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Serum sP-Selectin Level and Brachial Artery Flow Mediated Dilation as Predictors of No Reflow in Patients with ST Segment Elevation Myocardial Infarction Undergoing Primary PCI

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ABSTRACT

Background: no reflow phenomenon is associated with major adverse cardiac events, prediction of no reflow using laboratory and noninvasive imaging techniques can help in early prevention and management of this phenomenon.

Objectives: to investigate the predictive value of serum sP-selectin and endothelial dysfunction assessed by using brachial artery flow mediated dilation (FMD) in patients with STEMI undergoing primary PCI to address patients with high incidence of no reflow.

Methods: the prognostic performance, clinical and angiographic correlates of sP-selectin and FMD was assessed in 96 patients admitted in National Heart Institute and Ain Shams University Hospitals by STEMI and underwent primary PCI as a reperfusion strategy. Each patient was subjected to (history taking, clinical examination, laboratory investigations including withdrawal of serum samples for detection of sP-selectin levels, echocardio-graphy, assessment of endothelial dysfunction by measuring the FMD, assessment of the angiographic results using TIMI flow grade and myocardial blush grade. Follow up of the patients during hospital stay and after one month for the incidence of MACE.

Results: a significant correlation between patients with high serum sP-selectin and TIMI flow ≤ II was found (P=0.038) and between the serum levels of the sP-selectin and the MBG score (P=0.009), also a significant correlation between the FMD and the MBG score among the study cases (P=0.029) as well as a significant correlation between the FMD and the serum P-selectin level among study cases (P=0.016). There were no statistical significance between TIMI flow grade and brachial artery FMD (P=0.075). Also no significant correlation was found between the patients' serum levels of sP-selectin, brachial artery FMD and the incidence of MACE during the hospital stay or during one month of follow up after discharge (P=0.127 and P=0.693, respectively).

Conclusions: serum sP-selectin level in patients with STEMI treated by primary PCI can predict the patients who will develop no reflow phenomenon after PCI, FMD could not predict the incidence of no reflow among those patients.

Key words: No reflow, sP-slectin, Flow mediated dilation

INTRODUCTION

No-reflow has been variably defined. In the setting of percutaneous coronary intervention (PCI) it is best defined as inadequate myocardial perfusion in the infarct related artery without evidence of mechanical epicardial vessel obstruction. Angiographic no-reflow is defined as less than Thrombolysis in Myocardial Infarction (TIMI) 3 flow and it occurs in around 2% of all PCI cases [(1)].

Studies showed that no reflow was associated with high incidence of major adverse cardiac events following primary PCI [(2,3,4)]. Several trails tried to address the clinical and procedural predictors of no reflow [(5)], others tried to find correlation between the different biomarkers and no reflow; thus several therapeutic and interventional procedures could be applied to prevent the occurrence of no reflow [(6)].

P-selectin is an adhesion molecule located in the platelet alpha granule and Weibel-Palade body of endothelial cells.

P-selectin plays a key role in diseases associated with injury and arterial thrombosis. Increased expression of P-selectin is observed

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in coronary artery disease, acute myocardial infarction, stroke, and peripheral arterial diseases [7].

Endothelial dysfunction as an integrating index of the risk factor burden and genetic susceptibility is an early marker of atherothrombotic disease. Flow-mediated dilation (FMD) of the peripheral conduit arteries is one of the most widely used tests of endothelial function [8].

There are no enough data about the use of the serum P-selectin level and the brachial artery flow mediated dilation to predict patients with high thrombotic burden and hence the incidence of no reflow in patients with STEMI who undergo primary PCI.

Aim of the study: to study the relation between the incidence of no Reflow, serum sP-selectin level and the brachial artery flow mediated dilation in patients undergoing primary PCI.

Patients and Methods

Patients: the study involved (96) patients from Ain Shams University Hospital and National Heart Institute presented with STEMI and treated by primary PCI.

Inclusion criteria:

1. Age between 18-70 years.
2. Presented with ST segment elevation myocardial infarction.
3. Undergoing primary PCI.
4. First attack of MI.

Exclusion criteria:

1. Patients with STEMI treated by thrombolytic therapy.
2. Patients with heart failure, renal failure, and cerberovascular stroke.
3. Patients with previous CABG or PCI.
4. Patients with contraindication to Thienopyridines and acetylsalicylic acid.

Methods:

Each patient was subjected to:

All patients were subjected to the following:

History taking: including age, sex, coronary risk factors (smoking, diabetes, hypertension, hyperlipidemia and family history of ischemic heart disease), time of onset of chest pain, pain to door time .

Cath Lab procedural details : door to balloon time , drugs used in the cath lab, balloons and stents used, number of balloon inflations and whether an aspiration thrombectomy device was used or not.

Clinical examination which include:

1. Blood pressure.
2. Heart rate and rhythm.
3. Chest examination.
4. Cardiac examination.
5. Grace score was calculated for every patient.

Investigations:

A) ECG:

Standard 12-lead surface ECG was done on admission, 90 minutes after reperfusion and serially every 8 hours to assess the ST segment resolution.

B) Transthoracic Echocardiography:

To assess the presence or absence of mechanical complications and the overall systolic function.

C) Llaboratory investigations:

Serum samples from all patients were taken for serum p selectin assessment using enzyme immuno assay before primary PCI.

1) Specimen Collection And Handling

Blood samples were taken from all cases by disposable syringe and centrifuged, the serum was frozen at -20°C degree.

2) The Procedure:

The procedure was done by technician in the immunology department in Ain Shams university hospital using (Sun Long Biotech Hangzhou,Zhejiang,China)Human solube P-Selectin Enzyme Immunoassay (EIA) Kit which is an in vitro quantitative assay for detecting sP-selectin levels in Human plasma.
Assay range: 8 pg/ml -500 pg/ml.
Sensitivity 1.6 pg/ml.

D) duplex ultrasonography:

To assess endothelial dysfunction using brachial artery flow mediated dilation, a phygmomanometric (blood pressure) cuff was first placed above the antecubital fossa, a baseline rest image was acquired, the brachial artery was imaged above the antecubital fossa in the longitudinal plane a segment with clear anterior and posterior intimal interfaces

between the lumen and vessel wall was selected for continuous 2D grayscale imaging. Thereafter, arterial occlusion was created by cuff inflation to supra systolic pressure, typically, the cuff was inflated to at least 50 mm Hg above systolic pressure to occlude arterial inflow for a standardized length of time (5 minutes), subsequent cuff deflation causes the brachial artery to dilate. The longitudinal image of the artery is recorded continuously from 30 s before to 2 min after cuff deflation. It was done by a highly qualified operator in the radiology department National Heart Institute, the invasive cardiologist was blinded to the results of brachial artery flow mediated dilation.

E) Primary PCI procedure:

A transradial or transfemoral artery approach according to the operator preference using a 6-F a sheath was done. A 6-F right and left Judkin diagnostic catheters were used for diagnosis and according to the angiographic findings guiding catheters were chosen for the primary PCI procedure, for each patient a preoperative loadingdose of Clopidogrel 600 mg, Aspirin loading dose of 300 mg were given. During the procedure a 10.000 IU of unfractionated heparin sodium was given, Glycoprotein IIB/IIIA inhibitors and thrombus aspiration device were used in cases of high thrombus burden as a pail out therapy, to assess the procedural success following the primary PCI TIMI flow and myocardial blush grades were used.

1) Thrombolysis In Myocardial Infarction (TIMI) grading system.

Grade 0: complete occlusion of the infarct-related artery.
Grade 1: some penetration of the contrast material beyond the point of obstruction but without perfusion of the distal coronary bed.
Grade 2: perfusion of the entire infarct vessel into the distal bed but with delayed flow compared with a normal artery.
Grade 3: full perfusion of the infarct vessel with normal flow [9,10].

2) Myocardial Blush Grade (MBG)

Is an angiographic measure of myocardial perfusion at the capillary level [11].
MBG was graded as follows:
Grade 0: indicates no myocardial blush or contrast density.
Grade 1: indicates minimal myocardial blush or contrast density.
Grade 2: indicates moderate myocardial blush or contrast density, but less than that obtained during angiography of a contralateral or ipsilateral non infarct-related coronary artery.
Grade 3: indicates normal myocardial blush or contrast density, comparable with that obtained during angiography of a contralateral or ipsilateral non infarct-related coronary artery [11].

When myocardial blush is persistent (staining), this suggests leakage of contrast medium into the extravascular space and is also graded 0. To determine blush grading, the length of the angiographic run is needed to visualize the venous phase of the contrast passage. When the left coronary artery was involved, we used the left lateral view. When the right coronary artery was involved, we used the right oblique view.

Follow up:

Follow up of the patients was done during the hospital stay and 30 days after discharge for the following:

A) During the hospital stay:

-In hospital mortality.
-Heart failure: based on symptoms and signs of heart failure detected during clinical examination of the patients.
-Mechanical complications of MI: ischemic mitral regurgitation, ventricular septal rupture and ventricular aneurysm detected by clinical examination and echocardiography.
-Recurrence of ischemic attacks: history of recurrent typical chest pain associated with dynamic ECG changes detected in the serial ECG.
-Occurrence of serious ventricular arrhythmias: Ventricular tachycardia, ventricular fibrillation detected by history taking from the cardiology resident or from a documented ECG.
-Stroke.
-Need for revascularization: whether by PCI or CABG.

B) follow up after 30 days:

Follow up for each patient was done 30 days after discharge from the hospital for detection of:

-Mortality.

-Recurrence of ischemic attacks:

History of recurrent typical chest pain after discharge ,patients with chest pain were reevaluated clinically and a new ECG was done for detection of dynamic ECG changes.

-Need for re-hospitalization:

Whether due to heart failure or new ischemic attacks.

-Need for revascularization:

Whether by CABG or PCI.

Statistical analysis:

The collected data was revised, coded, tabulated and introduced to a PC using Statistical Package for Social Science (SPSS 15.0.1 for windows; SPSS Inc, Chicago, IL, 2001). Data was presented and suitable analysis was done according to the type of data obtained for each parameter.

RESULTS

Description of personal and medical risk factors among cases:

The current study involved 96 patients; 84 (87.5%) male patients and 12 (12.5%) female patients, the mean age of the patients was 52.5 ranging from 28 to 72 years with SD ±9.6, 29 (30.2%) patients were hypertensives, 33 (34.4%) patients had Diabetes Mellitus, 62 (64.6%) patients were smokers, only 7 (7.3%) patients had history of dyslipidemia, 19 (19.8%) patients had a positive family history of IHD.

89 (92.7%) patients of the study cases were classified as killip class 1; while 3 (3.1%) patients were classified as killip class 2; and 4 (4.1%) patients were classified as killip class 4. The mean Grace score of the study cases for the 6 months prediction of mortality was 97.95 points (minimum 57 points and maximum 149 points) with SD of ±19.46 points.

Description of FMD and P selectin among the study cases:

The mean percentage of the FMD among study cases was 11.09% (minimum 0% and maximum 30%) with SD ± 7.22, the mean soluble P-selectin level of the study cases was 57 pg/ml (minimum 30 pg/ml and maximum 96 pg/ml) with SD of ±17.6.

Description of coronary angiography of study cases:

73 (76 %) patients of the study cases had LAD lesions and 23 patients had non LAD (24%) lesions (LCX, Ramus intermedius or RCA lesions), 54 (56.2%) patients had single vessel disease, while 30 (31.2%) patients had 2vessel disease, and 12 (12.5%) patients had 3 vessel disease, the mean number of vessel affected among cases was 1.56 with SD of ± 0.71.

The mean number of lesions in the affected vessels was 1.68 with SD of ±0.88 (minimum of 1 lesion and maximum of 5 lesions).

Description of methods of management during the primary PCI:

The mean pain to door time was 9.3 hours (minimum of 30 minutes and maximum of 49 hours) with SD of ± 7.9 hours, 31 (32.3%) patients underwent multiple balloon inflations, 32 (33.3%) patients underwent single balloon inflation and 33 (34.4%) patients underwent no balloon dilatation before stenting. In 15 (15.6%) patients of the study cases aspiration device was used. In 35 (36.5%) patients we used intra coronary injection of medications to manage no reflow such as (Nitroglycerin 100-500µg –Verapamil 25-200 µg and Adrenalin 100-200 µg).

Description of coronary angiography of study cases after primary PCI:

27 (28.1%) patients had TIMI flow ≤ 2 and 69 (71.9%) patients had TIMI 3 flow. One (1%) patient had MBG 0, 2 (2.1%) patients had MBG 1, 45 (46.9%) patients had MBG 2 (50%) and 48 patients had MBG 3.

Description of MACE during the hospital stays among study cases:

2 (2.1%) patients only had mechanical complication which was ischemic mitral regurgitation, one (1.1%) patient had recurrent ischemic attacks during the hospital stay, 2 (2.1%) patients had in hospital ventricular tachycardia, and 1 (1.1%) patient had 2nd degree A/V block, 5 (5.2%) patients developed

heart failure during the hospital stay, there were 2 (2.1%) mortalities during the hospital stay, 4 (4.2%) patients had cardiogenic shock during the hospital stay.

Description of MACE at follows up among study cases:

6 (6.38%) patients had recurrent ischemic attacks within one month after discharge; 3 patients of whom underwent revascularisation by PCI to the non target vessel, 2 patients to the target vessel, and one patient was managed medically. 2 (2.1%) patients of the study cases were readmitted to the hospital within one month after discharge one patient was admitted for unstable angina and underwent PCI to the non target vessels and the other one was admitted for heart failure, 7 (7.4%) patients developed symptoms of heart failure within one month after discharge, only one patient required hospital admission, there were 8 (8.4%) patients who underwent revascularization, 2 cases underwent PCI to the target vessels, 6 patients underwent PCI to the non-target vessel, there were 2 (2.2%) cases who died one month after discharge; most likely cardiac death was the etiology in both cases.

Relation between sP-selectin, FMD and TIMI flow among the study cases:

There was significant difference between the serum levels of soluble P-selectin and the incidence of TIMI ≤ 2 flow (no reflow) among study cases (P = 0.038).

There was a trend towards a significant difference (however not reaching statistical significance) between the post procedural TIMI flow and the brachial artery FMD, (median 7.6 among TIMI ≤ 2 compared to a median 11 among TIMI 3 cases) (p=0.075).

Correlation between FMD, sP-selectin and MBG among the study cases:

There was significant correlation between the serum levels of the P-selectin, the FMD and the MBG score (P=0.009, 0.029; respectively).

Correlation between different factors and TIMI flow score:

The variables that correlated with the TIMI flow ≤ 2 among the studied population (with this correlation reaching statistically significant levels) included the serum P-selectin level (P=0.012), the pain to door time (P=0.002) and number of balloon inflations (P=.031).

Correlation between FMD and sP-selectin:

There was significant correlation between the FMD and the serum P-selectin level among study cases (P=0.016).

Regression analysis to study independent factors affecting TIMI flow:

The regression analysis of different independent factors for no reflow showed significant value as regard serum P-selectin level (P=0.021) (Regression coefficient -0.028) and didn't show significant values as regard the other different independent factors.

Relation between sP-Selectin, FMD and MACE during the hospital stay and within one month after discharge among the study cases:

There were no significant difference between the patients' sP-Selectin levels, flow mediated dilation percentages and the incidence of MACE during the hospital stay and at the follow up period.

DISCUSSION

The current study demonstrated that the levels of serum sP-selectin were significantly higher in patients with ≤ TIMI II flow (P=0.038) these results were similar to Liu *et al*. [(12)] in which they measured the levels of sP-selectin in 195 consecutive patients with acute myocardial infarction (AMI) who underwent primary percutaneous coronary intervention (PCI) within 12 h of symptom onset and they found that the circulating levels sP-selectin were significantly higher in patients with high burden thrombus formation (HBTF) than that in patients with low burden thrombus formation (LBTF) and that patients with the HBTF group had a significantly lower rate of post-PCI TIMI grade-3 flow than that of patients in the LBTF group (84.52% vs 93.69%, P=0.037).

These findings were different from Chiu *et al*. [(13)] in which they found no significant difference between the plasma levels of sP-selectin in post-PCI TIMI-3 flow and those in ≤ TIMI-2 flow (p=0.569) in 142

consecutive patients with STEMI who underwent primary PCI. However in Chiu's study; tirofiban therapy loading dosage was administered to patients upon presentation in the emergency room, followed by a maintenance infusion for 18 to 24 hours this may explain the difference between this study and our study due to the major role of tirofiban in platelet inhibition.

The current study demonstrated a significant correlation between the serum levels of the sP-selectin and the MBG score (p=0.009)

These results were similar to Chiu *et al*. [13] in which they found a tendency toward a statistically significant difference in the plasma levels of sP-selectin between post- PCI MB grade $\geq$ 2 and MB grade $\leq$ 1 (P=0.062) in patients who presented with STEMI and who underwent primary PCI. The discrepancy between the P-selectin correlation to TIMI flow (as described above) and the MBG was attributed to large thrombi which have formed in the epicardial vessels and were crushed into small thrombi either by the balloon or the stent. These small thrombi were subsequently embolized distally and pluged the microvasculature; thus having an impact preferentially on the MBG. The second explanation for this discrepancy is the fact that Chiu *et al*. [13] used a PercuSurge device (distal protection device) in 32% of their patients. This may explain the difference in the epicardial coronary flow and the microvasculature which preferentially affects the MBG.

In this study we observed a significant correlation between the FMD and the MBG score among the study cases (P=0.029). Also there was a trend towards a significant difference (however not reaching statistical significance) between patients with $\leq$ TIMI II flow and patients with TIMI III flow as regard the brachial artery FMD (P=0.075).

To our knowledge researches thus far didn't identify the definite relation between endothelial dysfunction and no reflow in patients undergoing primary PCI. However Ari *et al*. [14] found a significant negative correlation between FMD and TIMI frame count (P=0.004) in 26 patients with normal coronaries and slow coronary flow. This study is different from our study with respect to the group; as well as with respect to the patient preparation. In our study; we were not justified (from an ethical stand point) to discontinue medications (such as nitrates, statins ACE inhibitors) that have a well proven effect on improvement of endothelial dysfunction. The fact that these patients were on medications that have an effect on endothelial dysfunction may have diluted the impact of other variables that adversely affect endothelial dysfunction. However all patients in our study used same medication groups.

The current study showed a significant association between the FMD and the serum P-selectin level among study cases (P=0.016). This observation might not necessarily point to a reciprocal or causative relationship between both variables; but might rather indicate the presence of both endothelial dysfunction (evidenced by impaired FMD) and platelet aggressiveness (indicated by P-selectin levels) in patients with acute myocardial infarction. A matter of potential further research would be correlating the outcome of AMI in patients with either endothelial dysfunction (impaired FMD) or platelet aggressiveness (high levels of P-selectin) or both.

The current study failed to find a significant correlation between the patients serum levels of sP-selectin and the incidence of MACE during the hospital stay or during one month of follow up after discharge (P=0.127).

This result was similar to Baeza *et al*. [15] who found no significant correlation between serum levels of sP-selectin in 70 patients presented with ACS and the incidence of MACE during hospital stay and 6 months after discharge (P=0.601).

The current study also failed to find significant correlation between the patients' values of brachial artery flow mediated dilation and the incidence of MACE during the hospital stay or during one month of follow up after discharge (P=0.693).

These results were different from Guazzi et al. [16] who found significant correlation between the values of brachial

artery flow mediated dilation in 197 patients who presented with myocardial infarction and the incidence of MACE during a period of 13.7 (+/-9.5) months(p=0.01).

This difference between the two studies may be due to the longer time of follow up and a larger number of patients in the Guazzi *et al*. [16]

Frick *et al*. [17] found no significant correlation between the brachial artery FMD in 398 male patients (in whom coronary angiography was performed due to chest pain) and MACE in those patients in a follow up period which extended up to 4 years (P=0.79) . However, in Frick's study patients admitted with ACS were excluded; which may explain the difference in the results between Frick *et al*. [18] and Guazzi *et al*. [16].

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Tables and figures

Table (1): Percentage of FMD and levels of sP-selectin among the study cases

	Mean	±SD	Minimum	Maximum	Median
FMD%	11.09	7.22	.00	30.00	10.00
P selectin	57.1	17.6	30.0	96.0	55.5

Table (2): The TIMI flow and MBG among the study cases

		Number	%			
TIMI flow	TIMI<3	27	28.1%			
	TIMI 3	69	71.9%			
MBG	0	1	1.0%			
	1	2	2.1%			
	2	45	46.9%			
	3	48	50.0%			

Table (3): Relation between risk factors of CAD and TIMI flow among study cases

		No reflow				P	Sig
		TIMI<3		TIMI 3			
		Mean	±SD	Mean	±SD		
Age		53.7	9.8	52.0	9.6	.447‡	NS
Number of risk factors		1.6	1.1	1.6	.9	.858‡‡	NS
Sex	Male (n %)	26	31.0%	58	69.0%	.169**	NS
	Female (n %)	1	8.3%	11	91.7%		
Smoking	Yes (n %)	18	29.0%	44	71.0%	.789*	NS
	No (n %)	9	26.5%	25	73.5%		
HTN	Yes (n %)	8	27.6%	21	72.4%	.938*	NS
	No (n %)	19	28.4%	48	71.6%		
DM	Yes (n %)	7	21.2%	26	78.8%	.276*	NS
	No (n %)	20	31.7%	43	68.3%		
Dysliplidemia	Yes (n %)	2	28.6%	5	71.4%	1.0**	NS
	No (n %)	25	28.1%	64	71.9%		
Family history of IHD	Yes (n %)	7	36.8%	12	63.2%	.345*	NS
	No (n %)	20	26.0%	57	74.0%		

‡student t test ‡‡Mann Whitney test *Chi-Square Test

Table (4): Correlation between FMD, sP-selectin and MBG among the study cases

		FMD%	Pselectin
MBG	R	.256*	-.424
	P	.029	.009
	Sig	S	S

*Chi-Square Test

Table (5): Relation between Grace Score, Killip class, pain to door time and TIMI flow among the study cases

		No reflow						P	Sig
		TIMI<3			TIMI 3				
		Mean	±SD	Median	Mean	±SD	Median		
Grace score		98.7	18.5	96.0	97.6	19.9	97.0	.804‡	NS
Pain to door time		10.3	10.5	7.5	8.9	6.7	6.0	.403‡‡	NS
killip	Class 1	24	88.8%		65	94.2%		0.245**	NS
	Class 2	1	3.8%		3	4.3%			
	Class 3	0	0%		0	0%			
	Class 4	2	7.4%		1	1.5%			

‡Student t test ‡‡Mann Whitney test *fisher exact Tests

Table (6): Relation between P-selectin, FMD and TIMI flow among the study cases

	No reflow						P	Sig
	TIMI ≤ 2			TIMI 3				
	Mean	±SD	Median	Mean	±SD	Median		
P selectin	79.7	9.6	80.0	68.3	10.8	68.0	.038‡	S
FMD%	8.2	6.6	7.6	11.8	7.3	11.0	.075‡‡	NS

‡student t test ‡‡Mann Whitney test *Chi-Square Tests

Table (7): Correlation between the FMD and the sP-selectin levels among the study cases

		sP-selectin
FMD%	R	-.320
	P	.016
	Sig	S

Table (8): Relation between sP-Selectin, FMD and MACE during the hospital stay and within one month after discharge

	MACE				P	Sig
	no		Yes			
	Mean	±SD	Mean	±SD		
P-selectin	55.7	17.9	62.5	15.7	.127	NS
FMD%	10.9	7.4	11.9	6.6	.693	NS

Table (9): Regression analysis of the independent factors affecting the TIMI flow with sP-selectin being the only significant variable

	Regression coefficient	P	Sig.	95 % CI for regression coefficient	
				Lower Bound	Upper Bound
P-selectin	-.028	.021	S	-.038	-.019
FMD%	-.003	.662	NS	-.017	.011
Pain to door time	-.004	.594	NS	-.020	.011
Number of balloon inflations	-.065	.152	NS	-.154	.024
MPG	.069	.616	NS	-.204	.342

Table (10): Cut off value of sP-selectin for prediction of the no reflow

Cut off	AUC (CI)	Sensitivity	Specificity	PPV	NPV	**P(Sig)**
68.5 pg/m	0.775(0.657 to 0.821	76.30	77.10	72.9	78.5	.001 (S)

Table (11): Cut off value of sP-selectin for prediction of MBG ≤ 2

P selectin cut off level	**AUC (CI)**	**Sensitivity**	**Specificity**	**+PV**	**-PV**	**P (Sig)**
>54 pg/ml	0.925(0.85-0.969)	87.50	81.25	82.4	86.7	0.001(S)

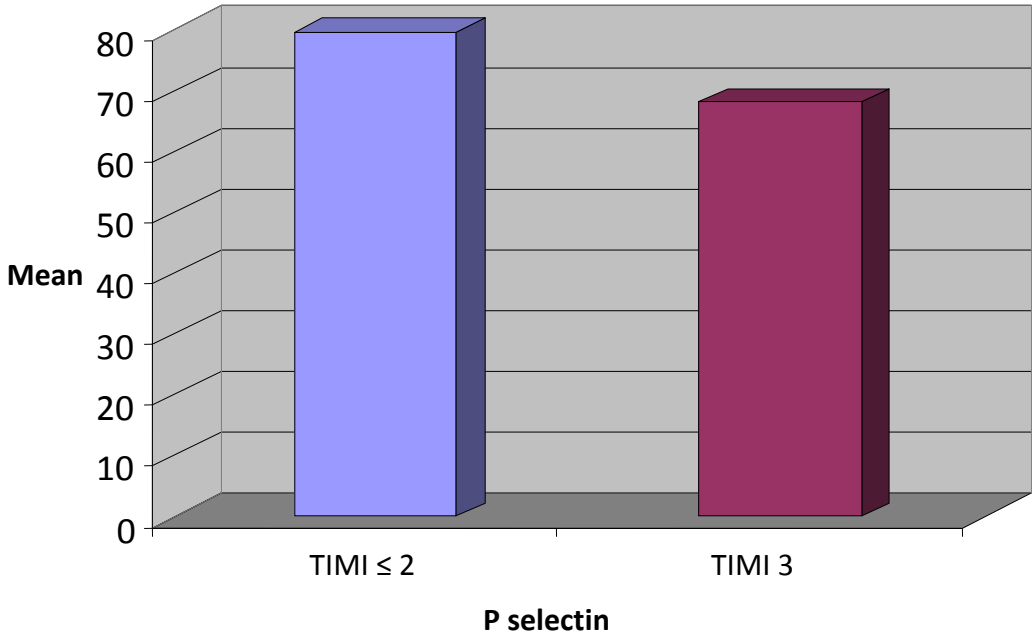

Figure (1): Relation between the sP-selectin levels and the TIMI flow among the study cases

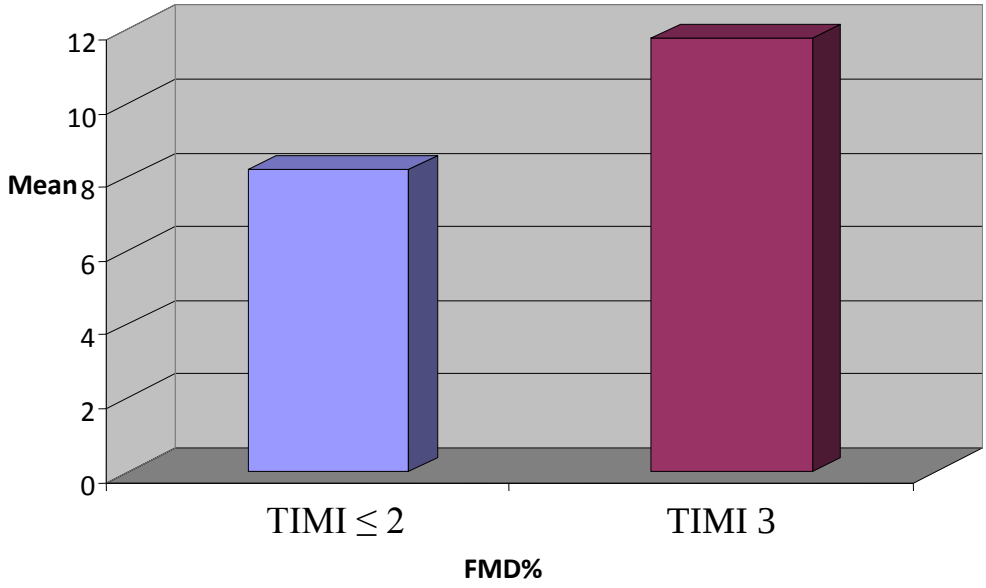

Figure (2): Relation between FMD % and the TIMI flow among the study cases

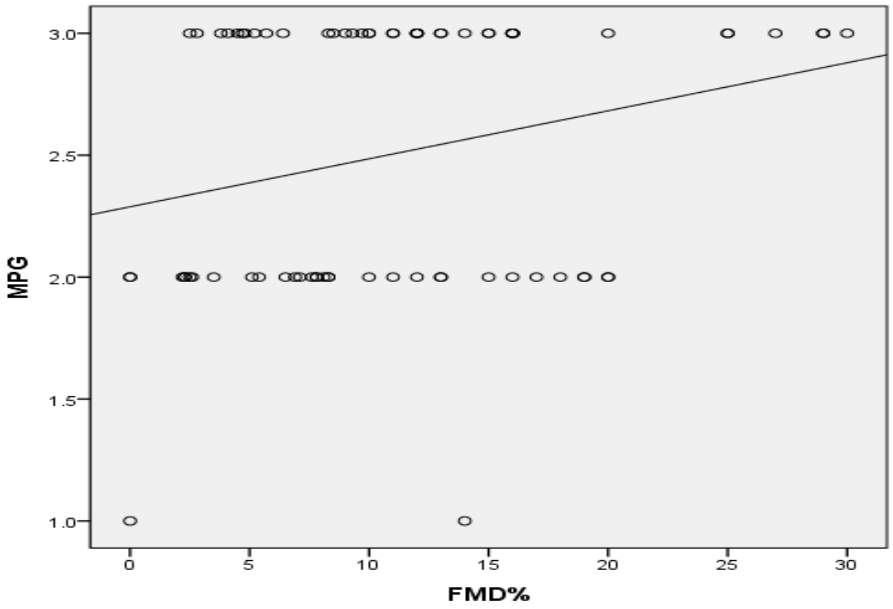

Figure (3): showing the correlation between FMD and MBG among the study cases

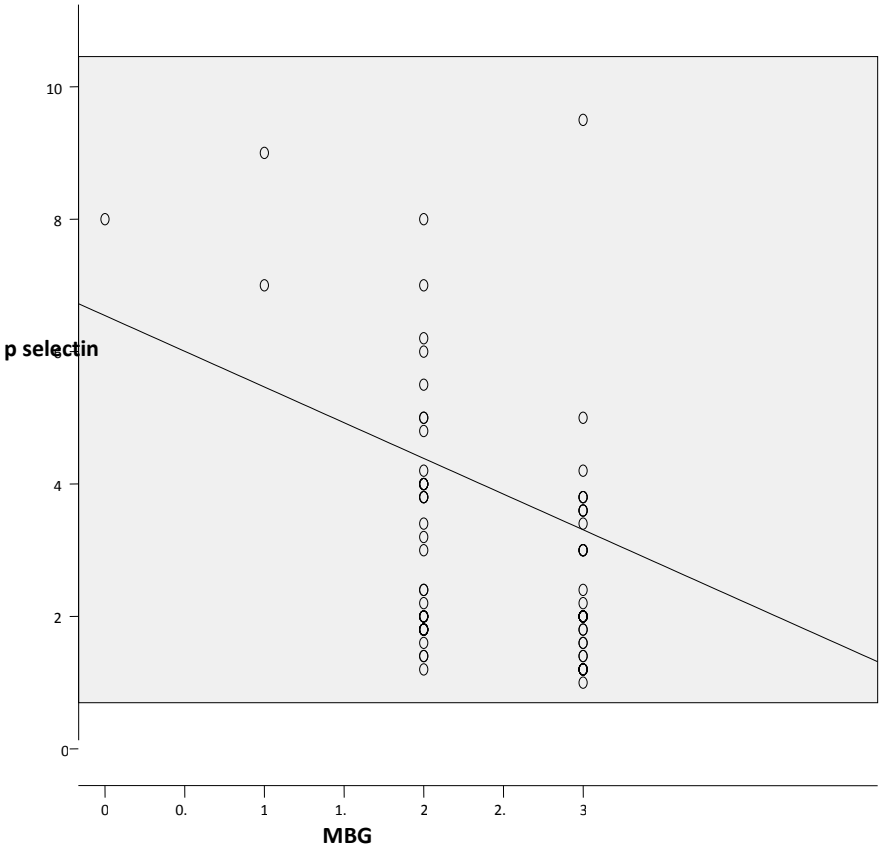

Figure (4): showing the correlation between sP-selectin and MBG among the study cases

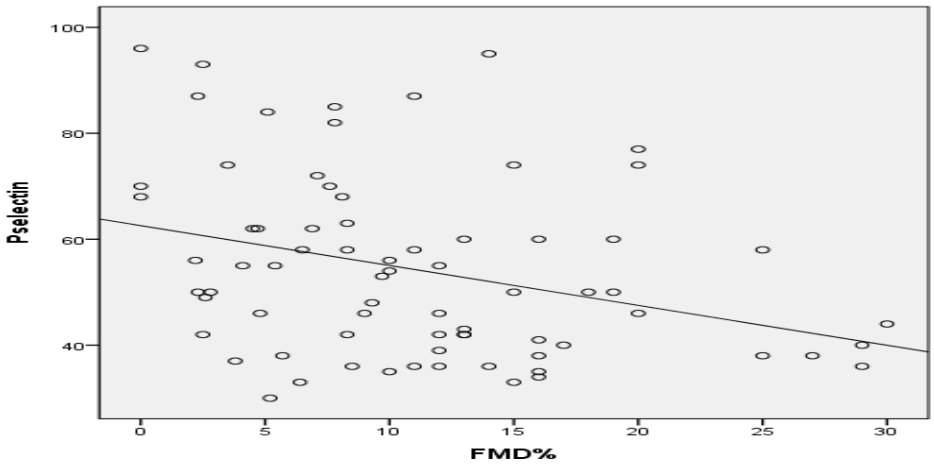

Figure (5): Showing the significant correlation between the FMD and the sP-selectin levels among the study cases

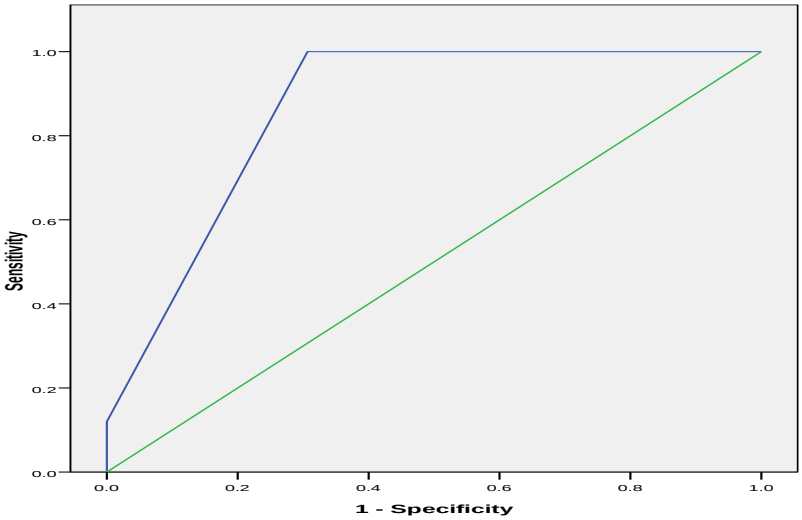

Figure (6): ROC curve for prediction of TIMI flow ≤ 2 using sP-selectin

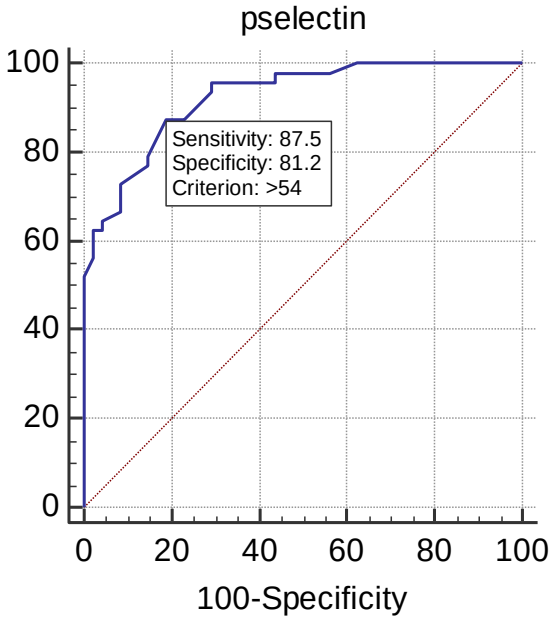

Figure (7): ROC curve for prediction of BMG ≤ 2 using sP-selectin