HEMODYNAMIC AND MIXED VENOUS OXYGEN SATURATRION CHANGES DURING POSITIONING OF THE HEART FOR OBTUSE MARGINAL ARTERY BYPASS GRAFTING IN OFF PUMP CORONARY ARTERY BYPASS GRAFTING

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Abstract

The better knowledge of the side effects of CPB and advancements in surgical instruments and techniques, coronary artery bypass grafting on the beating heart has grown in cardiac surgery. Off-pump coronary bypass grafting (OPCAB), will shifts the beating heart and restricts cardiac motion to expose the intended anastomosis site and entirely revascularize the heart. This can cause significant hemodynamic changes, myocardial ischemia and a loss in the performance of left ventricle. The aim of this study was to evaluate the hemodynamics of patients undergoing off-pump coronary artery bypass graft surgery.

INTRODUCTION

The better knowledge of the side effects of CPB and advancements in surgical instruments and techniques, coronary artery bypass grafting on the beating heart has grown in cardiac surgery. Off-pump coronary bypass grafting (OPCAB), will shifts the beating heart and restricts cardiac motion to expose the intended anastomosis site and entirely revascularize the heart. This can cause significant hemodynamic changes, myocardial ischemia and a loss in the performance of left ventricle. The aim of this study was to evaluate the hemodynamics of patients undergoing off-pump coronary artery bypass graft surgery.

Mean arterial blood pressure (MAP), HR (Heart Rate), pulmonary arterial pressure (MPAP), venous oxygen saturation (SvO2) and CVP (central venous pressure) were constantly monitored in 90 patients having total OPCAB revascularization. Hemodynamic changes were monitored and contrasted with baseline values prior to the onset and stabilization of anesthesia.

The displacement of the heart was associated with a considerable reduction in MAP and SvO2, but an increase in MPAP, HR and CVP. During anastomosis, HR was considerably elevated in all arteries except RI, and it was notably elevated in the OM (obtuse marginal) and RCA (Right Coronary Artery). During anastomosis, CVP rose markedly in all arteries, but mainly in the PDA and RI. During anastomosis, the mean PAP rose dramatically in all arteries, but mainly in the PDA and diagonal arteries (DG). During anastomosis, SvO2 fell markedly in all arteries, but mainly in the PDA and RCA. During anastomosis, MAP was dramatically reduced in all arteries, but particularly in the PDA, RI, and RCA.

Patients who are not candidates for coronary angioplasty have been proven to benefit from CABG. For myocardial revascularization, the majority of cardiac units in underdeveloped nations undertake OPCABG surgery due to cost restrictions. Using stabilizing devices in combination with deep pericardial traction sutures, the surgeon is able to execute multi-vessel coronary revascularization while the heart is still beating. This technique eliminates the detrimental consequences of cardiopulmonary bypass associated with on-pump CABG. However, even this treatment poses a substantial risk of life-threatening complications. The patient's comorbid diseases and the location of the heart during the surgery greatly decrease oxygenation of the important organs, resulting in an elevated risk of morbidity and death owing to malfunction of numerous organ systems.

Numerous investigations and clinical trials have been done in an attempt to prevent these consequences by employing goal-directed, evidence-based, and hemodynamic therapeutic techniques. Certain factors of optimum cerebral perfusion have acquired impetus in addition to the monitoring of hemodynamic parameters.

When a beating heart with one deep pericardial stay suture and an octopus tissue stabilizer, the mean ABP and SvO2 dramatically decreased whereas PAP, HR and CVP gets increased in arteries during anastomosis.. As a result, proper care and routine monitoring are crucial during graft anastomosis.

AIMS AND OBJECTIVE:

To study the hemodynamic and mixed venous oxygen saturation changes during OM grafting in patients undergoing OPCABG.

Secondary aim is to observe the subset of patients with Left ventricular dysfunction while OM grafting.

MATERIALS AND METHODS

It is a prospective longitudinal study. It will be conducted in Department of Cardiothoracic surgery, SRIHER, over a period of 6 months. Written and informed consent will be taken.

Inclusion criteria:

1] Age: 19-80yrs

2] Elective OPCABG patients who undergo grafting to Left anterior descending artery (LAD) and OM

Exclusion criteria:

1] Chronic Obstructive Pulmonary Airway disease.

2] Occupational Lung disease

3] Patients with co-existing valvular /congenital heart disease.

4] Patients with unstable preoperative hemodynamics.

Adetailedpreoperativeechocardiographywillbedoneinallpatients.Leftventricularsystolicfunction will be assessed. According to American College of Cardiology (ACC) recommendations [1], patients with left ventricular systolic dysfunction (Left ventricular ejection fraction 50%) will be classified as mild (40-49%), modest (30-39%), or severe (<30%).All patients will be recruited by consecutive enumerated sampling (N=90).

Sample size calculation

$$n=\left(\frac{Z_{1-\alpha/2}+Z_{1-\beta}}{ES}\right)^2$$

α - level of significance

Z 1-α /2 - normaldistribution holding(1- α/2 or below it).

1- β–Selected –power

Z 1-β –standard normal distribution holding(ranges from 1-β or below).

For 80% power,

Z0.80=0.84.

α=5%.

Effect size (ES) was defined as:

$$\textit{Effect Size}=ES=\frac{|\mu_1-\mu_0|}{\sigma}$$

where

μ0 - mean under H0,

μ1 -mean under H1

σ -standard deviation.

Based on this calculation, we arrived at a sample size (n) of 89. Hence, we will study 90patients.

Between November 2021 and April 2022, 90 patients who undergoes CABG for multiple vessel disease were chosen for OPCABG surgery. All patients gave their informed consent. Every patient underwent full revascularization.

Anesthesia:

The patient had been supplied heart drugs up to the morning of the procedure, but beta-blockers were not administered at that time. All patients received injectable morphine 0.01 mg/kg an hour before surgery. Under local anesthesia, a 7F triple-lumen central catheter and a pulmonary artery catheter (A Swan- Ganz catheter -Baxter Healthcare, Irvine, CA) were inserted through the right internal jugular vein for ongoing monitoring of the RAP, PAP, and SvO2. These processes were all carried out in the operation room.

In order to facilitate endotracheal intubation, anesthesia was induced with intravenous midazolam about 0.1 mg/kg, 0.3 mg/kg of intravenous cisatracurium and intravenous fentanyl (5mcg/kg). In order to maintain normocapnia, ventilation was started with a FIO2 of 0.5 following a 5-lead ECG, SpO2, bispectral index, invasive AP monitoring and connection of central venous catheter, Swan-Ganz and arterial catheter. The nasopharyngeal temperature, end-tidal carbon dioxide, urine output, HR and BP were all continuously monitored during the process.

Infusions of 2 mcg/kg/h intravenous fentanyl, 0.15 mg/kg cisatracuriume, adjusted isofluoran to mainain the bispectral index (whose values ranges from 40 and 60) and 1 mg/kg/hrpropofol were used to maintain anaesthesia.

Infusions of 1 mg/kg/hrpropofol, isofluoran adjusted to keep the bispectral index between 40 and 60, 2 mcg/kg/h intravenous fentanyl, and 0.15 mg/kg cisatracuriume were used to maintain anaesthesia.

Following the procedure, after removing the fentanyl and cisatracurium, the patient was shifted to the critical care unit under the sedation (1 mg/kg/hour) infusion of propofol. To avoid hypothermia, the operating room was maintained at or above 25 degrees Celsius, and all fluids remains warmed. The patients were also warmed up using heated beds.

During the heart displacement phase, ringer lactates were given at a constant rate (8 ml/kg/h) and blood loss was replaced by a bloodor by a distillation of colloid solution depending on the hematocrit level. In the event of hypotension, epinephrine and/or norepinephrine were administered to maintain the MAP above 60 mmHg.

After severing the left internal mammary artery (LIMA), intravenous heparin (1.5 mg/kg) was supplied to maintain the anastomosis' active clotting time above 250 s.

During the heart displacement and grafting procedures, a Trendelenberg position or a norepinephrine infusion was utilised to maintain MAP above 60 mmHg.

When considerable hypotension (MAP fall < 40 mmHg) was discovered, the movements were promptly stopped and the heart immediately returns to its normal position.

Once the patient's hemodynamics had stabilised, stabilisation was attempted once more, but this time, hemodynamic disruptions were minimised by changing the stabiliser's location and cardiac mobilisation. Nitroglycerin infusion was initiated when continuous ECG monitoring revealed signs of ischemia.

Operative sequence:

A median sternotomy exposed the heart, which dangled in a pericardial cradle. The heart was displaced using the left inferior pulmonary vein, a wide gauze/mop (12-70 cm) swab, and tissue stabilizer to reduce translational cardiac motion in the coronary area with mild compression on the beating heart. Typically, the right coronary artery and the obtuse marginal, ramus, or diagonal were grafted on after the left internal mammary artery was first grafted to the left anterior descending coronary artery (LAD). By encircling the arteriotomy site with a silastic ring, the coronary blood flow was stopped. Coronary anastomosis was carried out under visual observation, and the anastomosis site was cleaned with an air source. To do surgery on the OM and posterior branches, the heart's apex was moved closer to the patient's head. The patient's right side was turned as the table was placed in the Trendelenburg position (20- 30 degrees).

The incision's apex, which needs to be pointed up (90 degrees), was forced out of the wound using two big gauze swabs that were placed posterior to the heart and tension given to the stay suture. The LAD and diagonal coronaries were exposed using the identical settings, with the exception of the strain on the stay suture and the absence of side rotation. The table's Trendelenburg position and exteriorization of the apex contributed to the PDA's stability.

The saphenous vein or left RA were employed to avoid the other locations whereas the left internal thoracic artery was used to circumvent the LAD in all patients. One aortic partial side-bite clamping completed the proximal anastomosis to the ascending aorta.

Hemodynamic monitoring:

After hemodynamic stability was attained and before surgical procedures, baseline measurements of the patient's HR, ABP, right AP, PAP and SvO_2were made. The same hemodynamic measurements as at baseline were taken after coronary snaring was released and the anastomosis was complete.

Procedure

In the operating room, the radial artery will be cannulated to enable ongoing mean arterial pressure monitoring (MAP). Information on the partial pressure of oxygen will be available through the examination of arterial blood gases (PaO_2). The perioperative monitoring included a five-lead ECG with ST-segment analysis, pulse oximetry, end tidal CO_2 ($EtCO_2$) measurement, and implantation of a Swan-Ganz catheter.

PaO_2, $EtCO_2$, SvO_2, HR, MAP, PADP and MAP will all be measured. Prior to Obtuse Marginal (OM) anastomosis, 5 minutes after the heart is in the proper position for anastomosis, and 5 minutes after it is finished, data will be collected.

The anesthetic techniques used on all patients will be uniform. Anesthesia is induced using titrated dosages of injectable midazolam, fentanyl, and thiopentone. Neuromuscular inhibition results after vecuronium injection.

After 180 seconds of 100% oxygen bag and mask breathing, the trachea is intubated with a suitable size cuffed endotracheal tube. Following induction, end-tidal carbon dioxide, nasopharyngeal temperature, urine production, and arterial pressure are all tracked. To sustain anesthesia, the doses of fentanyl, midazolam, sevoflurane, and nitrous oxide in oxygen (50%) are titrated to a Bispectral index (BIS) value of 40 to 60.

A midline sternotomy will be used for all procedures. After the heart has been inspected, saphenous vein and left internal mammary (LIMA) grafts are acquired. The left side receives deeper pericardial stay sutures than the right. In order to achieve a target activated clotting time of more than 250 seconds, the patient receives 1.5 mg/kg of heparin. A tissue stabiliser (Medtronic Inc., Minneapolis, MN, USA) is used to position the heart such that the target coronary arteries may be seen. The posterior descending (PDA), obtuse marginal (OM), and diagonal (D) arteries are grafted after the left anterior descending (LAD) artery. An intra-coronary shunt and CO_2 blower are used to construct the anastomosis.

The obtuse marginal is grafted using a deep pericardial stitch next to the left inferior pulmonary vein. The patient is turned to the right side while the table is in the Trendelenburg position.

The pericardium is inserted between the left ventricle and a moistened gauze pad (10 10 cm in size). The lateral and posterior surfaces of the heart are made visible by traction on the pericardial sutures.

The heart is then raised from the pericardial cradle, rotated, and lifted cephalad. The target OM is then covered with the tissue stabilizer to enable the creation of the coronary anastomosis. The heart is returned to its normal place when there is severe hypotension (Systolic arterial blood pressure less than 70 mmHg). After hemodynamic stabilization, the heart is moved for grafting with minor alterations to the position of the stabilizer.

In all patients, the LAD is bypassed using the left internal mammary artery, while other areas are bypassed using saphenous vein grafts. The proximal anastomosis of the saphenous vein graft to the ascending aorta is finished using a partial aortic sidebiting clamp.

Utilizing volume expansion with crystalloid solutions, intravenous boluses of injectable ephedrine, and, if necessary, inotrope infusion, the patient's hemodynamic stability is maintained (Dobutamine)

StatisticalMethod:

Descriptive and inferentialstatistics were used to analyse the data. Mean and standard deviation were calculated forHR, MAP, PADP, SvO2, PaO2 and EtCO2 (Data was collected before Obtuse Marginal(OM) anastomosis, 5 minutes after positioning of the heart for anastomosis and 5 minutes after its completion).

Data was analyzed by one-way repeated-measures ANOVA (Analysis of variance).
A significant ANOVA(P<0.05) will be followed by a Bonferroni–Holmposthoctest.

RESULTS

HR significantly decreased in Base and Ramus compared to LAD, DG, OM, RCA and PDA. CVP significantly decreased in Base compared to LAD, DG, OM, Ramus, RCA and

PDA. It significantly decreased in LAD compared to DG, Ramus, RCA and PDA. However, it significantly increased in PDA compared to DG, OM, and RCA(Table1)

TABLE (1) HEART RATE AND CVP

Statistics Parameters		N	Range	Mean ± SD	P-value
HR	Base(1)	90	66.0-79.0	70.2±3.0	0.0001* 1,5vs2,3,4,6,7
	LAD(2)	90	71.0-84.0	76.3±3.1	
	DG(3)	48	75.0-82.0	78.3±1.9	
	OM(4)	90	77.0-86.0	80.3±2.5	
	Ramus(5)	30	.0-82.0	67.7±29.9	
	RCA(6)	85	75.0-84.0	80.3±2.3	
	PDA(7)	57	77.0-82.0	79.3±1.8	
CVP	Base(1)	90	6.0-11.0	8.8±1.7	0.0001* 1vs2,3,4,5,6,7 2vs3,5,6,7 7vs3,4,6
	LAD(2)	90	7.0-12.0	9.9±1.6	
	DG(3)	54	8.0-13.0	11.2±1.7	
	OM(4)	90	8.0-13.0	10.7±1.5	
	Ramus(5)	56	10.0-13.0	11.8±1.2	
	RCA(6)	22	9.0-14.0	11.7±1.4	
	PDA(7)	78	11.0-14.0	13±1.1	

TABLE (2)

Statistics Parameters		N	Range	Mean ± SD	P-value
MeanABP	Base(1)	90	80.0-97.3	90.6±4.2	0.0001* 1vs2,3,4,5,6,7 2 vs 3,4,5,6,7 3 vs7
	LAD(2)	90	67.3-82.0	76.8±3.2	
	DG(3)	34	66.0-77.7	71.7±3.9	
	OM(4)	90	64.0-77.0	71.1±3.2	
	Ramus (5)	46	63.0-77.0	69.8±4.7	
	RCA(6)	30	60.7-	69.9±3.5	

			74.3		
	PDA(7)	58	62.7-72.3	68.2±3.5	
MeanPAP	Base(1)	90	23.0-35.0	26.7±2.4	0.0001* 1vs2,3,4,5,6,7 2vs3,6,7 7vs4,6
	LAD(2)	90	25.7-35.3	29.5±2.5	
	DG(3)	34	26.7-36.3	32.1±2.6	
	OM(4)	90	27.0-34.0	30.2±2.1	
	Ramus (5)	46	29.7-33.0	31.0±1.4	
	RCA(6)	30	25.0-34.7	31.2±2.3	
	PDA(7)	58	31. 0-35.7	33.4±1.9	

Mean ABP significantly increased in base compared to LAD, DG, OM, Ramus, RCA and PDA. It significantly increased in LAD compared to DG, OM, Ramus, RCA and PDA. Also,itsignificantlyincreasedinDGcomparedtoPDA.However,it significantlydecreasedinBasecompared to LAD, DG, OM, Ramus, RCA and PDA, and in LAD compared to DG, RCA andPDA. On the other hand, PAP significantly increased in PDA compared to OM and RCA.(Table2)

SVO2 significantly increased in Base compared to LAD, DG, OM, Ramus, RCA and PDA and in LAD compared to Ramus, RCA and PDA and increased in DG and OM compared toPDA.(Table (3))

TABLE (3)

Statistics Parameters		N	Range	Mean ± SD	P-value
SvO2	Base(1)	90	78.0-85.0	81.8±1.8	0.0001* 1vs2,3,4,5,6,7 2vs5,6,7 3,4vs7
	LAD(2)	90	76.0-82.0	79.6±1.4	
	DG(3)	54	76.0-80.0	78.4±1.2	
	OM(4)	90	75.0-80.0	78.4±1.4	
	Ramus (5)	36	76.0-79.0	78.0±1.3	
	RCA(6)	20	74.0-80.0	77.3±1.8	
	PDA(7)	58	75.0-79.0	76.9±1.2	

DISCUSSION

This study's goal was to examine the sequential changes in hemodynamic parameters occurring following coronary artery graft anastomosis in patients with OPCAB using octopus tissue stabiliser. No anticipated anastomosis or conversion to CPB could not be carried out in the investigation because of hemodynamic instability.

Hemodynamic degradation is the main issue with coronary anastomosis, and numerous studies have shown the changes in hemodynamic values during anastomosis and their recovery after the anastomosis. To expose the target coronary grafting site during OPCAB, the heart must be moved, leading in varying degrees of iatrogenic hemodynamic impairment. Changes in cardiac geometry have a number of effects that contribute to hemodynamic compromise.

First, the atria are positioned below the ventricles, resulting in greater atrial size and pressure (Mathison et al., 2000 and George et al., 2002). Second, the right heart is directly compressed, resulting in right ventricular (RV) dysfunction (Mathison et al., 2000 and Nierich et al., 2000).

Third, the tricuspid and mitral annuli deform, resulting in stenosis or regurgitation of the corresponding valve (George et al., 2002). Fourth, the stabilizer device constrains the myocardium, resulting in localized myocardial dysfunction (Mishra et al., 2002).

These changes manifest primarily as poor filling and diastolic dysfunction of the ventricles, resulting in lower stroke volume and hence a drop in SvO2 and mean MPP, particularly during posterior wall exposure (Ngaage, 2003 and Chassot et al., 2004).

Although earlier studies focused on RV dysfunction (Mathison et al., 2000), the resulting hemodynamic impairment is thought to be due to bi-ventricular contribution (Do et al., 2002). By increasing preload and maintaining mean ABP, the hemodynamic repercussions of heart displacement are usually transitory, reversible, and well tolerated (Shim et al., 2009).

SvO2 is affected by haemoglobin levels, arterial oxygenation, and cardiac output. Variations in SvO2 during heart manipulation are dependent on changes in cardiac output since haemoglobin and oxygen levels stay relatively steady.

SvO2 is a helpful measure for assessing global tissue oxygenation: a reduction in SvO2 below 50% has been linked to the development of intestinal ischaemia (Chassot et al., 2004).

In the present study, SvO2 decreased in all coronary arteries and SvO2 were significantly greater during anastomosis of the PDA and RCA arteries.

Nierich et al. (2000),Mueller et al. (2002) and Shinn et al. (2004) found that SvO2 decreased significantly after stabilizer application in all coronary arteries and SvO2 were significantly greater during OManastomosis.

Also, Kwak et al. (2004) concluded that SvO2 significantly decreased during the LAD and OM anastomosis, but Shim et al. (2009) reported that SvO2 decreased significantly in all three arteries and SvO2 significantly greater during RCA anastomosis.

Muelleretal.(2002) reported that the HR increased significantly at the anastomosis of the left anterior descending artery and mean ABP, exhibited their largest drop, at the anastomosis ofthe OM.

CONCLUSION

Hemodynamic changes in patients during OPCABG surgery are quite noticeable due to the pounding heart manipulation. MAP and SvO2 greatly decreased throughout every coronary artery anastomosis when the procedure was carried out using a single deep pericardial stay suture and an octopus tissue stabilizer on the beating heart, whereas MPAP, heart rate, and central venous pressure dramatically rose in all arteries. Therefore, during the procedure, careful observation and appropriate anesthetic treatment could maintain hemodynamic stability.