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Prognostic value of red cell distribution width and echocardiographic parameters in patients with pulmonary embolism

The authors declare no financial disclosure

Abstract

Introduction: Pulmonary embolism (PTE) is a common cardiovascular emergency. We aimed to predict mortality in the acute phase and to assess the development of pulmonary hypertension in the chronic period with the combined use of red cell distribution width (RDW) and echocardiography (ECHO) for the prognosis of PTE.

Material and methods: Cases diagnosed with acute PTE were prospectively monitored in our clinic. The initial data of 56 patients were evaluated. The subjects were separated into two groups basing on RDW; group 1 had RDW ≥ 15.2%, while group 2 had RDW < 15.2%.

Results: Ninety-eight patients were enrolled in the study. We established the sensitivity (73.3%) and the specificity (73.2%) of RDW to determine mortality in the cases with PTE. RDW ≥ 15.2% value was significant as an independent risk factor for predicting mortality (OR:7.9 95% CI, 1.5–40.9 p = 0.013) in acute PTE. The mean tricuspid annular plane systolic excursion (TAPSE) value was significantly different between the group-1 (RDW ≥ 15.2%, 2.20 cm [± 0.43] and group-2 (RDW < 15.2%, 1.85 cm [± 0.53] [p = 0.007]). The threshold value for tricuspid jet velocity was > 2.35m/s, the sensitivity and specificity were 76.9% and 61.9%, respectively for predicting mortality (AUC: 0.724, 95% CI: 0.591–0.858, p = 0.033).

Conclusion: Our results indicate that high RDW levels are an independent predictor of mortality in acute PTE. Lower TAPSE levels show right heart failure in PTE patients; this may also be indicative of right ventricular systolic function. We believe that developing new scoring systems, including parameters such as RDW, TAPSE, and tricuspid jet velocities, may be effective in determining the prognosis of pulmonary embolism.

Key words: chronic thromboembolic pulmonary hypertension, red cell distribution width, pulmonary embolism, tricuspid annular plane systolic excursion, tricuspid jet velocity

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Introduction

Pulmonary thromboembolism (PTE) is a common cardiovascular emergency. Pulmonary arterial bed obstruction may lead to life-threatening acute, but often reversible, right ventricular failure. The first 30-day early mortality rate for PTE is between 7% and 11% [1].

Echocardiography (ECHO) is important in determining any right ventricular dysfunction or dilatation that may occur in massive/submassive PTE. ECHO is especially useful in discrimina-

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ting between massive PTE and other high-risk conditions, such as aortic dissection, pericardial tamponade, myocardial infarction, and cardiogenic shock [2, 3]. Tricuspid annular plane systolic excursion (TAPSE) is a simple echocardiographic measure of the right ventricular ejection fraction and tricuspid jet velocity. It is used to calculate pulmonary artery pressure (PAP), and may replace the usual parameters for detecting PTE severity [4]. This measure may also be able to help with the identification of PTE and any cases requiring a close follow-up.

Red cell distribution width (RDW) is a marker indicating the heterogeneity of red blood cells; and may be useful in detecting and following PTE. Results from one study showed that an increase in RDW (> 14.6%) and the presence of shock in the acute phase were associated with early mortality in PTE [5].

The aim of the study was to predict mortality in the acute phase and prognosis and development of pulmonary hypertension (PHT) in the chronic phase by using RDW and ECHO, which are simple and inexpensive routine laboratory tests.

Material and methods

Study group

The study was carried out between June 2012 and July 2013 at the chest diseases clinic of a university hospital, and was approved by the local ethical committee. New patients diagnosed with PTE were included in the study. These cases were followed up for 3 months according to the initial therapy, or for 6 months according to the risk factor assessment. The 90-day mortality rates of all patients were recorded.

Exclusion criteria of the study were as follows: patients < 18 years old, subjects with known hematologic malignancies, transfusion history within the last 2 weeks, with CKD (chronic kidney disease) beginning dialysis, those receiving chemotherapy, patients with left heart failure, individuals undergoing treatment with anemia diagnosis and those without consent.

Study design

Patient data that were recorded and followed up in this study included demographic parameters, vital signs, risk factors for PTE, diagnostic imaging method [computerized tomography pulmonary angiography (CTPA), pulmonary perfusion scintigraphy, or lower extremity Doppler ultrasonography (USG)], findings of right heart failure in ECHO (PAP, right ventricular dilatation, TAPSE, tricuspid jet velocities, right ventricular diameter, RV/LV ratio), complications related to treatment, Wells score in the acute phase, laboratory parameters, and simplified pulmonary embolism severity index (sPESI).

We treated non-massive cases with either standard heparin dose adjustments (80 U/kg bolus dose and 18 U/kg/hr continued infusion) according to active partial thromboplastin time level (aPTT, 1.5–2.5-fold to normal), or low molecular weight heparin (LMWH, 2 × 100 IU/kg); patients receiving either treatment plan underwent follow-up. The subjects with massive PTE tissue plasminogen activator (TPA) were given (100 mg in 2h), and after that, standard heparin was administered. Oral anticoagulant treatment was given to patients with the appropriate clinical conditions, and these individuals also underwent follow-up. Vena cava filtration was performed in patients with a high contraindication of anticoagulation treatment and a high risk of recurrent venous thromboembolism.

Echocardiographic parameters:

Echocardiographic examinations were carried out with 2-D, conventional, and tissue Doppler echocardiography using the Vivid 7 system (GE Vingmed Ultrens, Horten, Norway) with a 3.4 MHz transducer probe. Systolic PAP was calculated by adding the mean right atrium pressure (5 mm Hg) to the tricuspid regurgitation pressure gradient ($BG = 4v^2$) using the modified Bernoulli equation. Systolic PAP > 35 mm Hg was defined as pulmonary hypertension. Dilatation was considered in the patients with the right ventricular diameter parameters of parasternal > 30 mm Hg and mid-level > 35 mm Hg, while right ventricular systolic failure was considered in those with TAPSE ≤ 1.5 cm. Ventricular dilation was considered in the subjects with RV/LV ≥ 0.9, while pulmonary artery hypertension was considered in those with tricuspid jet velocity < 2.8 – 2.9 m/s and PAP ~ 36 mm Hg [4, 6].

Blood samples taken from the patients for hemogram analysis were examined with the Beckman Coulter LH-750 Hematology Analyzer. Reference (normal) values of RDW (calculated by the following: standard deviation of erythrocyte volume × 100/MCV) were accepted between 11.6–16.5%. Blood was considered positive for troponin if it met the following criteria: troponin-I ≥ 0.04, troponin T ≥ 0.014.

Statistical analysis

Data characterized by a normal distribution were expressed as means and standard deviations. Parameters without such a normal distribution were conveyed as medians with minimum-maximum. Student's t-test (normal distribution) or Mann-Whitney and Wilcoxon (non-normal distribution) tests were used to compare data between the 2 groups. Discrete variables were contrasted using the Fisher's exact test (chi-square test). The effects of the examined parameters on mortality were investigated with a stepwise (backward) logistic regression analysis. ROC analysis was used to calculate the RDW cut-off score. All data were analyzed using IBM SPSS V15 (Chicago, USA). The values of $p < 0.05$ were considered statistically significant.

Results

Clinical settings of patients

A total of 98 patients with acute PTE were initially evaluated. The mean age of all subjects was 67.57 years (± 16.7). Eighty-seven (88.8%) patients were diagnosed with CTPA, 6 (6.1%) -with scintigraphy, and the remaining patients were examined with additional methods, such as clinical and Doppler ultrasonographic analyses. As initial treatment, LMWH was used in 65 patients (66.3%), and standard heparin was applied in 33 persons (33.7%). Thrombolytic therapy was given in addition to standard heparin as an initial treatment in eight patients (8.2%) who were considered as having massive PTE. A vena cava filter was placed in one individual with persistent risk factors. Follow-up treatment was continued in the appropriate patients with oral anticoagulant.

Clinical data, RDW values, and ECHO parameters of 56 prospectively monitored subjects meeting the study criteria were statistically evaluated. Fourteen of these patients (25%) died within the first 90 days after acute PTE. Twelve individuals did not come to the 6th month of the follow-up, and only data taken at the 3 month of the follow-up could be included. Thirty of the 56 patients were observed over the entire 6 months. These 56 subjects were divided into 2 RDW groups, as low-RDW (RDW < 15.2%: Group-1) and high-RDW (RDW ≥ 15.2%: Group-2) according to the value determined in the ROC curve analysis for predicting PTE mortality. The characteristics of the 56 patients in the study group are presented in Table 1.

Echocardiographic evaluation of patients

ECHO parameters of all patients were evaluated and compared with RDW. The mean TAPSE value was 2.20 cm (± 0.43) in the group 1 (RDW < 15.2%) and 1.85 cm (± 0.53) in the group 2 (RDW ≥ 15.2%). There was a significant difference between the two groups ($p = 0.007$) with regard to having right ventricular systolic failure. RDW levels significantly negatively correlated with the TAPSE level at ECHO assessment (Fig. 1, $p = 0.008$, $r = -0.352$). There was a significant increase in the risk of developing right ventricular systolic dysfunction as the levels of RDW grew. Threshold values for tricuspid jet velocity were calculated *via* ROC analysis for survivor and non-survivors. When the threshold value for the tricuspid jet velocity was > 2.35 m/s, the sensitivity and specificity were 76.9% and 61.9%, respectively for predicting mortality (AUC: 0.724, 95% CI: 0.591–0.858, $p = 0.033$).

There was a statistically significant difference in TAPSE and tricuspid jet velocity ($p = 0.018$, $p = 0.033$, respectively) between the survivor and non-survivor groups; however, there was no significant difference in RV/LV ratio to predict mortality. TAPSE and tricuspid jet velocities were found to be more useful than RV/LV ratio in evaluating right heart failure in acute PTE (Table 2). There was a negative correlation between RV/LV ratio and TAPSE ($p = 0.001$, $r = -0.443$), and a positive correlation between RV/LV ratio and tricuspid jet velocity ($p = 0.025$, $r = 0.302$).

Follow-up and outcome data

We compared the data at the first evaluation and at the six-month evaluation of 30 PTE patients who were followed up for six months. The mean PAP of the patients at the first evaluation was 31.37 mm Hg (± 14.78); by six months, this value had decreased to 24.24 mm Hg (± 7.24), as expected ($p = 0.004$). The mean tricuspid jet velocity value (as determined by ECHO) was 2.28 m/s (± 0.66) at the initial evaluation, and 2.01 m/s (± 0.50) at the 6th month ($p = 0.005$). The mean TAPSE value was 2.24 cm (± 0.37) at the initial evaluation and 2.41 cm (± 0.36) at the 6-month evaluation ($p = 0.033$) (Table 3).

ROC analysis was used to identify the optimal RDW cut-off value for all deaths (Fig. 2). In the ROC analysis, the area under the curve (AUC) was 0.755 (95% CI; 0.622-0.860, $p = 0.005$) for RDW levels of all-cause mortality. Serum RDW ≥ 15.2% showed sensitivity and specificity for all-cause deaths as 73.3% and 73.2%, respectively.

Table 1. Baseline patient characteristics according to baseline RDW level

	Total n = 56	Group-1 (RDW < 15.2%) n = 32	Group-2 (RDW ≥ 15.2%) n = 24	*p
Characteristics				
Mean Age (± SD, years)	65.68 ± 16.87	60.28 ± 17.31	72.88 ± 13.48	**0.005**
Sex, Female (%)	34 (60.7)	19 (59.4)	15 (62.5)	1.000
Smoker (%)	12 (21.4)	9 (28.1)	3 (12.5)	0.280
Risk factors				
Surgery	12 (21.4)	8 (25.0)	4 (16.7)	0.072
Immobility	27 (48.2)	11 (34.4)	16 (66.7)	**0.034**
Malignancy	17 (30.4)	5 (15.6)	12 (50.0)	**0.013**
Obesity	1 (1.8)	1 (3.1)	0	1.000
Previous embolism	6 (10.7)	2 (6.3)	4 (16.7)	0.385
FV Leiden mutation	4 (7.1)	4 (12.5)	0	0.127
Laboratory parameters				
RDW (%)	15.29 ± 2.21	13.95 ± 0.65	17.09 ± 2.30	**< 0.001**
CRP (mg/dl)	6.59 ± 6.73	6.43 ± 7.28	6.80 ± 6.05	0.842
Hemoglobin (g/dl)	12.54 ± 1.79	12.87± 1.79	12.10 ± 1.72	0.111
BUN (mg/dl)	20.39 ± 13.95	18.05 ± 8.33	23.51 ± 18.82	0.195
O_2 saturation (%)	91.83 ± 6.0	92.17± 4.93	91.37 ± 7.27	0.627
D-Dimer μg/ml (min-max)	9.19 (0.74–45)	10.88 (0.74–43.40)	6.94 (1.41–45)	0.987
**Troponin elevated (ng/ml%)	27 (48.2)	14 (43.8)	13 (54.2)	0.616
ECHO parameters				
PAP (mm Hg)	35.18 ± 15.60	34.25 ± 15.53	36.47 ± 15.97	0.606
RV (cm)	32.28 ± 6.23	31.40 ± 4.44	33.45± 7.98	0.226
EF (min-max)	63.21 (45–65)	64.06 (55–65)	62.08 (45–65)	0.169
RV/LV	0.76 ± 0.23	0.73 ± 0.13	0.81 ± 0.31	0.243
TAPSE (cm)	2.05 ± 0.50	2.20 ± 0.43	1.85 ± 0.53	**0.007**
T. jet.vel. (m/s)	2.41 ± 0.70	2.37 ± 0.73	2.46 ± 0.67	0.649

CRP: C-reactive protein; PAP: pulmonary artery pressure; RV: right ventricular; RV/LV: right ventricle/left ventricle diameter ratio; RDW: red cell distribution width; TAPSE: tricuspid annular plane excursion; T. jet. vel: Tricuspid jet velocity; ± SD: standard deviation; Values are presented as means ± standard deviation
*group 1 (RDW < 15.2%) and group 2 (RDW ≥ 15.2%) are compared
**Troponin-I ≥ 0.04, Troponin-T ≥ 0.014
Statistically significant differences between survival and non-survival groups are shown in bold

Eleven (45.8%) of the 24 patients in the group 1 (RDW < 15.2%) died and 3 (9.4%) of the 32 patients in the group 2 (RDW≥ 15.2%) died within ninety days (p = 0.005) (Fig. 3).

Mortality predictors of univariate analysis included demographics (age), laboratory parameters (RDW ≥ 15.2%, BUN (md/dl)), ECHO parameters (TAPSE ≤ 1.5 cm, tricuspid jet velocity ≥ 2.35 m/s), clinical findings (respiratory rate > 30/min), and comorbidity (chronic obstructive pulmonary disease, COPD), BUN, tricuspid jet velocity (≥ 2.35 m/s), and RDW were significant independent predictors of mortality in patients with PTE by multivariate regression analysis. RDW was associated with a 7.9-fold (95% CI: 1.5–40.9, p = 0.013) increase in predicting PTE mortality (Table 4).

Discussion

In the present study, we aimed to determine the prognostic value of RDW and ECHO parameters in cases with acute PTE. We found that an RDW cut-off value ≥ 15.2% showed a sensitivity of 73.3% and a specificity of 73.2% for predicting mortality in patients with PTE. Similarly to us,

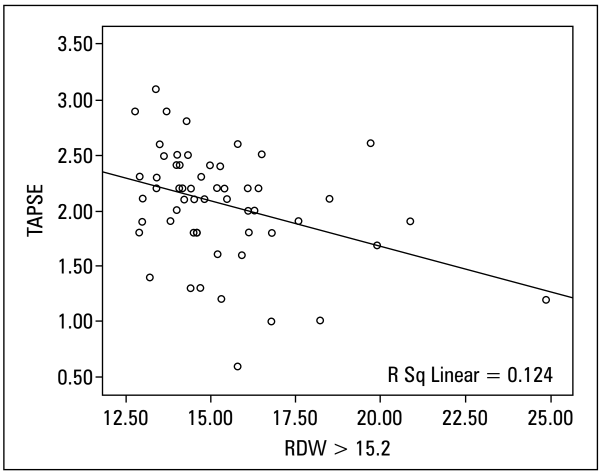

Figure 1. Correlation curve between RDW and TAPSE

Ozsu *et al*. [7] found that RDW is a predictor of all causes of death with an optimal RDW value ≥ 15%. In that study, an RDW ≥ 15% was associated with a 1.2-fold increase in predicting mortality in multivariate analysis. In a retrospective study with 208 PTE patients, it was found that an RDW value ≥ 16.25% was associated with a 4.04-fold growth in forecasting mortality (95 % CI: 1.229–13.335, p = 0.021) [8]. Similarly, in the present study, we found that high RDW levels were associated with a 7.9-fold increase in predicting PTE mortality.

In a retrospective study with a primary end point of hospital mortality, 455 of 1539 patients with PTE died. In the same paper, the subjects were grouped as RDW > 14.8% and ≤ 14.8% by

Table 2. ECHO parameters of survivor or non-survivor patients with PTE

ECHO parameters	Total n = 56 (%)	Survivor n = 42 (%)	Non-Survivor n = 14 (%)	p
TAPSE (≤ 1.5 cm)	8 (14.3)	3 (7.1)	5 (35.7)	0.018
T. jet.vel. (≥ 2.35 m/sn)	26 (47.3)	16 (38.1)	10 (76.9)	0.033
PAP (> 35 mm Hg)	21 (38.2)	13 (31.7)	8 (57.1)	0.170
RV/LV (≥ 0.73)	30 (53.6)	21 (50.0)	9 (64.3)	0.536

TAPSE: tricuspid anuular plane systolic excursion; T. jet vel.: tricuspid jet velocity; PAP: pulmonary artery pressure; RV/LV: right ventricle/left ventricle ratio, threshold values are shown in parenthesis
Statistically significant differences between survival and non-survival groups are shown in bold

Table 3. Parameters of patients at inital and 6 month follow-up

Parameters	Inıtial (SD)	6 Moths Follow-uo (SD)	*p
PAP (mm Hg)	31.37 ± 14.78	24.24 ± 7.24	**0.004**
RV (cm)	30.90 ± 4.83	29.63 ± 4.31	0.132
RV/LV	0.72 ± 0.15	0.73 ± 0.21	0.770
EF (%-min-max)	64.00 (55–65)	64.16 (50–65)	0.666
TAPSE (cm)	2.24 ± 0.37	2.41 ± 0.36	**0.033**
T. jet vel. (m/s)	2.28 ± 0.66	2.01 ± 0.50	**0.005**
RDW (%)	14.33 ± 1.0	14.7 ± 1.1	0.078
HGB (g/dl)	12.50 ± 1.77	13.02 ± 1.74	0.095
Creatinin (mg/dl)	0.85 ± 0.40	0.84 ± 0.38	0.778
BUN (mg/dl)	16.83 ± 8.10	17.3 ± 9.90	0.578
CRP (min-max)	6.69 (0.11–26.0)	1.68 (0.12–17.10)	**< 0.001**
D-Dimer (min-max)	8.38 (1.21–40.0)	0.85 (0.17–2.20)	**< 0.001**

SD: standart deviation; PAP: pulmonary artery pressure; RV: right ventricle; RV/LV: right ventricle/left ventricle ratio; EF: ejection fraction; TAPSE: tricuspid anuular plane systolic excursion; T. tet vel: tricuspid jet velocity; RDW: red blood cell distribution width; HGB: haemoglobin; BUN: blood urea nitrogen; CRP: c-reacitve protein
EF, CRP and d-dimer (non-normal distribution) were assessed by Wilcoxon test
Statistically significant differences between survival and non-survival groups are shown in bold

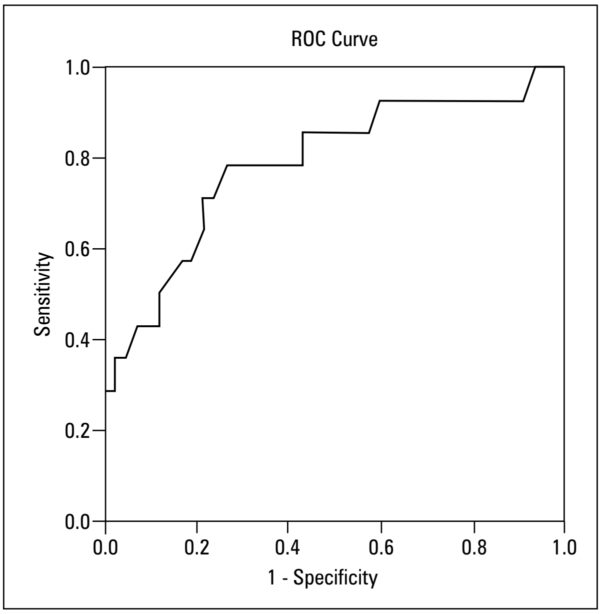

Figure 2. Receiver-operating characteristic curve of red blood cell distribution width (RDW)

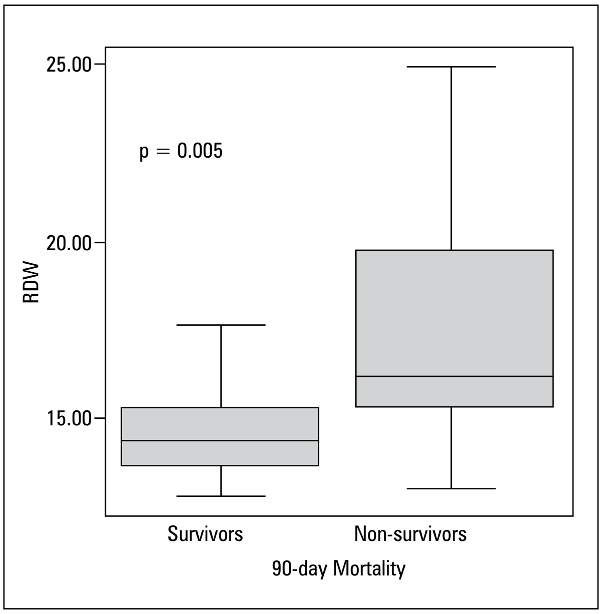

Figure 3. 90-day mortality assessment, survivors vs non-survivors

Table 4. Independent predictors of PE mortality by multivarite logistic regression analysis

	OR	95% CI	p-value
Age, years	1.0	0.9–1	0.907
BUN > 20 mg/dl	5.2	1–25.1	**0.038**
RDW ≥ 15.2%	7.9	1.5–40.9	**0.013**
T. jet.vel. ≥ 2.35 m/s	5.5	1–28.8	**0.042**

CI: confidence interval; OR: odds ratio; BUN: blood urea nitrogen; RDW: red blood cell distribution width; T. tet vel: tricuspid jet velocity
Statistically significant differences between survival and non-survival groups are shown in bold

ROC analysis, and RDW was found to be a significantly independent predictor of mortality by multivariate analysis (OR: 1.1, p = 0.002). The authors surmised that the increase in RDW was mostly due to the inflammatory response to oxidative stress. Furthermore, they found that RDW was significantly elevated in patients with cardiopulmonary disease, those who had undergone abdominal surgery or neurosurgery, and non-survivors [9]. In the current study, RDW was significantly raised in all causes of death within 90 days after PTE.

The mechanism as to why increased levels of RDW are linked to mortality is not yet clear. However, many studies suggest that growths in RDW levels in the acute phase of PTE are caused by increases in inflammatory cytokines, suppression of bone marrow function, decreases in erythrocyte maturation, and rises in oxidative stress. RDW levels tend to be higher particularly in patients with mortal diseases [10, 11].

Another important assessment of PTE prognosis is the development of right heart failure. In the current study, in addition to the relationship between RDW level and mortality, we also assessed the connection between RDW level and right ventricular function. Furthermore, right ventricular function plays a substantial role in the development of massive/submassive PTE.

The assessment of right ventricular function is difficult when it is asymptomatic and the dimensions are normal. In recent years, studies have shown that right ventricular function can be reliably assessed *via* cardiac catheterization, MR (magnetic resonance), radionuclide ventriculography, and 3D echocardiography [12]. However, these methods are not readily available and are not able to be performed in the short term. Among the new methods, TAPSE (as measured by ECHO) is a readily available method. It is a simple echocardiographic measure of the right ventricular ejection fraction. Longitudinal RV measurements

< 16 mm indicate right ventricular dysfunction. Most of the right ventricular motion can be explained by the subendocardial-myocardial fibers that are longitudinally located in the thin right ventricular wall. Therefore, it is thought that the tricuspid annular excursion that occurs between the long axis annular plane and apex can provide important information about global right ventricular functions. TAPSE is recommended for routine use, it provides direct information about right ventricular systolic functions, and has a good correlation with the RV ejection fraction [6, 13].

Tricuspid jet velocity is a parameter that is used to measure right ventricular systolic pressure by adding right atrium pressure. Generally, tricuspid jet velocity is 2.8–2.9 m/s, suggesting that the sPAP is about 36 mm Hg, assuming that the right atrium pressure is 3-5 mm Hg [6].

In their study, Park *et al.* [13] established that both TAPSE and tricuspid annular systolic velocity (TASV) were significantly correlated with echocardiographic parameters in terms of right heart failure. In Park's study, the mean TAPSE of 44 PTE patients was 1.5 (± 4 cm) at the time of admission. This value increased to 2.2 (± 3 cm) at follow-up, which was significant. In the present study, we observed a significant difference between admission and 6-month follow-up values of TAPSE and tricuspid jet velocity used in the measurement of PAP.

Pruszczyk *et al.* [14] found that TAPSE was preferred to the RV/LV (> 0.9) ratio for predicting 30-day mortality in studies investigating the prognostic value of ECHO in normotensive PTE patients. In the current study, there was a significant difference in TAPSE and tricuspid jet velocity between the survivors and non-survivors ($p = 0.018$, $p = 0.033$, respectively). However, there was no significant difference between survivors and non-survivors with regard to the RV/LV ratio. Only tricuspid jet velocity ≥ 2.35 (m/sec) was found to be an independent risk factor for mortality in multivariate logistic regression analysis. TAPSE and tricuspid jet velocities were found to be more valuable than RV/LV ratio in predicting mortality in acute PTE.

In the present study, the TAPSE values of the group 1 were significantly higher than TAPSE values of the group 2 ($p = 0.007$). Furthermore, the TAPSE values of the group 2 revealed a decrease in right ventricular systolic function. Although the TAPSE values measured in our study are not as low as recommended in the guidelines, there was a significant negative correlation between RDW and TAPSE ($p = 0.008$, $r = -0.352$). Our current results revealed that there is a significant increase in the risk of developing right ventricular systolic dysfunction with increasing RDW levels. Tricuspid jet velocities and RV/LV values were not significantly different between the two groups. However, there was a negative correlation between RV/LV ratio and TAPSE and a positive correlation between RV/LV ratio and tricuspid jet velocity. On the whole, these data reveal that many parameters can provide valuable information about right heart failure, but only RDW level and TAPSE level are correlated.

In the current study, we excluded hematologic malignancy patients, subjects with malignant growth who had received active chemotherapy, pregnant women, patients with chronic renal failure undergoing dialysis, and those who had received erythrocyte transfusion within the past 2 weeks; these subjects were excluded because these conditions may increase RDW levels. However, these stringent exclusion criteria and patient inconsistency in follow-ups resulted in a small number of subjects in the current study. This can be considered a limitation of our study. Another weak point is that the relationship between increase of RDW level and chronic thromboembolic pulmonary hypertension (CTEPH) could not be determined due to the absence of pulmonary hypertension in 30 patients during the 6-month follow-up. In their study, Vittorio Peng *et al.* [15] found that the incidence of CTEPH was 1% at the 6-month follow-up, 3.1% at 1-year follow-up, and 3.8% at 2-year follow-up. Other studies have reported the incidence of CTEPH as 1.3% [16] and 5.1% [17] at 1-year follow-up. It is not surprising that we have not seen any pulmonary hypertension development in the current study due to the short observation period and limited number of patients followed up for the full 6 months.

Conclusions

In conclusion, the results of the current study indicate that a high RDW level can be helpful as an independent predictor of mortality in acute PTE. Therefore, close monitoring of these patients can be useful in the clinic. Furthermore, in our study the increase in RDW levels have correlated with the TAPSE level, which indicates the presence of right heart failure in PTE patients and may predict right ventricular systolic function.

Basing on the results of the study, we believe that after randomized clinical trials with more patients, new scoring systems should be developed that include parameters such as RDW, TAPSE, and tricuspid jet velocities, which may be useful in predicting the prognosis of patients with PTE.

Conflict of interest

The authors declare no conflict of interest.

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