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IMPACT OF AORTIC CLAMP TIME ON SHORT TERM OUTCOMES FOLLOWING ELECTIVE CARDIAC SURGERY: AN AFIC&NIHD EXPERIENCE

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ABSTRACT

Objective: To compare the impact of aortic clamp time on the immediate postoperative outcomes in high and low risk patients undergoing elective CABG surgery.

Study Design: Descriptive cross sectional study.

Place and Duration of The Study: Armed forces Institute of Cardiology and National Institute of Heart Disease (AFIC/NIHD) Rawalpindi from June to August 2015.

Material and Methods: All the data was prospectively collected in the adult cardiac surgery registry database. Society for Cardiothoracic Surgery STS risk SCORE was used to stratify patients into low-risk (i.e. STS SCORE < 16) and high-risk (i.e. STS SCORE >16) groups.

Results: The mean age of our study population was 56.89 ± 9.95 and there was male predominance 49(86%) and 8(14%) females. The cohort was subdivided into two subsets based on the STS RISK SCORE stratification of surgical risk. The first subset included low risk patients with STS SCORE of < 16 (N= 35, 61.4%) and the second subset included high risk patients with STS SCORE of > 16 (N=22, 38.6%). Both of these groups were then subdivided into two groups based on their CXP time as follow: clamp time < 60 minutes and clamp time > 60 minutes. Among the low risk group 35 (61.4%) there was no statistically significant difference in most of the variables in both the subgroups. However, the postoperative complications showed a statistically significant rise in post operative stay (*p*- value 0.017) and prolonged ventilation (*p*- value 0.05) with the rise of aortic clamp time.

Conclusion: Prolonged cross-clamp time significantly associated with immediate key post-operative morbidity and mortality and affects both low- and high-risk patients in our local population.

Keywords: Aortic clamp time, Cardiac surgery, Coronary artery disease, Myocardial ischaemia.

INTRODUCTION

Coronary artery disease is managed with medical treatment, percutaneous coronary intervention (PCI) and coronary artery bypass graft (CABG) surgery. CABG surgery provides symptomatic and survival benefit in a subset of coronary artery disease patients. During on pump CABG surgery, cardiaopulmonary bypass is established, the ascending aorta is clamped and cardioplegia administered into the aortic root to provide a operative field with good visibility during surgical intervention, however aortic clamping results in myocardial ischemia. Cardiopulmonary bypass and aortic clamping is associated with pathophysiologic disturbances. The duration of aortic cross clamp not only affects vital organs but also the results of the surgical intervention[1,2].

Previously, aortic cross-clamp (XCL) time was coupled with adverse outcome following cardiac surgery. However, whether or not XCL time has the same effect on low versus high-risk cardiac surgery patients remains unknown. Aortic cross clamp time (XCT) and cardiopulmonary bypass time (CPBT) are predictors of immediate postoperative morbidity and mortality[3,4]. Cardiac procedures with CPBT less than 240 min and XCT less than 150 min were related with a rather low risk of postoperative undesirable events independently of the intricacy of surgery & patient's operative risk[5]. Despite improvements over time with regard to morbidity, mortality and long-term survival, CPB time remains a

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significant factor determining mediastinal blood loss, ICU and hospital length of stay, and

Table-1: Pre and per operative characteristics and their distribution among two groups with STS Score < 16 (Low risk) N=35.

Variables	< 60 MIN N=26	> 60 MIN N=9	*p*-value
Age (Mean , SD) yr	53.8 ± 10.4	55.7 ± 6.9	0.53
BMI (Mean , SD)	24.7 ± 3.5	25.4 ± 2.9	0.54
Gender [N (%)]			
Male	24 (92.3%)	8(88.8%)	0.752
Female	2 (7.7%)	1(11.1%)	
Angina [N (%)]			
CCS I,II	26(100%)	7(77.8%)	0.04
CCS III, IV	-	2(22.2%)	
NYHA [N (%)]			
I	3 (11.5%)	1(11.1%)	
II	11 (42.3%)	3(33, 3%)	0.91
III	12 (46.2%)	5(55.6%)	
No of MI [N (%)]			
1	8(30.8%)	2(22.2%)	0.62
Time to MI [N (%)]			
<30 days	3 (11.5%)	-	
>30 days	5 (19.2%)	2(22.2%)	0.68
Diabetes [N (%)]	8 (30.8%)	4(44.4%)	0.45
Hypertension [N (%)]	15 (57.7%)	5(55.6%)	0.91
Smoking [N (%)]			
Current	2(7.7%)	3(33.3%)	0.15
Ex smokers	7(26.9%)	-	
Extent of CAD [N (%)]			
SVCAD	2(7.7%)	-	
DVCAD	3(11.5%)	1(11.1%)	0.68
TVCAD	21(80.8%)	8(88.8%)	
Left main stem [N (%)]	5(19.2%)	3(33.3%)	0.35
Ejection fraction [N (%)]			
Good (> 50%)	17(65.4%)	7(77.8%)	0.71
Fair (40-50%)	8(30.8%)	2(22.2%)	
Poor (>40%)	1(3.8%)	-	
IABP [N (%)]			
Pre op	2(7.7%)	-	0.19
Per op	-	1(11.1%)	
No of grafts [N (%)]			
1	2(7.7%)	-	
2	14 (53.8%)	1 (11.1%)	0.05
3	9(34.6%)	6 (66.7%)	
4	1(3.8%)	2(22.2%)	
CPB time in min (Mean, SD)	75.3 ± 21.2	124 ± 39.7	0.000

in-hospital mortality[6]. In this study we will observe the effect of aortic clamp time on post-operative outcome in patients, thereby increasing our understanding of its probable implications in the cardiac surgery setting with the expectation of potentially reducing its injurious effect.

MATERIAL AND METHODS

A descriptive cross sectional study was conducted in the department of adult cardiac surgery AFIC&NIHD from May to July 2015 after approval from Institutional Ethical Review Board. Individual patient verbal consent was obtained for entry into the database. A total number of 57 patients who underwent isolated CABG surgery for the first time were included in the study. All the data was prospectively

collected in the adult cardiac surgery registry database. STS risk SCORE (morbidity and mortality). was used to stratify patients into low-risk (i.e. STS SCORE < 16) and high-risk (i.e. STS SCORE >16) groups. Each of these two groups were analyzed separately. Each of these

Table-2: Post operative characteristics and their distribution among two groups with STS Score < 16 (Low risk) N=35.

Variables	< 60 Min N=26	> 60 Min N=9	*p* value
Ventilation (Mean, SD) hrs	7.6 ± 4.5	7.5± 7.9	0.98
Prolonged ventilation [N (%)]			
<24 hrs	26(100%)	8(88.8%)	0.05
> 24 hrs	-	1(11.1%)	
Inotropes [N (%)]			
Mild	10(38.5%)	5(55.6%)	
Moderate	8(30.8%)	2(22.2%)	0.60
Heavy	6(23.1%)	2(22.2%)	
Reoperation [N (%)]	-	1(11.1%)	-
Length of stay [N (%)]			
<6 days	12(46.2%)	1(11.1%)	
6-14 days	14(53.8%)	6(66.7%)	0.017
> 14 days	-	2(22.2%)	
Risk of mortality (Mean SD)	0.53 ± 0.23	0.50 ± 0.20	0.025

Table-3: Pre and per operative characteristics and their distribution among two groups with STS Score > 16 (High risk) N=22

S no	Variables	< 60 Min N=10	> 60 Min N=12	*p*-value
1	Age (Mean , SD)	62.9 + 11.1	59.3 + 7.7	0.405
2	BMI (Mean , SD)	23.4 + 4.5	27.7 +4.6	0.037
3	Gender [N (%)]			
	Male	9(90%)	8(67%)	0.193
	Female	1(10%)	4(33%)	
4	Angina [N (%)]			
	CCS I,II	7(70%)	9(75%)	0.188
	CCS III, IV	2(20%)	3(25%)	
5	NYHA [N (%)]			
	I	2(20%)		
	II	3(30%)	5(41.7%)	0.193
	III	5(50%)	7(58.3%)	
6	No of MI [N (%)]			
	1	3(30%)	3(25%)	
	2	1(10%)	-	0.499
	3	1(10%)	-	
7	Time to MI [N (%)]			
	<30 days	2(20%)	-	0.262
	>30 days	3(30%)	4(33%)	
8	Diabetes [N (%)]	6(60%)	7(58.3%)	0.937
9	Hypertension [N (%)]	8(80%)	9(75%)	0.78
10	Smoking [N (%)]	-	5(41.7%)	-
11	Arrhythmia [N (%)]	2(20%)	4(33%)	0.64
12	Extent of CAD [N (%)]			
	DVCAD	2(20%)	2(16.7%)	
	TVCAD	8(80%)	10(83.3%)	1.0
13	Left main stem [N (%)]	3(30%)	3(25%)	1.0
14	Ejection fraction [N (%)]			
	Good (> 50%)	5(50%)	7(58.3%)	0.15
	Fair (40-50%)	1(10%)	4(33.3%)	
	Poor (>40%)	4(40%)	1(8.3%)	
15	IABP [N (%)]			
	Pre op	3(30%)	-	
	Per op	-	3(25%)	0.049
	Post op	1(10%)	1(8.3%)	
16	No of grafts [N (%)]			
	2	5(50%)	5(41.7%)	0.40
	3	5(50%)	5(41.7%)	
	4	-	2(16.7%)	
17	CPB time in min (Mean, SD)	80 + 25.9	134 + 52.7	0.006

two subsets were then stratified into 2 subgroups based on their aortic cross-clamp (XCL) time as follows: group 1 is clamp time<60 min , group 2 is clamp time >60 min. Outcome measures studied included in-hospital mortality, post-operative complications, length of hospital stay. Both descriptive and inferential statistical analyses were done in SPSS version 21. Catagoric data were presented as percentages and frequency whereas descriptive statistics were used for quantitative analyses. Independent sample t chi square test was used to compare the means of two groups and a *p*-value of 0.05 was considered as significant.

Cardiopulmonary Bypass (CPB) and definitions

All the coronary artery bypass graft surgeries were conducted through a median sternotomy and CPB. Following full anticoagulation with heparin administered at a dose of 300 IU/kg in order to maintain an activated clotting time of 400 to 600 s, CPB was instituted using cannulation of ascending aortia and a two-stage right atrial venous cannulation.The extracorporeal circuit was primed with Hartmann's solution (1400 ml) and heparin (5000 IU). CPB was maintained with flow with a least flow rate of 2.4 L/m2/min at normothermia with temperature was allowed to drift to 32 degree Celcius. Arterial line filtration (Sentoy, Cobe Cardiovascular Inc.) was used in all the cases. Cardiotomy suction was used to recycle shed blood. Myocardial safety was achieved with intermittent ante grade cold or tepid blood cardioplegia. After all the distal anastomoses were achieved, the aortic cross-clamp was removed and the proximal anastomoses was accomplished with partial aortic clamping[7].

For this study in hospital mortality has been defined as all the deaths within the same admission after cardiac surgery regardless of the length of hospital stay. Renal complications refer to post operative renal failure that required dialysis or were managed conventionally in patients with no previous history of the same or patients with pre existing renal impairment that aggravated after the surgery requiring dialysis. Neurological complications refer to the occurrence of transient ischemic attacks or permanent stroke. Infective complications were documented as sternal and leg wound infections (that required antibiotics and surgical intervention) and sepsis. Pulmonary complications refer to postoperative chest infections, pleural effusions requiring drainage, tracheostomy insertion and reintubation[8,9].

Table-4: Post operative characteristics and their distribution among two groups with STS Score > 16 (High risk) N=22.

Variables	< 60 min N=10	> 60 min N=12	*p*- value
Ventilation (in hrs) (Mean ,median, SD)	9.2, 7.7 +6.1	9.5,5.5 +6.5	0.64
Prolonged ventilation [N (%)]			
<24 hrs	8(80%)	3(25%)	0.01
> 24 hrs	2(20%)	9 (75%)	
Inotropes [N (%)]			
Mild	6(60%)	-	
Moderate	2(20%)	5(41.7%)	0.006
Heavy	2(20%)	7(58.3%)	
Stroke [N (%)]	-	1(8.3%)	1.0
Reoperation [N (%)]	1(10%)	1(8.3%)	1.0
Length of stay [N (%)]			
<6 days	4(40%)	1(8.3%)	
6-14 days	-	7(58.3%)	0.002
> 14 days	-	4(33.4%)	
Mortality observed [N (%)]	-	-	-
Risk of mortality (Mean , SD)	1.8 + 0.86	1.16 ± 0.39	0.03

RESULTS

The mean age of our study population was 56.89 ± 9.95 and there was male predominance of 49(86%) and 8(14%) females. The cohort was subdivided into two subsets based on the STS SCORE stratification of surgical risk. The first subset included low risk patients with STS Score of < 16 (N= 35, 61.4%) and the second subset included high risk patients with STS SCORE of > 16 (N=22, 38.6%). Both of these groups were then subdivided into two groups based on their CXP time as follow: clamp time < 60 minutes and clamp time > 60 minutes. Results hereby are presented in a systemic order: Table-1&2 is for the patients with STS SCORE < 16 and Table-3&4 are results for patients with STS SCORE >16. These tables include pre, per and post operative characteristics with their relevant *p*- values as determined by statistical analysis.

Mean BMI for the low risk group was 24.89 ± 3.36. Among them there were 12 (34.3%) diabetics, 20 (57.1%) hypertensives and 15(43%) smokers. Table-1 summarizes the pre and preoperative characteristics of the low risk patients.

There was no statistically significant difference in most of the variables in both the subgroups. However, the postoperative complications showed a statistically significant rise in post operative stay (*p*- value 0.017) and prolonged ventilation (p- value 0.05) with the rise of aortic clamp time. There was no mortality in both the subgroups and the STS risk score for mortality& morbidity was 0.53-0.50 %.

Table-3 summarizes the pre and preoperative characteristics with their p- values of the high risk patients. The mean BMI in this group was 25.8± 4.9. There were 13(60%) diabetics, 17(77.3%) hypertensives and 5(22.7%) smokers. The use of IABP was more in patients with prolonged aortic time *p*- value 0.049. Table- 4 is a summary of the analysis of post-operative complications in this group. As shown, the rate of post-operative complications was significantly increased with increasing aortic XCL time: prolonged ventilation time (*p*-value 0.01), ionotropic requirement (*p*-value 0.006), ICU and hospital stay (p- value 0.002). All of these have shown a steady incremental increase in relation to the incremental increase in aortic XCL time. No mortality was reported in both subgroups of patients despite a predictive STS mortality score of 1.16- 1.8%.

DISCUSSION

Prolonged aortic cross clamp time has historically been linked to adverse postoperative outcomes[10-12]. Present study was designed to see the impact of aortic clamp time on short term outcomes in patients undergoing CABG surgery. To stratify patients according to the pre and peroperative risk, the STS system of risk stratification was done and high and low risk groups were identified. The impact of clamp time across these groups was analyzed.The outcomes of interest were operative mortality, any reoperation, stroke, renal failure, prolonged ventilation, and postoperative length of stay exceeding 14 days.

We found that the low risk group patients requiring longer clamp time were more symptomatic than the patients with shorter clamp times, these patients had more diseased coronaries and received more grafts during surgery. Patients with prolonged clamp time had longer perfusion times. These patients in turn had prolongedventilation times and extended hospitalization.

In the high risk group the ventilation times, requirement of inotropes, hospital stay and the requirement of mechanical circulatory support were significantly higher in the longer clamp time group.

Our study revealed that the postoperative complications showed a significant rise in post-operative stay and prolonged ventilation with the increase in aortic clamp time in both low and high risk group subsets. There was no mortality in both the subgroups and the STS risk score for mortality 1.16-1.8%

During the conduct of cardiac surgery, aortic cross-clamp results in myocardial ischemia as the perfusion to the coronaries is stopped, this ischemia may be exacerbated by reperfusion when the clamp is released as the

transition from a state of hypoxia to re oxygenation can exacerbate tissue injury[13].

Prolonged clamp time is associated with myocardial ischemia resulting in myocardial stunning, although our study did not show an increase in inotrope requirement in patients with prolonged clamp time in the low risk group however the inotrope requirements were more in the high risk group and there was a significant increase in the number of patients requiring peroperative intraaortic balloon pump.

Our results are in line with other studies showing an association between prolonged cross-clamp time with lengthy intensive care unit stay[14] and increased morbidity[15] including pulmonary dysfunction[16], low cardiac output requiring more inotropes and mechanical support[17].

Postoperative atrial fibrillation is seen in 30-40% post CABG.New onset postoperative atrial fibrillation is associated with prolonged hospital stay and worse postoperative outcomes. Khosrow Hashemzadeh[18] in their study on factors associated with post-operative atrial fibrillation showed a intraoperative factors associated with post-operative AF included cardiopulmonary bypass time, aortic cross-clamp time, bicaval cannulation, valve surgery, ASD surgery and cardiac venting technique. Cardiopulmonary bypass deprives the heart of blood flow and thus could result in atrial ischemia-reperfusion injury and post-operative AF[18].

Preoperative risk factors for stroke include age, cerebrovascular disease, peripheral vascular disease and left ventricular dysfunction, peroperative factors include cross-clamping and the number of periods of aortic cross-clamping as independent risk factors for CVA[19]. Similarly factors implicated for postoperative renal dysfunction after CABG surgery include prolonged cardiopulmonary bypass (CPB), and aortic clamp times[20]

The main study limitation was the relative small sample size, as the total number of patients participating in the study were further split into four subgroups. A larger patient number would result in more credible conclusions. Our study was underpowered to draw conclusions on myocardial injury and its association with longer clamp time[21], multiorgan system failure[22], as well as intraoperative death 17 and mortality[23].

CONCLUSION

Prolonged cross-clamp time is significantly associated with immediate key post-operative morbidity and mortality and affects both low- and high-risk patients in our local population. This impact increases with increasing XCL time. Prior information on this effect can help in preventing various complications.

CONFLICT OF INTEREST

This study has no conflict of interest to declare by any author.

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