Dynamic Monitoring of Erythrocyte Distribution Width (RDW) and Platelet Distribution Width (PDW) in Treatment of Acute Myocardial Infarction

CEF 1 Jian Yu*
B 1 Li Wang*
D 2 Yuchong Peng*
E 3 Mingjie Xiong
F 1 Xiaozhong Cai
C 1 Juan Luo
AEG 1 Minghao Zhang

* Jian Yu, Li Wang and Yuchong Peng are co-first authors

Corresponding Author: Minghao Zhang, e-mail: zhangminghao@cqmu.edu.cn

Source of support: This study was supported by the Chongqing Science and Technology Commission (cstc2015shmszx120069)

Background: This study investigated the role of erythrocyte distribution width (RDW) and platelet distribution width (PDW) in evaluating the treatment efficacy for acute myocardial infarction (AMI).

Material/Methods: A total of 120 AMI patients receiving conventional myocardial infarction treatment were included. The patients were divided into an effective group and an ineffective group based on treatment efficacy. The RDW and PDW were measured before and after treatment. We used the independent samples t test, chi-square test, logistic regression, and ROC curves for analysis.

Results: The change and change rate of RDW and PDW were significantly improved (p<0.01) and the positive change rate of RDW, PDW, and RDW + PDW were significantly lower in the effective group compared with those in the ineffective group (p<0.01). The change and change rate of RDW and PDW are independent factors for treatment efficacy evaluation (p<0.05). ROC curve analysis showed that the changes and change rate of RDW and PDW were all significant in evaluating treatment efficacy (p<0.05).

Conclusions: The change and change rate of RDW and PDW or their combination can be used to evaluate treatment efficacy; however, the absolute value of RDW and PDW are not as significant.

MeSH Keywords: Aftercare • Blood Platelets • Erythrocyte Indices • Myocardial Infarction

Full-text PDF: https://www.medscimonit.com/abstract/index/idArt/904916
Background

Patient with acute myocardial infarction (AMI) usually present with chest pain, feeling of suffocation, or even death [1]. AMI results from the sharp reduction or interruption of coronary blood caused by coronary atherosclerosis, leading to the corresponding myocardial ischemia and severe acute myocardial necrosis [2]. Pathologically, lipids invade the arterial vessels, accumulate in the smooth muscle cells, collagen, and elastic fibers, and cause smooth muscle hyperplasia [3]. The blood-derived mononuclear cells can engulf a large number of lipids, become foam cells, release active substances, stimulate fibrous tissue proliferation, activate inflammatory responses [4], form atherosclerotic plaque, increase endothelial damage, and promote coronary stenosis, eventually leading to AMI [5].

For AMI, early evaluation and prediction of prognosis are needed to plan individualized treatment [6,7]. In recent years, the prediction value of erythrocyte distribution width (RDW) and platelet distribution width (PDW) in AMI has been reported [8,9]. For example, in 2007, Felker et al. [10] first found that elevated RDW could be used as an independent prognostic factor in patients with heart failure. RDW reflects the size differences of red blood cells and can differentiate the false-negative of mean corpuscular volume in the measure of erythrocyte morphological changes. RDW is significantly correlated with the incidence and development of coronary heart disease (CHD); therefore, it can be used as a sensitive indicator for CHD risk stratification [11,12]. Platelet distribution width (PDW) indicates the heterogeneity of platelet volume, and the elevated PDW indicates a large disparity in the platelet volume [13]. High PDW value suggests hypercoagulability, possibly due to a large amount of platelet adhesion and aggregation, high activation, and subsequent platelet reduction, leading to spontaneous induction of platelets by megakaryocytes [14]. Most relevant studies have focused on the absolute value of RDW and PDW. However, the reference intervals of the normal values of RDW and PDW are too large to accurately distinguish between individual differences between patients. Thus, it is of great importance to develop new indicators that can better distinguish the individual differences.

The change and change rate of RDW and PDW before and after treatment for the early treatment efficacy of AMI patients have seldom been studied. It has been reported [15] that there are little differences between a coronary heart disease group and a healthy control group in RDW and PDW before treatment, indicating its limited prognosis prediction value. It has also been reported that RDW change rate can be used for AMI treatment efficacy and prognosis evaluation, presenting as a significant RDW decrease after treatment [16]. Therefore, instead of the absolute values of RDW and PDW, the change and change rate of RDW and PDW before and after treatment can be used as important indicators for evaluating the early AMI treatment efficacy.

In the present study, we analyzed the absolute value, change, and change rate of RDW and PDW to determine their value in evaluation of early AMI treatment efficacy.

Material and Methods

Patient recruitment

Patients diagnosed with AMI and admitted to Chongqing Medical University Beibei Affiliated Hospital from April 2014 to March 2015 were included in this study. The patients were diagnosed based on the WHO Clinical Diagnostic Criteria for Coronary Heart Disease, 2003 version. Inclusion criteria were: 1) Patients with “non-ST-elevation myocardial infarction” of first onset and hospitalized within 12 h of onset; and 2) Patients with similar first course treatment strategy. Patients were excluded if they had diabetes, malignancies, chronic respiratory diseases, or coagulation disorders, or received interventional therapy. The study was approved by the Medical Ethics Board of Chongqing Medical University Beibei Affiliated Hospital. Informed consent for participation in a clinical trial was obtained from all patients or their families.

The treatment was based on the Guidelines for the Treatment of Acute Myocardial Infarction, prepared by the Chinese Medical Association Cardiovascular Society in 2001. Patients all received treatment including conventional treatment (sedation drugs, analgesic drugs, statins, rehydration, oxygen, thrombolysis, and nitrates). The first course of treatment lasted for 7–10 days. The RDW and PDW were measured before (within 2 h of hospitalization) and after the first course of treatment (at 7:00 am–8:00 am of the last day of the first treatment course). Patients were divided into an effective group and an ineffective group based on treatment efficacy. Treatments were considered effective if the following 3 conditions were met: 1) serum levels of CTNi, CTNt, and CRP decreased to levels below the diagnostic threshold; 2), ECG significantly improved, especially that ST segment and T wave returned to normal; 3) chest tightness and chest pain of patients disappeared. Otherwise, treatments were considered ineffective. After discharge, all patients were followed up by telephone or clinic visits for 12 months.

Measurement of RDW and PDW

Venous blood samples collected into tripotassium EDTA tubes were analyzed within 2 h after venipuncture. The RDW and PDW values were determined by an Automated Hematology Analyzer (SF-3000, SYSMEX 2001, Kobe, Japan). The reference
range of RDW was 37–50 fl and the reference range of coefficient variation of PDW was 9–16%.

Definitions

The small letter “c” represents the changes before and after treatment. The letters “cr” represent the change rate before and after treatment. Thus, the formulas to calculate the change and change rate of RDW and PDW were as follows: RDW_c=RDW after treatment–RDW before treatment; if the value of (RDW after treatment – RDW before treatment) is larger than or equal to zero, RDW_cr=(RDW after treatment–RDW before treatment)/RDW after treatment; if the value of (RDW after treatment – RDW before treatment) is less than zero, RDW_cr=(RDW after treatment–RDW before treatment)/RDW after treatment. The letters “c” represent the changes before and after treatment. Thus, the formulas to calculate the change and change rate of RDW and PDW were as follows: RDW_c=RDW after treatment–RDW before treatment; if the value of (RDW after treatment – RDW before treatment) is larger than or equal to zero, RDW_c=RDW after treatment–RDW before treatment; if the value of (PDW after treatment – PDW before treatment) is less than zero, PDW_c=PDW after treatment–PDW before treatment; if the value of (PDW after treatment – PDW before treatment) is larger than or equal to zero, PDW_c=PDW after treatment–PDW before treatment; PDW_c=PDW after treatment–PDW before treatment)/PDW before treatment. To avoid the maximum value, the smaller absolute value of cr obtained by the 2 algorithms was used.

After treatment, if the detected value of RDW or PDW is greater than the upper limit of the reference value, the detected value is defined as positive (P); otherwise, the detected value is defined as negative (N). If the change and change rate of RDW or PDW before and after treatment are larger than or equal to zero, the related value is defined as P; otherwise, the related value is defined as N. If the detected values of RDW and PDW after treatment are both P, the combined detection of RDW and PDW is defined as P; otherwise, it is defined as N. If the change and change rate of RDW and PDW before and after treatment are both P, the combined change and change rate of RDW and PDW are defined as P; otherwise, it is defined as N.

Statistical analysis

SPSS17.00 was used for data analysis. All continuous variables were assessed for normal distribution with the Kolmogorov-Smirnov test. Since all the variable were not distributed normally, the changes and change rates of RDW and PDW before and after treatment were compared between the effective group and the ineffective group by use of the non-parametric independent samples t test. The chi-square test was used to compare the positive rate and positive change rate of RDW and PDW before and after treatment between the effective group and the ineffective group.

The effect of age, sex, and length of treatment, as well as positive rate, positive change rate, value, and value change of RDW and PDW, on treatment efficacy was analyzed by multivariate logistic regression. A total of 4 logistic regressions were performed with different variables. Model I used values of RDW and PDW after treatment. Model II used positive and negative results of RDW and PDW after treatment. Model III used changes of RDW and PDW before and after treatment. Model IV used positive and negative results of RDW and PDW changes before and after treatment. ROC curves were generated based on value change and change rate of RDW and PDW. The area under the curve (AUC) was calculated and the critical point and corresponding sensitivity and specificity points were identified. p<0.05 was considered as statistically significant.

Results

Patient demographics

A total of 120 AMI patients were included in the study. In the effective group, the mean age was 73.15±10.821 years, length of treatment was 8.25±4.938 days, and the sex ratio of males to females was 36/25. In the ineffective group, the mean age was 73.24±10.828 years, length of treatment was 7.41±3.797 days, and the sex ratio of males to females was 34/25. There was no significant difference in patient demographics between the 2 groups.

In the effective group, the follow-up rate was 62.29% (38/61), including 3 cases of AMI and 1 death. In the ineffective group, the follow-up rate was 57.62% (34/59), including 4 cases of AMI and 2 deaths. There were no significant differences between AMI recurrence rate and death rate (p>0.05).

Change and change rate of RDW and PDW

The change and change rate of RDW (RDW_c and RDW_cr) and PDW (PDW_c and PDW_cr) between effective treatment group and ineffective treatment group were compared. There was no significant difference of RDW before treatment, RDW_after treatment, PDW_before treatment and PDW_after treatment between the 2 groups, as shown in Table 1. RDW_c, PDW_c, RDW_cr and PDW_cr were all significantly different (p<0.01) (Table 2). Results showed that the changes in RDW and PDW significantly decreased in the effective group compared with the ineffective group.

The positive rate and positive change rate of RDW, PDW, and RDW + PDW

The positive rate and positive change rate of RDW, PDW, and RDW + PDW between the effective treatment group and ineffective treatment group were compared. We found that the positive rates of RDW_c, PDW_c, and RDW_c + PDW_c were
### Table 1. The value of RDW and PDW in the effective group and ineffective group before and after treatment.

|                     | RDW before treatment | RDW after treatment | PDW before treatment | PDW after treatment |
|---------------------|----------------------|---------------------|----------------------|---------------------|
|                     | Effective group      | Ineffective group   | Effective group      | Ineffective group   |
| Number of case (n)  | 61                   | 58                  | 58                   | 54                  |
| Mean ±SD            | 47.2±5.1             | 46.6±7.6            | 46.2±4.9             | 48.3±8.8            |
| Z(t)                | 4.567                | 3.559               | 4.484                | 3.442               |
| P                   | 0.000                | 0.000               | 0.000                | 0.000               |

RDW_c = RDW after treatment–RDW before treatment; RDW_cr = min{(RDW after treatment–RDW before treatment)/RDW after treatment or (RDW after treatment–RDW before treatment)/RDW before treatment}; PDW_c = PDW after treatment–PDW before treatment; PDW_cr = min{(PDW after treatment–PDW before treatment)/PDW after treatment or (PDW after treatment–PDW before treatment)/PDW before treatment}.

### Table 2. The differences, change and change rate of RDW and PDW between the effective group and ineffective group before and after treatment.

|                     | RDW_c | PDW_c | RDW_cr | PDW_cr |
|---------------------|-------|-------|--------|--------|
|                     | Effective group | Ineffective group | Effective group | Ineffective group |
| Number of case (n)  | 61     | 58     | 58     | 54     |
| Mean ±SD            | -1.08±3.78 | 1.72±4.5 | -2.14±7.2 | 3.12±7.3 |
| Z(t)                | 4.567  | 3.559  | 4.484  | 3.442  |
| P                   | 0.000  | 0.000  | 0.000  | 0.001  |

### Table 3. The difference and positive rate of RDW, PDW, RDW with PDW of the effective and ineffective groups before and after treatment.

|                     | RDW_after treatment | PDW_after treatment | RDW_after treatment + PDW_after treatment | RDW_c | PDW_c | RDW_c + PDW_c |
|---------------------|---------------------|---------------------|------------------------------------------|-------|-------|--------------|
|                     | N    | P | N    | P | N    | P | N | P | N | P | N | P | N | P |
| Effective           | 48   | 13 | 47   | 11 | 58   | 3 | 45 | 16 | 41 | 17 | 56 | 5 |
| Ineffective         | 42   | 16 | 45   | 9  | 53   | 1 | 13 | 45 | 22 | 32 | 28 | 5 |
| Chi-square value    | 0.635|    | 0.101|    | 0.802|    | 31.386|    | 10.192|    | 22.215|    |
| P value             | 0.425|    | 0.751|    | 0.370|    | 0.000|    | 0.001|    | 0.000|    |
| Odds ratio          | 1.407|    | 0.855|    | 0.365|    | 9.736|    | 3.508|    | 10.000|    |
| 95%CI               | Lower|    | 0.607|    | 0.324|    | 0.037|    | 4.201|    | 1.602|    | 3.458|    |
|                     | Upper|    | 3.261|    | 2.257|    | 3.615|    | 22.561|    | 7.682|    | 28.920|    |

P – positive; N – negative.
significantly different (p<0.01), but there was no significant difference in the positive rate of RDW_after treatment, PDW_after treatment, and RDW_after treatment + PDW_after treatment between the 2 groups (p>0.05), as shown in Table 3. These results indicate that the positive change rate of PDW and RDW can better reflect the treatment effects.

**The impact of sex, age, length of treatment, RDW, and PDW index on treatment efficacy**

To analyze the impact of sex, age, length of treatment, RDW, and PDW index on the treatment efficacy, multivariate logistic regression was used. The results are shown in Table 4. The total effective rate was 49.5% for model I and 54.1% for model II. The above 5 indicators were not independent factors for both model I and model II (p>0.05). The total effective rate of model III was 69.4%, and the changes of RDW and PDW were independent factors (p<0.01). The total effective rate of model IV was 72.1%, and the positive change rates of RDW and PDW were independent factors (p<0.05).

**ROC for RDW and PDW index on treatment efficacy**

The RDW_after treatment, RDW_c, and RDW_cr values were used to draw the ROC curve of RDW after treatment (Figure 1). The AUC for RDW after treatment was 0.536 [95% CI (0.431–0.640), p>0.05]. At the critical value of 45.750 fl, the corresponding prediction sensitivity was 55.2% and the specificity was 57.4%. The AUC of RDW_c was 0.743 [95% CI (0.651–0.834), p<0.001]. At the critical value of –0.050fl, the corresponding predictive sensitivity was 77.6% and specificity was 73.8%. The AUC of RDW_cr showed the AUC was 0.738 [95% CI (0.646–0.831), p<0.001]. At the critical value of –0.216%, the corresponding predictive sensitivity was 79.3% and the specificity was 73.8%.

The PDW_after treatment, PDW_c and PDW_cr value were used to generate the ROC curve of PDW after treatment. The AUC for PDW_after treatment was 0.513 [95% CI (0.406–0.621), p>0.05]. At the critical value of 12.650%, the corresponding prediction sensitivity was 61.1% and the specificity was 41.3%. The AUC of RDW_c was 0.694 [95% CI (0.595–0.794), p<0.001]. At the...
critical value of $-0.550\%$, the corresponding predictive sensitivity was 75.9% and specificity was 62.1%. The AUC curve of PDW_cr was 0.687 [95% CI (0.586–0.787), p<0.01]. At the critical value of $-4.686\%$, the corresponding predictive sensitivity was 79.6% and the specificity was 60.3% (Figure 2).

Discussion

AMI and ischemic heart disease have become major causes of emergency death [17]. Epidemiological studies [18, 19] have shown that the ischemic heart disease mortality rate has doubled in the past 2 decades, and the number of deaths has reached more than 1 million each year [20]. According to the World Bank, the MI-related death rate is increasing in China and may reach 230,000 in 2030 [21]. Clinically, patients may show chest pain, acute circulatory dysfunction, acute myocardial ischemia, myocardial damage, and necrosis on electrocardiogram and serum myocardial markers [22]. Its acute onset and high mortality rate leads to early death in the elderly [23].

Because of the acute onset of AMI and early insensitivity of therapeutic effect evaluation, it is of great importance of identifying the early response in AMI [24]. At present, serum enzyme indicators are used, including aspartate aminotransferase (AST), lactate dehydrogenase (LDH), and its isoenzymes [25]. However, AST and LDH are distributed in many organs of the body, and the diagnostic specificity is poor [26]. Abnormal increase of serum creatine kinase isoenzyme (CK-MB) and cardiac troponin (cTn) can also be early predictors of AMI and its treatment efficacy; however, CK-MB is expressed in multiple systems and thus may not accurately represent myocardial injury [27]. In addition, cTn has limited ability to predict treatment efficacy. Peripheral circulating DNA also has some predictive significance on AMI [28], but it is not universally used in clinical practice due to its high cost. Homocysteine (Hcy) can directly or indirectly lead to vascular endothelial cell damage, promote vascular smooth muscle cell proliferation, affect low-density lipoprotein oxidation, enhance platelet function, and promote thrombosis, but it is not widely used clinically due to the difficult procedure involved [29]. In assessing MI extent, aVF lead ST full-spectrum changes have prognostic significance in AMI, but with low sensitivity [30].

In recent years, the relationship between RDW/PDW and AMI has been reported. RDW is a parameter reflecting the difference in the size of red blood cells. The high RDW value reflects the large degree of red blood cell volume dispersion, and can also be used as an indicator of ischemia [31]. A high RDW value may be associated with cerebral vein thrombosis. PDW is a reflection of platelet volume heterogeneity, and the increase in platelet volume may indicate the disparity [8,32]. PDW is closely related to coronary artery diseases [33]. The PDW value of activated platelet may further change, presenting as increased number of pseudopods and morphology types [34]. A higher PDW value suggests that the blood is hypercoagulable and may further promote thrombosis [35]. The ischemia and hypoxia of corresponding tissue can accelerate platelet formation, induce the release of reticulated platelets by bone marrow [36], and further raise the PDW value. Ozuyurtlu et al. [37] found that compared with the normal control group, there were no significant differences in PDW before and after treatment in patients with coronary heart disease. Similarly, in our study, there were no differences in RDW and PDW between
the effective group and ineffective group before and after treatment, suggesting that the value of RDW and PDW cannot predict early treatment efficacy. Consistent with the report by Ozdemir et al. [15], our study found that there were significant differences in the amount of change and change rate of RDW and PDW before and after treatment between the effective and the ineffective groups, suggesting that they may be good indicators for treatment efficacy. At the same time, there were significant differences in the positive change rate of RDW and PDW between the effective and ineffective groups. We performed further analyses and found significant differences in the changes in RDW and PDW between the effective and ineffective group. Mulhsteen et al. [16] suggested that the change and change rate are of high value in determining the effect of early AMI treatment. In addition, multivariate logistic regression analysis in the present study showed that the RDW and PDW changes and change positive rates were independent risk factors for AMI. The ROC curve showed that the treatment evaluation value of RDW change and change rate was better than the RDW. Similarly, the treatment evaluation value of PDW change and change rate was better than the PDW. Therefore, we believe that the introduction of change and change rate as indicators for dynamic changes of RDW and PDW can better represent AMI treatment efficacy to guide individualized treatment. On the contrary, Wang Xiao et al. [38] showed that when compared with the control group, the RDW value did not significantly decrease in patients with successful treatment.

They also found that RDW first increased and then decreased in the first 7–9 days of the AMI treatment. Wang et al. [9] reported that PDW change was not significant during the course of MI treatment, and PDW was lower in KILLIP Class 3. These results indicate that more in-depth study is needed to elucidate the role of RDW and PDW in evaluation of treatment efficacy.

This study has some limitations. First, the sample size was relatively small, and studies with larger sample sizes are needed. Second, complete data on biochemical indexes were lacking. Furthermore, long-term follow-up data were not collected; therefore, the effect of RDW and PDW on long-term efficacy was not analyzed. Finally, the effect of antiplatelet drug on RDW and PDW was not investigated in this study.

Conclusions

RDW and PDW should be widely used due to their simplicity and low price. Compared with the absolute values of RDW and PDW, their changes or change rates can better reflect the treatment outcome for AMI.

Conflict of interest

The authors declare no conflict of interest.

References:

1. Celik A, Ozcan IF, Gündes A et al: Usefulness of admission hematological parameters as diagnostic tools in acute pulmonary embolism. Kaohsiung J Med Sci, 2015; 31: 145–49
2. Jin J, Chen M, Li Y et al: Detecting acute myocardial infarction by diffusion-weighted versus T2-weighted imaging and myocardial necrosis markers. Tex Heart Inst J, 2016; 43: 383–91
3. Badimon L, Vilahur G: Thrombosis formation on atherosclerotic lesions and plaque rupture. J Intern Med, 2014; 276: 618–32
4. Okopić B, Basiak M, Madej A et al: [Markers of inflammatory process in stable and unstable coronary artery disease]. Pol Merkur Lekarski, 2006; 21: 69–72 [In Polish]
5. Guo W, Liu X, Gao Z et al: Quantification of three-dimensional computed tomography angiography for evaluating coronary luminal stenosis using digital subtraction angiography as the standard of reference. Biomed Eng Online, 2015; 14: 50
6. Negi SI, Sokolovic M, Kolfin M et al: Contemporary Use of veno-arterial extracorporeal membrane oxygenation for refractory cardiogenic shock in acute coronary syndrome. J Invasive Cardiol, 2016; 28: 52–57
7. Gao L, Cao Z, Zhang H: Efficacy and safety of thrombectomy combined with intracoronary administration of tirofiban in ST-segment elevation myocardial infarction (STEMI). Med Sci Monit, 2016; 22: 2699–705
8. Vagadli† E, Gounari E, Lazaridou E et al: Platelet distribution width: A simple, practical and specific marker of activation of coagulation. Hippokratia, 2010; 14: 28–32
9. Wang XY, Yu HY, Zhang YY et al: Serial changes of mean platelet volume in relation to Killip Class in patients with acute myocardial infarction and primary percutaneous coronary intervention. Thromb Res, 2015; 135: 652–58
10. Felker GM, Allen LA, Pocock SJ et al: Red cell distribution width as a novel prognostic marker in heart failure: Data from the CHARM Program and the Duke Databank. J Am Coll Cardiol, 2007; 50: 40–47
11. Lippi G, Targher G, Salvagno GL, Guidi GC: Increased red blood cell distribution width (RDW) is associated with higher glycosylated hemoglobin (HbA1c) in the elderly. Clin Lab, 2014; 60: 2095–98
12. Cavaşoğlu E, Marmur JD, Hegde S et al: Relation of baseline plasma MMP-1 levels to long-term all-cause mortality in patients with known or suspected coronary artery disease referred for coronary angiography. Atherosclerosis, 2015; 239: 268–75
13. Sahin MS, Kızılirmak D: Changes at mean platelet volume and platelet distribution width levels after septoplasty and its correlation with Epworth sleepiness scale. J Craniofac Surg, 2017; 28: 71–73
14. Koku E, Yuksel IO, Arslan S et al: Predictors of symptom development in intermediate carotid artery stenosis: mean platelet volume and platelet distribution width. Angiology, 2016; 67: 622–29
15. Ozdemir S, Barutcu A, Gazi E et al: The relationship between some complete blood count parameters and myocardial perfusion: A scintigraphic approach. World J Nucl Med, 2015; 14: 197–201
16. Mulhsteen JB, Lappe DL, Anderson JL et al: Both initial red cell distribution width (RDW) and change in RDW during heart failure hospitalization are associated with length of hospital stay and 30-day outcomes. Int J Lab Hematol, 2016; 38: 328–37
17. Zhang XF, Hu DY, Ding RJ et al: Status and trend of cardio-cerebrovascular diseases mortality in China: Data from national disease surveillance system between 2004 and 2008. Zhonghua Xin Xue Guan Bing Za Zhi, 2012; 40: 179–87
18. Wang J, Zhang L, Wang F et al., China National Survey of Chronic Kidney Disease Working Group: Prevalence, awareness, treatment, and control of hypertension in China: Results from a national survey. Am J Hypertens, 2014; 27: 1355–61
19. Lim SS, Vos T, Flaxman AD et al: A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: A systematic analysis for the Global Burden of Disease Study 2010. Lancet, 2012; 380: 2224–60

20. Li J, Li X, Wang Q et al: ST-segment elevation myocardial infarction in China from 2001 to 2011 (the China PEACE-Retrospective Acute Myocardial Infarction Study): A retrospective analysis of hospital data. Lancet, 2015; 385: 441–51

21. Wang S, Marquez P, Langenbrunner J: Toward a healthy and harmonious life in China: Stemming the rising tide of non-communicable diseases. 2012; 1–48

22. Pursnani A, Lee AM, Mayrhofer T et al: Early resting myocardial computed tomography perfusion for the detection of acute coronary syndrome in patients with coronary artery disease. Circ Cardiovasc Imaging, 2015; 8: e002404

23. Nanase Y, Tada H, Harimura Y et al: Early repolarization increases the occurrence of sustained ventricular tachyarrhythmias and sudden death in the chronic phase of an acute myocardial infarction. Circ Arrhythm Electrophysiol, 2014; 7: 626–32

24. Fu C, Shi Y, Yao Z: sMICA as novel and early predictors for acute myocardial infarction. Eur J Med Res, 2016; 21: 25

25. Sarapultsev AP, Chupakhin ON, Sarapultsev PA et al: Effect of a new class of compounds of the group of substituted 5R1, 6H2-1,3,4-thiadiazine-2-amines on the inflammatory and cytokine response in experimental myocardial infarction. Curr Vasc Pharmacol, 2015; 13: 43–53

26. Danese E, Montagnana M: An historical approach to the diagnostic biomarkers of acute coronary syndrome. Ann Transl Med, 2016; 4: 194

27. Jin J, Chen M, Li Y et al: Detecting acute myocardial infarction by diffusion-weighted versus T2-weighted imaging and myocardial necrosis markers. Tex Heart Inst J, 2016; 43: 383–91

28. Xu Y, Liu B, Zhao Z et al: Clinical significance of peripheral blood circular DNA level measurements in patients with acute myocardial infarction. Zhongguo Yi Liao Qi Xie Za Zhi, 2012; 36: 456–58

29. Akyürek Ö, Akbal E, Günsel F: Increase in the risk of ST elevation myocardial infarction is associated with homocysteine level. Arch Med Res, 2014; 45: 501–6

30. Wong CK, Gao W, Stewart RA et al: The prognostic meaning of the full spectrum of aVR ST-segment changes in acute myocardial infarction. Eur Heart J, 2012; 33: 384–92

31. Miano A, Abbattista M, Bucciarelli P et al: Red cell distribution width and the risk of cerebral vein thrombosis: A case-control study. Eur J Intern Med, 2017; 38: 46–51

32. Zaccardi F, Rocca B, Pitocco D et al: Mean platelet volume, platelet distribution width, and platelet count in type 2 diabetes mellitus, impaired fasting glucose, and metabolic syndrome: Systematic review and meta-analysis. Diabetes Metab Res Rev, 2015; 31: 402–10

33. Sevuk U, Bahadir MV, Altindag R et al: Value of serial platelet indices measurements for the prediction of pulmonary embolism in patients with deep venous thrombosis. Ther Clin Risk Manag, 2015; 11: 1243–49

34. Iihara A, Kawamoto T, Matsumoto K et al: Relationship between hemostatic factors and the platelet index in patients with ischemic heart disease. Pathophysiol Haemost Thromb, 2006; 35: 388–91

35. Hamzianpour N, Chan DL: Thromboelastographic assessment of the contribution of platelets and clotting proteases to the hypercoagulable state of dogs with immune-mediated hemolytic anemia. J Vet Emerg Crit Care, 2016; 26: 295–99

36. Yardan T, Meric M, Kati C et al: Mean platelet volume and mean platelet volume/platelet count ratio in risk stratification of pulmonary embolism. Medicina (Kaunas), 2016; 52: 110–15

37. Ozyurtlu F, Yavuz V, Cetin N et al: The association between coronary slow flow and platelet distribution width among patients with stable angina pectoris. Postepy Kardiol Interwencyjnej, 2014; 10: 161–65

38. Wang X: Dynamic changes of RDW in acute myocardial infarction and evaluation of short-term prognosis. Zhongnan University, 2012