

Novel anaesthetic approach for surgical access and haemodynamic management during off-pump coronary artery bypass through a left thoracotomy

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ABSTRACT

For myocardial revascularization on a beating heart through a thoracotomy, a properly deployed endobronchial blocker (EBB) provides ideal conditions for surgical access. In addition, adequate volume replacement to achieve optimal cardiac performance is a primary goal of haemodynamic management in patients undergoing off-pump coronary artery bypass grafting. To achieve both these ends, this case report describes the combined use of a left-sided EBB along with a volumetric pulmonary artery catheter in a patient who underwent a successful off-pump coronary artery bypass surgery through an anterolateral thoracotomy.

Key words: Off-pump coronary artery bypass, right/physiology, thoracic surgical procedures, ventricular function

Access this article online
Website: www.ijaweb.org
DOI: 10.4103/0019-5049.93351
Quick response code


INTRODUCTION

One lung ventilation with an endobronchial blocker and optimisation of hemodynamic parameters based on data derived from a volumetric pulmonary catheter would improve surgical access as well as the final outcome during off pump coronary artery bypass surgery through a left thoracotomy.

This is a case report of a patient who underwent myocardial revascularization on a beating heart through an anterolateral left thoracotomy (ThoraCAB). A left-sided endobronchial blocker (EBB) was used to provide one lung ventilation (OLV) for improved surgical access. Haemodynamic variables were managed based on data obtained from a volumetric pulmonary artery catheter. As per our English literature search, this is probably the first time the combined use of an EBB and a volumetric pulmonary artery catheter has been described in a ThoraCAB surgery.

CASE REPORT

A 56-year-old male (weight: 65 kg, height: 163 cm) with a 3-month history of coronary artery disease and no other co-morbid conditions underwent coronary angiography, which showed a long 80% proximal lesion in the left anterior descending artery and a 95% lesion in the first obtuse marginal artery. Transthoracic echocardiography revealed normal left ventricular size with grade 1 diastolic dysfunction, no regional wall motion abnormalities and no valvular abnormalities. The EuroSCORE (European System for Cardiac Operative Risk Evaluation) was 4, with a predicted death rate of 3.2%, and pre-operative evaluation placed him in American Society of Anesthesiologists grade III physical status.

An informed consent was obtained and he was scheduled for a ThoraCAB surgery. After premedication as per institutional protocol, general anaesthesia was induced with intravenous (IV) inj. midazolam 0.1 mg/kg, inj. Fentanyl 3 mcg/kg, inj. thiopentone 2 mg/kg,

How to cite this article: Maddali MM, Al-Jadidi AM, Zacharias S. Novel anaesthetic approach for surgical access and haemodynamic management during off-pump coronary artery bypass through a left thoracotomy. *Indian J Anaesth* 2012;56:75-8.

inj. cisatracurium 0.1 mcg/kg and isoflurane up to 1 minimum alveolar concentration (MAC). Anaesthesia was maintained with continuous intravenous infusions of propofol, remifentanyl and cisatracurium with an FiO_2 of 0.5 in air and isoflurane 1 MAC.

Invasive haemodynamic monitoring was achieved with a 20-G right radial artery catheter and an 8 F volumetric pulmonary artery catheter (777HF8, Edwards Lifesciences, Irvine, CA, USA) inserted through the right internal jugular vein, which was used in conjunction with a vigilance monitor (Edwards Lifesciences). Continuous Cardiac Output Index (CCI), Continuous Right Ventricular End Diastolic Volume Index (CEDVI), stroke volume Index (SVI), Right Ventricular Ejection Fraction (RVEF) and Mixed Venous Oxygen Saturation (SvO_2) were continuously measured and values at different stages of the operation are shown in Table 1.

A 9F Arndt EBB (Cook Group Inc., Bloomington, IN, USA) was guided into position into the left main bronchus with the help of a flexible fiberoptic bronchoscope (FOB) through a 9.0 size endotracheal tube. The patient was continuously ventilated during EBB placement with the help of the dedicated multiport airway adapter. Pressure control ventilation was used throughout the surgery.

After positioning the patient in the lateral decubitus, a left anterolateral thoracotomy was performed via the fifth intercostal space. Correct placement of the EBB was reassessed by the FOB and dependent OLV was initiated. During OLV, the ventilator parameters were peak inspiratory pressure (PIP): 19–23 cm H_2O , mean airway pressure (Pmean): 9–12 cm H_2O , positive end expiratory pressure (PEEP): 4–6 cm H_2O , respiratory rate (RR): 20 breaths per min and inspired oxygen concentration (FiO_2): 0.5–0.7 to coincide with an end tidal carbon dioxide concentration (EtCO_2) of 36–40 mmHg and arterial oxygen saturation (SaO_2) >95%.

Left internal mammary artery was harvested and systemic anticoagulation was achieved with heparin 2 mg/kg. The proximal saphenous vein anastomosis to the ascending aorta was completed first and, during this time, the mean arterial blood pressure was maintained between 60 and 70 mmHg.

The distal anastomosis to the left anterior descending artery and the 1st obtuse marginal artery were performed on the beating heart using an Octopus (Medtronic Inc., Minneapolis, MN, USA) stabilizing device and an intracoronary shunt. Fluid transfusions and low doses of epinephrine and non-epinephrine were used based

Table 1: Intra-operative haemodynamic parameters

Events	SvO_2	CCI 2.5–4.0 L/min/m ²	EDVI	SVI 35–60 ml/beat/m ²	PVRI 255–285 dynes* sec/cm ⁵ /m ²	SVRI 1970–2390 dynes* sec/cm ⁵ /m ²	MAP mmHg	MPAP mmHg	CVP mmHg	PCWP mmHg	HR
Baseline (prior to OLV)	85	2.8	120	43	248	1687	82	20	12	17	55
LIMA dissection (OLV)	84	3.5	152	50	285	1620	78	24	12	21	65
During proximal aortic clamping (OLV)	84	3.5	182	50	275	1650	60	24	12	21	68
Before distal anastomosis (OLV)	79	2.4	181	35	265	1650	80	24	14	21	67
During distal anastomosis (OLV)	78	2.4	180	38	280	1700	100	20	14	21	65
After distal grafting (OLV)	89	3.3	195	51	275	1503	70	24	8	23	66
Before extubation	90	3.8	137	63	216	1179	64	20	8	23	62
After extubation	89	3.7	126	51	205	1523	70	18	8	16	66

SvO_2 – Venous oxygen saturation; CCI – Continuous cardiac output index; EDVI – End diastolic volume index; SVI – Stroke volume index; PVRI – Pulmonary vascular resistance index; SVRI – Systemic vascular resistance index; MAP – Mean arterial pressure; MPAP – Mean pulmonary artery pressure; CVP – Central venous pressure; PCWP – Pulmonary capillary wedge pressure; HR – Heart rate; *OLV: One lung ventilation; LIMA: Left internal mammary artery

on CEDVI and its effect on SVI, RVEF, CCI and SvO₂, to maintain satisfactory haemodynamic parameters.

Following the completion of the coronary anastomosis, the heparin activity was reversed with protamine sulphate. To minimize post-operative incision pain, in addition to intercostal nerve blocks, a continuous infusion of 0.125% bupivacaine (6–8 mL) was administered through an indwelling intrapleural catheter that was inserted through the surgical wound at the time of wound closure. The patient's trachea was extubated following completion of surgery and post-operative pain control was further achieved with Tab. ibuprofen 400 mg (TDS) and inj. paracetamol 1gm IV (QID). On the first post-operative day, the patient was pain free and had no recall of awareness during surgery.

DISCUSSION

The prerequisites for a successful myocardial revascularization through a thoracotomy are an unhindered surgical access to the aorta as well as to all the myocardial vessels with minimal interference of haemodynamic parameters. In this case report, an EBB and a volumetric pulmonary artery catheter were used to accomplish these goals in a patient who underwent a successful off-pump ThoraCAB.

Optimization of cardiac performance with adequate volume replacement is the primary goal of haemodynamic management in patients undergoing Off Pump Coronary Artery Bypass Graft [OPCABG] surgery. Frequently used standard pre-load indexes such as central venous pressure (CVP) or pulmonary capillary wedge pressure (PCWP) often fail to provide reliable information on cardiac pre-load in mechanically ventilated patients.^[1]

As an alternative to these static variables, dynamic variables like assessment of pulse pressure variation (PPV) and stroke volume variation (SVV) have been used as monitoring parameters for guiding fluid therapy in patients receiving mechanical ventilation.^[2,3] As fluid responsiveness relies more on the slope of the Frank-Starling curve than on the cardiac pre-load itself, these two pre-load indices, i.e. PPV and SVV, might also fail to predict the reaction of the heart to fluid loading.^[3]

A decrease in ventricular contractility decreases the slope of the relationship between end-diastolic volume

and stroke volume,^[4] and moves the Frank-Starling curve to the right. Therefore, patients with a dilated left ventricle could still respond to fluid despite increased measures of static cardiac pre-load. Consequently, fluid responsiveness, defined as the response of SVI to volume challenge,^[5] cannot be accurately predicted simply by assessing cardiac pre-load, and the terms “cardiac preload” and “fluid responsiveness” are not exchangeable. Therefore, it has been suggested that in contrast to SVV and PPV, volumetric measures of pre-load are better as pre-load indices.^[1] Della Rocca *et al.* suggested that volumetric monitoring with advanced volumetric pulmonary artery catheter could give better definitions of pre-load in clinical practice.^[6]

Our strategy in this case was to administer fluid challenges of 200 mL each despite high static pressures (CVP and PCWP) and continuously observe the response on SvO₂, CCI, EDVI, SVI, PVRI, SVRI and ejection fraction (EF). Although a value of CEDVI greater than 138 mL/m² was suggested as not associated with a response to fluid administration, there is no absolute threshold value proposed to discriminate between responders and non-responders.^[7,8] We administered fluids even up to 180 mL/m² as we noticed improvement in SVI, CCI and SvO₂. Vasopressors and vasodilators were used to maintain appropriate mean arterial pressures as desired by the surgeon during proximal and distal vascular anastomosis.

Pulmonary artery catheters often would come to lie in the Zone 1 or 2 of the right lung of the patients. In case of right thoracotomies with right lung collapse, a right-sided pulmonary artery catheter would reflect the airway pressures rather than the PCWPs. On the other hand, in case of left thoracotomies, as in this case report, we assumed that a pulmonary artery catheter in the right lung would reflect the PCWPs reasonably accurately.

The role of a volumetric pulmonary artery catheter and the changes in the derived values in patients subjected to OLV is not clear as per our English literature search. This is the interesting aspect of this case report. The reasons for our observation that higher continuous end diastolic volume (CEDV) values were associated with improvement in cardiac output variables could be as follows:

1. The myocardial contractility of this patient could have been on the ascending limb of the Frank-Starling curve and hence could respond to higher CEDVI values.

2. When a patient has a high CEDV, it is usually accompanied by a low EF, low stroke volume and a high heart rate. Once the cardiac output (CO), EF and stroke volume start improving, the CEDV might lag behind. CEDV might also be high if the heart rate is controlled by beta blockers. The heart rate in our patient was well controlled.
3. During OLV, due to one lung collapse, the after-load to the right ventricle increases. Under such circumstances, the right ventricle might need a higher end diastolic volume for maintaining the cardiac output variables. This aspect is of interest and is to be investigated in our future research. It is probable that in patients on OLV, the CEDV values are totally different compared with when both lungs are ventilated.

It is possible to undertake ThoraCAB surgery without resorting to such extensive and expensive lung isolation techniques and monitoring modalities. Lung isolation can be achieved by EBBs, or double-lumen endobronchial tubes. We preferred an EBB as one-time intubation with a single-lumen tube allows for the conversion to OLV with EBB insertion and simple removal of the blocker at the end of the procedure is all that is required if post-operative ventilatory support is needed.^[9] In addition, if a double-lumen endobronchial tube were to have been used for OLV in this type of cases, post-operative ventilation would most often necessitate change to a single-lumen endotracheal tube at the end of the procedure. This would entail much wider changes in haemodynamic parameters as compared with simple removal of an EBB. Volumetric pulmonary artery catheter was useful in fluid management as an improvement in SVI, CCI and EF emboldened us to further administer volume. Lastly, it would be of clinical interest to assess how

the volumetric pulmonary artery catheter variables perform during OLV.

In conclusion, providing good surgical access with the help of an EBB and optimization of haemodynamic parameters based on data derived from a volumetric pulmonary catheter along with proper analgesic regimen resulted in a successful outcome.

ACKNOWLEDGMENTS

The authors acknowledge the support of Dr. Roger Green, FRCS, in the preparation of the manuscript.

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Source of Support: Nil, **Conflict of Interest:** None declared