Mean Platelet Volume (MPV): New diagnostic indices for co-morbidity of Tuberculosis and Diabetes Mellitus

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Research article

Keywords: Tuberculosis, Diabetes Mellitus, diagnosis indices, mean platelet volume, plateletcrit

Posted Date: January 20th, 2020

DOI: https://doi.org/10.21203/rs.2.21281/v1

Abstract

Background: Tuberculosis (TB) and type 2 diabetes mellitus (DM) are global health diseases with high morbidity and lethality . Few studies had focus on the platelet indices in TB-DM co-morbidity patients. The objective of this work was to analyze the platelet indices in TB, DM and TB+DM to assess the predictive value of platelet index for the risk of these diseases.

Methods: In total, 246 patients were distribute d into three groups (113 TB, 59 DM and 74 TB+DM) admitted in our hospital along with 133 healthy controls (HC). Platelet indices namely platelet count (PC), mean platelet volume (MPV), plateletcrit (PCT) and platelet distribution width (PDW) were compared among the four groups and explored the relationship with inflammatory markers by using statistical software.

Results: Our study discovered that MPV and PCT were significantly down-expressed in TB+DM patients (9.95±1.25fL, 0.20±0.05%, P <0.0001, P =0.0121, separately) than those in DM individuals (10.92±1.17fL, 0.22±0.04%). Moreover, on comparison of TB (9.42±1.01fL), the changes of MPV were significantly higher in TB+DM patients (9.95±1.25fL, P =0.0041). No differences were found in PLT and PDW among the four groups (P >0.05). The sensitivity and specificity of MPV in differential diagnosis of DM patients vs TB+DM patients were defined as 64.9% and 66.1% (P <0.0001), as well as 60.8% and 66.4% of MPV in differ from TB patients and TB+DM patients (P =0.003). MPV improved the diagnosis sensitivity when combined with clinical golden parameters as fasting blood glucose in DM and mycobacterium tuberculosis culture result in TB. In addition, the sensitivity and specificity of PCT in the differential diagnosis of DM patients vs TB+DM patients were defined as 69.5% and 59.4% (P =0.008). PCT improved the diagnosis sensitivity when combined with fasting blood glucose in DM (72.9% vs 64.9%, P =0.004). In addition, MPV was connected with CRP and ESR in the TB+DM patients rather than PCT.

Conclusions: Our research shows that MPV and PCT might be the clinical laboratory markers distinguished TB+DM patients from TB or DM individuals, thus providing support for earlier clinical diagnosis, prevention, and therapy.

Background

Tuberculosis (TB) is a global health disease infected by mycobacterium tuberculosis (MTB), despite its advanced developments in diagnosis and therapy.[1] Researches had demonstrated that some diseases could accelerate TB occurrence and development.[2] Type 2 diabetes mellitus (DM) has been verified as one of the threatening risk factors of TB and having three times risk of developing into TB compared to non-diabetics.[3] The DM prevalence among TB sufferers in diversified low-income and middle-income countries ranged from 1.8–45% and TB prevalence among individuals with DM varied from 0.1–6.0%.[4] Clinically, DM facilitates TB development and hampers TB therapy, while conversely, TB impairs blood glucose control.[5] To a great extent, TB and DM diagnosis based on definitive detections including clinical symptoms, characteristic X-ray and laboratory examinations with limitations separately.[6]

Nevertheless, few researches focus on diagnosis markers to predict TB or DM developing into TB-DM co-morbidity patients (TB + DM). Thus, findings of a feasible and cost effective marker from laboratory reporting papers for TB + DM earlier prevention and control is significantly essential.

Platelets are anucleate cells and have certified have critical roles in thrombosis, homeostasis as well as inflammatory response.[7] When internal environment altered, platelets may be altered platelet morphology and function as a role of causative agent reflecting on some platelet associated parameters mainly including platelet count (PC), plateletcrit (PCT), platelet distribution width (PDW) and mean platelet volume (MPV).[8, 9] Researches have demonstrated that changes in PC, especially during the process of TB infections might be correlated with the mortality and severity of the infection.[10, 11] MPV is a marker reflecting the average size of platelets present involved various diseases such as DM, metabolic syndrome and TB.[12] However, the role of MPV in TB is disputing. A study conducted by G, Gunluoglu et al. suggested that MPV as a role of inflammation marker decreased in active pulmonary tuberculosis related to the formation of microthrombi in TB cavities.[13] Contrary to the research, Tozkoparan et al. suggested MPV was significantly increased in patients suffering from active TB and down-expressed with anti-TB treatment.[10] In addition, MPV also served as a clue for the reflection of platelet activation in DM regardless of the diabetic retinopathy stage.[14] Besides MPV, other platelet indices PDW and PCT calculated by PC and MPV, have reported as roles in atherosclerosis and thrombosis, as well in TB.[15] Higher PDW and PCT values were developed frequently in PTB with a strong correlation between phase reactants and acute thrombocytosis.[16] However, few studies have explored the relationship between platelet associated parameters and TB-DM co-morbidity patients.

Prediction of risk of TB-DM co-morbidity is absolutely vital for the TB and DM patients. The purpose of the study is to assess the possible relationships of TB + DM with platelet indices PC, MPV, PCT and PDW. To this end, we also determined the relationship of these parameters with inflammatory markers (CRP and ESR index). We hypothesized of offering novel bio-markers for diabetes with tuberculosis earlier diagnose and treatment.

Methods

Study setting and data sources

This was a single-centre study. All data were collected in our hospital from July 2018 to August 2019. The study complied with the Declaration of Helsinki, and the Human Ethical Committee of the Sixth People's Hospital of Nantong approved the study protocol. We obtained informed consent from all participants involved in our study. Participants enrolled in the study were given written informed consent. In all, 379 participants were included: 133 healthy controls (HC), 113 TB patients, 59 DM patients and 74 TB + DM patients. HC included with no expose of MTB, no clinical characteristic of TB and the PPD test were negative. TB diagnose based on positive results of Xpert MTB/RIF (Cephaid Inc., CA, USA), BACTEC MGIT 960 rapid liquid isolate culture (Becton Dickinson, Sparks, USA) by GenoTypeH check system (Hain Lifescience, Nehren, Germany) and MTB smear confirmation by Ziehl-Neelsen acid-fast stain (Zhuhai DL

biotech co,. Ltd, Guangdong, China). DM patients excluded TB were enrolled from the Endocrine Department in our hospital and diagnosed with DM previously according to a WHO-criteria. TB-DM co-morbidity patients were certified TB along with hyperglycemia (fasting glucose ≥ 7.0 mmol/L) and HbA1c ≥ 6.5%. Full blood counts were carried out using Mindray BC-6900 chemistry analyzer (Shenzhen Mindray Bio-Medical Electronics Co. Ltd, China). The data of ESR (Erythrocyte sedimentation rate) and CRP (C-reactive protein) were picked from the Clinical Laboratory Department of our hospital measured by Eriline AR Linear (Barcelona, Spain) and Beckman Coulter 5800 (Tokyo, Japan). Participants were obviated if they were positive HIV examination, pregnant, Hepatitis B positive or combined with cancer.

Data analysis

All data processing and analyses were applied using GraphPad Prism version 5.0 software (San Diego, CA) and SPSS 17.0 software (SPSS Inc., Chicago, IL, USA). The difference between unpaired and paired samples was analyzed using one-way ANOVA, t-test or chi-squared test. For the basic statistic for the cases enrolled in this study, percentiles and Mean ± SD were used. The area under the curve (AUC), 95% confidence interval (95% CI) sensitivity and specificity were determined by a Receiver Operating Characteristic (ROC) curve. The association between 2 quantitative variables was measured using bivariate correlation (Pearson or Spearman). All tests were two-tailed and a threshold of $P < 0.05$ was perceived as statistically significant.

Results

Characteristics of the study population

Patient characteristics were shown in Table 1. In this present study, the age ranged from 14 to 90 years. On average, DM (59.6 ± 14.0) and TB + DM (58.1 ± 12.5) were older and have a lower BMI (20.0 ± 1.9, 20.6 ± 2.2) compared with the HC (45.4 ± 17.2, 20.9 ± 2.1) and TB (47.0 ± 17.8, 21.1 ± 2.4) groups. In the present study, total numbers of males among the four groups were 204 (53.83%) diagnoses and total numbers of females were 175 (46.17%). The numbers of males in the TB were 112 (54.90%) compared to 92 (45.10%) in non-TB group, as well as 75 (42.86%) compared to 100 (57.14%) in females. The numbers of males in DM were 78 (38.24%) compared to 126 (61.76%) in non-TB individuals as well as 55 (31.43%) compared to 120 (68.57%) in females. All (without TB) DM patients were on anti-DM drugs treatment, while there were the cases for 67.6% of TB + DM suffers. TB + DM patients not on any treatment were newly maked a definite diagnosis of DM. In addition, the increased glucose has no affection for interferon-γ release, TB drug resistant and TB pulmonary cavity forms (TB vs TB + DM).

MPV and PCT might be the new laboratory indicators in TB combined with DM patients

To investigate whether the platelet influence involved in TB + DM patients, the changes of platelet related parameters in the four groups were picked from our laboratory. As shown in results, no differences were

found in PC and PDW among the four groups (P > 0.05, respectively, Fig. 1A, D, Table 2). On comparison of TB (9.42 ± 1.01fL), the changes of MPV were significantly increased in TB + DM (9.95 ± 1.25fL, P = 0.0041, Fig. 1B, Table 2). On comparison of DM (10.92 ± 1.17fL, 0.22 ± 0.04%), the changes of MPV and PCT were significantly decreased in TB + DM (9.95 ± 1.25fL, 0.20 ± 0.05%, P < 0.0001, P = 0.0121, Fig. 1B-C, Table 2). ROC curve analysis was used for the MPV and PCT values among DM patients vs TB + DM patients and MPV value among TB patients vs TB + DM patients. The sensitivity and specificity of MPV in differential diagnosis of DM patients vs TB + DM patients were defined as 64.9% and 66.1% (Fig. 1G, Table 3, P < 0.0001), as well as 60.8% and 66.4% of MPV in differ from TB patients and TB + DM patients (Fig. 1H, Table 3, P = 0.003). MPV improved the diagnosis sensitivity when combined with clinical golden parameters as fasting blood glucose in DM and mycobacterium tuberculosis culture result in TB (76.3% vs 64.9%, 72.6% vs 60.8%, Fig. 1G-H, Table 3, P < 0.0001, P = 0.001, separately). In addition, the sensitivity and specificity of PCT in the differential diagnosis of DM patients vs TB + DM patients were defined as 69.5% and 59.4% (Fig. 1I, Table 3, P = 0.008). PCT improved the diagnosis sensitivity when combined with fasting blood glucose in DM (72.9% vs 64.9%, Fig. 1I, Table 3, P = 0.004). ROC related parameter data were shown in Table 3. Sex and Age have affection for MPV and PCT expression (Fig. 1E-F). Thus, MPV and PCT might be the laboratory markers distinguished TB + DM patients from TB or DM patients.

MPV associated with the course of an inflammatory condition, instead of PCT

CRP and ESR were common markers for inflammatory status. The correlation of these with MPV and PCT were also analyzed. MPV was be associated with ESR (r = 0.3203, P = 0.0054) and CRP (r = 0.2504, P = 0.0307) values in the TB + DM group, while it was not associated with CRP and ESR in PCT (r = 0.1905, r = 0.008675, P > 0.05, separately). Thus, MPV might be a predictive marker for TB or DM developing into TB + DM and associated with inflammatory index (CRP and ESR).

Discussion

Platelet indices have been reported to be associated with multiple diseases of the immune system and hemopoietic system.[17] In our study, we found MPV and PCT were significantly decreased in DM combined with TB (TB + DM) than those in DM individuals. The indices of MPV were higher in DM combined with TB than those in TB patients. The increase of MPV was correlated with ESR and CRP in the DM combined with TB patients. As for the indices of PLT and PDW, there was no significant change between in TB, DM, and TB combined with DM and in healthy controls. Moreover, the factors of age and gender did not significantly affect MPV and PLT indices.

The MPV reflects platelet size and extent of inflammation, and which used to reveal the function of platelet. The platelet size is associated with the inflammatory intensity.[18] In patient infected by Mycobacterial tuberculosis, acute phase reactants and pro-inflammatory cytokines affect megakaryocyte, which decreased the platelet size, and smaller platelets are delivered from the bone marrow,[19] this can

be used to explain the reason of MPV decrease. Tozkoparan E et al. found PDW and PCT were higher in the active TB patient and decreased significantly after anti-tuberculous therapy.[10] Sahin et al. indicated that MPV in active TB patients was identical to healthy individuals and non-specific pneumonia patients.[12] These results were in accordance with our findings that there have no significant differences between TB patients and healthy controls. Gunluoglu et al suggested that the value of MPV was slightly decreased in TB patient, the MPV never reflect severity of the tuberculosis.[13]

ESR also has been regarded as a predictor of inflammatory and autoimmune diseases. In principle, the increase in ESR can be due to changes in serum proteins, or it can be due to changes in erythrocytes. The former usually includes hypergammaglobulinemia, monoclonal blood diseases, and elevated fibrinogen levels. The latter is mainly to reduce the number of erythrocyte and the size of erythrocyte.[20] Our results displayed that MPV, but not PLT, correlated with ESR in TB patients with DM. thus, it can be deduced that, as an index of blood in patient with TB and DM, maybe, MPV is an important hematological indicator to evaluate the risk of TB and DM along with ESR.

It is well known that diabetes mellitus (DM) is a metabolic dysfunction characterized by hyperglycemia, which leads to vascular complications. TB is an immemorial and common infectious disease. DM and TB co-morbidity is a widely public health issue. The number of TB patient with DM is much more than the number of TB patient with HIV. Previous studies have shown that DM is a strong risk factor of the development of TB. DM patient are three times risk to develop TB compared to the non-diabetic inhabitant.[21] The increasing prevalence of DM is turning into a challenge to TB prevalence and vice versa.[22] Reinforced the management of DM and improving glycemic control can improve the treatment outcomes of TB.[23, 24] Tuberculosis often worsen glycemic control in patients with DM.[25] Other studies have indicated that TB increases the risk of DM in those previously unknown to be diabetic.[26] There is still a lack of knowledge and assessment whether TB makes individuals susceptible to DM. Several cross-sectional studies have displayed the relationship between TB outcome and the occurrence of hyperglycaemia.[27] As DM and TB worsen in low- and middle-income countries, WHO and the International Union Against Tuberculosis and Lung Disease (IUATLD) encourage the establishment of a cooperative framework that recommends two-way screening including TB testing among individual with DM.[28] WHO recommends screening for DM at the start of TB treatment; however, little is unclear which indicators of blood samples and which patients are at risk for developing TB.

MPV detection and assay are generally valid in clinical as it is routinely detected. MPV is increased in intestine diseases, respiratory diseases, cardiovascular diseases, cerebral stroke, several cancers and diabetes. Conversely, MPV is decreased in the disease of ulcerative colitis, neoplasm, SLE and tuberculosis. The mechanisms for an increased MPV are not well clarified. Several factors may influence MPV value, including genetic variations, applied treatment drugs, lifestyle (diet, smoking, alcohol consumption, and physical activity), pre- and analytical procedures, hormonal profile, age, gender and race/ethnicity.[9] A major aim of this study is the comparison of platelet indices (MPV and PCT) and ESR in DM, TB and DM with TB patients in order to assess that TB or DM is at the risk for developing TB combining with DM. Among diabetes, MPV and PCT were lower in those with tuberculosis as compared

to those without tuberculosis. Screening for TB or DM through platelet indices may improve early TB-DM co-morbidity detection and diagnosis. This analytical performance serves a clinical goal and establishes a diagnosis standard for the clinical laboratory.

Limitations Of The Study

Known limitation to the results of the study was a single-center study, neglect of race and genetic variations. Moreover, there may be a lack of prospective study with a definite diagnosis. In order to popularize and apply the value of MPV and ESR as a diagnostic marker of TB with DM, we should furtherly verify these indices on the multicenter clinical sample, and conduct cohort studies in the near future, both in China and abroad. The mechanism of abnormal MPV level in TB, DM and DM-TB co-morbidity patients, yet to be fully understood.

Conclusions

MPV is a valuable diagnostic marker to verify TB-DM co-morbidity risk, as the occurrence of TB developing TB-DM co-morbidity risk will increase MPV level, DM developing DM-TB co-morbidity risk will decrease MPV. Moreover, MPV has a positive correlation with ESR and CRP. MPV has significant specificity and sensitivity for predicting and diagnosing DM-TB co-morbidity.

Abbreviations

TB, Tuberculosis group; DM, Diabetes; HC, Healthy; group; PLT, Platelet; MPV, Mean platelet volume; PDW, Platelet distribution width; PCT, Plateletcrit; ESR, Erythrocyte sedimentation rate; CRP, C-reactive protein.

Declarations

Authors' contributions

YW Q and FF X designed the study; FF X and SY Q collected data; L W and SY Q analyzed and interpreted data; YW Q and FF X drafted the article; FF X and YW Q critically revised the article. All authors approved the final version of the manuscript.

Funding

The work was supported financially by a grant from the Nantong Science and Technology Program (Grant No. JC2018069), a medical project supported by the 13th Five-Year Plan Foundation of Nantong, a project supported by Nantong Junhan business Company (19ZH425).

Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The study protocol was approved by the Medical Ethics Committee of the Sixth People's Hospital of Nantong. Informed verbal consent was taken from each participant and this procedure was approved by the Medical Ethics Committee.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Tables

Due to techinical limitations, Tables 1-3 are provided in the Supplementary Files section

Table 1: Patient characteristics in the four groups (n=379).

Table 2: Comparison of platelet indices among the four groups.

Table 3: The associated parameters of ROC in TB, DM and TB+DM groups.

Figures

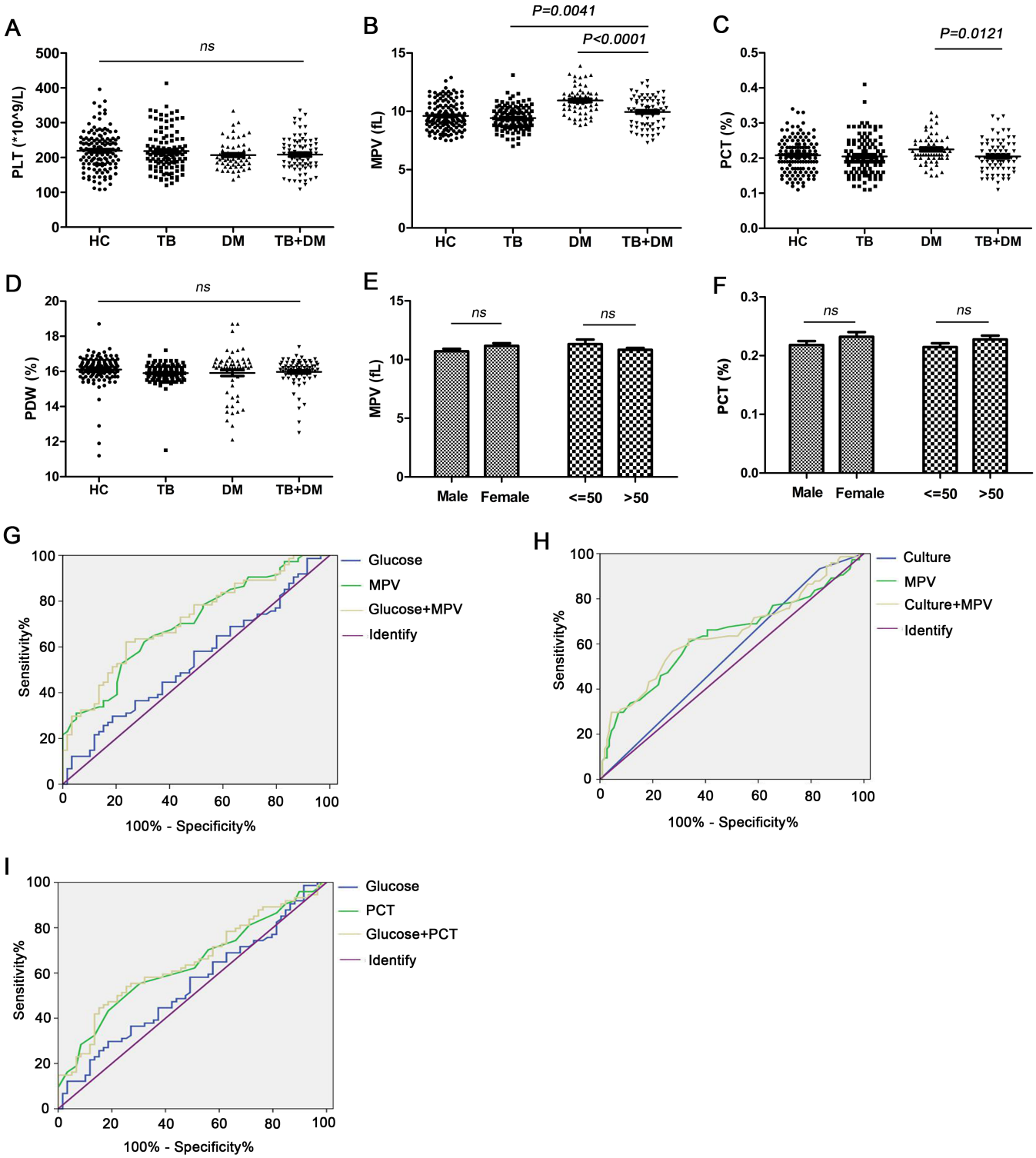

Figure 1

The changes of platelet related parameters in the four groups. (A-D) The comparison of PLT, MPV, PCT and PDW values in HC, TB, DM and TB+DM groups; (E) ROC curve for using MPV and PCT levels in the differential diagnosis of TB+DM from DM or TB. (F-G) MPV and PCT levels in different sex and age groups. HC, Healthy community controls; TB, Tuberculosis group; DM, Diabetes group; TB+DM, TB-DM co-

morbidity group. PLT, Platelet; MPV, Mean platelet volume; PDW, Platelet distribution width; PCT, Plateletcrit.

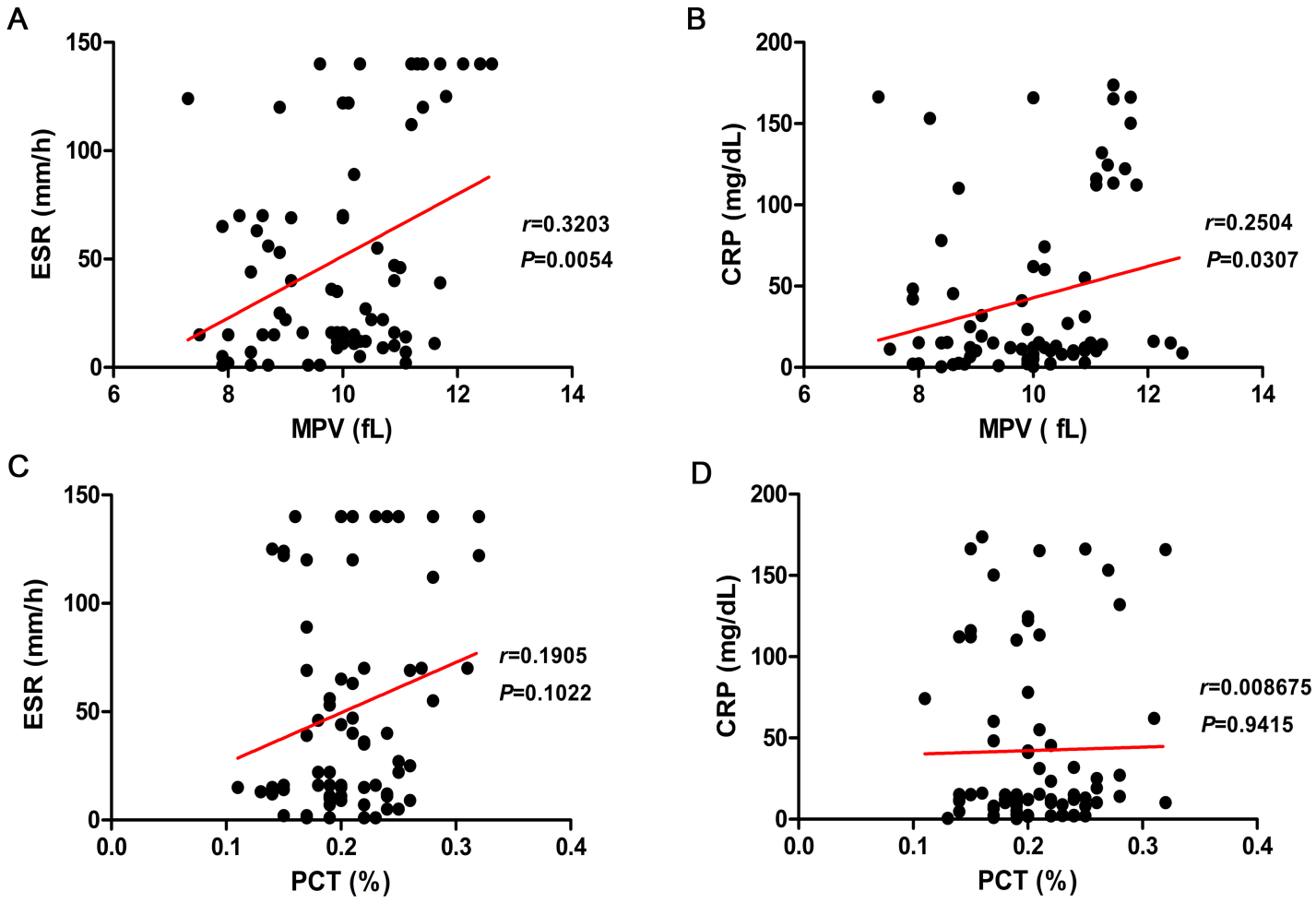

Figure 2

The correlation of MPV and PCT with ESR and CRP in the TB+DM group. (A) The relevance curve of MPV with ESR; (B) The relevance curve of MPV with CRP; (C) The relevance curve of PCT with ESR; (D) The relevance curve of MPV with CRP. MPV, Mean platelet volume; PCT, Plateletcrit; ESR, Erythrocyte sedimentation rate; CRP, C-reactive protein.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Table.32.docx
- Table.12.docx
- Table.22.docx