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Hemodynamic Changes and their Management during off Pump Coronary Artery bypass: An Observational study

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Abstract

Background: Coronary artery bypass grafting (CABG) without cardiopulmonary bypass is one of the alternative with an intention to avoid all the complications related to extracorporeal circulation. Off pump CABG (OPCABG) is associated with various hemodynamic alterations and its management is really challenging.

Methodology: The objective of our case series is to study the hemodynamic changes during each artery grafting, its complications and its management. In this study we have studied 27 patients who underwent OPCABG. Heartrate, blood pressure and cardiac output were measured during each grafting and analyzed. The major complications that occurred and its management are discussed.

Result: The heartrate and blood pressure significantly decreased during LAD, OM and RCA grafting compared to the baseline. The cardiac output decreased significantly during OM and RCA grafting. One patient had intra-operative myocardial ischemia. One patient had cardiac arrest in the ICU followed by LAD and LCX graft revision. Two patients had increased post-op bleeding and taken for re-exploration.

Conclusion: Hemodynamic management of OPCABG is always challenging but feasible to manage. All the patients tolerated the hemodynamic changes well and had a good post-operative outcome.

Keywords: Hemodynamic changes; Off pump coronary artery bypass; Coronary artery disease; Cardiac stabilisers; Cell saver; inotropes.

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INTRODUCTION

Coronary artery disease is one of the major causes of death worldwide. Surgical coronary artery bypass graft (CABG) surgery is the gold standard for revascularization of left main or three vessel CAD. CABG without cardiopulmonary bypass (CPB) is one of the alternatives with the intention to avoid all the complications related to extracorporeal circulation. Off pump (OP) CABG

is expected to improve long term outcomes by decreasing the cerebrovascular complications, perioperative myocardial injury and cardiac related mortality.[1]

Hemodynamic variations during OPCABG surgery may be due to mobilization and stabilization of the heart or myocardial ischemia occurring during coronary occlusion.[2] Anaesthetist play a key role in managing the swing in blood pressure, heart rate and cardiac output. The present study is focused on the hemodynamic challenges encountered during OPCABG and its management.

AIMS AND OBJECTIVES

To study the hemodynamic changes during OPCABG and its management.

METHODOLOGY

Type of study: A Prospective Observational Study

Duration of study: 6 months from august 2023 to February 2024.

Inclusion criteria: All the patients who were posted for elective OPCAB surgery between the ages of 30 to 65, with normal biventricular function were included in the study.

Exclusion criteria: Hemodynamically unstable patients, posted for emergency surgery, re-do surgeries, patients having coagulopathy, abnormal ejection fraction and difficult airway were excluded.

Procedure: The pre-operative evaluation involves thorough history, physical examination, laboratory investigations and imaging. All the patients received alprazolam 0.25mg the night before the surgery and on the day of surgery. The Intra-operative monitoring used were electrocardiogram, capnograph, invasive blood pressure, central venous pressure, oxygen saturation, ICON (Index of Contractility) non-invasive cardiac output monitoring, core temperature, urine output, bispectral index (BIS) and Trans oesophageal echocardiography (TEE). Right radial arterial line was assessed with 20g cannula before induction. Induction was done using Inj. fentanyl 1mcg/kg, Inj.midazolam 1mg, Inj. etomidate 0.3mg/kg and Inj.rocuronium 1.2mg/kg. Proper maintenance of myocardial oxygen demand supply balance were given utmost priority. After induction right internal jugular vein was accessed with a central venous catheter and right femoral artery was accessed with 16G leader catheter. Maintenance was done with inhalational agent Isoflurane, intravenous drugs fentanyl, midazolam and cis-atracurium. The anaesthetic depth was monitored to a BIS target of 40-60 throughout the surgery.

OP-CABG was done after median sternotomy with CPB standby. After mobilization of Left Internal Mammary Artery (LIMA), heparin 2mg/kg IV was given to maintain a target Activated clotting time (ACT) between 250 to 300s. Distal grafting was performed using octopus-II tissue stabilizer. Intra coronary shunt was used in all the cases. Proximal anastomosis was done with aortic partial clamping.

Normothermia was maintained throughout the surgery by maintaining a warm room temperature, warming of intravenous fluid, warming and humidification of ventilator gases and by using warm air blower. Goal directed fluid management was done using ringer lactate and hydroxy ethyl starch. The threshold for allogenic red blood cell transfusion was a haemoglobin <9 and a haematocrit 27%. Cell saver was used as a routine in all the cases and the washed salvaged blood was transfused to the patient towards the end of the surgery. No antifibrinolytic agents were used.

Infusion noradrenaline and nitro-glycerine were used to maintain a MAP 70 to 90 to ensure coronary perfusion pressure. Whenever the patient's Systemic Blood Pressure decreased from 20% of baseline, it was managed by trendelenburg position, vasoconstrictors, administrating fluid and optimizing heart rate between 50-70 per minute. Whenever the patient's SBP increased from 20% of baseline, it was managed by increasing the depth of anaesthesia, by reverse trendlenberg and by titrating infusion nitro-glycerine. Temporary epicardial Pacemaker was used whenever the heart rate (HR) decreased below 50. Whenever the HR increased above 100, the depth of anaesthesia was ensured. Persisting tachycardia was managed by titrating esmolol infusion between 50 to 350 mcg/kg/min. HR, systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP) and cardiac output (CO) were documented before the surgery, immediately after positioning the heart for left anterior descending artery (LAD) grafting, obtuse marginal (OM) grafting and right coronary artery (RCA) grafting, before the application of the pacemaker. Inotropes like dobutamine and adrenaline were used based on intra-operative TEE findings. At the end of the procedure, protamine 50mg was given if the ACT > 300s. Patients were electively ventilated at the end of surgery, and early

extubation protocol was applied to all patients.

Statistical analysis: The data was analysed in SPSS 27 version. Data were expressed as mean ± SD and percentiles. Non parametric and parametric tests were used to compare the data appropriately. A two tailed p value of less than 0.05 was considered significant.

RESULT

The patient demographics and characteristics are given in the table 1 and fig. 1. The hemodynamic changes during LAD, OM and RCA grafting are given in the table 2.

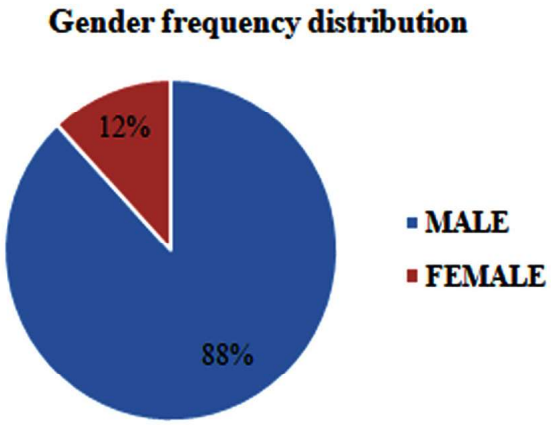

Fig. 1: Gender frequency distribution

Table 1: Patient demographics and characteristics

-	Age (years)	Weight (kgs)	Number of grafts	Duration of surgery (hours)
Mean ± SD	55.62±9.9	69.1±12.38	3.17±0.58	5.97±1.49

Table 2: Hemodynamics during LAD, OM and RCA grafting

Descriptive Statistics					
-	Mean	Std. Deviation	Percentiles		
			25th	50th (Median)	75th
HR_BASELINE	72.6538	12.69312	63.0000	74.5000	83.2500
SBP_BASELINE	131.4615	10.97718	126.0000	133.0000	140.5000
DBP_BASELINE	82.1538	10.35255	78.0000	84.0000	90.5000
MAP_BASELINE	103.3846	13.72320	96.0000	109.0000	112.7500
CO_BASELINE	4.6769	.39830	4.4000	4.6500	5.0000
CI_BASELINE	2.7577	.27448	2.5000	2.8000	3.0000
HR_OM	57.8462	10.55156	48.0000	58.0000	65.0000
HR_LAD	69.8462	11.8	64.0000	70.0000	78.0000
HR_RCA	56.3846	10.41183	47.5000	55.0000	64.5000
SBP_LAD	126.1538	8.01844	120.0000	130.0000	132.0000
SBP_OM	109.3077	9.01452	104.5000	112.0000	116.0000
SBP_RCA	97.7692	10.07693	90.0000	95.0000	108.0000
DBP_LAD	76.4615	10.78232	76.0000	80.0000	82.5000
DBP_OM	68.5385	10.08060	59.0000	70.0000	78.0000
DBP_RCA	60.5385	10.03287	56.0000	60.0000	70.0000
MAP_LAD	97.4615	12.49074	92.0000	102.0000	106.0000
MAP_OM	86.0000	10.21372	80.0000	90.0000	92.5000
MAP_RCA	70.2308	7.90599	64.0000	72.0000	74.5000
CO_LAD	4.6231	.42550	4.3000	4.6000	4.9250
CO_OM	4.2115	.38192	4.0000	4.2000	4.5000
CO_RCA	4.1038	.27493	3.8000	4.0500	4.3250
CI_LAD	2.7308	.23112	2.5750	2.7500	2.8250
CI_OM	2.4692	.21122	2.3000	2.5000	2.7000
CI_RCA	2.4154	.14884	2.3000	2.4000	2.5250

By Wilcoxon signed rank test hemodynamic parameters during LAD, OM and RCA grafting

were compared with the baseline parameters in which p value was found to be significant (<0.001) except for the parameters CO and CI during LAD grafting compared with the baseline.

Table 3: Complications

Cardiovascular complications	Case 4 had intra-op MI f/b 2 episodes of VT, patient was shifted to ICU with IABP support.
	Case 12 had cardiac arrest on shifting to ICU, taken for LAD & OM graft revision. The sternum was left open for 24hrs
Conversion to on pump CABG	NIL
Respiratory complications	NIL
Bleeding	Case 8 & case 14 had bleeding – taken for re-exploration for hemostasis
Need for IABP	1
Renal failure/ Need for post-op dialysis	NIL
Post-op stroke/ Reversible neurological deficit	NIL
Infection	NIL
Duration of inotrope use (days)	2
Duration of ICU stay (days)	4.3
Duration of hospital stay (days)	8.5

Unpaired student t test was used to compare hemodynamic parameters during OM grafting with hemodynamics during RCA grafting. SBP, DBP and MAP were found to be significant (<0.01). The complications during the surgery were noted in Table 3.

DISCUSSION

In this study we have studied the hemodynamic changes during OPCABG and its management. The HR during LAD grafting, OM grafting and RCA grafting were found to be significantly reduced compared to the baseline HR.

The SBP, DBP and MAP during LAD, OM and RCA grafting were significantly reduced compared to the baseline values, also it was significantly reduced during RCA grafting compared to OM grafting. The CO and CI during LAD was not changed significantly compared to the baseline. But the CO and CI during OM and RCA grafting were significantly reduced compared to the baseline values. The change in HR, CO and CI during OM grafting compared to RCA grafting were similar.

Right ventricle compression is more during the exposure of lateral and posterior wall. Since the apex will be at its uppermost position, diastolic filling happens against gravity while the ventricles are already being restricted by the mechanical constraint of the stabilizers. Both the atria become enlarged with high filling pressures which are needed to fill the constrained ventricles. The net hemodynamic effect of this bi-ventricular systolic and diastolic dysfunction causes decrease in CO with or without valvular insufficiency.[3]

Major complications

Case 4 had Intra-operative Myocardial Ischemic (MI) changes during the grafting of RCA. There was ST segment elevation in leads II, III & avF and sudden increase in inotropic supports. Infusion Nitro-glycerine 0.5mcg/kg/min was continued and infusion noradrenaline was titrated to maintain MAP above 70mmHg. Patient had 2 episodes of ventricular tachycardia, which reverted back to sinus rhythm after defibrillation with 20 joules using internal paddles. IV lignocaine 100mg was given and electrolytes were corrected. Intra-Aortic Balloon Pump (IABP) was inserted and the patient was shifted to ICU.

It is very difficult to diagnose intra-operative MI during OPCABG because ECG gain is very much reduced and the electrical depolarization vector of the myocardium is changed due to the cardiac displacement. The detection of new Regional Wall Motion Abnormality (RWMA) changes in TEE is also challenging due to the limited window, when the heart is displaced. In such cases, increase in Pulmonary Artery Occlusion Pressure (PAOP) and superimposition of accentuated A, C and V waves

by decreased LV compliance with or without mitral regurgitation on a pulmonary artery waveform, helps diagnosing Intra-op MI.[3] The other cardiac output monitors which can be used are pulse contour analysis and Electric cardiometry (ICON) monitor. If the coronary artery is not opened, the heart should be returned back to its normal position. If these are observed during grafting, facilitating the distal perfusion using intra-coronary shunt should be considered.

Case 13 had cardiac arrest on reaching the ICU. The patient attained return of spontaneous circulation (ROSC) with 2 cycles of CPR. There were new ST changes in leads I & aVL and new onset RWMA in the anterior and lateral wall. The patient was taken for LAD and OM graft revision, which was done off pump uneventfully. Since the patient had diffuse bleeding under the sternum, the sternum was closed 24 hrs after the surgery.

Case 9 and Case 15 had increased drain and fall in hemoglobin post operatively. Both the cases were taken for re-exploration and hemostasis was achieved. Both the patients were shifted back to ICU uneventfully.

Jae-Kwang Shim *et al* reviewed proper targets for safe execution and troubleshooting during OPCABG. The targets are the maintenance of MAP above 70mmHg, maintenance of SvO2 above 60% and preventing the CVP from rising above the (PADP), which may indicate compressive syndromes and/or severe RV failure. TEE monitoring should be used to watch for ventricular interdependence manifested by dyskinesia of LV wall or septum. Observation for diastolic opening of the pulmonary valve, left ventricular outflow tract obstruction, mitral regurgitation and air embolism has to be observed to rule out rare causes of hemodynamic collapse.[3] In our case series none of the patients had hemodynamic collapse and conversion to on pump CABG. All the hemodynamic challenges were timely managed.

Quoc-Bao Do *et al* did continuous monitoring of Systemic Arterial Pressure(SAP), Mean Pulmonary Artery Pressure (PAP), mixed venous oxygen saturation (SVO2) and Cardiac Output Index (COI) in 55 patients who were undergoing OPCABG. Mean PAP increase and COI drop were more significant during manipulation of the anterior territories suggesting a more severe diastolic restrictive disease during anterior wall manipulation. In our case series we have used ICON for cardiac output monitoring. There was a significant drop in the cardiac output during OM and RCA grafting.[4]

Alexandre R Carvalho et al studied 27 patients who underwent aorta no touch OPCABG and recorded the hemodynamic and metabolic changes during LAD, OM and RCA grafting. There were no significant change in HR and MAP during all anastomosis except that, there was significant fall in MAP during RCA grafting. There was significant decrease in stroke volume and mixed venous oxygen saturation during OM and RCA grafting. CVP drop after RCA manipulation was strongly associated with a higher lactate during the first hour after surgery.[5] In our case series there was significant decrease in HR and MAP in LAD, OM and RCA grafting, also significant fall in CO during OM and RCA grafting. We have not studied the metabolic changes during every grafting like in this study. In this study Flotrac pulse contour analysis was used for CO monitoring whereas in our study we have used electric cardiometry for CO monitoring.

Limitations: This is an observational study of hemodynamic changes in OPCABG surgery. The number of patients studied are less. Another limitation is that we have not used any invasive CO monitoring.

Conclusion: Hemodynamic management during OPCABG is challenging but feasible. In our case series we have studied the hemodynamic changes when the heart is displaced during each grafting and the challenges faced. The hemodynamic changes were more significant during the exposure of LCX territory and RCA territory. The blood pressure fall was more during RCA grafting compared to OM grafting. All the cases were timely managed and had a good post-operative outcome.

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