International Journal of Research in Medical Sciences
Yadav SS et al. Int J Res Med Sci. 2020 Nov;8(11):4079-4083
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012
DOI: https://dx.doi.org/10.18203/2320-6012.ijrms20204908

Original Research Article

Haemodynamic assessment during off pump coronary artery bypass grafting in patients with ejection fraction ≥40% and it's relation to myocardial ischaemia in early postoperative period

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Received: 02 October 2020
Revised: 15 October 2020
Accepted: 16 October 2020

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ABSTRACT

Background: Subtle haemodynamic alterations that happen during manipulation, displacement and mechanical stabilization of the heart in off pump coronary artery bypass grafting (CABG), may be missed if only conventional parameters like Central venous pressure (CVP); Mean arterial pressure (MAP) and Mean pulmonary arterial pressure (MPAP) are being monitored. In this study we have tried to find out if such alterations may be detected by monitoring cardiac output (CO), cardiac index (CI) and stroke volume (SV) in addition to the conventional parameters.
Methods: Over a period of one year (February 2014 to January 2015), 40 patients with left ventricular ejection fraction (LVEF) ≥40%, undergoing off-pump CABG were monitored for the above parameters at baseline and while grafting the anterior, lateral and inferior surfaces of heart. Their quantitative Troponin-I values were also measured preoperatively and 24 hours after shifting to intensive therapy unit (ITU) to find out if the subtle haemodynamic compromises were in anyway related to myocardial injury.
Results: CO, CI and SV decreased significantly compared to baseline values while grafting anterior, lateral and inferior surfaces of heart in every patient. MAP decreased significantly only while grafting the left circumflex territory. Only 8 patients showed an elevation of troponin-I value postoperatively ($p>0.05$).
Conclusions: We concluded that during Off-pump CABG (OPCABG) there will be subtle alterations in haemodynamic. However, pharmacological interventions, addition of fluids and lowering head end of table based on the changes seen by the new monitoring parameters are more logically guided and becomes more scientific and objective rather than being just arbitrary decisions.

Keywords: Off pump, Cardiac output, Cardiac index

INTRODUCTION

The potential advantages of Off-pump coronary artery bypass grafting (OPCABG) when compared with On pump CABG are numerous and well documented, such as reduced systemic inflammatory response syndrome (SIRS), coagulopathy, athero-embolism, brain edema etc.[1,2] However, improper handling of the heart, injudicious placement of stabilizers, traction sutures while exposing the target vessel can cause haemodynamic compromises which can be very detrimental. The subtle changes that occurs to the physiology can often be missed if patient is monitored only by the conventional methods, such as Central venous pressure (CVP), Mean pulmonary artery pressure (MPAP) and Mean arterial pressure (MAP)- which only tend to detect the overt embarrassments. In this study we have tried to evaluate whether additional monitoring by using cardiac output (CO), cardiac index (CI) and stroke volume (SV), could bring to light these subtle changes and guide the surgical

team to take early remedial steps. We also measured the troponin-I values in all our patients preoperatively and 24 hours after shifting to intensive therapy unit (ITU) to find out if the subtle haemodynamic compromises were in anyway related to myocardial injury.

Aims and objectives

The aims of the study were to analyze of Cardiac Indices(CO, CI, SV) during off pump CABG as an addition to mean arterial pressure (MAP) , central venous pressure (CVP) and mean pulmonary artery pressure (MPAP), to assess any incipient changes in the haemodynamics not detected by the conventional tests and to assess myocardial injury during OPCABG by measuring troponin I level in early postoperative period.

METHODS

Present observational analytical study was done for a period of 1 year (February 2014 to January 2015) in the Cardiothoracic and vascular surgery (CTVS) department of Medical College and Hospital, Kolkata. All patients who had double or triple vessel coronary artery disease, with or without left main disease and requiring grafts to anterior and/or lateral and/or inferior surfaces of heart.

To make the population homogeneous, all patients with Left ventricular ejection fraction (LVEF) ≥40% were only included.

We did not include patients who had: atrial fibrillation, valvular heart disease, ischemic MR of grade >II/IV, ventricular aneurysm, emergency CABG and single vessel coronary artery disease.

Ultimately, we had 40 patients (n=40), in whom the following parameters were studied: Central venous pressure (CVP), Mean arterial pressure (MAP), Mean pulmonary arterial pressure (MPAP), Cardiac output (CO), Cardiac index (CI) and Stroke volume (SV).

Study tools and technique

A 'Swan-Ganz' catheter was introduced through internal jugular vein to measure MPAP. A separate CVP line was put in through internal jugular vein/ subclavian vein to monitor CVP and administer fluid/ drugs. Along with this, a radial arterial catheter was also put in and connected to Edward's flotrac /EV-1000 continuous cardiac output monitor to see MAP, CO, CI, SV.

The heart was positioned with sterile packs and gauze pieces. Then it was stabilized using Maquet ACROBAT-i vacuum stabilizer system before anastomosis using standard techniques. Wall vacuum suction of 250-300 mm Hg was applied. Star fish was not used and pleura not opened.

CVP, MAP, MPAP, CO, CI and SV were measured before positioning of the heart (ie., baseline) and after each anastomosis.

For all the cases, a quantitative troponin I was measured preoperatively and in the post-operative ITU, 24 hours after the patient was shifted (Troponin I levels remain elevated for 4-7 days after a myocardial injury and also that the prognostic utility of cardiac Troponin I measured 2 hours postoperatively is inferior to the 24-hour value, which suggests very early troponin values may not be as useful as measurements taken later after surgery. This is supported by other studies, which demonstrated that troponin levels in patients with good and bad outcomes did not separate well until 12 to 24 hours after surgery).[3,4]

Statistical analysis

Data was presented as mean ± standard deviation (SD). For comparison of baseline data with the data obtained after heart positioning and stabilization, a paired Student's t test was used.

Statistical calculations were made with Statistical package for social sciences (SPSS) 7.5 for windows (SPSS, Chicago, IL), and a p values less than 0.05 was regarded as statistically significant.

RESULTS

It was noted that the mean age of our patients was 53±10.7 years, of whom majority were males (82.5%). 52.5% patients had history of acute myocardial infarction at least 3 weeks before operation. The risk factors for coronary artery disease (CAD) the distribution of disease amongst the study population is detailed in Table 1.

According to table 2, while positioning and stabilizing the heart for left anterior descending artery (LAD) territory grafting (ie. LAD and diagonals), MAP fell by 5% as compared to baseline value, but did not achieve statistical significance. However, CO, CI and SV reduced by 14%, 17% and 12% respectively and had significant 'p' values.

While grafting the left circumflex territory (ie. OM and Ramus), it was found (as in table 3) that the values of MAP, CO, CI and SV significantly decreased after positioning and stabilizing the heart, when compared to baseline values. The changes in CVP and MPAP values, however, did not achieve clinical significance.

Again, during the Right territory (RCA, PDA and PLV) grafting, only the values of CO, CI and SV reduced significantly (table 4) after positioning and stabilization of heart. The reduction in MAP value by 10% did not achieve statistical significance.

We could not find any significant changes in CVP or MPAP during operation in any of our patients.

Table 1: Patient profile.

Patient characteristics			Number of subjects (%)
Mean age **(years)**			53±10.7
Sex			33 (82.5%) males 7 (17.5%) females
Presentation (n=40)			
History of acute myocardial infarction (not within preceding 3 weeks of operation)			21 (52.5%)
Chronic stable angina			15 (37.5%)
Unstable angina			4 (10%)
Risk factors (n=40)			
Dyslipidemia			36 (90%)
Smoking			34 (85%)
Diabetes			19 (47.5%)
Hypertension			28 (70%)
Family history of ischaemic heart disease			17 (42.5%)
Coronary artery disease (n=40)			
Single vessel			00 (0%)
Left main + double vessel			03 (7.5%)
Double vessel			08 (20%)
Left main + triple vessel			08 (20%)
Triple vessel			21 (52.5%)
Estimate of affected coronary arteries which were grafted	**Arteries grafted**	**Arteries affected**	**% of affected arteries grafted**
LAD	40	40	100
Diagonal artery	17	20	85
Ramus artery	04	04	100
Obtuse Marginals (OM)	30	34	88.24
Right territory (PDA/ PLV/ RCA)*	29	35	82.86

*PDA=Posterior descending artery, PLV=Posterior left ventricular artery, RCA=Right coronary artery.

Table 2: Hemodynamic changes during LAD territory (LAD/Diagonal) grafting.

Parameters	Baseline	After positioning and stabilization of heart	P value
CVP (mmHg)	9±2	9±3	>0.05
MAP (mmHg)	71±12	68±11 (↓ 5%)	>0.05
MPAP (mmHg)	17±2	18±3	>0.05
CO (l/min)	5±1.5	4.2±1.4 (↓ 14%)	<0.01
CI (l/min)	3.1±1.4	2.6±1.5 (↓ 17%)	<0.01
SV (ml)	67±9	59±10 (↓ 12%)	<0.01

Table 3: Hemodynamic changes during Left Circumflex territory (OM/Ramus) grafting.

Parameters	Baseline	After positioning and stabilization of heart	P value
CVP (mmHg)	9±3	10±3	>0.05
MAP (mmHg)	72±12	62±13 (↓ 14%)	<0.05
MPAP (mmHg)	18±3	20±2	>0.05
CO (L/min)	4.8±1.4	3.7±1.2 (↓ 22%)	<0.01
CI (L/min)	3±0.6	2.3±0.7 (↓ 24%)	<0.01
SV (ml)	66±11	51±12 (↓ 23%)	<0.01

Table 4: Hemodynamic changes during Right territory (PDA/RCA/PLV) grafting.

Parameters	Baseline	After positioning and stabilization of heart	P value
CVP (mmHg)	9±2	10±3	>0.05
MAP (mmHg)	68±13	63±13 (↓ 10%)	>0.05
MPAP (mmHg)	18±2	20±3	>0.05

Continued.

Parameters	Baseline	After positioning and stabilization of heart	P value
CO (L/min)	4.8±1.7	3.9±0.9 (↓ 18%)	<0.01
CI (L/min)	3±1.1	2.4±0.5 (↓ 21%)	<0.01
SV (ml)	63±15	54±12 (↓ 15%)	<0.01

It was also noted that all 40 patients had a baseline preoperative troponin I value of ≤0.4 ng/ml; while 8 patients (20%) showed an elevation of this value (ie. >0.4 ng/ml) measured 24 hours after being shifted to post-operative ITU. This finding did not achieve statistical significance.

DISCUSSION

Haemodynamic changes and the preservation techniques of such haemodynamic changes during OPCABG are always concern to cardiac surgeons all over the world. Hemodynamic variations in OPCAB may be due to mobilization and stabilization of the heart for distal anastomosis. This study was conducted to analyse the haemodynamic changes during off pump CABG during distal anastomosis of LAD, circumflex and right coronary territories. i.e anterior, posterior and inferior surface of heart and to analyse the cardiac indices (CO, CI, SV) during off pump CABG and its relation to MAP, central venous pressure and MPAP. To make this study population homogenous we have included only patients with EF ≥40%. LAD was grafted in all of our cases, diagonals in 17 cases, OM was grafted in 30 cases, Ramus in 4 and RCA/PDA/PLV was grafted in 29 cases. LAD was always grafted first in our cases, to optimize the perfusion to the most important coronary system; followed when required by PDA and OM respectively. Appropriate size intracoronary shunt was used in all cases during creating of distal anastomosis. Conventionally MAP, CVP and mean PAP are measured during off pump CABG, and changes seen in them during displacement and compression of heart is considered an adequate reflection of the haemodynamic alteration that occur during this manoeuvres. We wanted to prove the veracity of this concept by simultaneously monitoring CO, CI) and SV along with MAP, CVP and MPAP in off pump CABG.

Changes in conventionally measured parameters

In our study the changes in CVP and MPAP was not statistically significant in construction of anastomosis in any of the three settings and decrease in MAP was statistically significant for OM only. This could be ascribed to better surgical skills, Trendelenburg maneuver, rotation of the operating table, bolus fluid and use of inotropes when required. Contrary to previous reports by Mathison et al, Shinn HK et al and Quoc-Bao Do et al, we did not find any statistically significant changes in MPAP and CVP.[5-7] However, like the study by Mathison et al, we also found significant decrease in MAP during anastomosis of circumflex territory only.[5]

Changes measured cardiac indices (CO, CI, SV)

In our study decrease in CO, CI and SV were statistically significant after application of pack and stabilizer when compared to the baseline values during grafting of all three coronary territories. Exposure and stabilization of the OM showed the most extensive changes followed by PDA and LAD. These findings corroborate with the previous studies by Mathison et al, Shinn HK et al, Do et al and Nierich AP et al,where the changes in cardiac indices are significant in all territories and more for the branches of circumflex artery.[5-8]

Measurement of Troponin I

Although the troponin I was elevated in 8 of our patients; it was not statistically significant and did not affect the post-operative outcome. It was noted that all these 8 patients had significant changes in their CO, CI and SV values in all coronary territories while being grafted. Parvizi et al showed significantly lower release of the enzymes and Troponin I during CABG by off-pump technique; suggesting that the OPCABG technique causes less myocardial injury.[9]

Generally, the management of patients undergoing OPCABG has been focused on the maintenance of the MAP, CVP, HR. Especially, intravenous fluid loading, head down position are recommended to compensate for decreased MAP. However, these methods were not enough to compensate the reduced CO during anastomosis in our study; which corroborates with the result of Shinn et al.[6]

Limitations

Firstly, our study included only 40 patients. A larger study group would have been more representative. Secondly, in this study, the alteration in haemodynamic during operation was managed by the Anaesthetist by adjusting the inotropes, vasodilators and fluids. The study would have been more meaningful, if we had included the intraoperative variation in inotrope and fluid requirements during grafting of the coronaries in the anterior, lateral and inferior surfaces of the heart.

CONCLUSION

In conclusion, complete myocardial revascularization on the beating heart can be performed without significant changes MAP, CVP, mean PAP which often lulls us into a false sense of security because there is a definite and measurable decrease in CO, CI and SV when the other

parameters are within normal limit. The decrease in CO, CI, SV is due to displacement of heart as well as compression of both RV and LV by pack, octopus and pericardial retraction sutures, thus reducing their diastolic filling though this is not significantly reflected in MAP, CVP and mean PAP. What we have found is that pharmacological interventions, addition of fluids and lowering head end of table based on the changes seen by the new monitoring parameters are more logically guided and becomes more scientific and objective rather than being just arbitrary decisions.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Yadav SS, Chakrabarty U, Datta S, Mukherjee P. Haemodynamic assessment during off pump coronary artery bypass grafting in patients with ejection fraction ≥40% and it's relation to myocardial ischaemia in early postoperative period. Int J Res Med Sci 2020;8:4079-83.