Predictor of In-hospital Mortality among Acute Coronary Syndrome Patients after Treatment with an Intra-aortic Balloon Pump in Tertiary Hospital, Thailand

Chorchana Wichian, M.D.*, Thotsaporn Morasert, M.D.*, Surat Tongyoo, M.D., Naruebeth Koson, M.NS.*****

**Department of Internal Medicine, Suratthani Hospital, Suratthani 84000, **Department of Medicine, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700, ***Department of Cardiovascular and Thoracic Intensive Care Unit, Suratthani Hospital, Surat Thani 84000, Thailand.*

ABSTRACT

Objective: Intra-aortic balloon pump (IABP), a mechanical hemodynamic support device, had widely been used to treat cardiogenic shock patients for several decades. However, the information about the predictive factors associated with mortality was scarce. This study aims to identify the predictive factors associated with in-hospital mortality in acute coronary syndrome (ACS) patients who performed IABP for their hemodynamic support during admission.

Methods: We conduct a retrospective cohort study design. All admission records of ACS patients with IABP at Suratthani Hospital between October 2015 and September 2019 were retrieved.

Results: Overall 75 ACS patients with IABP insertion were enrolled. Thirty-one patients died during admission, in-hospital mortality was 41.3%. From the multivariable analysis, we identified 3 predictors associated with in-hospital mortality included cardiac arrest at presentation (adjusted OR [aOR]=11.18, 95%CI: 2.42-51.57, P=0.002), a higher number of inotropes or vasopressors (aOR 6.10, 95%CI 1.36-27.24, P=0.018) and Killip class IV (aOR 5.64, 95%CI 1.01-31.39, P=0.048).

Conclusion: ACS patients who required IABP support had high mortality. Cardiac arrest, Killip class IV (cardiogenic shock) at presentation and requiring a higher number of inotropes or vasopressors were independent predictive factors of in-hospital mortality.

Keywords: Acute coronary syndrome; in-hospital mortality; intra-aortic balloon pump (Siriraj Med J 2020; 72: 462-469)

INTRODUCTION

Coronary artery disease (CAD), an important non-communicable disease, is a leading cause of death in adults which accounting for one - thirds of all death in the subject over 35 years as reported by the World Health Organization.[1] Data from Thailand reported that CAD caused 31 deaths per 100,000 population.[2] The CAD can be categorized according to the clinical presentation into acute coronary syndrome (ACS) and stable CAD. ACS is divided into ST-segment elevated myocardial infarction (STEMI) and non-ST segmented elevated myocardial infarction (NSTEMI) by initial electrocardiogram. Patients who presented with ACS had a significantly higher mortality rate than those with stable CAD. Data from the Thai acute coronary syndrome (Thai ACS registry), reported high 1-year mortality in both STEMI (14%) and NSTEMI (25%).[3]

Corresponding author: Chorchana Wichian
E-mail: chorchana@gmail.com
Received 30 July 2020 Revised 28 August 2020 Accepted 1 September 2020
ORCID ID: http://orcid.org/0000-0001-8929-644X
http://dx.doi.org/10.33192/Smj.2020.62

Although, the restoration of epicardial coronary artery blood flow by either percutaneous coronary intervention (PCI) or coronary artery bypass graft surgery (CABG) can improve the outcome of many ACS patients but the in-hospital mortality was still high.[3] The previous study identified factors associated with in-hospital mortality among STEMI patients which included age older than 75 years, diabetes mellitus, cardiac arrhythmias and cardiogenic shock.[4] The treatment of cardiogenic shock composed of pharmacological treatment with inotropic drug plus vasopressors and mechanical circulatory support for the critically ill patients.

Mechanical circulatory support (MCS) takes an important role in unstable conditions or high-risk patients, especially patients with left main coronary artery stenosis, severely impaired left venticular systolic function, multivessel coronary artery stenosis disease, elderly patients and anterior wall STEMI.[5] Following the current guidelines[6] recommend using many types of MCS systems include intra-aortic balloon pump (IABP), Tandem heart, Impella, or veno-arterial extracorporeal membrane oxygenation (VA-ECMO). The MCS can increase forward blood flow from the left ventricle, reduce left ventricular end-diastolic pressure result in improving coronary artery blood flow as well as systemic circulation. However, the level of augmented cardiac output difference by each type of MCS. Comparing among the mechanical devices that can be a bed-side, percutaneous insertion; ECMO is a device that can increase systemic blood flow in the highest volume, followed with Impella and IABP. In The recent years, VA-ECMO and Impella had been recommended over IABP for hemodynamic support for cardiogenic shock patients. Although, IABP can increase cardiac output only about 0.5 litres per minute, it still the most common device that is widely used for hemodynamic support among cardiogenic shock patients in Thailand due to its relatively low price and more available of experienced physicians for device insertion and management.

Up to now, in the era that almost every ACS patient received timely reperfusion therapy by either PCI or CABG. To the best of our knowledge there is scarce information about the result of IABP usage for hemodynamic support among cardiogenic shock patients. Therefore, the objective of this study is to evaluate the predictors of in-hospital mortality in ACS patients with cardiogenic shock receiving IABP insertion for hemodynamic support.

MATERIALS AND METHODS

Study design and setting

We conducted a retrospective cohort design in a university-affiliated tertiary care centre, Suratthani Hospital (SH), Thailand. The study was approved by the ethic committee review board of SH. The number of approval was 34/2020.

Study participants

All admission records of ACS patients in the cardiac catheterization unit of SH between October 2015 and September 2019 were screened. The ACS patients, aged 18 years or more and required an IABP insertion were included. The diagnosis of ACS is based on international guidlines.[7-9] All patients were confirmed coronary artery occlusion by the coronary artery angiography. Patients were considered to have cardiogenic shock if their systolic blood pressure (SBP) < 90 mmHg or required any vasopressor to maintain SBP ≥ 90 mmHg. The exclusion criteria were normal coronary angiography (CAG) or diagnosis of non-obstructive coronary disease.

Data collection

The patients' baseline clinical characteristic, initial laboratory data, and complication during admission included sepsis, performed hemodialysis, limb ischemia and stroke were extracted from the medical records. Patients were categorized to Killip classification (I-IV) at the presentation by a cardiologist who was blinded to the patients' survival status. The left ventricular ejection fraction (LVEF) results by transthoracic echocardiography were obtained if they were performed within the first seven days of admission. The timing of IABP insertion and information of revascularization procedures included CABG and PCI were also collected. All patients admission records were separated into two groups: non-survived (all-cause in-hospital death) admission and survived admissions based on the survival status of the patient.

Statistical analysis

We analyzed the characteristics of ACS patients who performed IABP and compared non-survived cases with survived cases. Categorical variables are presented as percentages and were compared using Fisher's exact test. Continuous variables are presented as the mean ± standard deviation (SD) and were compared using the two-sample t-test. Non-parametric continuous variables are presented as interquartile ranges (IQRs) and were compared using the Wilcoxon rank-sum (Mann-Whitney) test. All proportions and P values were calculated based on variables with no missing data. Logistic regression analysis was carried out to determine the factors associated with in-hospital mortality. Odds ratios (ORs) and their 95% confidence intervals (CIs) were estimated.

Variables at P < 0.1 on univariable analysis, as well as those considered a priori as possible associated factors based on previous research, were selected for inclusion in the final multivariable model. Variables with more than 20 per cent missing were excluded from statistical modelling. All analyses were two-sided with a p-value < 0.05 as a critical value for statistical significance.

RESULTS

A total of 76 ACS patients with IABP were enrolled. Of this number, one patient was excluded due to normal CAG. Finally, 75 patients were included for analysis. The patients were predominantly male (70.7%), with the mean age of 63.9 years (±SD 13.0). During the study period, 31 patients died. The in-hospital mortality of the cohort was 41.3% (31/75). Thirty-seven patients (49.3%) were acute STEMI and 38 patients (50.7%) were NSTEMI/UA. The cardiogenic shock, Killip class IV at presentation was found in 44 patients (58.7%) while the 35 patients (46.7%) had a cardiac arrest at presentation. More than half of the patients were revascularized by PCI (64%) and was inserted IABP in peri- or post-revascularization period (65%). The median duration of IABP use was 3 days (IQR 2-4). Almost all patients (94.7%) received at least one vasopressor or inotropic agent.

In comparison with survived cases, non-survived cases were significantly more likely be the elderly (age ≥65 years) (65% vs. 36%), had Killip class IV (87% vs. 39%), had lower SBP (84.6 mmHg vs. 99.6 mmHg), had lower DBP (54.7 mmHg vs. 64.3 mmHg), had lower MAP (64.7 mmHg vs. 76.1 mmHg), presented with cardiac arrest (84% vs. 20%), had higher serum creatinine (1.3 mg/dL vs. 1.0 mg/dL), were revascularized by PCI (84% vs. 52%), were performed IABP in the peri- or post-revascularization period (84% vs. 53%) and had a higher number of inotropic agents or vasopressors use before start IABP (Tables 1 and 2). Among the ACS patients who performed PCI, complete revascularization (PCI all stenotic vessel), the complete revascularized group had lower in-hospital mortality (70.8% vs 28%, p = 0.004).

The complications after IABP insertion was shown in Table 3. Hemodialysis was the leading complication followed by sepsis, stroke and limb ischemia.

On the univariable analysis, the following parameters were considered to be significantly associated with in-hospital mortality: elderly (age ≥65 years), Killip class IV, SBP <90 mmHg, DBP <60 mmHg, MAP <65 mmHg, cardiac arrest at presentation, revascularization by PCI, IABP insertion during the peri-/post-revascularization period and a higher number of inotropic agents or vasopressors use (Table 4). On multivariable analysis, we identified 3 independent predictors associated with in-hospital mortality among ACS patients in IABP included cardiac arrest at presentation (adjusted OR [aOR] 11.18, 95%CI 2.42-51.57, P=0.002), a higher number of inotropes/vasopressors (aOR 6.10, 95%CI 1.36-27.24, P=0.018) and Killip class IV (aOR 5.64, 95%CI 1.01-31.39, P=0.048) (Table 4).

DISCUSSION

In this 4-year retrospective study, patients who presented with acute myocardial infarction and were treated with an IABP had high in-hospital mortality especially in the elderly, cardiogenic shock and cardiac arrest patients. In the multivariable analysis, we identified 3 independent predictive factors of in-hospital mortality which included Killip class IV, cardiac arrest, and number of inotrope or vasopressors use. Furthermore, the adverse events after IABP was reported significantly higher among the patients who died during the admission.

For identify the predictive factors associated with poor outcome among patients who received IABP support, a retrospective study from Japan, enrolled 104 patients who underwent PCI for treatment the coronary artery lesion responsible for acute myocardial infarction and received IABP insertion, showed that shock stage and low glomerular filtration rate were the predictive factors for dead, while inserted IABP before start PCI was the factor associated with survival.[10] However, only 47.1% of patients in the Japanese cohort were in the shock stage. Although, we also found that hemodialysis after IABP was significantly higher among non-survived patients in our study, we did not include this factor into the final model due to we aimed to explore the predictor of in-hospital mortality before IABP insertion. The others independent predictive factors in the current study for in-hospital dead, included Killip class IV, presented with cardiac arrest and high number of inotropic used were all represent the more severe form of myocardial infarction.

Comparing to the participants of IABP Shock II trial, the largest randomized controlled trial which included 600 myocardial infarctions with cardiogenic shock patients who had planned for early reperfusion therapy, our participant were relatively younger, lower proportion of reperfusion therapy with PCI (64.5% vs 96%) but had similar baseline blood pressure and heart rate.[11] The higher proportion of our acute myocardial infarction with cardiogenic patients who received CABG surgery for reperfusion therapy could be mainly explained by the higher incidence of left main stenosis which was 51.3% in our study, compared with only 9.3% in IABP-Shock II

TABLE 1. Clinical characteristics of non-survived and survived ACS patients with IABP (n=75).

Characteristics	Non-survived, (n=31)	Survived, (n=44)	*P*-value
Age			
years, mean (SD)	66.9 (14.7)	61.8 (11.4)	0.091
≥65 years	20 (65)	16 (36)	0.020
Male sex, n (%)	22 (71)	31 (70)	1.000
Diabetes Mellitus, n (%)	14 (45)	21 (48)	1.000
Hypertension, n (%)	21 (68)	33 (75)	0.600
Previous history of CAD, n (%)	7 (23)	11 (25)	1.000
Previous PCI, n (%)	5 (16)	2 (5)	0.120
STEMI, n (%)	17 (55)	20 (45)	0.490
Anterior wall lesion, n (%)	10 (32)	10 (23)	0.430
Non-STEMI or Unstable angina, n (%)	14 (45)	24 (55)	0.490
Left main coronary artery stenosis	16 (52)	23 (52)	1.000
Killip class at presentation, n (%)			<0.001
I	0 (0)	7 (16)	
II	1 (3)	7 (16)	
III	3 (10)	13 (30)	
IV	27 (87)	17 (39)	
Systolic BP			
mmHg, mean (SD)	84.6 (13.4)	99.6 (25.7)	0.004
<90 mmHg, n (%)	22 (71)	17 (39)	0.009
Diastolic BP			
mmHg, mean (SD)	54.7 (11.6)	64.3 (18.8)	0.014
<60 mmHg, n (%)	20 (65)	17 (39)	0.036
Mean arterial BP			
mmHg, mean (SD)	64.7 (11.3)	76.1 (20.4)	0.007
<65 mmHg, n (%)	17 (55)	14 (32)	0.059
Heart rate, per minute, mean (SD)	94.1 (25.3)	88.0 (23.2)	0.280
Cardiac arrest at presentation, n (%)	26 (84)	9 (20)	<0.001
Serum creatinine, mg/dL, median (IQR)	1.3 (1.1, 1.5)	1.0 (0.9, 1.4)	0.017
Initial hemoglobin level, g/dL, mean (SD)	12.7 (2.1)	11.9 (2.1)	0.140
Current statin use	7 (23)	10 (23)	1.000
DAPT in first day	30 (96.8)	44 (97.8)	1.000
High potency statin first day	6 (19.4)	41 (91.1)	0.300
Left ventricular ejection fraction			
%, mean (SD)	42.6 (14.3)	44.2 (15.4)	0.670
missing, n (%)	9 (29)	1 (2)	0.004

All proportions (%) and P values calculated based on variables with no missing data.

Abbreviations: ACS, acute coronary syndrome; BP, blood pressure; CAD, coronary artery disease; IABP, intra-aortic balloon pump; IQR, interquartile range; PCI, percutaneous coronary intervention; SD, standard deviation; STEMI, ST-segment elevation myocardial infarction

TABLE 2. Comparison of treatment between non-survived and survived ACS patients with IABP (n=76).

Type of treatment	Non-survived, (n=31)	Survived, (n=44)	*P*-value
Mode of revascularization			0.015
PCI, n (%)	25 (81)	23 (52)	
CABG, n (%)	6 (19)	21 (48)	
PCI for STEMI, n (%)			
Primary	12 (39)	9 (20)	0.120
Rescue	3 (10)	4 (9)	1.000
PCI for Non-STEMI or Unstable angina, n (%)	10 (32)	10 (23)	0.430
PCI left main, n (%)	9 (29)	9 (20)	0.420
Number of vessel target for CABG			1.000
1	0 (0)	1 (5)	
2	1 (17)	4 (19)	
3	5 (83)	14 (67)	
4	0 (0)	2 (10)	
Valve surgery co-committed	2 (6)	2 (5)	1.000
Timing of IABP insertion, n (%)			0.006
Pre- revascularization	5 (16)	21 (48)	
Peri- and post revascularization	26 (84)	24 (52)	
Duration of IABP, days, median (IQR)	2 (2, 4)	3 (2, 4)	0.140
Inotrope or vasopressor(s) use prior to IABP			
Any	31 (100)	41 (91)	0.140
No. of medication use			<0.001
1	0 (0)	12 (27)	
2	17 (55)	21 (48)	
3	14 (45)	7 (16)	

Abbreviations: ACS, acute coronary syndrome; CABG, coronary artery bypass graft; IABP, intra-aortic balloon pump; IQR, interquartile range; PCI, percutaneous coronary intervention; SD, standard deviation; STEMI, ST-segment elevation myocardial infarction

TABLE 3. In-hospital complication after IABP (n=76).

Complication	Non-survived (n=31)	Survived (n=44)	*P*-value
Hemodialysis, n (%)	10 (32)	2 (5)	0.003
Sepsis, n (%)	5 (16)	1 (2)	0.076
Stroke, n (%)	2 (6)	0 (0)	0.170
Limb ischemia, n (%)	1 (3)	1 (2)	1.000

Abbreviation: IABP, intra-aortic balloon pump

TABLE 4. Predictor of in-hospital mortality among ACS patients with IABP by univariable and multivariable logistic regression analysis.

Predictor	Univariable			Multivariable		
	OR	(95% CI)	*P*-value	aOR	(95% CI)	*P*-value
Age, years						
<65	1	Reference				
≥65	3.18	(1.22-8.30)	0.018	2.45	(0.54-11.03)	0.245
Test for trend (every 1 increased)	1.03	(0.99-1.07)	0.094			
Killip class						
I	1	Reference				
IV	10.72	(3.19-36.05)	<0.001	5.64	(1.01-31.39)	0.048
Systolic BP, mmHg						
≥90	1	Reference				
<90	3.88	(1.45-10.39)	0.007	0.75	(0.09-6.52)	0.799
Test for trend (every 10 decreased)	1.04	(1.01-1.06)	0.008			
Diastolic BP, mmHg						
≥60	1	Reference				
<60	2.89	(1.11-7.49)	0.029	1.50	(0.03-71.13)	0.838
Test for trend (every 10 decreased)	1.04	(1.01-1.07)	0.018			
Mean arterial BP, mmHg						
≥65	1	Reference				
<65	2.60	(1.01-6.73)	0.049	0.92	(0.02-48.21)	0.967
Test for trend (every 10 decreased)	1.04	(1.01-1.07)	0.010			
Cardiac arrest at presentation						
No	1	Reference				
Yes	20.22	(6.06-67.49)	<0.001	11.18	(2.42-51.57)	0.002
Serum Creatinine, mg/dL						
Test for trend (every 0.1 decreased)	1.00	(0.97-1.03)	0.993			
PCI						
No	1	Reference				
Yes	3.80	(1.31-11.09)	0.014	4.41	(0.29-66.96)	0.285
Timing of IABP						
Pre- revascularization	1	Reference				
Peri- and post revascularization	4.75	(1.54-14.63)	0.007	1.90	(0.15-23.38)	0.615
No. of inotrope/vasopressor						
Test for trend (every 1 agent added)	4.80	(2.02-11.43)	<0.001	6.10	(1.36-27.24)	0.018

Abbreviations: ACS, acute coronary syndrome; aOR, adjusted OR; BP, blood pressure; CI, confidence interval; IABP, intra-aortic balloon pump; PCI, percutaneous coronary intervention trial. Furthermore, the incidence of significant stenosis in 3 vessels was 70% in our patients, compared with 52.3% in IABP-Shock II trail. For the 30-days mortality outcome which was reported about 39.7% among IABP group of IABP-Shock II trail, similar with 42.1% in our population. Recently, there was a study reported 4-years experience at Hua Hin hospital, a large local government hospital in the southern part of Thailand, enrolled 57 acute myocardial infarction with cardiogenic shock and received IABP insertion for hemodynamic support.[12] Most patients (50.9%) presented with acute subendocardial myocardial infarction, following with acute transmural myocardial infarction (45.6%). Only 3.5% of patients had a cardiac arrest at presentation. The overall in-hospital mortality was 23% which was lower than 40.8% in our report. However, considering patients in our study who did not have cardiac arrest, the in-hospital mortality rate was only 25% which was comparable with the mentioned study.

Intra-aortic balloon pump, a percutaneously inserted catheter base mechanical device, had been used for hemodynamic support among cardiogenic shock patients since it first successful clinical application in 1968.[13] Due to IABP ability to improve patients' mean arterial blood pressure, restoration of myocardial perfusion and slight improve cardiac output, this device became the most common mechanical support device usage worldwide for almost 3 decades. Evidence from observational studies and small-sized randomized controlled trial support the benefit of IABP in cardiogenic shock patients caused by acute myocardial infarction for timely reperfusion therapy.[14] However, the recent evidence from a large multicenter randomized controlled trial did not show any benefit of IABP support among acute myocardial infarction with cardiogenic shock who underwent early reperfusion therapy thus the European Society of Cardiology 2018 guideline downgraded the routine using of IABP for hemodynamic support among cardiogenic shock to be class III recommendation.[15]

Our study had some limitations. Firstly, this is a retrospective observational study conducted at a single centre. The number of enrolled patients was limited. So we could unable to identify another potential factor that might be associated with poor outcome among IABP inserted patients. Secondly, the application of information from our study could be considered under the context of the individual institute, and according to the different of patients' baseline characters and their receiving standard of care which may vary from our institute. Thirdly, our mortality rate was reported high, which could be explained by a significantly high proportion of cardiac arrest patients that were enrolled in the study.

CONCLUSION

The acute coronary syndrome patients who required intra-aortic balloon pump support had high mortality. Cardiac arrest, Killip class IV (cardiogenic shock) at presentation and requiring a higher number of inotropes or vasopressors were independent predictive factors of in-hospital mortality.

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