

# Changes in Haemodynamic Parameters during Off Pump Coronary Artery Bypass Grafting (CABG) in Patients with Ejection Fraction $\geq 40\%$

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## ABSTRACT

**Introduction:** Presently off-pump CABG has proved itself to be a safe, cheaper and effective alternative of on-pump CABG. However, it requires manipulation, displacement, positioning & mechanical stabilization of the heart during grafting which may cause haemodynamic alteration. Study was done with the objective of finding out the changes in Central Venous Pressure (CVP); Mean Arterial Pressure (MAP); Mean Pulmonary Arterial Pressure (MPAP); Right Ventricular End Diastolic Pressure (RVEDP) & Left Ventricular End Diastolic Pressure (LVEDP) while grafting the anterior, lateral & inferior surfaces of heart during off-pump CABG.

**Material and methods:** Over one year time, 50 patients with LVEF  $\geq 40\%$ , undergoing off-pump CABG were monitored for the above parameters at various stages of their operation, namely:- 1. During manipulation & shunt introduction, 2. During anastomosis without shunt, 3. During anastomosis with shunt & 4. After anastomosis; while grafting the anterior, lateral & inferior surfaces of heart. These results were compared with the baseline values of CVP, MAP, MPAP, RVEDP & LVEDP, to look for statistical significance.

**Results:** During manipulation & shunt introduction; CVP (mmHg) significantly increased during Ramus grafting -  $12 \pm 1.8$  ( $p < 0.047$ ); and also during OM grafting -  $12.6 \pm 1.9$  ( $p < 0.045$ ), when compared to a baseline value of  $9 \pm 1.8$ . The MAP (mmHg) was significantly decreased during manipulation & shunt introduction in Diagonals -  $70 \pm 5.8$  ( $p < 0.046$ ), Ramus -  $70 \pm 5.8$  ( $p < 0.048$ ), OMs -  $65 \pm 5.8$  ( $p < 0.028$ ) & in the Right territory -  $69 \pm 5.9$  ( $p < 0.032$ ); as compared with baseline MAP of  $76 \pm 11.7$ . During anastomosis without shunt also, the MAP (mmHg) significantly decreased while grafting LAD -  $70 \pm 3.8$  ( $p < 0.048$ ), Diagonals -  $68 \pm 3.8$  ( $p < 0.039$ ), OMs -  $71.8 \pm 4.8$  ( $p < 0.039$ ) & Right sided arteries  $70.8 \pm 4.6$  ( $p < 0.039$ ), as compared with baseline MAP values. The MPAP (mmHg) was significantly increased -  $18.3 \pm 3.7$  ( $p < 0.047$ ) as compared to the baseline value of  $16 \pm 2.4$  during manipulation & shunt introduction in the OMs.

**Conclusion:** During OPCABG there will be significant alterations in haemodynamics mostly due to mobilization of the heart, which is necessary to visualise the target vessels properly & stabilisation of the concerned area with stabiliser. However, by observing the haemodynamic variations constantly & by making necessary mechanical & pharmacological adjustments, unnecessary conversion to On-pump technique can be avoided.

**Keywords:** OFF-PUMP, CABG, SWAN-GANZ

on beating heart, without a pump oxygenator (off-pump CABG) has potential advantages, such as - no activation of proteolytic & inflammatory systems, no depression of immune system & no consumption of clotting factors & platelets.<sup>1,2</sup> However, off-pump CABG demands meticulous handling of the heart, particularly when grafting the obtuse marginals & terminal branches of the right coronary arteries. This often causes haemodynamic compromise.<sup>3,4</sup> Hence, it is important to analyze these haemodynamic changes during the periods when heart is manipulated for inferior & lateral surface grafts. Nierich et al<sup>5</sup> & Jansen et al<sup>6</sup> reported an experience of 100 patients undergoing off-pump CABG with Octopus stabilisation & concluded that such haemodynamic disturbances during cardiac handling could be corrected by anaesthetic interventions - like fluid loading & low doses of inotropes. The purpose of this study is to analyze the haemodynamic changes in patients whose hearts are manipulated during off-pump grafting of the anterior, lateral & inferior surface vessels.

The objective of this study was to monitor the intraoperative haemodynamic changes in a cohort of patients undergoing off-pump CABG by measuring the Central Venous Pressure (CVP); Mean Arterial Pressure (MAP); Mean Pulmonary Arterial Pressure (MPAP); Right Ventricular End Diastolic Pressure (RVEDP) & Left Ventricular End Diastolic Pressure (LVEDP).

Thus, this study was aimed at enriching our present knowledge of haemodynamic alterations which occur while grafting different surfaces of heart.

## MATERIAL AND METHODS

Present study was done in from 1<sup>st</sup> November 2018 to 31<sup>st</sup>

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## INTRODUCTION

Unlike On Pump CABG, coronary artery bypass grafting

October 2019, in the Department of CTVS, Medical College & Hospital, Kolkata.

### Patient population & parameters measured

All patients who had single, double or triple vessel coronary artery disease, with or without left main disease & requiring grafts to anterior &/or lateral &/or inferior surfaces of heart. To make the population homogeneous, all patients with Left Ventricular Ejection Fraction (LVEF)  $\geq$  40% were only included.

We did not include patients:-

1. Who required Cardio Pulmonary Bypass(CPB) support at any time during operation.
2. Those who had associated Valvular heart disease, ASD or VSD.
3. Those who had contraindication for 'Swan – Ganz' catheter.
4. Those who had significant haemodynamic alterations on induction of anaesthesia.
5. Those with LVEF <40%.

Finally we had 50 patients(n=50), who were studied for the following parameters:-

1. Central Venous Pressure (CVP)
2. Mean Arterial Pressure (MAP)
3. Mean Pulmonary Arterial Pressure (MPAP)
4. Right Ventricular End Diastolic Pressure (RVEDP) ie RA pressure
5. Left Ventricular End Diastolic Pressure (LVEDP) ie LA pressure ie PCWP

Our sample size (n=50), was more than the sample required for this study; which was 44 (considering prevalence of Coronary Artery Disease in India to be 3%<sup>7</sup> & a confidence interval of 95% as per Daniel's formula -1999<sup>8</sup>).

### Study tools & techniques

Continuous hemodynamic monitoring was done by insertion of 'Swan-Ganz' catheter through internal jugular vein & separate arterial catheter, inserted through radial/ femoral artery, was used for Systemic Arterial Pressures in a Multichannel invasive monitor.

A separate CVP line was put in through Internal Jugular vein/ Subclavian vein to administer fluid & drugs.

During operation, positioning of the heart was done with sterile packs & gauze pieces.

Heart was stabilized with Maquet ACROBAT-i Vacuum Stabilizer System (stabilizer, tubings, canister & platform with standard blade). Wall vacuum suction of 250-300mm Hg was applied.

We did not use Star-fish stabilizers. We did not open the right pleura.

Coronary anastomosis were done using standard described techniques by competent coronary surgeons.

The haemodynamic parameters, mentioned previously were recorded under 4 broad headings:-

1. During manipulation & shunt introduction
2. During anastomosis without shunt
3. During anastomosis with shunt
4. After anastomosis

Highest recorded values of CVP, MPAP, RVEDP, LVEDP

1.	Mean age (years)	55±10.8		
2.	Sex	43(86%) males & 7(14%) females		
3.	Presentation: (n=50)			
	History of Acute Myocardial Infarction (not within preceding 3 weeks of operation)	28(56%)		
	Chronic stable angina	15(30%)		
	Unstable angina	7(14%)		
4.	Risk factors: (n=50)			
	Dyslipidemia	39(78%)		
	Smoking	36(72%)		
	Diabetes	21(42%)		
	Hypertension	28(56%)		
	Family history of Ischaemic Heart Disease	10(20%)		
5.	Coronary artery disease: (n=50)			
	Single vessel	05(10%)		
	Left main + Double vessel	04(08%)		
	Double vessel	09(18%)		
	Left main + Triple vessel	07(14%)		
	Triple vessel	25(50%)		
6.	Estimate of affected coronary arteries which were grafted:			
		Arteries grafted	Arteries affected	% Of affected arteries grafted
	Left Anterior Descending (LAD) artery	48	50	96%
	Diagonal artery	17	19	89%
	Ramus artery	08	08	100%
	Obtuse Marginals (OM)	37	43	86%
	Right territory (PDA/ PLV/ RCA)*	28	34	82%

\*PDA- Posterior Descending Artery, PLV – Posterior Left Ventricular Artery, RCA – Right Coronary Artery.

**Table-1:** Patient profile (n = 50)

& lowest value of MAP during the above mentioned stages were taken into account.

### STATISTICAL ANALYSIS

Data was presented as Mean  $\pm$  Standard deviation. For comparison of baseline data with the data obtained during the procedure, between the groups & various grafts; Students Paired T- Test were used. Statistical calculations were made with SPSS 8 for Windows (SPSS,Chicago,IL).

' p – values ' of  $< 0.05$  were regarded as statistically significant.

### RESULTS

We found that the mean age of our patient population to be  $55 \pm 10.8$  years; who primarily comprised of males (43 out of

50, ie 86%). 56% of this population had past history of acute myocardial infarction; 14 % had unstable angina ; while remaining 30% presented with chronic stable angina. The prevalence of risk factors for the development of coronary artery disease in our patients; the distribution of disease in their coronary arteries ; as well as the percentage of the affected coronary arteries which were grafted in this study can be understood from Table-1.

It was noted (as in Table-2) that during LAD grafting without a shunt, only the changes in MAP appeared statistically significant. In our study, out of 48 patients who had LAD grafts, 3 had their LADs grafted without a shunt.

Table-3 shows that during Diagonal artery grafting, the MAP showed significant alteration during manipulation & coronary shunt introduction; as well as, when this anastomosis was

Parameters (mmHg)	Baseline	During manipulation & shunt introduction	During anastomosis without shunt	During anastomosis with shunt	After anastomosis
1.CVP	9 $\pm$ 1.8	10 $\pm$ 1.2 p>0.05	9.8 $\pm$ 1.2 p>0.05	9.8 $\pm$ 1.3 p>0.05	9.5 $\pm$ 1.6 p>0.05
2.MAP	76 $\pm$ 11.7	74 $\pm$ 5.3 p>0.05	70 $\pm$ 3.8 p<0.048	75 $\pm$ 6.8 p>0.05	80.2 $\pm$ 4.8 p>0.05
3.MPAP	16 $\pm$ 2.4	15 $\pm$ 2.8 p>0.05	15.3 $\pm$ 1.6 p>0.05	16.4 $\pm$ 1.1 p>0.05	16.8 $\pm$ 1.8 p>0.05
4.RVEDP	9 $\pm$ 2	10 $\pm$ 1.2 p>0.05	9.5 $\pm$ 0.8 p>0.05	10.2 $\pm$ 1.5 p>0.05	9.2 $\pm$ 1.5 p>0.05
5.LVEDP	14 $\pm$ 1.6	14.5 $\pm$ 0.8 p>0.05	14.2 $\pm$ 1.4 p>0.05	15 $\pm$ 1.2 p>0.05	14.6 $\pm$ 1.2 p>0.05

**Table-2:** Haemodynamic changes during LAD grafting

Parameters (mmHg)	Baseline	During manipulation & shunt introduction	During anastomosis without shunt	During anastomosis with shunt	After anastomosis
1.CVP	9 $\pm$ 1.8	11 $\pm$ 1.4 p>0.05	9.6 $\pm$ 1.6 p>0.05	9.6 $\pm$ 1.2 p>0.05	9.1 $\pm$ 1.4 p>0.05
2.MAP	76 $\pm$ 11.7	70 $\pm$ 5.8 p<0.046	68 $\pm$ 3.8 p<0.039	74 $\pm$ 6.6 p>0.05	78 $\pm$ 5.8 p>0.05
3.MPAP	16 $\pm$ 2.4	14 $\pm$ 2.6 p>0.05	15.7 $\pm$ 1.8 p>0.05	16.1 $\pm$ 1.3 p>0.05	15.8 $\pm$ 1.8 p>0.05
4.RVEDP	9 $\pm$ 2	11 $\pm$ 1.4 p>0.05	9.8 $\pm$ 1.1 p>0.05	10.2 $\pm$ 1.3 p>0.05	9.8 $\pm$ 1.5 p>0.05
5.LVEDP	14 $\pm$ 1.6	14.5 $\pm$ 1.2 p>0.05	14.5 $\pm$ 1.2 p>0.05	14.8 $\pm$ 1.5 p>0.05	14.9 $\pm$ 1.5 p>0.05

**Table-3:** Haemodynamic changes during Diagonal grafting

Parameters (mmHg)	Baseline	During manipulation & shunt introduction	During anastomosis without shunt	During anastomosis with shunt	After anastomosis
1.CVP	9 $\pm$ 1.8	12 $\pm$ 1.8 p<0.047	-	10 $\pm$ 1.2 p>0.05	8.8 $\pm$ 1.4 p>0.05
2.MAP	76 $\pm$ 11.7	70 $\pm$ 5.8 p<0.048	-	73 $\pm$ 6.8 p>0.05	76.2 $\pm$ 6.8 p>0.05
3.MPAP	16 $\pm$ 2.4	14 $\pm$ 2.6 p>0.05	-	15.4 $\pm$ 1.8 p>0.05	16.3 $\pm$ 1.5 p>0.05
4.RVEDP	9 $\pm$ 2	11 $\pm$ 1.4 p>0.05	-	10.8 $\pm$ 1.5 p>0.05	9.9 $\pm$ 1.4 p>0.05
5.LVEDP	14 $\pm$ 1.6	14.5 $\pm$ 1.2 p>0.05	-	14.1 $\pm$ 1.6 p>0.05	14.3 $\pm$ 1.8 p>0.05

**Table-4:** Haemodynamic changes during Ramus grafting

Parameters (mmHg)	Baseline	During manipulation & shunt introduction	During anastomosis without shunt	During anastomosis with shunt	After anastomosis
1.CVP	9±1.8	12.6±1.9 p<0.045	9.2±0.8 p>0.05	10.2±1.0 p>0.05	9.8±1.8 p>0.05
2.MAP	76±11.7	65±5.7 p<0.028	71.8±4.8 p<0.039	75.1±6.6 p>0.05	78.2±6.2 p>0.05
3.MPAP	16±2.4	18.3±3.5 p<0.047	15±1.9 p>0.05	15.8±1.6 p>0.05	16.8±1.9 p>0.05
4.RVEDP	9±2	10.9±1.9 p>0.05	10.2±1.3 p>0.05	10.2±1.4 p>0.05	10.3±1.3 p>0.05
5.LVEDP	14±1.6	14.3±1.1 p>0.05	13.9±1.5 p>0.05	14.6±1.2 p>0.05	13.9±1.4 p>0.05

**Table-5:** Haemodynamic changes during Obtuse Marginal (OM) grafting

Parameters (mmHg)	Baseline	During manipulation & shunt introduction	During anastomosis without shunt	During anastomosis with shunt	After anastomosis
1.CVP	9±1.8	10.6±0.8 p>0.05	8.5±1.6 p>0.05	10.6±1.1 p>0.05	10.3±1.5 p>0.05
2.MAP	76±11.7	69±5.9 p<0.032	70.8±4.6 p<0.039	73.1±4.6 p>0.05	78.6±6.5 p>0.05
3.MPAP	16±2.4	16.5±2.5 p>0.05	16.8±1.2 p>0.05	16.1±1.8 p>0.05	16.3±1.5 p>0.05
4.RVEDP	9±2	10.1±1.3 p>0.05	10±1.3 p>0.05	9.8±1.7 p>0.05	10.6±1.5 p>0.05
5.LVEDP	14±1.6	14.8±1.5 p>0.05	13.6±1.7 p>0.05	14.9±1.4 p>0.05	14.2±1.8 p>0.05

**Table-6:** Haemodynamic changes during PDA/RCA/PLV grafting

done without using the shunt (in 3 out of 17 patients who had their diagonals grafted). We did not graft any Ramus artery without an intracoronary shunt. However, it was seen that, the rise in CVP & fall in MAP during manipulation & shunt introduction, while grafting this artery achieved statistical significance (as in Table-4).

We found that there is significant haemodynamic alteration during manipulation & shunt introduction in form of CVP, MAP & MPAP, while OM grafting. However, it was seen that, while anastomosing without shunt (5 such out of 37 OMs which were grafted) only the MPAP was significantly altered (as in Table-5).

Interestingly, it was also noted that, during grafting of the right side coronaries, the MAP was altered significantly during manipulation & shunt introduction as well as in performing anastomosis without shunt (2- PLV, 3 -PDA, 1 -RCA = Total- 6 such out of 28 patients who received right side coronary grafts) (as in Table-6).

## DISCUSSION

The application of mechanical stabilizers & manual handling of heart during off-pump CABG (OPCABG) causes haemodynamic compromise. This study enriched the present knowledge of the haemodynamic changes which occur while grafting the different surfaces of heart. We observed 5 haemodynamic parameters namely – CVP, MAP, MPAP, RVEDP & LVEDP in different timings during OPCABG on 50 patients. Among these patients, 48 got LAD grafts, 17 got Diagonal grafts, 8 got Ramus grafts, 37 got OM grafts & 28 got Right sided (RCA/PDA/PLV) grafts.

All these patients tolerated their operations well. In our study, during OPCABG, a total of 3 LAD grafts, 3 Diagonal grafts, 5 OM grafts & 6 Right sided grafts (2- PLV, 3 -PDA, 1-RCA) were anastomosed without shunt as per the surgeons preference or because shunt introduction was not possible or feasible.

We found that during manipulation & shunt introduction; CVP(mm Hg) significantly increased during Ramus grafting - 12±1.8 (p<0.047); and also during OM grafting – 12.6±1.9 (p<0.045), when compared to a baseline value of 9±1.8. Our results corroborate with M.Yeatman et al<sup>9</sup>, where they showed significant increase in CVP during manipulation & shunt introduction.

The MAP (mmHg) was significantly decreased during manipulation & shunt introduction in Diagonals - 70±5.8 (p<0.046), Ramus - 70±5.8 (p<0.048), OMs - 65±5.8 (p<0.028) & in the Right territory - 69±5.9 (p<0.032); as compared with baseline MAP of 76±11.7.

During anastomosis without shunt also, the MAP(mmHg) significantly decreased while grafting LAD - 70±3.8 (p<0.048), Diagonals - 68±3.8 (p<0.039), OMs – 71.8±4.8 (p<0.039) & Right sided arteries 70.8±4.6 (p<0.039), as compared with baseline MAP values. This corroborates with the findings of M.Yeatman et al<sup>9</sup> as mentioned earlier, but differs from the findings of Quo Bao Do et al<sup>10</sup>, where they showed that MAP was maintained throughout the anastomosis of all coronaries.

The MPAP(mmHg) was significantly increased – 18.3±3.7 (p<0.047) as compared to the baseline value of 16±2.4 during manipulation & shunt introduction in the OMs.

This finding does not corroborate with the finding of Quo Bao Do et al<sup>10</sup>, who showed that MPAP increased during LAD grafting & as well as M.Yeatman et al<sup>9</sup>, who found significant increase in MPAP during PDA grafting.

In our study, RVEDP & LVEDP did not show any significant changes anytime during OPCABG. This finding does not match with the results of Mathison et al<sup>11</sup> who found significant increase in both RVEDP & LVEDP during the grafting of Circumflex artery territory. This could have happened due to the fact that in our study, we measured RVEDP & LVEDP indirectly. RA pressure was taken as RVEDP & PCWP was taken as LVEDP. This could be a reason for getting insignificant 'p values'.

## CONCLUSION

During OPCABG there will be significant alterations in haemodynamics. However, by observing the haemodynamic variations constantly & by making necessary mechanical & pharmacological adjustments, unnecessary conversion to On-pump technique can be avoided. CVP shows significant increase during manipulation & shunt introduction while grafting the lateral surface of heart. MAP decreases significantly while manipulating heart for grafting all surfaces (anterior/ lateral / inferior). MPAP increases significantly on manipulating heart while grafting its lateral surface. There were no changes in RVEDP & LVEDP during surgery. The haemodynamic changes are mostly due to mobilization of the heart, which is necessary to visualise the target vessels properly; & stabilization of the concerned area with stabilizer which not only compress the heart but has a suction effect on the myocardium.

Along with the dislocation needed, the compression of the RV, more than the LV, are responsible for altered haemodynamics. In addition, compression of the LV outflow tract, especially for Ramus grafting plays a significant role. Also the deformation of the LV geometry due to the stabiliser, causes abnormal diastolic filling due to altered diastolic expansion, as well as some mitral regurgitation due to altered geometry. Transient ischaemia during introduction of shunt or "no shunt" adds to this.

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