UTILITY OF SHOCK INDEX FOR PREDICTION OF CARDIOGENIC SHOCK DEVELOPED DURING PRIMARY PERCUTANEOUS CORONARY INTERVENTION

Cardiology

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ABSTRACT

Introduction: Cardiogenic shock (CS) is a distinct clinical entity with a high morbidity and mortality. CS after primary PCI usually portends a bad prognosis and needs prompt recognition. Shock Index (SI) serves as one of the valuable non-invasive marker for development of CS.

Methods: This was a single centre prospective observational study wherein patients with ST elevated myocardial infarction (STEMI) were enrolled. In all these patients, prior to performing the coronary angiogram, shock index (SI) was calculated as heart rate (HR) divided by SBP on admission. Primary outcome was the occurrence of CS during the period of hospitalisation post primary PCI. Study population was divided into two groups: Group 1: patients with ACS without CS and Group 2: patients with ACS with CS.

Results: A total of 240 patients were included in the study of whom 19 (7.9%) developed CS. Patients with CS (Group 2) had a significantly higher frequency of anterior wall MI, prior history of stroke, heart rate and a lower left ventricular ejection fraction. Multivariate logistic regression analysis revealed pre-procedure SBP, pre-procedure HR, Killip class, serum creatinine and Shock Index to be the independent predictors of developing CS post primary PCI. ROC curve showed that SI (AUC: 0.8113; $P=0.004$) had a better predictive ability as compared to pre-procedural heart rate (AUC: 0.7111; $P=0.01$) and pre-procedural SBP (AUC: 0.7582; $P=0.001$) for prediction of CS post primary PCI.

Conclusion: SI is a promising tool to detect presence of shock post primary PCI in STEMI patients.

KEYWORDS

Acute coronary syndrome; Cardiogenic shock; Coronary artery disease; Primary PCI; STEMI,

INTRODUCTION:

Acute coronary syndrome (ACS) is one of the common cardiovascular diseases which is increasingly being seen in developing countries such as India¹. Over the past 30 years, with better diagnostic modalities and newer therapies, outcomes in patients with STEMI have improved². The in-hospital and 1-year mortality of STEMI has remarkably decreased owing to timely revascularization of the infarct related artery (IRA)³. However, one subset of patients which still portrays a bad prognosis includes patients with ACS who develop cardiogenic shock (CS) with a mortality ranging between 30-50% in these patients⁴. One of the important worries is the worsening of cardiac function post STEMI which is still rising despite of optimal reperfusion and pharmacological therapy. Infarct-related heart failure leads to an increase in the long-term comorbidity and mortality, which often counterbalances the benefits which has been from the timely reperfusion⁵. A fraction of patients with STEMI presenting with normal hemodynamic parameters may deteriorate post the primary PCI following they may develop CS⁶. Previous studies have shown that around 50% of final infarct myocardium is caused by the reperfusion injury (RI) which occurs following PCI⁷. It is considered to be one of the leading causes of increase in the infarct size following restoration of the patency of the infarct-related artery (IRA), which could lead to the development of CS during or post primary PCI. Hence, a prompt recognition of CS with timely management can alter the natural course of the disease.

Shock index (SI) is one of the newly proposed clinical tool which can be used to assess the haemodynamic state and is defined as heart rate (HR) divided by systolic blood pressure (SBP)⁸. Patients with elevated SI, even with normal blood pressure and heart rate, should be paid more attention for the high risk of shock. In patients presenting with ACS or STEMI, SI serves as one of the independent predictor of long-term MACE or mortality⁹. However, its utility in patients developing CS post PCI has still not been definitely explored. We aim to evaluate the predictive capability of SI for CS developed during primary PCI in the cohort of STEMI patients.

MATERIALS AND METHODS:

This was a single centre prospective observational study over a two year period carried out in the Department of Cardiology in a tertiary care medical centre. Patients who presented to the Emergency Department with acute coronary syndrome (ACS) were enrolled in the

study. The inclusion criteria used in the study was : (1) the patients were diagnosed STEMI, (2) no evidence of cardiogenic shock at time of admission and (3) consenting for primary PCI. The following patients were excluded: (1) patients presenting with cardiogenic shock in the Emergency Department, (2) refusal to undergo emergency angiography/primary PCI, (3) patient did not need emergency revascularization or needed emergency coronary artery bypass graft (CABG) surgery, (4) patients who were deployed prophylactic IABP before revascularization. All the patients with acute chest pain in Emergency Department underwent an ECG within 10 minutes of presentation as per the standard ACS guidelines. In all these patients, STEMI was defined as new onset of ST segment elevation at the J point in at least 2 contiguous leads of more than 2 mm in men or more than 1.5 mm in women in V2 and V3 lead and/or of more than 1 mm in other leads. In patients with presentation of new onset left bundle branch block was considered an equivalent to STEMI and were enrolled in the study. CS was defined as systolic blood pressure (SBP) < 90 mmHg for more than 30 min or the need for inotropic agents to maintain the SBP above 90 mmHg accompanied with pulmonary congestion and/or peripheral perfusion impairment⁴. Patients who were willing to undergo primary PCI were administered a loading dose of aspirin 300 mg and ticagrelor 180 mg or clopidogrel 600 mg prior to the procedure. After a radial or femoral artery puncture, a 6 French (F) / 7F sheath was inserted. Heparin was administered at a dose of 70-100 IU/kg, while eptifibatide were used if considered necessary. Thrombus aspiration catheter was used if there was a high burden of thrombus post angiography. After blood flow recovery of IRA, the stent was deployed immediately. Post procedure, all these patients were monitored in the coronary care unit for a period of 24 hours including the documentation of vitals intermittently. In all these patients, prior to performing the coronary angiogram, shock index (SI) was calculated as heart rate (HR) divided by SBP on admission⁸. Primary outcome in this study was the occurrence of CS during the period of hospitalisation post primary PCI. Based on the occurrence of CS in these patients, the study population was divided into two groups: Group 1: patients with ACS without CS and Group 2: patients with ACS with CS.

Statistical analysis:

Descriptive statistics was obtained for all the study subjects with continuous data being expressed as mean $\pm$ SD while categorical data as number or proportions. Kolmogorov- Smirnov test was used to assess distribution pattern. Comparison of the means of the continuous

data was done using the Student's t-test. Similarly, the categorical variables were compared using the χ^2 test. Initially univariate logistic regression analysis followed by a step-wise multivariate logistic regression analysis was carried to identify the independent predictors of CS. Significant covariates were tested for the accuracy with receiver-operating characteristics (ROC) analysis. Area under curve (AUC) was calculated to compare the diagnostic capability of the predictors along with specificity and sensitivity of the test. Data analysis was done using the SPSS software package version 24 (SPSS, Chicago, Illinois, USA). P values of <0.05 were considered significant.

RESULTS:

Of the 240 patients enrolled in the study, CS was reported in 19 (7.9%) patients. The comparison between the baseline demographic characters between the two groups have been tabulated in table 1. There was no significant difference in terms of age and sex distribution between the two groups. Patients with CS (Group 2) had a significantly higher frequency of anterior wall MI, prior history of stroke, heart rate and a lower left ventricular ejection fraction. The frequency of hypertensives, smokers, body mass index, systolic and diastolic blood pressures and total ischemic time were comparable between the two groups. In terms of the haematological parameters, patients in Group 2 (CS) had a significantly higher total leucocyte count and platelet count as compared to those in Group 1. In addition, patients in Group 2 had significantly higher urea and creatinine levels.

The coronary angiographic profile has been reported in Table 2. Most of the patients had double or triple vessel disease with PCI of only the IRA done at the time of presentation followed by complete revascularisation during the period of hospital stay. In both the groups, left anterior descending (LAD) was the most common IRA involved followed by the right coronary artery (RCA). All the patients underwent drug eluting stent implantation.

Univariate logistic regression analysis showed that pre-procedure SBP, pre-procedure HR, Killip class, multivessel disease, serum creatinine, Shock Index were independent predictors of developing CS post primary PCI (Table 3). Multivariate logistic regression analysis revealed pre-procedure SBP, pre-procedure HR, Killip class, serum creatinine and Shock Index to be the independent predictors of developing CS post primary PCI (Table 4). ROC curve showed that SI (AUC: 0.8113; $P=0.004$) had a better predictive ability as compared to pre-procedural heart rate (AUC: 0.7111; $P=0.01$) and pre-procedural SBP (AUC: 0.7582; $P=0.001$) for prediction of CS post primary PCI. The cut-off values of SI to predict CS post primary PCI was 0.84 (sensitivity: 33.2% and specificity: 92.8%).

DISCUSSION:

Our study showed that 7.8% patients developed CS post primary PCI with patients with anterior wall myocardial infarction having a higher incidence for development of CS. Studies have shown previously that CS occurs in approximately 5-15% of patients with acute STEMI¹⁰. Patients with a decreased SBP and an increase in the heart rate are at an increased for developing CS⁵. In our study, pre-procedure SBP and EF were significantly lower in patients who developed CS while pre-procedure HR, urea, creatinine were significantly higher. Shock index serves to be an accurate and a simple clinical tool at the time of initial evaluation¹¹. Previous studies have reported that the shock index can be a more promising marker of hemodynamic stability as compared to SBP or HR alone^{8,11,12}. SI is a reliable predictor for early shock in different clinical scenarios such as trauma, infection, pulmonary embolism, which is usually set 0.9 as the threshold of elevation¹³. In our study, the cut-off of SI was established to be 0.84 for prediction of CS post primary PCI. However, there are several other cut-off values in different studies which means the diagnostic capability of SI varies over different conditions¹⁴.

Ideally SI should have been more sensitive in reflecting pre-shock state as in this stage the heart rate usually elevates as a compensatory response before the decrease in SBP. Bilkova et al.¹⁵ in their retrospective study involving 644 patients who underwent primary (92%) or rescue PCI (7%) found that the admission SI had an independent association with in-hospital mortality. Similarly, Huang et al.¹⁶ in their study showed that the SI serves to be a useful predictor for short-term mortality and MACE. In a study evaluating the role of SI and myocardial damage using cardiac magnetic resonance imaging (CMR), patients with a SI value of ≥ 0.62 on admission had significantly larger volume of infarcts, higher reperfusion injury and subsequently a greater reduction in LV ejection fraction¹⁷. It has been seen that SI has a high specificity and low sensitivity which can be

attributed to the relatively low incidence of developing CS during primary PCI. In our study too, SI had a sensitivity of 33.2% and a specificity of 92.8%. The predictive ability of SI was far superior to that of HR and SBP alone as was seen in the higher AUC for the SI compared to that of pre-procedure SBP or HR.

SI provides for a better prognostic value which serves as an addition to the well-established Killip classification. In a previous study among patients with STEMI who developed CS later on, SI had a better discriminative ability than BP or HR alone¹⁸. SI was found to be an independent risk factor for developing CS as was seen in our study. Some authors have previously proposed a cut-off of 0.90 for SI for predicting CS however, in our study the cut off was 0.84. The values of SI often change with age and gender as the SBP and HR itself varies with age and gender¹⁹. SI has been reported to decline about 0.01- 0.02 over a period of five years in males and by 0.02- 0.03 every five years in females¹⁹. The important limitations of the study were a small sample size as this was single centre study performed over a short time span. In addition, owing to the time limitations, a long term follow-up could not be planned. The study needs to be validated in larger population groups

CONCLUSION

Considering the increasing evidence regarding SI, it can be seen as a promising tool to predict CS in patients with ACS. SI is a simple and objective index which has been derived from two readily available vital signs, and hence it can be used in routine clinical practice to risk stratify patients presenting with STEMI. There is a need for well-designed prospective studies to assess the role of SI in terms of clinical benefit over a period of time.

Table 1: Comparison of the baseline parameters between the two groups

Parameter	Group 1 (N= 221)	Group 2 (N=19)	P-value
Age	64.2 $\pm$ 9.8	63.1 $\pm$ 10.1	0.63
Sex (Male)	159 (71.9%)	13 (68.4%)	0.74
MI			
Anterior wall MI	112 (50.6%)	14 (73.6%)	0.05
Inferior Wall+ Right Ventricular MI	70 (31.6%)	5 (26.3%)	0.62
Inferior Wall MI	35 (15.8%)	0	-
Posterior Wall MI	4 (1.8%)	0	-
Hypertension	132 (59.7%)	10 (52.6%)	0.54
Diabetes	68 (30.7%)	8 (42.1%)	0.30
Smoking	142 (64.2%)	12 (63.1%)	0.92
Stroke	12 (5.4%)	1 (5.3%)	0.98
Systolic Blood Pressure (mm Hg)	124 $\pm$ 13	108 $\pm$ 7	<0.0001
Diastolic Blood Pressure (mm Hg)	81 $\pm$ 16	74 $\pm$ 8	0.060
Heart Rate (/min)	77 $\pm$ 14	89 $\pm$ 10	0.0003
Door to Balloon time	52.4 $\pm$ 18.2	53.1 $\pm$ 14.9	0.87
LVEF (%)	43.4 $\pm$ 7.8	38.7 $\pm$ 6.6	0.01
Hemoglobin (g/dl)	12.4 $\pm$ 2.2	11.6 $\pm$ 1.8	0.12
Total leucocyte count (mm3)	7.67 $\pm$ 1.18	8.64 $\pm$ 1.24	0.0007
Platelets (lakh/mm3)	2.74 $\pm$ 0.96	2.12 $\pm$ 0.71	<0.0001
Blood Urea (mg/dL)	27.92 $\pm$ 10.1	48.97 $\pm$ 11.08	<0.0001
Serum Creatinine (mg/dL)	1.20 $\pm$ 0.98	2.49 $\pm$ 1.26	<0.0001
RBS (mg/dL)	79 $\pm$ 12.6	81 $\pm$ 11.8	0.21
Serum Triglyceride	156.31 $\pm$ 12.8	150.02 $\pm$ 11.76	0.18
Serum HDL cholesterol (mg/dL)	38.2 $\pm$ 5.6	37.6 $\pm$ 2.9	0.07
Serum LDL cholesterol (mg/dL)	98.9 $\pm$ 9.2	93.4 $\pm$ 6.8	0.90

HDL: high density lipoprotein; LDL: low density lipoprotein; LVEF: left ventricular ejection fraction; MI: myocardial infarction; mg/dL: milligram per decilitre; RBS: Random blood sugar

Table 2: Coronary angiographic profile of the study subjects

Parameter	Group 1 (N= 221)	Group 2 (N=19)	P-value
Single vessel disease	61 (27.6%)	6 (36.4%)	0.71
Double vessel disease	91 (41.2%)	7 (38.1%)	0.72
Triple vessel disease	69 (31.2%)	6 (36.4%)	0.97
IRA			
LAD	113 (51.2%)	10 (55.6%)	0.90
LCX	34 (15.3%)	0	0.06
RCA	53 (24.2%)	8 (42.1%)	0.08
PDA/PLV	21 (9.8%)	1 (5.2%)	0.53

DES	221	19	-
BMS	0	0	-

Table 3: Independent predictors of developing CS: univariate analysis

	OR	P-value
Age	0.98	0.68
Gender	1.01	0.72
Pre-procedure SBP	1.28	<0.001
Pre-procedure HR	1.19	<0.001
Killip class	3.2	<0.001
MVD	1.8	0.02
DM	1.3	0.06
HTN	1.12	0.08
CVA	1.54	0.12
Dyslipidemia	0.98	0.98
Smoking	0.90	0.68
Hemoglobin	1.08	0.28
Serum Creatinine	2.2	0.04
Shock Index	2.4	<0.0001

Table 4: Independent predictors of developing CS: multivariate analysis

	OR	95% CI	P-value
Pre-procedure SBP	1.12	1.05-1.44	<0.001
Pre-procedure HR	1.26	1.06-1.61	<0.001
Killip class	2.6	1.99-4.11	0.002
MVD	1.2	0.48-1.59	0.86
Serum Creatinine	2.8	1.27-3.89	0.01
Shock index	1.92	1.62-2.26	<0.001

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