Original Article

Association of Platelet Count and Mean Platelet Volume in Acute ST- Elevated Myocardial Infarction

Md. Shakur Ahmed[1], Mir Jamal Uddin[2], Ummey Zahira Popy[3], Mohammad Ali[4], Bishnu Pada Saha[5], Fahdia Afroz[6], Md Mozammel Haque[7], Zahidul Islam Khan[8], Md Saiful Islam[9], Monwarul Haque Tohin[10], Nur Alam[11], Tariq Ahmed Choudhury[12], Md Wareshuzzaman[13], Iftekhar Alam[14]

Abstract:

Background: Early prediction and quick diagnosis with simple, quick and easily available tool is essential part of early management of acute coronary syndrome e.g. ST segment elevated myocardial infraction. As platelet has a significant role in thrombus formation and larger sized platelets are more active in thrombotic pathogenicity, as such platelet indices can be the early predictor for acute coronary syndrome.

Objective: Aim of this study was to assess the association of platelet count and mean platelet volume (MPV) in acute ST-elevated myocardial infarction.

Methodology: This observational study was conducted at the department of Cardiology of National Institute of Cardiovascular Diseases (NICVD), Dhaka, Bangladesh from November 2019 to October 2020. Total 166 subjects were enrolled in this study. Among them 82 subjects (Group I) had acute ST-elevated myocardial infarction on resting ECG were admitted at CCU of NICVD and without any prior history of anti-platelet drugs intake, another 84 subjects (Group II) were enrolled in this study as control group with normal 12 lead resting ECG with normal Troponin-I.

Results: No significant age difference observed between two groups (p =0.063). Significantly higher smoking and family history of coronary artery disease observed with ST elevated MI subjects (p:0.002 and <0.001 respectively). Associated risk factors like hypertension, diabetes and dyslipidaemia were significantly high (<0.001) in ST-elevated MI patients. No significant difference observed in platelet count between ST elevated MI groups compared with the control (258 X 10⁹/L vs. 267 X10⁹/L). Mean platelet volume (MPV) was found to be higher in group I patients as compared to control (12.20±0.86 vs. 9.26±0.77) and it was significant (p <0.001).

Conclusion: In acute ST-elevated myocardial infraction, higher mean platelet volume (MPV) and lower platelet count may be a useful marker.

Key Wards: ST segment elevated myocardial infarction (STEMI), Platelet Count, Mean Platelet Volume (MPV)

1 Perfusionist, National Institute of Cardiovascular Diseases, Dhaka
2 Director & Professor of Cardiology, NICVD, Dhaka.
3 Associate Professor of Biochemistry (CC), NIKDU, Dhaka.
4 Associate Professor of Haematology, NICRH, Dhaka.
5 Junior Consultant of Cardiology, Department of Cardiology, NICVD, Dhaka
6 Associate professor of Cardiology (CC) & RP, Department of Cardiology, NICVD, Dhaka
7 Assistant Professor of Cardiology, Department of Cardiology, NICVD, Dhaka
8 Assistant Registrar of Cardiology, Department of Cardiology, NICVD, Dhaka
9 Assistant Registrar of Cardiology, Department of Cardiology, NICVD, Dhaka
10 Assistant Registrar of Cardiology, Department of Cardiology, NICVD, Dhaka
11 Associate professor of Cardiology, Department of Cardiology, NICVD, Dhaka
12 Assistant Professor of Cardiology, Department of Cardiology, NICVD, Dhaka
13 Assistant Professor of Cardiology, Department of Cardiology, NICVD, Dhaka
14 Assistant Professor of Cardiology, Department of Cardiology, NICVD, Dhaka
Address of Correspondence: Dr. Md. Shakur Ahmed, Perfusionist, National Institute of Cardiovascular Diseases, Dhaka, Bangladesh. Mobile: +880171259322, e-mail: shakur.rubon@gmail.com

121   Association of Platelet Count and Mean Platelet Volume in Acute ST- Elevated
Ahmed MS et al.

Bangladesh heart j Vol. 38, No. 2
July 2023

Introduction

Significant advancements have been made in using biomarkers and electrocardiogram to diagnose STEMI, these methods measure myocardial necrosis, as opposed to the cause and therapeutic target; coronary thrombosis. Since myocardial necrosis follows thrombosis, these diagnostic criteria for acute MI may fail to identify patients before the induction of irreversible myocardial necrosis. Additionally, the current diagnostic methods do not target the differentiation of thrombotic and non-thrombotic causes of MI such as demand ischemia and stress cardiomyopathy, which has varying therapeutic and prognostic implications.[1] While the fourth universal definition of acute MI identifies angiographic confirmation of coronary thrombus as a criterion for the diagnosis of acute MI and differentiating myocardial necrosis caused by thrombotic versus non-thrombotic etiologies.[2]

Acute coronary syndrome (ACS) refers to a group of conditions due to decreased blood flow in the coronary arteries such that part of the heart muscle is unable to function properly as a consequence of platelet rich coronary thrombus formation.[3] Platelets have a major role in the pathogenesis of acute coronary syndrome (ACS) .[4] Activated platelets are larger in size, which can be measured by mean platelet volume (MPV).[5] Larger platelets are more adhesive and tend to aggregate more as they contain more dense granules. They are metabolically and enzymatically more active than small platelets and produce more thromboxane A2.[6, 7] Increased platelet volume will increase the tendency for coronary thrombus formation in ACS patients.[8] The activated platelet is the major biological risk factor in the pathogenesis of ACS, so inhibition of this process could play an important role in prevention of ACS .[9]

The diagnostic criteria of ACS are clinical presentation, biochemical markers of acute ischemic injury and electrocardiographic findings.[10, 11] The present cardiac markers are not sufficiently sensitive at an early stage of ACS. That's why an early and reliable marker is needed for early diagnosis of ACS when patients will attend in cardiac emergency. Platelet parameters especially MPV may be an important marker in early detection of ACS when other markers are not available.

Platelets have a primary function of stopping hemorrhage from vascular endothelium or tissue following an injury.[5] In a pathological spin-off to their apportioned physiological function of plugging endothelial defects, platelet activation in response to plaque disruption, results in occlusive thrombosis, is the paradigm for acute MI. The process of plaque progression and disruption is triggered by inflammatory and immune changes that convert the surface endothelium into a pro-atherothrombotic surface via cell adhesion molecules, primarily P-selectin and E-selectin.[12] Upon damage to the plaque, platelet activation is enhanced through the secretion of storage granules and adhesive ligands, which further promote platelet aggregation.[9] In the event of atherosclerotic plaque disruption, elevated rates of platelet aggregation potentiate the release of larger, more reactive platelets from the bone marrow.[13]The enhanced reactivity of these newly released platelets is attributed to elevated concentrations of active substances within microgranules (e.g., thromboxane A2 and B2, platelet factor 4, P-selectin, platelet derived growth factor), as well as increased expression of adhesive receptors (glycoprotein IIb/IIIa).[14, 15] Prior studies have demonstrated a significantly higher mean platelet volume (MPV) in patients presenting with ACS.[14, 16]

The MPV is a measure of platelet size and activity and the role of platelet activation is fundamental in the development of an acute MI.[5] Thus, we hypothesize that platelet count and MPV could be used as surrogate for platelet consumption and activation and therefore aid in the diagnosis of an acute STEMI, specifically acute thrombotic STEMI. Increase platelet volume will increase the tendency of coronary thrombus formation in acute STEMI. So, platelet count and MPV can be used as an early marker in acute STEMI. There are few studies in abroad regarding this issue but in our country no significant study was done previously. So, this study was done to explore the results in Bangladeshi population at a tertiary care hospital.

Methods

This cross-sectional observational study was carried out from November 2019 to October 2020 in the Department of Cardiology at National Institute of Cardiovascular Diseases (NICVD), Dhaka, Bangladesh. The study protocol was approved by the Ethical Review Committee of NICVD. Informed consent was taken from each patient or near relatives and utmost confidentiality was maintained. Data was collected in an approved data collection form.

On the basis of inclusion and exclusion criteria by purposive sampling method 166 subjects were recruited as study population. In group I 82 patient with acute ST-elevated myocardial infarction admitted in CCU who did not take anti-platelet drugs were included. On the other

hand, in group II 84 patients with chest pain who underwent physical examination with normal ECG and normal cardiac biomarker and no prior history of anti-platelet therapy were included. Apart from that, patients with hematological diseases, severe co morbidity (CKD, CVD, COPD etc.), valvular heart disease, peripheral vascular disease, cardiomyopathies, previous history of CABG/ PCI and age below 18 years were excluded.

From all study subject's, meticulous history was taken and detailed clinical examination was done and recorded in predesigned structured questionnaire. Demographic data including age, sex and occupation were recorded. Conventional risk factors of CAD profile was noted. Hemodynamic data; pulse and BP was recorded. 12 lead resting ECG was done at a paper speed of 25 mm/s and 10 mm standardization at admission. Blood was collected aseptically for CBC with platelet count and MPV with EDTA tube and determined by automated Hematology analyzer (Beckman Coulter, Model-DxH 500) before getting anti-platelet and anti-thrombotic. Other laboratory investigations e.g., RBS, serum creatinine, serum electrolytes, and serum troponin were carried out. Loading dose of Aspirin 300 mg, Clopidogrel 300 mg and Atorvastatin 40 mg were given after collection of blood who were diagnosed as acute STEMI.

Data were analyzed by using SPSS version 20 (Statistical package for social science). Quantitative data was expressed as mean and standard deviation and comparison was done by "student t" test. Qualitative data was expressed as frequency and percentage and comparison was carried by Chi-square ($\div 2$) Test. A two-tailed $p<0.05$ was considered statistically significant.

Results

In between the study groups, no significant gender difference was observed. Slight male predominance than female observed between two groups. Male, female ratio was 1.13. No significant difference observed in occupation between two groups. (Table I)

Incidence of all risk factors were significantly high in group I subjects (Table II). In table III presentation of symptoms of the subjects were analyzed, and as expected all symptoms were significantly high in group I. There was no significant difference observed in heart rate between the groups but both systolic and diastolic blood pressure was significantly high in group I subjects (Table IV).

In ST-elevated MI group mean platelet count was 258 $X10^9$/L and in control group mean platelet count was 267 $X10^9$/L. There was no significant difference observed in mean platelet count between the groups. In ST-elevated MI group mean platelet volume was 12.71 fl. and in control group mean platelet volume was 9.26 fl. In ST-elevated MI group mean platelet volume was significantly higher (<0.001) than control group. (Table V)

Table-I
Patient Demographic Characteristics. n:166

Demographics		Group I Case; n: 82	Group II Control; n: 84	p value
Age (mean ±SD)		48±6	47±7	0.063^{ns}
Gender (n, %)				
	Female	37 (22.3)	41 (24.7)	0.634^{ns}
	Male	45 (33.1)	43 (25.9)	
Occupation (n, %)				
	Housewife	22 (13.3)	32 (19.3)	0.060^{ns}
	Farmer	15 (9.0)	5 (3.0)	
Service	19 (11.4)	26 (15.1)		
	Business	18 (10.8)	15 (9.0)	
	Day labor	8 (4.8)	6 (3.6)	

Table-II
Distribution of risk factors in study subjects. n: 166

Characteristics	Group I (n=51) Frequency (%)	Group II (n=71) Frequency (%)	P value
Smoking	50 (30.1)	31 (18.7)	0.002^{s}
Diabetes	50 (30.1)	28 (16.9)	0.001^{S}
Hypertension	49 (29.5)	26 (15.7)	0.001^{S}
Dyslipidaemia	22 (13.3)	5 (3.0)	0.001^{S}
Family H/O IHD	24 (14.5)	06 (3.6)	0.001^{s}

Table-III

Clinical presentations of study subjects. n:166

Clinical Presentations	Group I	Group II	P-value
	Case; n: 82	Control; n: 84	
Chest discomfort	68 (41.0)	52 (31.3)	0.002[S]
Chest pain	76 (45.8)	68 (41.0)	0.026[S]
Shortness of breath	59 (35.5)	35 (21.1)	<0.001[S]

Table-IV

Heart rate and blood pressure of study subjects. n:166

On examination findings(Mean ± SD)	Group I	Group II	P-value
	Case; n: 82	Control; n: 84	
Heart rate in beat/min.	79±8	77±7	0.236[ns]
Systolic blood pressure in mm of Hg	129±15	119±12	<0.001[S]
Diastolic blood pressure in mm of Hg	82±15	74±9	<0.001[S]

Table-V

Platelet count and mean platelet volume of study subjects. n:166

Test; (Mean ± SD)	Group I	Group II	P-value
	Case; n: 82	Control; n: 84	
Total platelet count in X 10^9/L	258±44	267±55	0.239[ns]
Mean platelet volume in fl	12.20±0.86	9.26±0.77	<0.001[S]

Discussion:

This study aimed to compare total platelet count and mean platelets volume in ST-elevated MI cases (Group I) with control cases of normal ECG and normal Troponin-I biomarker (Group II) in our setting.

Acute coronary syndrome is the disease of middle and old age but the disease process usually starts in young age. In our study, overall mean age 46 years and there were no significant differences observed between cases and controls in respect of age. The mean age of the patients with ST elevated MI group was 48±6 years as compared to 55±10.73 years, 66±16 years, 56.59±13.6 years, 63.8 years and 63.4±13.0 years and 55.4±13.1 years in studies done by Pervin S et al., Ulusoy R E et al. Assiri A S et al, the ENACT study, Euro Heart Survey ACS and SPACE registry respectively is relatively lower than other study groups.[17, 18, 11, 19, 20, 21]

Except mild male predominance, no significant gender difference observed in our study (p - 634) like other studies of Pervin S et al., Ulusoy R E et al. Assiri A S et al, the ENACT study, Euro Heart Survey ACS and SPACE registry. [17, 18, 11, 19, 20, 21] In Birader S B et al., Ahmed H et al., Hassan N A E et al. study, their sample size was also had

male predominance.[22, 23] Though occupation is not an established risk factor for MI but it can provide information about lifestyle. In this study, no significant difference (p: 0.060) observed between two groups among different occupation groups.

We found overall 48.8% of study subjects were smoker and all were male and in group I (cases) had significantly higher (30.1%, p: 0.002) smoking history than control which indicates that smoking in an important risk factor in occurrence of MI. No smoking history in females as in our country traditionally female smoking is negligible. Ahmed H. et al. had found 30% smoker in cases, Assiri A S et al. had found 35% smokers in cases group, 29.7% smokers in cases in Manchanda, J. et al. meta-analysis, 46% smokers found with MI in Europian population observed in the ENACT study is more or less similar with our study.[23, 11, 25, 19]

In our study, significantly high (p <0.001) positive family history of CAD is more (14.5%) in ST-elevated MI groups than control. So, positive family history of CAD is also an important risk factor for coronary artery diseases. Similar result observed in Assiri A S et al. study where 37.7% study subjects of ACS groups than control.[11] In

Manchanda, J. et al. meta-analysis Positive family history was also high in acute coronary syndrome groups observed.[25]

Diabetes, hypertension and dyslipidemia are well established risk factors for coronary artery disease. Pre-existing co-morbidity, we found, significantly high incidence of hypertension, diabetes and dyslipidemia (29.5%, 30.1% and 13.3% respectively) in ST elevated MI group than control group (15.7%, 16.9% and 3.0% respectively). But ethnic variation observed in meta-analysis the ENACT study of European population with MI had Hypertension was 41%, Diabetes 19% and 20% were treated for dyslipidemia. Similar result observed like European population observed in Saudi population differs from our study.[19, 21] But different result observed in an Indian meta-analysis, where in ST-elevated MI groups had 17.7% hypertension, 19.4% diabetes probably due to lack of randomization in our study.[25]

Regarding presenting symptoms, our suspected patients of both groups had chest discomfort, chest pain and shortness of breath. But in group I, that is subjects with MI had significantly high (p: 0.002, 0.026 and <0.001 respectively) incidence of chest discomfort, chest pain and shortness of breath than control group indicates these symptoms are more in MI patients and urgent ECG and Troponin I are essential investigations to exclude MI.

In our study, no significant difference (p - 0.226) observed in heart rate between two groups. But we found significantly high (p <0.001) systolic and diastolic blood pressure in MI groups than control groups, that is relative high blood pressure is significant indicator in occurrence if MI where early ECG and Troponin I biomarker is indicated for confirmation of MI. Al Habib K F et al., Gheissari A et al. also found significant high Systolic blood pressure in MI but Gheissari A et al. found no difference in diastolic blood pressure between two groups.[21, 26]

The study reveals that the mean (±SD) value of total platelet count was lower in cases than controls without any significant statistical difference (p - 0.239). Total platelet count was 258±44 X 10^9/L in ST-elevated MI group and 267±55 X 10^9/L in control groups. Another Bangladeshi study by Pervin S et al. also reports similar findings like ours.[17] Saudi study of Assiri AS et al. and Turkish study of Ulusoy, R.E. et al. also found similar observation like our study.[11, 18] On the other hand, Cameron H A et al. and Hassan, N.A.E. et al. observed significantly lower platelet count on admission in ST elevated MI subjects than normal control group.[27, 24]

In our study, we found that ST-elevated MI was associated with higher mean platelet volume (MPV) which was significantly higher (p <0.001) in group I than group II. In our study, MPV was 12.20±0.86 fl and 9.26±0.77 fl respectively. MPV was significantly higher in patients with ST-elevated MI cases compared to control group. These results are consistent with the results of Pervin S et al., Biradar, S.B. et al., Ahmed H et.al., Hassan, N.A.E. et al., Mathur A et al. meta-analysis of Manchanda, J. et al., meta-analysis of Chu S. G. et. al. Huczek, Z. et al., Ulusoy, R.E. et al. and Assiri AS et al. They conclude that platelets parameters mainly MPV was raised in ACS compared to controls. So, mean platelet volume is a significant useful predictor of MI.[17, 22, 23, 24, 25, 14, 8, 18, 11]

In our study, we found no significant difference (p - 0.239) in mean platelet count between two groups. In such the prediction of MI is not possible from platelets count. In similar studies of Assiri AS et al., Ulusoy R E et al., Pervin S et al. also found no significant difference in platelets count.[11, 18, 17] All these findings lead to the hypothesis that higher mean platelets volumes (MPV) can be significant useful markers in patients with ST-elevated MI patients for early detection.

Conclusion:

In conclusion, larger platelet may contribute to the pre-thrombotic state in acute ischemic syndromes. In this study, mean platelet volume was higher and platelet count was lower in patients with acute coronary syndrome who had ST-elevation than those in control group. Larger platelets are haemostatically more active and hence carry risk for developing coronary thrombosis leading to acute coronary syndrome. Patients with increased mean platelet volume and lower platelet count could be easily identified during routine haematological analysis. It could play an important role in early detection of acute coronary syndrome.

Reference:

1   Newby LK, Jesse RL, Babb JD, Christenson RH, De Fer TM, Diamond GA, Fesmire FM, Geraci SA, Gersh BJ, Larsen GC, Kaul S, McKay CR, Philippides GJ, Weintraub WS. ACCF 2012 expert consensus document on practical clinical considerations in the interpretation of troponin elevations: a report of the American College of Cardiology Foundation task force on Clinical Expert Consensus Documents. J Am Coll Cardiol. 2012 Dec 11;60(23):2427-63. doi: 10.1016/ j.jacc.2012.08.969. Epub 2012 Nov 12. PMID: 23154053.

2   Thygesen, K., Alpert, J.S., Jaffe, A.S., Simoons, M.L., Chaitman, B.R. and Vasileva, E.Y., 2012. Task Force for the Universal Definition of Myocardial Infarction. Third universal definition of myocardial infarction. Nature Reviews Cardiology, 9(11), pp.620-633.

3   Chu, H., Chen, W.L., Huang, C.C., Chang, H.Y., Kuo, H.Y., Gau, C.M., Chang, Y.C. and Shen, Y.S., 2011. Diagnostic performance of mean platelet volume for patients with acute coronary syndrome visiting an emergency department with acute chest pain: the Chinese scenario. Emergency Medicine Journal, 28(7), pp.569-574.

4   Endler, G., Klimesch, A., Sunder Plassmann, H., Schillinger, M., Exner, M., Mannhalter, C., Jordanova, N., Christ, G., Thalhammer, R., Huber, K. and Sunder Plassmann, R., 2002. Mean platelet volume is an independent risk factor for myocardial infarction but not for coronary artery disease. British journal of haematology, 117(2), pp.399-404.

5   Davì, G. and Patrono, C., 2007. Platelet activation and atherothrombosis. New England Journal of Medicine, 357(24), pp.2482-2494.

6   Mercan, R., Demir, C., Dilek, I., Asker, M. and Atmaca, M., 2010. Mean platelet volume in acute coronary syndrome. Van Tip Dergisi, 17(3), pp.89-95.

7   Cesari, F., Marcucci, R., Caporale, R., Paniccia, R., Romano, E., Gensini, G.F., Abbate, R. and Gori, A.M., 2008. Relationship between high platelet turnover and platelet function in high-risk patients with coronary artery disease on dual antiplatelet therapy. Thrombosis and haemostasis, 99(11), pp.930-935.

8   Huczek, Z., Kochman, J., Filipiak, K.J., Horszczaruk, G.J., Grabowski, M., Piatkowski, R., Wilczynska, J., Zielinski, A., Meier, B. and Opolski, G., 2005. Mean platelet volume on admission predicts impaired reperfusion and long-term mortality in acute myocardial infarction treated with primary percutaneous coronary intervention. Journal of the American College of Cardiology, 46(2), pp.284-290

9   Ruggeri, Z.M., 2002. Platelets in atherothrombosis. Nature medicine, 8(11), pp.1227-1234.

10   Alpert, J.S., Antman, E., Apple, F., Armstrong, P.W., Bassand, J.P., De Luna, A.B., Beller, G., Breithardt, G., Chaitman, B.R., Clemmensen, P. and Falk, E., 2000. Myocardial infarction redefined-A consensus document of The Joint European Society of Cardiology/American College of Cardiology Committee f or the redefinition of myocardial infarction. Journal of the American College of Cardiology, 36(3), pp.959-969.

11   Assiri, A.S., Jamil, A.M., Mahfouz, A.A., Mahmoud, Z.S. and Ghallab, M., 2012. Diagnostic importance of platelet parameters in patients with acute coronary syndrome admitted to a tertiary care hospital in southwest region, Saudi Arabia. Journal of the Saudi Heart Association, 24(1), pp.17-21.

12   Borissoff, J.I., Spronk, H.M. and ten Cate, H., 2011. The hemostatic system as a modulator of atherosclerosis. New England Journal of Medicine, 364(18), pp.1746-1760.

13   Ranjith, M.P., Divya, R., Mehta, V.K., Krishnan, M.G., KamalRaj, R. and Kavishwar, A., 2009. Significance of platelet volume indices and platelet count in ischaemic heart disease. Journal of clinical pathology, 62(9), pp.830-833.

14   Chu, S.G., Becker, R.C., Berger, P.B., Bhatt, D.L., Eikelboom, J.W., Konkle, B., Mohler, E.R., Reilly, M.P. and Berger, J.S., 2010. Mean platelet volume as a predictor of cardiovascular risk: a systematic review and meta analysis. Journal of Thrombosis and Haemostasis, 8(1), pp.148-156.

15   DeFilippis, A.P., Oloyede, O.S., Andrikopoulou, E., Saenger, A.K., Palachuvattil, J.M., Fasoro, Y.A., Guallar, E., Blumenthal, R.S., Kickler, T.S., Jaffe, A.S. and Gerstenblith, G., 2013. Thromboxane A2 generation, in the absence of platelet COX-1 activity, in patients with and without atherothrombotic myocardial infarction. Circulation Journal, pp.CJ-12.

16   Dehghani, M.R., Taghipour-Sani, L., Rezaei, Y. and Rostami, R., 2014. Diagnostic importance of admission platelet volume indices in patients with acute chest pain suggesting acute coronary syndrome. Indian heart journal, 66(6), pp.622-628.

17   Pervin, S., Ferdoushi, S., Hossain, M., Joarder, A.I. and Sultana, T., 2013. Elevated mean platelet volume is a marker of acute coronary syndrome. Bangladesh Medical Journal, 42(2), pp.45-50.

18   Ulusoy, R.E., Yokuþoðlu, M., Kýrýlmaz, A., Nevruz, O., Baysan, O., Kýlýçaslan, F. and Cebeci, B.S., 2011. Mean platelet volume in ST elevation and non-ST elevation myocardial infarction. Gulhane Med J, 53(2), pp.114-8.

19   Fox, K.A.A., Cokkinos, D.V., Deckers, J., Keil, U., Maggioni, A. and Steg, G., 2000. The ENACT study:

a pan-European survey of acute coronary syndromes. European heart journal, 21(17), pp.1440-1449.

20   Hasdai, D., Behar, S., Wallentin, L., Danchin, N., Gitt, A.K., Boersma, E., Fioretti, P.M., Simoons, M.L. and Battler, A., 2002. A prospective survey of the characteristics, treatments and outcomes of patients with acute coronary syndromes in Europe and the Mediterranean basin. The Euro Heart Survey of Acute Coronary Syndromes (Euro Heart Survey ACS). European heart journal, 23(15), pp.1190-1201.

21   Al Habib, K.F., Hersi, A., AlFaleh, H., AlNemer, K., AlSaif, S., Taraben, A., Kashour, T., Bakheet, A., Al Qarni, A., Soomro, T. and Malik, A., 2011. Baseline characteristics, management practices, and in-hospital outcomes of patients with acute coronary syndromes: results of the Saudi project for assessment of coronary events (SPACE) registry. Journal of the Saudi Heart Association, 23(4), pp.233-239.

22   Biradar, S.B., Kashinakunti, S.V. and Manjula, R., 2016. Platelet volume indices in acute coronary syndrome–a case control study. Int. J. Adv. Med, 3(2), pp.349-352.

23   Ahamed H, Henry R A, Pai. R. 2017 Association of mean platelet volume and acute coronary syndrome. International Journal of Research in Medical Sciences, Apr;5(4):1217-1220

24   Hassan, N.A.E., El-Ddin, T.M.K., Kafafy, T.A.N. and Mahran, E.H., 2020. Platelet indices and blood cell ratios in acute coronary syndrome and their predictive values. Journal of Current Medical Research and Practice, 5(1), p.57.

25   Manchanda, J., Potekar, R.M., Badiger, S. and Tiwari, A., 2015. The study of platelet indices in acute coronary syndromes. Annals of pathology and laboratory medicine, 2(1), pp.A30-A35.

26   Gheissari, A., Dehghan, B., Ghaed Sharafi, B., Abedini, A., Merrikhi, A., Madihi, Y. and Mehrkash, M., 2019. Importance of Mean Platelet Volume in Predicting Cardiac Mechanics Parameters and Carotid Intima Media Thickness in Children With End Stage Renal Disease and Comparison With Healthy Children. Therapeutic Apheresis and Dialysis, 23(5), pp.451-459.

27   Cameron, H.A., Phillips, R., Ibbotson, R.M. and Carson, P.H., 1983. Platelet size in myocardial infarction. Br Med J (Clin Res Ed), 287(6390), pp.449-451.