at 1-month after discharge (14.4 ± 2.2 % vs. 14.8 ± 1.9 %, $p = 0.125$). In correlation analysis, $RDW\Delta_{adm\text{-}1Mdis}$ was well correlated with $RDW\Delta_{adm\text{-}dis}$ ($r = 0.770$, $p < 0.001$) but not with $Hb\Delta_{adm\text{-}dis}$ ($r = -0.036$, $p = 0.674$) nor $Hb\Delta_{adm\text{-}1Mdis}$ ($r = -0.062$, $p = 0.485$).

Table 1. Baseline characteristics of patients with acute heart failure by $RDW\Delta_{adm\text{-}1Mdis}$

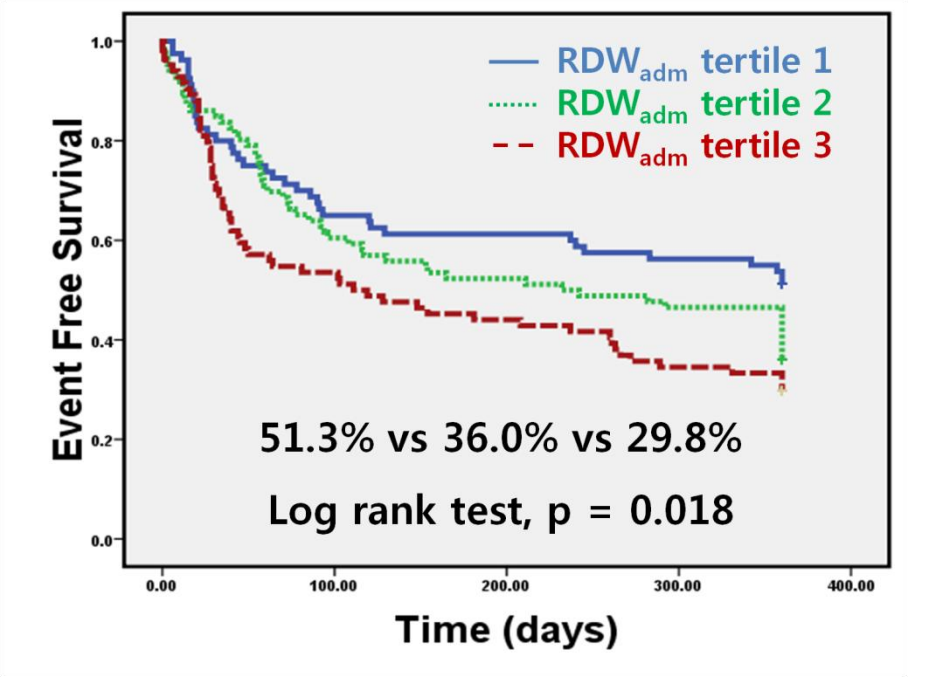
	Total (n=250)	**Positive $RDW\Delta_{adm\text{-}1Mdis}$ (n=62)**	**Negative $RDW\Delta_{adm\text{-}1Mdis}$ (n=78)**	***p value***
Male sex (n, %)	129 (51.6)	34 (47.9)	37 (52.1)	0.242
Age (years)	65.4 ± 14.2	60.9 ± 16.1	64.3 ± 12.1	0.151
BMI (kg/m^2)	22.8 ± 5.0	22.8 ± 4.6	22.7 ± 4.2	0.841
NYHA III, IV (n, %)	196 (77.2)	42 (67.7)	51 (65.4)	0.617
Admission history (n, %)	108 (43.2)	24 (38.7)	25 (32.1)	0.412
Ischemic origin (n, %)	95 (38.0)	21 (33.9)	24 (30.8)	0.979
Diabetes (n, %)	89 (35.6)	22 (35.5)	20 (25.6)	0.207
Hypertension (n, %)	133 (53.2)	33 (53.2)	42 (53.8)	0.942
Atrial fibrillation	105 (42.0)	33 (53.2)	39 (50.0)	0.704
RDW_{adm} (%)	14.6 ± 2.1	13.6 ± 1.2	15.0± 2.5	<0.001
$RDW\Delta_{adm\text{-}1Mdis}$ (%)		0.88 ± 0.69	-0.77 ± 0.99	<0.001
Hb_{adm} (g/dL)	12.3 ± 2.2	13.0 ± 2.4	12.4 ± 2.1	0.108
$Hb\Delta_{adm\text{-}1Mdis}$ (g/dL)		-0.58 ± 1.94	-0.15 ± 1.40	0.146
Cholesterol (mg/dL)	150 ± 41	151 ± 44	153 ± 40	0.827
eGFR ($mL/min/1.73m^2$)	54.92 ± 29.81	57.5 ± 30.1	58.7 ± 26.7	0.815
$NT\text{-}proBNP_{adm}$ (pg/mL)	5715.5	5619.0	4901.5	0.469
LVEF (%)	32.0 ± 14.7	32.3 ± 16.3	33.9 ± 13.8	0.561
ACE inhibitor/ARB	195 (78.0)	53 (85.5)	61 (78.2)	0.190
Beta blocker	87 (34.8)	23 (37.1)	30 (38.5)	0.505
Diuretics	198 (79.2)	51 (82.3)	64 (82.1)	0.577

Values are mean ± SD or n (%) or median. RDW indicates red cell width; BMI, body mass index; NYHA, New York heart association functional class; eGFR, estimated glomerular filtration ratio; $NT\text{-}proBNP_{adm}$, N-terminal pro-brain natriuretic peptide at admission; LVEF, left ventricular ejection fraction; ACE, angiotensin coverting enzyme; ARB, angiotensinⅡ receptor blocker; RDW_{adm} means RDW at admission, $RDW\Delta_{adm\text{-}1Mdis}$ means (RDW at 1 month after discharge – RDW_{adm}), Hb_{adm} means hemoglobin at admission, $Hb\Delta_{adm\text{-}1Mdis}$ means (Hb at 1 month after discharge – Hb_{adm}). *P value* means positive $RDW\Delta_{adm\text{-}1Mdis}$ vs. negative or no $RDW\Delta_{adm\text{-}1Mdis}$ by t-test or chi-square test or Mann-Whitney U test.

2. RDW level at admission has an incremental prognostic value to NT-proBNP level in AHF

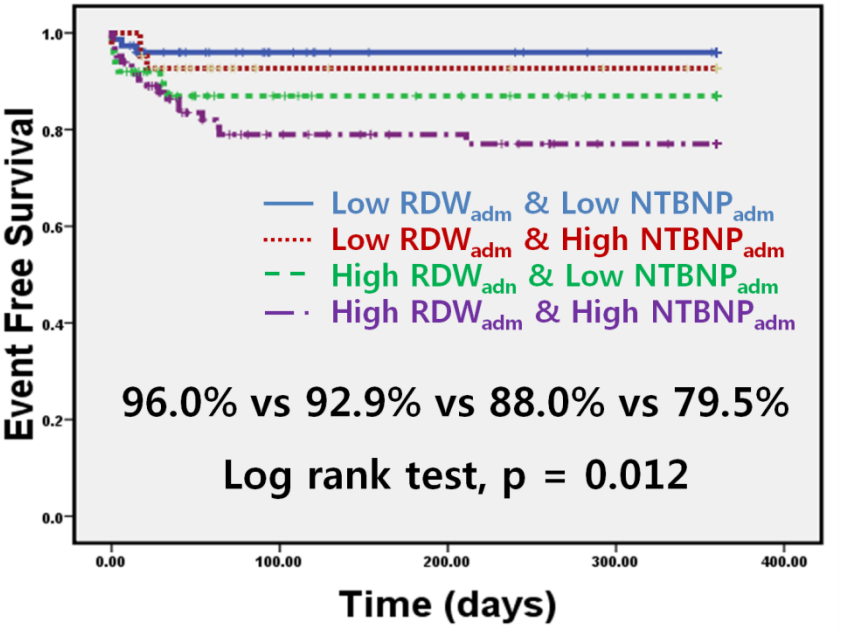
In our total study group (n=250), high tertile RDW_{adm} group (tertile 3, >14.8%) had significantly higher CV events compared with lower tertile RDW_{adm} group (tertile 1, ≤ 13.5 %) (70.2 % vs 48.7 %, log-rank: p = 0.018). (Figure 1) Then we investigated whether RDW_{adm} had an incremental prognostic value to NT-proBNP levels in AHF patients. We divided AHF patients into four groups by the median of RDW and NT-proBNP levels. The patients with both high RDW_{adm} (> 14 %) and high $NT\text{-}proBNP_{adm}$ (> 5700 pg/mL) had a higher mortality rate compared with the patients with only high RDW_{adm} or high $NT\text{-}proBNP_{adm}$ (20.5% vs 12.0% or 7.1%, log-rank: p = 0.012). (Figure 2) A high RDW_{adm} was an independent predictor of increased mortality risk after adjusting age, sex, LVEF, eGFR and log $NT\text{-}proBNP_{adm}$ (hazard ratio : 3.199 95% CI 1.194-8.576, p = 0.011) in Cox proportional hazard analysis. (Table 2)

Figure 1. Kaplan-Meier curves for cardiovascular mortality and rehospitalization by RDW_{adm} tertile group



RDW_{adm} means RDW at admission. RDW_{adm} tertile 1 (≤ 13.5 %), RDW_{adm} tertile 2 (> 13.5% , ≤ 14.8%), RDW_{adm} tertile (> 14.8%)

Figure 2. Kaplan-Meier curves for cardiovascular mortality by both RDW_{adm} and $NT\text{-}proBNP_{adm}$ level



RDW_{adm} means RDW at admission, $NT\text{-}proBNP_{adm}$ means NT-proBNP at admission. Low RDW_{adm} ($\leq$ 14 %), High RDW_{adm} (> 14 %), Low $NT\text{-}proBNP_{adm}$ ($\leq$ 5700 pg/ml), High $NT\text{-}proBNP_{adm}$ (> 5700 pg/ml)

Table 2. Cox proportional hazards regression analysis for cardiovascular mortality

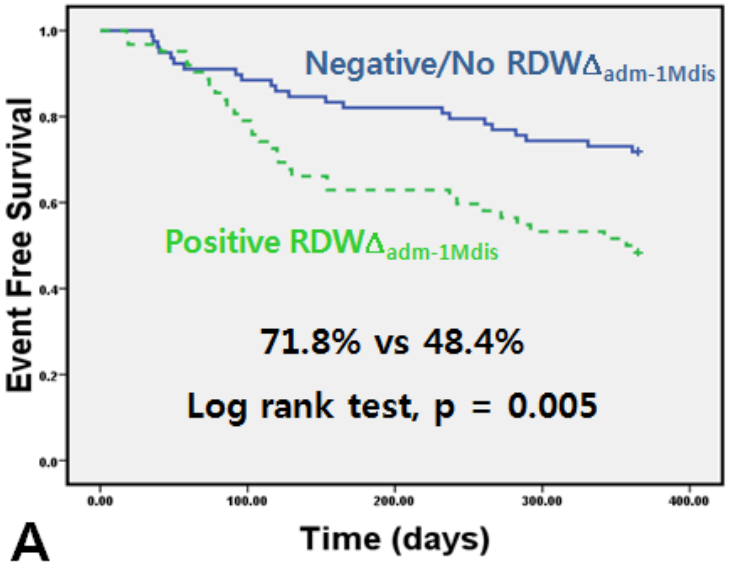
Variable	Univariate		Multivariate	
	HR (95% CI)	*p value*	HR (95% CI)	*p value*
Sex	0.86 (0.41 - 1.79)	0.689		0.453
Age (years)	1.01 (0.98 – 1.04)	0.394		0.691
Admission history	1.32 (0.64 – 2.75)	0.447		0.369
High RDW_{adm} (> 14.0 %)	3.33 (1.49 - 9.00)	0.005	4.05 (1.37 – 11.99)	0.011
LVEF (%)	0.98 (0.95 – 1.01)	0.153		0.204
Hemoglobin (g/dL)	0.89 (0.75 – 1.05)	0.152		0.789
High $NT\text{-}proBNP_{adm}$	2.23	0.046		0.921
(> 5700pg/mL)	(1.01 – 4.89)			
eGFR ($mL/min/1.73m^2$)	0.98 (0.97 – 0.99)	0.024		0.165

Abbreviations as in Table 1.

3. RDW change between admission and 1-month after discharge as an independent predictor of CV events in AHF

In Kaplan-Meier curves, positive $RDW\Delta_{adm\text{-}1Mdis}$ (n=62) group had significantly higher CV events compared with negative or no $RDW\Delta_{adm\text{-}1Mdis}$ (n=78) group (51.6% vs 28.2%, log-rank: p = 0.005) (Figure 3A) but there were no significant differences in CV events on the analysis of $RDW\Delta_{adm\text{-}dis}$ (38.8% vs 33.3%, p = 0.413) (Figure 3B). In multiple Cox regression model, the positive $RDW\Delta_{adm\text{-}1Mdis}$ was an independent predictor of higher CV events after adjusting age, sex, LVEF, log $NT\text{-}proBNP_{adm}$, eGFR, Hb_{adm}, RDW_{adm} and $Hb\Delta_{adm\text{-}1Mdis}$ (hazard ratio : 4.61, 95% CI 2.05-10.37, p < 0.001) (Table 3).

Figure 3. Kaplan-Meier curves for cardiovascular mortality and rehospitalization by RDWΔ$_{adm-1Mdis}$ (Panel A) and RDWΔ$_{adm-dis}$ (Panel B)



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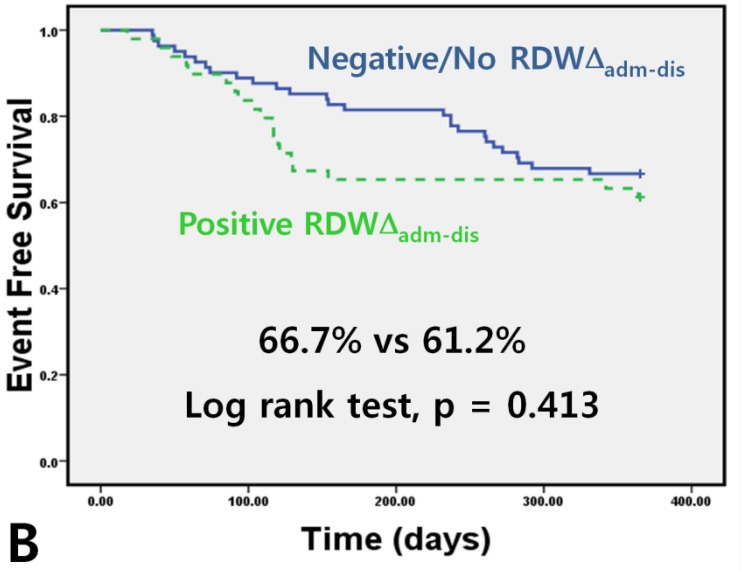

RDWΔ$_{adm-1Mdis}$ means RDW$_{1Mdis}$ - RDW$_{adm}$, RDWΔ$_{adm-dis}$ means RDW$_{dis}$ - RDW$_{adm}$.

Table 3. Cox proportional hazards regression analysis for cardiovascular events

Variable	Multivariate	
	HR (95% CI)	*p value*
Sex (male)	1.49 (0.70 – 3.19)	0.302
Age (years)	1.01 (0.98 – 1.04)	0.618
LVEF (%)	1.02 (1.00 – 1.05)	0.105
Log NT-proBNP	0.99 (0.74 – 1.32)	0.943
eGFR (mL/min/1.73m^2)	1.00 (0.98 – 1.01)	0.592
RDW_{adm} (%)	1.22 (1.02 – 1.45)	0.032
Hb_{adm} (g/dL)	1.07 (0.89 – 1.29)	0.449
Negative or no $RDW\Delta_{adm\text{-}1Mdis}$ (%)	1.00	
Positive $RDW\Delta_{adm\text{-}1Mdis}$ (%)	4.61 (2.05 – 10.37)	< 0.001
Negative or no $Hb\Delta_{adm\text{-}1Mdis}$ (g/dL)	1.00	
Positive $Hb\Delta_{adm\text{-}1Mdis}$ (g/dL)	0.31 (0.14 – 0.68)	0.004

Abbreviations as in Table 1.

IV. DISCUSSION

The principal findings of this study are that 1) $RDW\Delta_{adm\text{-}dis}$ is not associated with CV events in patients with AHF. 2) Positive $RDW\Delta_{adm\text{-}1Mdis}$ is an independent prognostic factor for CV events in AHF patients. 3) The serial measurements of RDW have an additive role for predicting CV events compared to baseline measurement of RDW in AHF patients.

RDW was first known to be a prognostic marker in symptomatic chronic heart failure patients from CHARM (Candesartan in Heart Failure: Assessment of Reduction in Mortality and Morbidity) study. [1] Following studies showed that higher RDW levels at admission and discharge were associated with worse long-term outcome regardless of anemia status, and its prognostic power had incremental value to NT-proBNP in patients with AHF. [5, 7, 8, 11] In our total study group (n=250), high RDW_{adm} could predict higher cardiovascular mortality and rehospitalization during 1-year follow-up period and RDW had an incremental prognostic value to NT-proBNP levels in AHF patients (Figure 1, 2). These results were compatible with previous studies. In addition, the measurement of RDW is a simple, fast, inexpensive and widely-used test so many researchers have paid attention to this old but uprising marker for predicting prognosis more accurately in patients with HF.

Serial measurements and the change of biomarker over time have been known to have additive prognostic value compared to single measurement. In line with this perspective, the prognostic value of serial measurements of BNP, NT-proBNP and ST2 were previously presented in patients with HF. [18, 20, 21] Recently, Dabbah et al reported that the increase in RDW during hospital stay was associated with poor clinical outcomes and demonstrated the prognostic importance of serial measurement of RDW in patients with acute myocardial infarction. [9] In our study, we found the prognostic importance of $RDW\Delta_{adm\text{-}1Mdis}$ but not $RDW\Delta_{adm\text{-}dis}$ in patient with AHF, although there was a significant connection between $RDW\Delta_{adm\text{-}1Mdis}$ and $RDW\Delta_{adm\text{-}dis}$ in correlation analysis. This discrepancy could be explained by either our relatively small-sample sized

study or the difference in hospital course of myocardial infarction and HF (e.g. day of hospital stay, existence of coronary intervention). It might be because RDW levels demonstrate the sub-acute marker of hemodynamic stress during one or two month in contrast to the acute marker, NT-proBNP. Based on our knowledge, our study is the first report on the prognostic value of serial measurements of RDW in HF, so further studies should follow and answer this discrepancy on the change of RDW.

In our multiple Cox regression model, both RDW_{adm} (HR 1.22 95% CI 1.02 – 1.45 p = 0.032) and positive $Hb\Delta_{adm\text{-}1Mdis}$ (HR 0.31 95% CI 0.14 – 0.68 p = 0.004) were independent predictors for CV events in addition to $RDW\Delta_{adm\text{-}1Mdis}$. These results are compatible with previous studies. Higher RDW_{adm} level was associated with increased mortality in patients with AHF [7, 11] and the changes in Hb over 12 months were inversely associated with mortality and rehospitalization in CHF patients from Valsartan Heart Failure Trial (Val-HeFT). [22] Therefore, $RDW\Delta_{adm\text{-}1Mdis}$ may have an additive prognostic power, independent of other known risk factors in HF.

There were several suggested mechanisms on how RDW level was elevated and became a prognostic marker in patients with AHF. Firstly, increased RDW levels in patients with AHF were associated with increased inflammatory status. Persistent inflammation is known to be a principal pathophysiologic finding and poor prognostic factor for heart failure. [23] There were recently-published reports about the association between RDW and inflammation. Lippi et al.'s study showed a strong, graded association between RDW and well-known inflammatory markers (e.g. high-sensitivity C-reactive protein (hsCRP), erythrocyte sedimentation rate (ESR) levels) in large unselected patients. [24] Recent reports showed that there were correlations between RDW and inflammatory cytokine such as interleukin-6, interleukin-1 beta. [25, 26] These results imply that RDW levels could be correlated with the severity and characteristics of inflammation in AHF. Secondly, increased RDW levels were associated with increased oxidative stress that characterizes the exacerbation of heart failure. [27] Oxidative stress is related to red cell survival so

could be a possible mechanism in the increase of RDW in AHF. [28] Recently, selenium, one component of the antioxidant defense system, was revealed to be an independent predictor of RDW in old aged women from the Woman's Health and Aging Study I. [26] Furthermore, increased RDW levels may be associated with increased hemodynamic stress which is important in the mechanism of heart failure exacerbation. [27] Elevated left ventricle filling pressure (LVFP) represents aggravation of hemodynamic stress in patients with HF. The estimation of LVFP is important in the AHF management because elevated LVFP indicates a poor prognosis, regardless of LVEF. [29, 30] Previous studies showed that noninvasive echocardiographic parameter, the early mitral inflow velocity to early diastolic mitral annular velocity (E/E'), using tissue Doppler imaging (TDI) was positively correlated with invasively-measured LVFP. [31, 32] In our previous study, higher RDW levels were well associated with elevated E/E' after adjusting NT-proBNP. [19] Recently, Hampole et al. reported an interesting finding that RDW was an independent prognostic marker in patients with pulmonary hypertension, especially better than NT-proBNP. [10] Taken this all into consideration, the simple measurement of RDW level can be used for assessing hemodynamic stress and clinical prognosis in both left and right-side heart failure. Finally, higher RDW level was correlated with higher erythropoietin and lower serum iron, total iron binding capacity (TIBC) saturation in patients with CHF. [25] This means that the ability to mobilize and use iron stores may be impaired. These concepts may answer why RDW was an independent predictive and prognostic marker in patients with heart failure and imply that RDW is a new surrogate marker of multiple pathophysiologic processes in HF.

This study does not go without limitations. First, RDW were measured at 1 month after discharge in only 140 patients (56%) although there were no differences in baseline laboratory characteristics between measured and unmeasured AHF patients. This relatively small-sized analysis could limit the clinical application of RDW change values, so a larger-sized study should follow our study and widen the clinical importance and application of serial

measurements of RDW. Second, we did not measure NT-proBNP levels at 1 month after discharge and could not compare the prognostic power of RDW change with that of NT-proBNP change due to limitation of retrospective study design. However we included NT-proBNP levels at admission in our multiple Cox hazard analysis. Further prospective studies will be needed to show whether serial measurements of RDW have incremental prognostic value compared to well-known markers such as NT-proBNP, ST2. [18, 21] Finally, we did not demonstrate the precise mechanism on how RDW levels were increased in AHF. We do not know whether higher RDW levels are resulted from an increase in bone marrow activity or a reflection of rheological change in peripheral blood. The red blood cell tracking experiments may provide an answer to this question.

V. CONCLUSION

In conclusion, we found that positive $RDW\Delta_{adm\text{-}1Mdis}$ is a powerful independent prognostic factor for CV events and that the serial measurements of RDW have additive role for predicting CV events compared to baseline measurement of RDW in AHF patients. Therefore, serial measurements of RDW, its simple, inexpensive method may help risk stratification in patients with AHF.

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ABSTRACT (IN KOREAN)

급성 심부전 환자에서 새로운 예후 예측 인자로서의 적혈구분포폭 역할

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배경 : 적혈구분포폭은 심부전 환자에서 새로운 예후, 예측 인자로 알려졌다. 본 연구에서는 적혈구분포폭의 반복 측정이 급성 심부전 환자에서 예후 예측 인자로서의 중요성을 갖는지에 대하여 연구 하였다.

방법 : 급성 심부전 치료를 위해 입원한 140 명 (남자 71 명, 평균 나이 62.8 ± 14.0 세)을 대상으로 혈액 검사와 심장 초음파 검사를 하여 그 결과를 분석하였다. 적혈구분포폭은 입원 당시, 퇴원 시, 퇴원 한 달 후 외래에서 측정되었다. 심혈관계 사건은 일년 동안의 심혈관계 사망과 심부전 악화로 인한 재입원으로 정의하였다.

결과 : 입원 시와 비교하여, 퇴원 시와 퇴원 한달 후의 적혈구분포폭 변화 (Δ)는 각각 -0.77 ± 1.58 % , -0.06 ± 1.19 %였다. Kaplan-Meier 분석을 시행한 결과, 퇴원 한달 후의 적혈구분포폭 변화가 양의 값인 환자 (n = 62)들에서 음의 값인 환자들 (n = 78)보다 유의하게 많은 심혈관계 사건이 발생하였다. (51.6 % vs. 28.2 %, log-rank: p = 0.005) 그러나 퇴원 시 적혈구분포폭 변화 값이 양과 음인 환자들 사이에는 유의한 차이가 없었다. (38.8 % vs. 33.3 %, p = 0.41). Cox 위험도 분석 결과, 퇴원 한 달 후의 적혈구분포폭 변화가 양인 값인 경우가 다른 여러 심혈관계 위험 인자들을 보정하더라도 심혈관계 사건을 예측할 수

있는 독립적인 예후 인자였다. (hazard ratio : 4.61, 95 % CI 2.05 - 10.37, $p < 0.001$)

결론 : 퇴원 한달 후의 적혈구분포폭 변화가 양의 값인 경우가 급성 심부전 환자의 독립적인 예후 인자였다. 따라서 퇴원 한달 후의 적혈구분포폭을 측정하는 것은 급성 심부전 환자에서 심혈관 사건을 예측하는 데 도움이 된다.

핵심되는 말 : 적혈구분포폭, 예후, 급성 심부전

PUBLICATION LIST

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