Assessment of bronchial asthma exacerbation: the utility of platelet indices
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Background Activated platelets and platelet indices have a vital role in bronchial hyper-responsiveness, bronchoconstriction, bronchial inflammation, airway remodeling, angiogenesis, allergic reactions, and repair and renewal of tissues; platelets contain mediators that lead to inflammatory response.

Aim The aim was to assess the use of platelet indices [mean platelet volume (MPV), platelet distribution width (PDW), plateletcrit (PCT), and platelet large cell ratio (PLCR)] as cheap and readily available biomarkers for bronchial asthma exacerbation.

Patients and methods A case–control study involved 45 bronchial asthma female patients during both stable and exacerbation phases, and 45 age-matched healthy female patients as a control group. Measurements of platelet counts, MPV, PDW, PCT, PLCR, C-reactive protein (CRP), spirometric indices, and arterial blood gases were performed for all participants.

Results The MPV and PDW were significantly lower, whereas the PCT and PLCR were considerably higher in exacerbation phase compared with stable phase and in stable phase in comparison with controls ($P<0.001$). The MPV and PDW were negatively correlated with white blood cells, PaCO2, symptoms duration, and hs-CRP (high sensitive), with positive correlation with forced expiratory volume in the first second and PaO2 ($P<0.001$). PCT and PLCR were positively correlated with white blood cells, PaO2, and symptoms duration, and negatively correlated with forced expiratory volume in the first second, symptoms duration, and hs-CRP ($P<0.001$).

Conclusion The platelet indices were altered in exacerbation phase compared with stable phase and control group. Therefore, clinicians should not ignore interpreting platelet indices during asthma exacerbation, especially as these tests are simple, readily available, and of lower cost. It appears that measurement of the platelet indices is a valuable indicator of asthma severity/activity and appears as a useful screening test for asthma exacerbation.

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Keywords: asthma exacerbation, mean platelet volume, platelet distribution width, platelet indices

Type and place of the study
This observation case–control study was conducted at Chest Diseases Department of our hospital during the period from October 2016 to January 2018.

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Inclusion criteria
The study was conducted on 45 known bronchial asthma female patients during both exacerbation and stable phase of their disease, in addition to 45 age-matched healthy women as a control group.

(1) Bronchial asthma patient group: it included 45 patients who were admitted to our department with symptoms of asthma exacerbation. Asthma exacerbation was defined as the existence of any one of the following events: emergency visits related to asthmatic attack (asthmatic attack-related hospitalization), or the use of systematic corticosteroids for at least 3 days. Inhaled short-acting and long-acting β2-agonist, inhaled steroids, oral steroids, and antibiotics were ordered to treat asthma exacerbation. After 8 weeks following the attack, the patients were re-evaluated when they were symptom free. Stable asthma was defined as no exacerbation of symptoms in the past 8 weeks [1].

(2) Controls: apparently healthy age-matched, nonsmoking women were included as a control group. They had no symptoms suggestive of any chest illnesses, and their spirometry and arterial blood gases (ABG) were in the normal range.

Exclusion criteria
As smoking and inflammatory, infectious, and allergic diseases tend to cause an increase in platelet production by stimulating the bone marrow, therefore, smokers, as well as patients with the following diseases were excluded from the study: diabetes mellitus, hypertension, malignancies, hematological disorder, valvular lesions, coronaries disease, heart failure, autoimmune diseases, liver cell failure, renal failure, those with other chest diseases. Moreover, to avoid possible effect of certain medications on platelet function, patients treated with an anticoagulant, statins, angiotensin-converting enzyme, acetylsalicylic acid, and clopidogrel were excluded from the study.

All participants were subjected to the following:

1. The BMI was measured as weight (kg)/height (m²).
2. Spirometry: it was carried out on MEDISOFT–HYPERAIR compact+flow meter pulmonary function testing (Medisoft Belgium (Headquarter), P.A.E de Sorinnes, 1 Route de la Voie Cuivrée, 5503 Sorinnes, Belgium). It was performed before and after the inhalation of short-acting B2-agonist. The following spirometric indices were recorded: forced vital capacity (FVC%), forced expiratory volume in the first second (FEV1%), FEV1/FVC ratio, and forced expiratory flow rate of 25–75 (FEF 25–75%). A postbronchodilator spirometry was done 10–15 min following the inhalation of 400 μg Salbutamol. A rise in FEV1 greater than 200 ml and/or 12% above the prebronchodilator FEV1 at time of diagnosis was considered diagnostic [8]. Positive result of reversibility with a bronchodilator is recorded [8]. Spirometric indices were calculated as the best of three technically acceptable performances, in agreement with the ERS recommendations [9].
3. ABG: it was performed following a 15-min resting period in room air using a Rapid Lab 248 blood gases analyzer; O₂ saturation, PaO₂, and PaCO₂ were recorded.
4. Complete blood count: venous samples were collected from participants in the morning between 8.00 and 9.00 a.m. after an 8 h overnight fasting. Venous blood samples were drawn from cubital vein and immediately placed in EDTA-containing tubes (Becton Dickinson Vacuum, Becton, Dickinson and Company, Franklin Lakes, New Jersey, USA) and mixed gently. White blood cells (WBC), platelet count, MPV (fl) and PDW (fl), PCT, and PLCR% were measured within 1–2 h of blood sampling using a hematological analyzer (Sysmex XE-21N, Kobe, Japan). The analyzer was calibrated daily using a standardized, commercially available calibrator kit. Blood samples were placed in standard tubes containing EDTA and analyzed within 1 h after venepuncture. Thus, we had standard EDTA tubes and time window for the analysis [10,11].
5. High-sensitivity CRP assay: to detect the hs-CRP level, 3 ml of venous blood sample was taken into standard biochemical tubes and centrifuged for 20 min. hs-CRP assay is based on the principle of solid-phase enzyme-linked immunosorbent assay. Expected values were based on published literature, and healthy adult individuals are expected to be 68–8200 ng/ml.

Ethical approval
The study was performed after the Ethical Review Committee approval. Participation was voluntary; an informed oral consent was attained individually from each study participant before enrolment into study.

Statistical analysis of data
Statistics were analyzed by the Statistical Package for the Social Sciences (SPSS) program version 17.0
Descriptive analysis was performed for each item and the results were stated as mean±SD for quantitative continuous variables, and as percentages for qualitative (categorical and nominal) variables. Comparisons for assessing the difference between the groups were done using the χ²-test for qualitative data and the analysis of variance test and Student’s t-test for quantitative data. A linear correlation coefficient was done to detect the correlation between two quantitative variables in the same group. Statistical significance was considered by a P value less than 0.05 (with a confidence limit at 95%).

Results

Asthmatic patients and controls were matched regarding age (40.0±15.2 and 41.2±15.1, respectively) and BMI (27.2±3.3 and 26.3±3.6, respectively) (P>0.05). Table 1 shows that the FEV₁/FVC, FEV₁, FEF₂₅₋₇₅%, O₂ saturation, and PaO₂ were significantly declined in exacerbation phase compared with both stable phase and control group, and in stable phase compared with control group (P<0.05). Additionally, FVC% was significantly decreased in exacerbation phase compared with both stable phase and control group. PaCO₂ was significantly higher in exacerbation phase in comparison with both stable phase and control group (P<0.01).

Table 1: Comparison of spirometric indices and arterial blood gases parameters during exacerbation phase, stable phase, and control group

|                      | Bronchial asthma group (mean±SD) | Control group (mean±SD) | ANOVA test | Post-hoc analysis |
|----------------------|----------------------------------|-------------------------|------------|------------------|
|                      | Exacerbation phase               | Stable phase            |            |                  |
| FEV₁/FVC             | 69.9±4.7                        | 77.8±4.6                | 69.1±4.0   | 163.9            | 0.001* 0.002 0.001 |
| FEV₁%                | 53.5±16.0                       | 63.3±14.6               | 83.7±2.7   | 67.3             | 0.001* 0.002 0.001* |
| FVC%                 | 81.6±3.8                        | 85.4±2.8                | 85.2±4.2   | 15.1             | 0.002 0.85 0.002* |
| VC%                  | 87.2±3.3                        | 88.6±3.1                | 89.6±4.1   | 6.01             | 0.003* 0.15 0.045 |
| FEF₂₅₋₇₅%            | 59.1±6.4                        | 62.7±4.9                | 68.8±3.7   | 40.6             | 0.002 0.002 0.001* |
| O₂ saturation        | 95.0±2.3                        | 96.0±1.7                | 96.2±1.3   | 4.8              | 0.009 0.05 0.014* |
| PaO₂                 | 82.5±6.0                        | 84.9±3.6                | 89.4±3.4   | 26.9             | 0.001 0.001 0.001 0.014* |
| PaCO₂                | 40.6±3.3                        | 38.8±2.2                | 38.9±2.0   | 7.0              | 0.002 0.89 0.001 |

ABG, arterial blood gas; ANOVA, analysis of variance; FEF, forced expiratory flow rate; FEV₁, forced expiratory volume in the first second; FVC, forced vital capacity; P₁, exacerbation phase vs controls; P₂, stable phase vs controls; P₃, exacerbation phase vs stable phase. *Significant test.

Table 2: Comparison of platelet count, platelet indices, white blood cells, and high-sensitivity C-reactive protein during exacerbation phase, stable phase, and control group

| Items              | Bronchial asthma group (mean±SD) | Control group (mean±SD) | Test value* P value Post-hoc analysis |
|--------------------|----------------------------------|-------------------------|--------------------------------------|
|                    | Exacerbation phase               | Stable phase            |                                      |
| WBC                | 9.1±1.7                          | 7.9±1.1                 | 7.5±1.0                              | 17.6 0.001* 0.001* 0.13 0.001* |
| Platelet count     | 366.8±42.5                       | 360.2±37.5              | 363.5±57.0                           | 0.23 0.795 0.736 0.73 0.49 |
| MPV                | 8.39±1.1                         | 10.86±1.1               | 11.1±1.5                             | 61.8 0.001* 0.001* 0.25 0.001* |
| PDW                | 11.3±1.7                         | 11.9±1.3                | 12.1±1.2                             | 3.9 0.021* 0.007 0.449 0.050 |
| PCT                | 0.25±0.03                        | 0.25±0.02               | 0.23±0.01                            | 4.1 0.019 0.011 0.020 0.819 |
| PLCR               | 33.3±7.4                         | 30.5±3.3                | 25.3±5.4                             | 23.1 0.001* 0.001* 0.001 0.023* |
| hs-CRP ng          | 12030.4±5736.2                   | 10012.4±4328.2          | 8086.6±1926.8                        | 9.4 0.001 0.001 0.035 0.028 |

hs-CRP, high-sensitivity C-reactive protein; MPV, mean platelet volume (fl); P₁, exacerbation phase vs controls; P₂, stable phase vs controls; P₃, exacerbation phase vs stable phase; PCT, platelet crates; PDW, platelet distribution width (%); PLCR, platelet large cell ratio. *Significant test.

SPSS Inc., Chicago, Illinois, USA). Descriptive analysis was performed for each item and the results were stated as mean±SD for quantitative continuous variables, and as percentages for qualitative (categorical and nominal) variables. Comparisons for assessing the difference between the groups were done using the χ²-test for qualitative data and the analysis of variance test and Student’s t-test for quantitative data. A linear correlation coefficient was done to detect the correlation between two quantitative variables in the same group. Statistical significance was considered by a P value less than 0.05 (with a confidence limit at 95%).
saturation, and PaO₂, whereas both were positively correlated with PaCO₂, WBC, platelet count, hs-CRP, and PLCR during exacerbation phase and stable phase. Moreover, they were positively correlated with each other.

**Discussion**

As previously published studies have documented age [12], sex [13], obesity [14], smoking [15], certain diseases [16], and drugs [17] as confounders affecting platelet indices, we selected our participant as females, nonsmokers, in the same age group, having approximately the same BMI, and without co-morbidities that could affect platelet function.

An important finding of our study is that platelet count was nonsignificantly different between asthmatic patients during either exacerbation or stable phase and controls. However, the MPV and PDW were

**Table 3 Correlation of mean platelet volume and platelet distribution width with other studied variables during exacerbation phase and stable phase**

| Items                | Exacerbation phase | Stable phase | Exacerbation phase | Stable phase |
|---------------------|--------------------|-------------|--------------------|--------------|
|                     | r      | p       | r      | p       | r      | p       | r      | p       |
| PDW                 | 0.84*  | 0.002   | 0.98*  | 0.001   | –      | –       | –      | –       |
| PCT                 | -0.82* | 0.002   | -0.97* | 0.001   | -0.97* | 0.001   | -0.98* | 0.001   |
| PLCR                | -0.84* | 0.002   | -0.97* | 0.001   | -0.99* | 0.001   | -0.99* | 0.001   |
| Platelet count      | -0.84* | 0.002   | -0.97* | 0.001   | -0.99* | 0.001   | -0.99* | 0.001   |
| WBC                 | -0.84* | 0.002   | -0.97* | 0.001   | -0.99* | 0.001   | -0.99* | 0.001   |
| hs-CRP ng           | -0.84* | 0.002   | -0.95* | 0.001   | -0.94* | 0.001   | -0.85* | 0.002   |
| Symptoms duration /day | -0.84* | 0.002   | –      | –       | -0.94* | 0.001   | –      | –       |
| FEV₁/FVC %          | 0.88*  | 0.001   | 0.84*  | 0.002   | 0.84*  | 0.001   | 0.87*  | 0.001   |
| FEV₁ %              | 0.84*  | 0.001   | 0.94*  | 0.001   | 0.99*  | 0.001   | 0.96*  | 0.001   |
| FVC%                | 0.80*  | 0.002   | 0.85*  | 0.002   | 0.95*  | 0.001   | 0.86*  | 0.001   |
| VC%                 | 0.68*  | 0.002   | 0.57*  | 0.003   | 0.82*  | 0.001   | 0.59*  | 0.002   |
| FEF₂₅-₇₅%           | 0.84*  | 0.002   | 0.95*  | 0.001   | 0.99*  | 0.001   | 0.97*  | 0.001   |
| O₂ saturation       | 0.81*  | 0.002   | 0.92*  | 0.001   | 0.96*  | 0.001   | 0.94*  | 0.001   |
| PaO₂                | 0.84*  | 0.001   | 0.97*  | 0.001   | 0.99*  | 0.001   | 0.98*  | 0.001   |
| PaCO₂               | -0.84* | 0.001   | -0.94* | 0.001   | -0.98* | 0.001   | -0.96* | 0.001   |

FEF, forced expiratory flow rate; FEV₁, forced expiratory volume in the first second; FVC, forced vital capacity; hs-CRP, high-sensitivity C-reactive protein; MPV, mean platelet volume (fl); PCT, platelet crates; PDW, platelet distribution width (%); PLCR, platelet large cell ratio; WBC, white blood cells. *Significant test.

**Table 4 Correlation of platelet crates and platelet large cell ratio with other studied variables during exacerbation phase and stable phase**

| Items                | Exacerbation phase | Stable phase | Exacerbation phase | Stable phase |
|---------------------|--------------------|-------------|--------------------|--------------|
|                     | r      | p       | r      | p       | r      | p       | r      | p       |
| PLCR                | 0.98*  | 0.001   | 0.98*  | 0.001   | –      | –       | –      | –       |
| Platelet count      | 0.96*  | 0.001   | 0.98*  | 0.001   | 0.97*  | 0.001   | 0.93*  | 0.001   |
| WBC                 | 0.97*  | 0.001   | 0.98*  | 0.001   | 0.99*  | 0.001   | 0.93*  | 0.001   |
| hs-CRP              | 0.97*  | 0.001   | 0.95*  | 0.001   | 0.83*  | 0.002   | 0.84*  | 0.002   |
| Symptoms duration /day | 0.84*  | 0.002   | 0.85*  | 0.002   | 0.92*  | 0.001   | 0.94*  | 0.001   |
| FEV₁/FVC %          | -0.85* | 0.001   | -0.87* | 0.001   | -0.81* | 0.002   | -0.86* | 0.002   |
| FEV₁ %              | -0.97* | 0.001   | -0.95* | 0.001   | -0.96* | 0.001   | -0.93* | 0.001   |
| FVC%                | -0.95* | 0.001   | -0.85* | 0.001   | -0.93* | 0.001   | -0.84* | 0.002   |
| VC%                 | -0.81* | 0.001   | -0.57* | 0.002   | -0.83* | 0.001   | -0.58* | 0.003   |
| FEF₂₅-₇₅%           | -0.97* | 0.001   | -0.95* | 0.001   | -0.94* | 0.001   | -0.95* | 0.001   |
| O₂ saturation       | -0.95* | 0.001   | -0.93* | 0.001   | -0.95* | 0.001   | -0.93* | 0.001   |
| PaO₂                | -0.98* | 0.001   | -0.97* | 0.001   | -0.97* | 0.001   | -0.93* | 0.001   |
| PaCO₂               | 0.97*  | 0.001   | 0.95*  | 0.001   | 0.93*  | 0.001   | 0.94*  | 0.001   |

FEF, forced expiratory flow rate; FEV₁, forced expiratory volume in the first second; FVC, forced vital capacity; hs-CRP, high-sensitivity C-reactive protein; MPV, mean platelet volume (fl); PCT, platelet crates; PDW, platelet distribution width (%); PLCR, platelet large cell ratio; WBC, white blood cells. *Significant test.
negatively correlated, whereas PCT and PLCR were positively correlated with platelet count during both exacerbation and stable phase. The results of the previous studies about platelet count in asthmatics are inconsistent. Our finding was in agreement with many other published studies, where there was no variance in platelet counts between asthmatic patients and matched control group [18–25]. However, another investigator reported significantly increased platelet count in exacerbated-asthmatic than stable-asthmatics [19]. Same variability in platelet count was found among asthmatic children, as Nacaroglu et al. [7] reported that platelet count was significantly increased in the patient group either in exacerbation phase or asymptomatic periods compared with controls. Dogru et al. [26] reported that the platelet count was significantly higher in both stable asthmatic and exacerbated asthmatic patients compared with controls, whereas there was no significant difference between stable asthmatic and exacerbated asthmatic patients. In the study by Tuncel et al. [24], platelet count in asthmatic children, either during an exacerbation or asymptomatic period, was nonsignificantly higher than control group. These differences in result regarding platelets count between children and adult may be owing to the immaturity of immune system among children.

The main results of this study are that the MPV and PDW were significantly lower, whereas PCT and PLCR were significantly higher during exacerbation phase compared with stable phase and controls (P<0.001). These findings indicate that platelet indices are more sensitive biomarkers for asthma exacerbation than platelets count. The alteration of platelet indices indicates increased systemic inflammation during exacerbation; therefore, they could be used as acute-phase reactants for asthma exacerbation. Moreover, the changes of platelet indices in stable phase compared with controls indicate that even in stable phase, the chronic underlying inflammatory process tends to affect platelet indices. The release of small volume platelets by cytokines induces stimulation of megakaryocytes in bone marrow and/or consumption of large volume/active platelets during inflammation have been proposed to be the possible reasons for this finding [27]. These findings are consistent with that reported by Sun et al. [18], Ellauriea and Wangb [28], and Yavuz et al. [29], as the MPV was reduced in asthmatics in exacerbation and in stable asthmatics in comparison with controls. Additionally, the MPV levels of stable asthmatics were higher than exacerbated asthmatics. Ibrahim et al. [22] found that MPV level was significantly lower in asthmatic patients in comparison with non-smoker and smoker healthy controls. However, the PDW levels were significantly higher in asthmatic patients compared with nonsmoker and smoker healthy controls. Not only the inflammation but also its surface area and type of inflammation affects the MPV value, as Akgedik and Yağız [23] reported that the MPV was found to be correlated with the inflamed surface area as the lowest MPV value was detected in bronchial asthma and allergic rhinitis, the moderate MPV was detected in asthma group, and the highest MPV was seen in the allergic rhinitis group, though the variance among the three groups was nonsignificant. However, the PDW was nonsignificantly differed among the three allergic groups and the controls. Additionally, Kara et al. [20] and Kin et al. [30] found that the percentage of eosinophils, total immunoglobulin E levels, and PDW were significantly higher in atopic asthma group. Different results were reported by other investigators who demonstrated that the neither MPV nor PDW differed between asthmatic patients and controls, or between exacerbated-asthmatics and stable-asthmatics [19,21,24,31,32]. Kepeki et al. [33] found a weak, positive, directional, and meaningful relationship between PDW and MPV variables in patients with nasal polyposis with or without asthma. These controversies between studies regarding the value of platelet indices in bronchial asthma may be owing to different population under concern, different patient age, different attack severity, and different measurement methods.

We found that both MPV and PDW were positively correlated, and PCT and PLCR were negatively correlated with spirometric indices during both exacerbation and stable phases. Therefore, we can suggest that not only the presence of inflammation but also its severity may be a determinant of the platelet indices in asthmatic patients. Therefore, platelet indices may be used to determine exacerbation severity. Similarly, Kara et al. [20] found that in the attack, only the group with severe attack had a negative correlation between platelet count and FEV1, and after the attack, PDW was positively correlated with FEV1, FVC, FVC, and FEF25–75%. However, Tuncel et al. [24] reported that MPV was not correlated with severity of attacks.

ABG analysis is an important parameter in asthma exacerbation and provides the best clues to acuteness and severity of disease and determines the need of ventilator support [15]. Both MPV and PDW had positive correlation with O2 saturation and PaO2 and

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negatively correlated with PaCO₂ (P<0.001) during both exacerbation and stable phases. However, both PCT and PLCR were negatively correlated with O₂ saturation and PaO₂ and positively correlated with PaCO₂ (P<0.001) during both exacerbation and stable phases. The relationship between platelet indices and PaO₂ and PaCO₂ could be bidirectional; first direction is that the more alteration in platelet indices, that is, severe the inflammation, the more the deterioration in ABG parameters, and the second direction is that the hypoxemia or hypercapnia could induce platelet consumption with subsequent changes of its indices.

The present study showed that WBC was significantly higher in exacerbation phase in comparison with both stable phase and control group. Moreover, the MPV and PDW were negatively correlated, whereas the PCT and PLCR were positively correlated with WBC during exacerbation and stable phases. These findings indicate that there is a strong link between platelets indices and WBC in underlying inflammation of asthma, which confirm the previously mentioned theory that the processes of airway wall remodeling and leukocyte infiltration fail to occur without the participation of platelets in a murine model [31]. Moreover, increased circulating platelet-leukocyte aggregates have been identified in allergic asthmatics after an antigen challenge [34]. Platelets act as companions in the process of extravasation of leukocytes into bronchopulmonary airways from pulmonary microcirculation and in chemotaxis stimulation [31]. In accordance with our results, Uysal et al. [31] and Akgedik and Yağrız [23] reported that leukocyte counts were significantly higher in exacerbated asthmatics than in stable asthmatics and controls. Kara et al. [20] reported that the WBC was significantly high in asthmatic children during the attack in comparison with those after attack.

Our study revealed that during exacerbation phase, the MPV and PDW were negatively correlated with symptoms duration and hs-CRP. The PCT and PLCR were positively correlated with symptoms duration and negatively correlated with hs-CRP. These findings indicate that during exacerbation, the more severe the underlying inflammation, that is, higher hs-CRP, higher WBC, higher PCT, and PLCR with lower MPV and PDW, the severer attacks, that is, the lower spirometric-indices and worsening ABG parameters. Similar results were reported in previous studies, as MPV was negatively correlated with CRP [18], WBC, and platelet count [23] in exacerbated asthma. Dogru et al. [26] described that the MPV had negative correlation with the WBC and platelets and was positively correlated with CRP during exacerbation. In asthmatic children, no correlation was found between MPV and CRP [24].

The negative correlation of hs-CRP with MPV and PDW and its positive correlation with PCT and PLCR during stable asthma phase in our study indicate that the underlying low-grade systemic inflammation in stable asthma has negative effects on platelet indices. Different results were reported by Sun et al. [18], as the reduced MPV is negatively correlated with CRP only in acute exacerbations and not in the stable phase. The study by Tuncel et al. [24] revealed that MPV was not correlated with CRP in asthmatic children. Our results were also in agreement with Shaaban et al. [35] in a population-based study, which suggested that increases in CRP concentration over time are associated with a significant decrease in pulmonary function, consistent with the hypothesis that low-grade systemic inflammation is associated with pulmonary damage.

The main strengths in the current study are as follows: first, the measurement of platelet-indices is a cost-effective test for assessment of asthma exacerbation, which can be applied easily to our patients with limited resources; second, the measurement of platelet counts and platelet indices was done in the same hospital with the same autoanalyzer using the same well-standardized method; and third, patients with other diseases or treated by drugs that could affect platelet function were excluded from the study. Therefore, our results reflect the actual effect of asthma exacerbation on platelet indices. However, this study had limitations that deserve to be mentioned, such as follows: the number of participants was relatively small. Therefore, we did not, classify patients according to exacerbation severity.

The MPV and PDW were found to be lower whereas PCT and PLCR were found to be higher during exacerbation phase compared with stable phase. Therefore, clinicians should not ignore interpreting platelet indices during asthma exacerbation, especially as the tests are simple, readily available, and low cost. It appears that measurement of the platelet-indices is a dependable indicator of asthma severity/activity and appears as a useful screening test for asthma exacerbation.

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Conflicts of interest
There are no conflicts of interest.

References
1 Reddel HK, Taylor DR, Bateman ED, Boulet LP, Boushey HA, Busse WW, et al. An official American Thoracic Society/European Respiratory Society statement: asthma control and exacerbations: standardizing endpoint for clinical asthma trials and clinical practice. Am J Respir Crit Care Med 2009; 180:59–99.
2 Ejaz S, Nasim F, Ashraf M, Ahmad S. Hematological and biochemical profile of patients suffering from non-atopic asthma. Insights Chest Dis 2017; 2:1–10.
3 Kasperska-Zajlc A, Grzanka A, Jarzab J, Misiolekt M, Wyszyńska-Chiap M, Kasperski J, et al. The association between platelet count and acute phase response in chronic spontaneous urticaria. Biomed Res Int 2014; 2014:1–6.
4 Johansson MW, Kruger SJ, Schiebler ML, Evans MD, Sorkness RL, Denlinger LC, et al. Markers of vascular perturbation correlate with airflow structural change in asthma. Am J Respir Crit Care Med 2013; 188:167–178.
5 Tsiara S, Elsaif M, Jagroop IA, Mikhailidis DP. Platelets as predictors of vascular risk: Is there a practical index of thrombotic activity? Clin Appl Thromb Hemost 2003; 9:177–190.
6 Budak YU, Polat M, Huysal K. The use of platelet indices, plateletcrit, mean platelet volume and platelet distribution width in emergency non-traumatic abdominal surgery: a systematic review. Biochimica Medica 2016; 26:178–193.
7 Nacaroglu HT, Isguder R, Bahocci SE, Ceylan G, Korkmaz HA, Karaman S, et al. Can mean platelet volume be used as a biomarker for asthma? Postepy Dermatol Alergol 2016; 33:182–187.
8 Pellegrino R, Vieg G, Brusasco V, Crapo F, Burgos F, Casaburi R, et al. Interpretative strategies for lung function tests. Eur Respir J 2005; 29:948–968.
9 Miller MR, Crapo R, Hankinson J, Brusasco V, Burgos F, Casaburi R, et al. General considerations for lung function testing. Eur Respir J 2005; 26:153–161.
10 Dastjerdi MS, Emami T, Najafian A, Amini M. Mean platelet volume measurement, EDTA or citrate? Hematology 2006; 11:317–319.
11 Lance MD, Henskens YM, Marcus MA. Mean platelet volume analysis needs more standardization. Platelets 2011; 22:241.
12 Verdoia M, Schauffer A, Barbieri IL, Verdoia M, Schauffer A, Barbieri L, et al. Novara Atherosclerosis Study (NAS) group. Impact of age on mean platelet volume and its relationship with coronary artery disease: a single-centre cohort study. Exp Gerontol 2015; 62:32–36.
13 Botma J, Mogonoga LF, Jaftha AD, Van Rensburg WJ. Reference Ranges for platelet indices using symex xe-2100 blood analyzer. Medical Technology SA 2012; 26:17–21.
14 Aydin M, Nalbantoglu B, Donma M, Gurel A. The effect of obesity and dietary habits on mean platelet volume and other platelet indices. J Pediatr Biochem 2014; 04:167–170.
15 Helmy TA, Baees AI, Algarahi AA. Mean platelet volume as an inflammatory marker in acute exacerbation of chronic obstructive pulmonary disease. Egypt J Broncho 2016; 10:46–51.
16 Steiriopoulos P, Papanas N, Nena E, Xanthoudaki M, Goula T, Froudarakis M, et al. Mean platelet volume and platelet distribution width in patients with chronic obstructive pulmonary disease: the role of comorbidities. Angiology 2013; 64:535–539.
17 Dolasik I, Sener SY, Celebi K, Aydin ZM, Korkmaz U, Canturk Z. The effect of metformin on mean platelet volume in diabetic patients. Platelets 2013; 24:118–121.
18 Sun WX, Zhang JR, Cao ZG, Li Y, Wang RT. A Decreased mean platelet volume is associated with stable and exacerbated asthma. Respiration 2014; 88:31–37.
19 Abd-Allahman HB, Gaufti NM. Assessment of platelet count and platelet indices among patients with stable and exacerbated asthma. Lab Med J 2017; 3:1–6.
20 Kara TT, Özbek OY, Köksal BT. Evaluation of platelet activation during an asthmatic attack in children. Turkish J Pediatr Dis 2016; 2:84–89.
21 Aydemir G, Sezer RG, Akcan AB, Gökhlan Baris Akcan, Onur Gungör, Halit Özkaya, et al. Finding Thrombocytosis at the time of the diagnosis in the patients with pneumonia, bronchiolitis and asthma, and its importance in terms of the diagnosis. Pediatri Therapeut 2012; 2:118.
22 Ibrahim KO, Yusuf D, Serdar D. Importance of mean platelet volume, platelet distribution width and red blood cell distribution width in asthmatic subjects. Eur Respir J Suppl 2015; 46:PA3596.
23 Akgedik R, Yaguz Y. Is decreased mean platelet volume in allergic airway diseases associated with extent of the inflammation area?. Am J Med Sci 2017; 354:33–38.
24 Tuncel T, Uysal P, Hocaoglu AB, Erge DO, Karaman O, Uzuner N. Change of mean platelet volume values in asthmatic children as an inflammatory marker. Allergol Immunopathol (Madr) 2012; 40:104–107.
25 Nastalek M, Potaczek DP, Wojas-Pelc A, Undas A. Plasma platelet activation markers in patients with atopic dermatitis and concomitant allergic diseases. J Dermatol Sci 2011; 64:79–82.
26 Dogru M, Akta A, Ozturkmen S. Mean platelet volume increased in children with asthma. US Natl Lib Med 2015; 26:823–826.
27 Bath PM, Butterworth RJ. Platelet size: Measurement, physiology and vascular disease. Blood Coagul Fibrinolysis 1996; 7:157–161.
28 Ellaurie M, Wang G. Platelet abnormalities in asthma and allergy. J Allergy Clin Immunol 2004; 113:161.
29 Yavuz ST, Gursel O, Koc O, Eker I, Demirel F, Babacan O, et al. Decreased mean platelet volume is associated with loss of asthma control and exacerbations in school age children with asthma. EAACI Online Lib 2015; 70:103750.
30 Ken TB, Erkoçğlu M, Dilek M, Sanderpen AF. The role of platelet indices in determining atopy in childhood asthma. Gaziantep Med J 2015; 21:185–189.
31 Uysal D, Tuncer T, Suat K. Evaluation of mean thrombocyte volumes in asthma patients during acute exacerbations and stable periods. Arch Clin Biomed Res 2018; 2:001–006.
32 Bozkurt B, Kızılألمى D. Relation of hemogram parameters with asthma. Eur Respir J Suppl 2015; 46 P A1102.
33 Kępekçı AH, Düzdar G, Kępekçı AB. Platelet distribution width (PDW) data of patients with nasal polyposis: is it important for clinical severity? ENT Updates 2017; 7:33–37.
34 Pitchford SC, Yano H, Lever R, Riffo-Vasquez Y, Ciferri S, Rose MJ, et al. Platelets are essential for leukocyte recruitment in allergic inflammation. J Allergy Clin Immunol 2003; 112:109–118.
35 Shaaban R, Kony S, Driss F, Leynaert B, Soussan D, Pin I, et al. Change in C-reactive protein levels and FEV1 decline: a longitudinal population-based study. Respir Med 2006; 100:2112–2120.