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Original Research Article

Mean platelet volume and mean platelet volume/platelet count ratio in risk stratification of pulmonary embolism

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ARTICLE INFO

Article history:
Received 9 September 2014
Received in revised form
17 April 2015
Accepted 1 March 2016
Available online 10 March 2016

Keywords:
Pulmonary embolism
Right ventricular dysfunction
Mean platelet volume
White blood cells
Red cell distribution width

ABSTRACT

Background and objective: Recently, some of the hemogram parameters were reported to predict early death in acute pulmonary embolism (PE). The aim of this study was to investigate the role of mean platelet volume (MPV) and MPV/platelet count ratio (MPV/P), WBC and red cell distribution width (RDW) in risk stratification of patients with acute PE.
Materials and methods: We retrospectively reviewed the medical records of patients with acute PE admitted to the Emergency Department. In addition to the clinical evaluation, the hemogram parameters were measured on admission.
Results: A total of 152 patients were included. Patients with RV dysfunction had significantly higher MPV levels and MPV/P than patients without RV dysfunction. Receiver operating characteristic curve analysis revealed that a MPV cut-off of 7.85 fL provided a sensitivity of 53.3% and a specificity of 68.5%, and a MPV/P cut-off of 0.0339 fL/(10^9/L) provided a sensitivity of 69.6% and a specificity of 65% for the prediction of RV dysfunction. There was a positive correlation between MPV and systolic pulmonary artery pressure (SPAP) and between MPV and RV diameter. There was a positive correlation between MPV/P and SPAP and between MPV/P and RV diameter. The low-risk PE group had lower MPV and MPV/P than the massive PE and submassive PE groups.
Conclusions: MPV and MPV/P were found to be associated with RV dysfunction and clinical severity in acute PE. Low MPV and MPV/P levels may be an indicator of low risk and, high WBC levels may be an indicator of high risk in patients with acute PE. RDW levels may not reflect severity of acute PE.

Presented at the 35th International Symposium on Intensive Care and Emergency Medicine, on 17–20 March 2015, in Brussels, Belgium.
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Peer review under the responsibility of the Lithuanian University of Health Sciences.

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.medici.2016.03.001

1. Introduction

Risk stratification of patients with acute pulmonary embolism (PE) represents an important step and may help to guide the initial therapeutic management. Right ventricular (RV) dysfunction as evaluated by echocardiography is associated with a high mortality risk in patients with acute PE [1]. Patients with RV dysfunction and arterial hypotension require more aggressive therapeutic strategies. In recent years, there has been an increasing interest in the risk stratification of patients with acute PE using standardized blood tests [2].

Acute PE is a consequence of deep vein thrombosis (DVT) in most cases [3]. Thrombosis begins with the aggregation of erythrocytes, fibrin, and platelets. Platelets have a central role in the pathogenesis of thromboembolic disease [4]. Platelets produce proinflammatory molecules, which have prothrombotic activity [5]. Platelet size has been shown to reflect platelet activity [4]. The mean platelet volume (MPV) is a parameter of platelet volume that can be determined routinely in nearly all clinical laboratories, and it is accepted as a marker in determining thrombocyte function [5,6].

Increased MPV in thromboembolic disease is considered an important risk factor [7]. It was found that MPV values were significantly increased in cerebral venous sinus thrombosis patients with brain parenchymal lesions [5]. An elevated MPV is also associated with acute DVT, MPV and the MPV/platelet count ratio (MPV/P) can be considered meaningful laboratory markers for determining the risk of DVT [7,8]. Platelet activation is observed in patients with acute PE [9]. It has been shown that MPV was significantly elevated in acute PE [10]. It was also reported that MPV is an independent predictor of early death in acute PE [11]. In addition, several studies showed the prognostic value of white blood cells (WBC) and red cell distribution width (RDW) in PE [12–15]. However, in the literature, the role of MPV, MPV/P, WBC and RDW in the evaluation of patients with acute PE is less clear. The aim of this study was to investigate the role of MPV, MPV/P, WBC and RDW in risk stratification of patients with acute PE.

2. Materials and methods

2.1. Study design and setting

This study was designed retrospectively by examining the files of all patients with confirmed acute PE who were admitted to the Emergency Department (ED), Ondokuz Mayis University, from January 2008 to December 2012. The study protocol was approved by the local ethics committee.

2.2. Selection of participants

The initial evaluation of the patients included clinical history and physical examination, hemogram parameters, arterial blood gas analysis, chest radiograph, and 12-lead electrocardiography. Patients presenting with clinically suspected PE were referred for further diagnostic workup. The diagnosis of PE was confirmed by contrast-enhanced spiral computed tomography (CT) or a high probability ventilation/perfusion lung scan [2]. The study group consisted of 166 patients with acute PE. Patients with chronic renal or hepatic disease were excluded from the study ($n = 6$). In addition, 8 patients without echocardiographic examination were excluded from the study.

Patients were divided into two groups based on the presence or not of RV dysfunction on the echocardiography. Moreover, patients were classified into three groups: (a) massive PE (RV dysfunction and cardiogenic shock), (b) submassive PE (RV dysfunction and a preserved arterial pressure) and (c) low-risk PE (no RV dysfunction) for risk stratification [16].

2.3. Echocardiography

Transthoracic echocardiography was performed by a cardiologist. Echocardiography for the assessment of RV dysfunction was performed (Vivid 7, GE Vingmed Ultrasound; Horten, Norway) using a 2.5 MHz phased-array transducer with the patients in the left lateral decubitus position, on the same day of diagnosis of acute PE. All parameters were measured according to the recommendations of the American Society of Echocardiography [17]. Patients with at least one of the following findings were diagnosed as having RV dysfunction: RV hypokinesis (asymmetrical or delayed contraction, usually in the RV base), paradoxical septal systolic motion or RV dilatation (end-diastolic diameter >30 mm or right-to-left ventricular end-diastolic diameter ratio ≥1 in an apical 4-chamber view) [18].

2.4. Baseline measurements

Initial hemogram parameters were evaluated in this study. In all patients, venous peripheral blood samples for measurements were drawn on admission. Blood samples were taken into standardized tubes containing dipotassium ethylenediaminetetraacetic acid (EDTA) and stored at room temperature. Blood samples were sent directly to the ED laboratory and analyzed immediately as per standard protocol. Hemogram parameters were analyzed on a fully-automated hematological analyzer, ADVIA 2120 (Siemens Medical Solutions Diagnostics; Tarrytown, NY, USA), within 30 min after blood sampling. According to our laboratory, the reference values of MPV are 6.1–8.9 fL.

2.5. Statistical analysis

All statistical calculations were made using the Statistical Package for the Social Sciences (SPSS) for Windows version 15.0 (SPSS Inc Headquarters, Chicago, IL, USA) software program. To identify the normal distribution, the Kolmogorov–Smirnov test was applied. Values are reported as median (min–max) for quantitative variables. Kruskal–Wallis analysis of variance, Mann–Whitney U, and Bonferroni-corrected Mann–Whitney U tests were used to compare the groups. Receiver operating characteristic (ROC) curves for predicting RV dysfunction were generated from the data. Sensitivity and specificity were also calculated for MPV levels and MPV/P. A P value of <0.05 was accepted as statistically significant for Mann–Whitney U and Kruskal–Wallis analysis

Table 1 – Baseline characteristics of patients with acute pulmonary embolism with and without right ventricular dysfunction.

Characteristic	All patients (n = 152)	RV dysfunction (n = 92)	No RV dysfunction (n = 60)	P
Age, years	65 (18–94)	68 (18–89)	52.5 (18–94)	<0.001
Female, n (%)	82 (54)	53 (57.6)	29 (48.3)	NS
SBP, mmHg	120 (70–180)	110 (70–180)	120 (90–150)	<0.05
Heart rate, beat/min	97 (50–152)	102 (50–150)	89.5 (60–152)	<0.05
Laboratory findings				
WBC, 1000/μL	7.8 (2.4–27.9)	8.9 (3.7–27.9)	7.7 (2.4–21)	NS
Hemoglobin, g/dL	12.8 (7.4–17)	13 (7.4–16.3)	12.5 (9.3–17)	NS
MPV, fL	8.1 (6–11.9)	8.3 (6–11.9)	7.7 (6.1–10)	<0.001
Platelet count, 1000/μL	230 (78–740)	206 (78–612)	263 (120–740)	<0.001
MPV/P, fL/(10^9/L)	0.0360 (0.01–0.09)	0.0389 (0.01–0.09)	0.0281 (0.01–0.06)	<0.001
RDW (%)	15.2 (10.2–26)	15.4 (10.2–26)	14.8 (12.4–24.3)	NS
Echocardiographic data				
LVEF, %	60 (41–70)	57.5 (41–70)	60 (49–68)	<0.05
RV hypokinesis, n (%)	36 (23.7)	36 (39.1)	0	<0.001
RVEDD, mm	32 (20–45)	35 (31–45)	27 (20–30)	<0.001
SPAP, mmHg	45 (20–85)	54 (25–85)	35 (20–55)	<0.001
Comorbidities (yes), n (%)				
Malignancy	18 (11.8)	9 (9.8)	9 (15)	NS
Coronary artery disease	11 (7.2)	6 (6.5)	5 (8.3)	NS
History of CVA	12 (7.9)	7 (7.6)	5 (8.3)	NS
History of pulmonary embolism	9 (5.9)	6 (6.5)	3 (5)	NS
History of DVT	25 (16.4)	15 (16.3)	10 (16.7)	NS

Values median (min–max) unless otherwise indicated.
SBP, systolic blood pressure; WBC, white blood cells; MPV, mean platelet volume; MPV/P, MPV/platelet count ratio; RDW, red cell distribution width; LVEF, left ventricular ejection fraction; RV, right ventricle; RVEDD, right ventricular end-diastolic diameter; SPAP, systolic pulmonary artery pressure; CVA, cerebrovascular accident; DVT, deep vein thrombosis.

of variance. P values of <0.017 were accepted as statistically significant for the Bonferroni-corrected Mann–Whitney U test. Spearman correlation analysis was used to examine the relationships between the variables.

3. Results

A total of 152 patients diagnosed with acute PE (median age, 65 years; range, 18–94; 82 women) were enrolled in this study. The baseline clinical characteristics of the patients are shown in Table 1.

There were 92 patients (60.5%) with RV dysfunction. Patients with RV dysfunction had significantly higher MPV, MPV/P and platelet levels than patients without RV dysfunction. There was no significance difference between patients with and without RV dysfunction with respect to WBC and RDW levels (Table 1). The cut-off value for the prediction of RV dysfunction was 7.85 fL for MPV, which was identified by ROC analysis. The area under the curve (AUC) was 0.671 (95% confidence interval [CI], 0.584; 0.758). A MPV of >7.85 fL had a sensitivity of 53.3%, specificity of 68.5%, positive predictive value of 69.2%, and negative predictive value of 52.4%. The cut-off value for prediction of RV dysfunction was 0.0339 fL/(10^9/L) for MPV/P. The AUC was 0.734 (95% CI, 0.653; 0.815). A MPV/P of >0.0339 fL/(10^9/L) had a sensitivity of 69.6%, specificity of 65%, positive predictive value of 75.3%, and negative predictive value of 58.2% (Figure).

There was a positive correlation between MPV and systolic pulmonary artery pressure (SPAP) and between MPV and RV diameter, as well as between SPAP and RV diameter (r = 0.305, $P < 0.05$; r = 0.253, $P < 0.05$; and r = 0.633, $P < 0.05$, respectively). There was a positive correlation between MPV/P and SPAP and between MPV/P and RV diameter (r = 0.342, $P < 0.05$ and r = 0.344, $P < 0.05$, respectively). There was a negative correlation between platelet count and MPV and between platelet

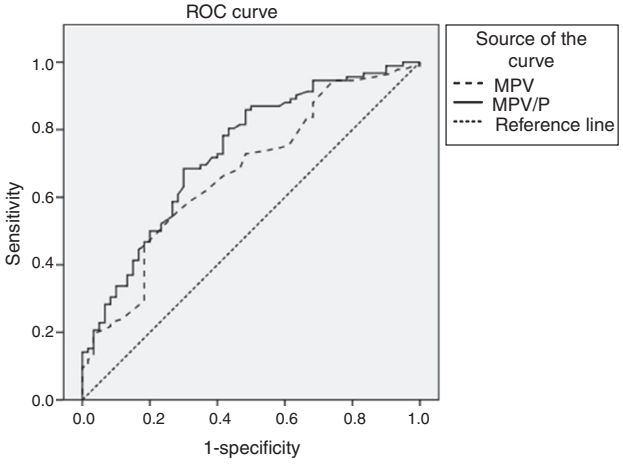

Figure – ROC curve analysis of MPV and MPV/P for prediction of RV dysfunction. At the cut-off value of >7.85 fL, sensitivity and specificity of MPV were 53.3% and 68.5%, respectively (AUC = 0.671, 95% CI, 0.584; 0.758). At the cut-off value of >0.0339 fL/(10^9/L), sensitivity and specificity of MPV/P were 69.6% and 65%, respectively (AUC = 0.734, 95% CI, 0.653; 0.815).

Table 2 – Comparison of hemogram parameters and systolic blood pressure according to clinical groups.

Parameter	Massive PE ($n = 20$)	Submassive PE ($n = 72$)	Low-risk PE ($n = 60$)
MPV, fL	8.4 (6.3–11)*	8.3 (6–11.9)*	7.7 (6.1–10)
MPV/P, fL/(10^9/L)	0.0424 (0.02–0.09)*	0.0377 (0.01–0.08)*	0.0281 (0.01–0.06)
Platelet count, 1000/μL	197 (78–342)*	212 (96–612)*	263 (120–740)
WBC, 1000/μL	12.9 (6.1–22)*,†	7.6 (3.7–27.9)	7.7 (2.4–21)
RDW, %	15.2 (13.3–26)	15.4 (10.2–24.8)	14.8 (12.4–24.3)
SBP, mmHg	80 (70–85)*,†	120 (95–180)	120 (90–150)

Values are median (min–max).
MPV, mean platelet volume; MPV/P, MPV/platelet count ratio; WBC, white blood cells; RDW, red cell distribution width; SBP, systolic blood pressure.
* $P < 0.017$ compared to the low-risk PE group.
† $P < 0.017$ compared to the submassive PE group.

count and MPV/P ($r = -0.238$, $P < 0.05$ and $r = -0.953$, $P < 0.05$, respectively).

Sixty (39.5%) patients were diagnosed with low-risk PE, 72 (47.4%) with submassive PE and 20 (13.2%) with massive PE. The low-risk PE group had lower MPV, MPV/P and platelet than the massive PE and submassive PE groups. However, there was no significant difference between the massive PE and submassive PE groups with respect to these parameters (Table 2). Massive PE group had higher WBC levels than other clinical groups. In addition, there was no significance difference between clinical groups with respect to RDW levels (Table 2).

4. Discussion

Human platelets are involved in many pathophysiological processes, including hemostasis and thrombosis, clot retraction, vessel constriction and repair, inflammation including promotion of atherosclerosis, host defense, and even tumor growth/metastasis [11]. Platelet size, measured as MPV, is a marker of its function. Increased platelet volume is associated with increased platelet reactivity, shortened bleeding time, increased platelet aggregation, and higher thrombotic potential [19]. It is known that cardiac dysfunction can cause platelet activation and increased MPV [20].

In the present study, patients with RV dysfunction had significantly higher MPV levels and MPV/P than patients without RV dysfunction. The cut-off value in the prediction of RV dysfunction was 7.85 fL for MPV, with a sensitivity of 53.3% and a specificity of 68.5%, and 0.0339 fL/(10^9/L) for MPV/P, with a sensitivity of 69.6% and a specificity of 65%. There was a positive correlation between MPV and SPAP and between MPV and RV diameter. There was a positive correlation between MPV/P and SPAP and between MPV/P and RV diameter. In addition, we found that patients with low-risk acute PE presented significantly lower MPVs and MPV/Ps than patients with submassive PE or massive PE acute PE. Our results revealed that MPV and MPV/P are associated with RV dysfunction and clinical severity in acute PE.

It is known that platelet activation is evident after acute PE. Platelet activation correlates with the severity of RV dysfunction and can persist for several months after acute PE [9]. Similar to our results, Kostrubiec et al. [11], Varol et al. [10], and Hilal et al. [21] reported a positive correlation between MPV and RV diameter in patients with acute PE. Kostrubiec et al. [11] also reported that MPV values were significantly related to the severity of acute PE. Similar to our results, they found that patients with low-risk acute PE presented significantly lower MPVs than patients with intermediate- or high-risk acute PE. Moreover, they reported that MPV was a significant predictor of 30-day mortality and, especially, 7-day mortality in acute PE. Similarly, Hilal et al. [21] reported increased MPV in non-surviving acute PE patients. Recently, Günay et al. [22] found a positive correlation between CT pulmonary arterial obstruction index and MPV in patients with acute PE. They suggested that MPV could be used for the determination of disease severity and lead to therapeutic strategies for PE patients.

The following potential explanations of increased MPV in patients with acute PE can be suggested. RV dysfunction and failure, in association with impaired left ventricular filling and reduced cardiac output and the resultant hypoxemia, are potent stimuli of platelet activation [10]. We found that MPV and MPV/P were negatively correlated with platelet count. MPV inversely correlates with the total platelet count, which could even suggest the consumption of small platelets and a compensatory production of larger reticulated platelets. Increased MPV and low platelet count could therefore be associated with activation of the coagulation system. An increased MPV/P can be regarded as increased MPV and a low platelet count status [7,23].

Recently, increased levels of MPV and MPV/P were identified as predictors of DVT [7]. PE and DVT are two clinical presentations of venous thromboembolism and share the same predisposing factors. In most cases, PE is a consequence of DVT [10]. To the best of our knowledge, the observation of MPV/P as a potential marker for risk stratification of acute PE has not been reported previously. Logically, MPV/P can bear a greater diagnostic value than MPV alone because MPV and the platelet count generally have an inverse relationship [7]. In our study, sensitivity and AUC of MPV/P were higher than those of MPV alone in the prediction of RV dysfunction. MPV/P may be a more useful predictor than MPV in risk stratification of acute PE.

In recent years, several studies focused the prognostic value of WBC and RDW in patients with acute PE [12–15]. However, relation between WBC and RDW levels and severity of PE is less clear. Regarding the WBC, a previous study demonstrated that leukocytosis may be associated with PE [24]. Huang et al. [15] suggested that elevated WBC on

admission can be used to identify the risk for a short-term fatal outcome within 30 days in patients with acute PE. In our study, there was no significance difference between patients with and without RV dysfunction in respect to WBC levels. However, massive PE group had higher WBC levels than other clinical groups. Present study suggests that high WBC levels may be a predictor of high risk in patients with acute PE.

Recently, Ozsu et al. [13] found RDW as a newly recognized and independent predictor of PE inhospital mortality. Similarly, Zorlu et al. [14] reported that RDW was moderately correlated with hemodynamic parameters and designated increased mortality in patients with acute PE. In addition they thought that RDW may reflect increasing severity of acute PE. In the present study, there was no significance difference between patients with and without RV dysfunction in respect to RDW levels. In addition there was no significance difference between clinical groups in respect to RDW levels. The present study suggests that RDW levels may not reflect the severity of acute PE. RDW increases during inflammation, similar to the increase seen in other inflammatory parameters, suggesting that RDW may be increased due to chronic inflammation [12]. PE is an acute process, and therefore, RDW levels may not direct reflect severity of PE. The reason for the increase of RDW in cardiovascular and pulmonary diseases is not clearly understood. Nutritional deficiencies, co-morbid diseases, and deterioration of renal function appear along with the clinical status of patients with chronic cardiopulmonary diseases [14]. Many chronic processes such as co-morbid diseases may be related with increased RDW levels in PE.

Our study has some limitations. It is a single-center study. Our analysis involved a simple baseline determination at a single time point that may not reflect the patient status over long periods. We also did not evaluate the prognostic value of MPV, MPV/P, WBC and RDW in patients with acute PE. Prospective and controlled studies involving larger numbers of patients with acute PE are needed.

5. Conclusions

The present study suggests that MPV and MPV/P are associated with RV dysfunction and clinical severity in acute PE. These parameters may be useful in the evaluation and risk stratification of patients with acute PE. Low MPV and MPV/P levels may be an indicator of low risk in patients with acute PE. High WBC levels may be a predictor of high risk in patients with acute PE. RDW levels may not reflect the severity of acute PE.

Conflict of interest

The authors state no conflicts of interest.

Acknowledgements

The authors thank Dr. Ahmet Tevfik Sunter for providing statistical advice.

REFERENCES

[1] Sanchez O, Planquette B, Roux A, Gosset-Woimant M, Meyer G. Triaging in pulmonary embolism. Semin Respir Crit Care Med 2012;33:156–62.
[2] Yardan T, Altintop L, Baydin A, Yilmaz O, Guven H. B-type natriuretic peptide as an indicator of right ventricular dysfunction in acute pulmonary embolism. Int J Clin Pract 2008;62:1177–82.
[3] Torbicki A, Perrier A, Konstantinides S, Agnelli G, Galiè N, Pruszczyk P, et al. Guidelines on the diagnosis and management of acute pulmonary embolism: the Task Force for the Diagnosis and Management of Acute Pulmonary Embolism of the European Society of Cardiology (ESC). Eur Heart J 2008;29:2276–315.
[4] Cil H, Yavuz C, Islamoglu Y, Tekbas EÖ, Demirtas S, Atilgan ZA, et al. Platelet count and mean platelet volume in patients with in-hospital deep venous thrombosis. Clin Appl Thromb Hemost 2012;18:650–3.
[5] Kamisli O, Kamisli S, Kablan Y, Gonullu S, Ozcan C. The prognostic value of an increased mean platelet volume and platelet distribution width in the early phase of cerebral venous sinus thrombosis. Clin Appl Thromb Hemost 2013;19:29–32.
[6] Aliosmanoglu I, Gul M, Oguz A, Basol O, Uslukaya O, Keles C. Can mean platelet volume be a new risk factor in portal venous thrombosis? Clin Appl Thromb Hemost 2013;19:433–6.
[7] Han JS, Park TS, Cho SY, Joh JH, Ahn HJ. Increased mean platelet volume and mean platelet volume/platelet count ratio in Korean patients with deep vein thrombosis. Platelets 2013;24:590–3.
[8] Canan A, Halıcioğlu SS, Gürel S. Mean platelet volume and D-dimer in patients with suspected deep venous thrombosis. J Thromb Thrombolysis 2012;34:283–7.
[9] Chung T, Connor D, Joseph J, Emmett L, Mansberg R, Peters M, et al. Platelet activation in acute pulmonary embolism. J Thromb Haemost 2007;5:918–24.
[10] Varol E, Icli A, Uysal BA, Ozaydin M. Platelet indices in patients with acute pulmonary embolism. Scand J Clin Lab Invest 2011;71:163–7.
[11] Kostrubiec M, Łabyk A, Pedowska-Włoszek J, Hrynkiewicz-Szymańska A, Pacho S, Jankowski K, et al. Mean platelet volume predicts early death in acute pulmonary embolism. Heart 2010;96:460–5.
[12] Sen HS, Abakay O, Tanrikulu AC, Sezgi C, Taylan M, Abakay A, et al. Is a complete blood cell count useful in determining the prognosis of pulmonary embolism? Wien Klin Wochenschr 2014;126:347–54.
[13] Ozsu S, Abul Y, Gunaydin S, Orem A, Ozlu T. Prognostic value of red cell distribution width in patients with pulmonary embolism. Clin Appl Thromb Hemost 2014;20:365–70.
[14] Zorlu A, Bektasoglu G, Guven FM, Dogan OT, Gucuk E, Ege MR, et al. Usefulness of admission red cell distribution width as a predictor of early mortality in patients with acute pulmonary embolism. Am J Cardiol 2012;109:128–34.
[15] Huang CM, Lin YC, Lin YJ, Chang SL, Lo LW, Hu YF, et al. Risk stratification and clinical outcomes in patients with acute pulmonary embolism. Clin Biochem 2011;44:1110–5.
[16] Kucher N, Goldhaber SZ. Cardiac biomarkers for risk stratification of patients with acute pulmonary embolism. Circulation 2003;108:2191–4.
[17] Schiller NB, Shah PM, Crawford M, DeMaria A, Devereux R, Feigenbaum H, et al. Recommendations for quantitation of the left ventricle by two-dimensional echocardiography. American Society of Echocardiography Committee on Standards, Subcommittee on Quantitation of

Two-Dimensional Echocardiograms. J Am Soc Echocardiogr 1989;2:358–67.
[18] Golpe R, Pérez-de-Llano LA, Castro-Añón O, Vázquez-Caruncho M, González-Juanatey C, Veres-Racamonde A, et al. Right ventricle dysfunction and pulmonary hypertension in hemodynamically stable pulmonary embolism. Respir Med 2010;104:1370–6.
[19] Braekkan SK, Mathiesen EB, Njølstad I, Wilsgaard T, Størmer J, Hansen JB. Mean platelet volume is a risk factor for venous thromboembolism: the Tromsø Study, Tromsø, Norway. J Thromb Haemost 2010;8:157–62.
[20] Chung I, Choudhury A, Lip GY. Platelet activation in acute, decompensated congestive heart failure. Thromb Res 2007;120:709–13.
[21] Hilal E, Neslihan Y, Gazi G, Sinan T, Zeynep Ayfer A. Does the mean platelet volume have any importance in patients with acute pulmonary embolism? Wien Klin Wochenschr 2013;125:381–5.
[22] Günay E, Sarinc Ulasli S, Kacar E, Halici B, Unlu E, Tünay K, et al. Can platelet indices predict obstruction level of pulmonary vascular bed in patients with acute pulmonary embolism? Clin Respir J 2014;8:33–40.
[23] Sewell R, Ibbotson RM, Phillips R, Carson P. High mean platelet volume after myocardial infarction: is it due to consumption of small platelets? Br Med J (Clin Res Ed) 1984;289:1576–8.
[24] Afzal A, Noor HA, Gill SA, Brawner C, Stein PD. Leukocytosis in acute pulmonary embolism. Chest 1999;115:1329–32.