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EFFECTS OF LOW VOLUME VENTILATION DURING CARDIOPULMONARY BYPASS ON POSTOPERATIVE PULMONARY OUTCOME AFTER CORONARY ARTERY BYPASS GRAFTING

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ABSTRACT

Objective: To study the effects of low volume ventilation during cardiopulmonary bypass on postoperative pulmonary outcomes after coronary artery bypass grafting.

Study Design:Randomized controlled trial.

Place andDuration of Study: Army cardiac Centre CMH Lahorefor durationof 6 months from Apr to Sep 2016

Material and Methods:After taking approval by the hospital ethics committee which written informed consent, was taken by 100 consecutive patients of either sex, undergoing CABG on CPB, were randomly divided into two groups. Patients in Group I received continuous low volume ventilation (2ml / Kg) throughout the CPB period, whereas ventilation was switched off and disconnected in patients of Group II.Frequency of post-operative respiratory complications, duration of mechanical ventilation after surgery and intensive care unit (ICU) length of stay (LOS) were noted in both groups.

Results:Whereas the demographics of both groups werealmost the same, patients in Group IIhad a significantly longer post-operative mechanical ventilation time (4.68 vs 2.8 hrs,)with *p*-value(*p*=0.031); longer ICU LOS (1.84 vs 1.28 days, *p*=0.016) and more requirement of oxygen (O_2) therapy (*p*=0.01); and had significant difference in post-operative pulmonary complications.

Conclusions:Our study reports that continued low tidal volume ventilation during CPB improved post-bypass oxygenation and lung mechanics.

Keywords: Coronary artery bypass, Intensive Care Unit, Pulmonary complications, Ventilation.

INTRODUCTION

Cardiopulmonary bypass (CPB) by serving four basic functions of respiration, circulation, temperature regulation and provision of bloodless field,not only facilitates the surgery on a non-beating heart, but also causes diversion from normal physiology resulting in many problems during early postoperative period[1-3]. After coronary artery bypass grafting (CABG), an often-considered risk factor is pulmonary outcome well known for post operativemorbidity and mortality[4-8].

Postoperative pulmonary dysfunction after CPB include atelectasis, pleural effusions, pneumonia, cardiogenic pulmonary edema, pulmonary embolism, and acute lung injury ranging from the mild to the most severe (i.e. acute respiratory distress syndrome [ARDS])[9].

In literature an association was observed between diagnosis of poorpulmonary outcome or low forced expiratory volume in 1 second (FEV1) and post CABG morbidity and mortality[1-6]. These outcomes are of more consideration, once the treatment cost, hospitalization stay, intensive care and mechanical ventilation were taken into account[10].

The etiology is multifactorial after open-heart surgery and based upon the mutual effect of cardiopulmonary bypass (CPB), anesthesia and surgical trauma[9]. CPB in particular is known to activate the inflammatory process, resulting in increased pulmonary capillary permeability. Even midline sternotomy causes significant reductions in lung volumes and capacities resulting in atelectasis and poor arterial oxygenation[10].

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DuringCPB a wide range of ventilatorystrategies have been attempted[2,11]that include continuous positive airway pressure (CPAP) with pressures of 5-15cmH2O,high frequency low tidal volume ventilation (100 breaths/min), inspired oxygen concentrations of 21% to 100% and bilateral extracorporeal circulation to oxygenate the blood while on bypass. Although some small and transient benefits for CPAP with 10cmH2O have been demonstrated, no convincing evidence of clinical benefits from any of the ventilatory strategies have thus far emerged[2,11].Among them low volume ventilation has gained particular interest[12]. We therefore conducted this study to evaluate the effects of low volume ventilation during bypass period on postoperative pulmonary outcome in patients undergoing CABG.

MATERIAL AND METHODS

This Randomized clinical trial was, conducted at Army Cardiac Centre, Lahore for durationof 6 months from 1 Apr to 30 Sep 2016. After approval of the hospital ethics committee and obtaining written informed consent of the patients,A total of 100 consecutive patients of either sex, in the age group of 18 to 70 years, undergoing CABG were selected for this study. They were randomized in two groupsI and II, using draw method.Patients with any pre-existing respiratory disorders like asthma, chronic obstructive pulmonary disease (COPD); known allergies;patients falling under American society of anesthesiologists (ASA)class III or more; patients withpoor left ventricular function (LVEF <30%); and patients with renal impairment (elevated serum creatinine>2mg/ml) were excluded from the study.All patients received similar protocol for induction (using morphine 0.2mg/kg and propfol 2mg/Kg) and maintenance of anaesthesia (with isoflurane 1.2%).

Patients in Group I were ventilated throughout the CPB duration using 2ml/kg tidal volume at a respiratory rate of 15/min with FiO2 of 0.5 and positive end-expiratory pressure (PEEP) of 3cmH2O. Whereas Patients in GroupIIreceived no ventilation during CPB and the breathing circuit was disconnected.Patients who had difficulty in coming off bypass and required intra-aortic balloon pump in the immediate post-CPB period were dropped from the study.

Postoperatively all patients were shifted to intensive care unit (ICU) intubated and were put on mechanical ventilation with synchronized intermittent mandatory ventilation(SIMV) mode using8ml/Kg tidal volume, 0.5 FiO2and PEEP of 5cmH2O. The decision of weaning from ventilation and extubation was made according to standard protocols including adequate oxygenation, hemodynamic stability and no bleeding.

Data was entered on separate proforma for each patient including his/her age, weight, co-morbidities, and smoking history. PaO2 was measured at the time of shifting to ICU and then post-extubation. From these values PaO2/FiO2 was calculated. FiO2 was kept constant and same for all patients of both groups after termination of CPB, while shifting to ICU till time of extubation i.e. 0.5.A portable chest x-rayantero-posterior (AP) view was done in every patienton the 1st postoperative day to rule out and record any evidence oflung collapse, consolidation or pleural effusion. Any episode of post-operative hypoxia (PaO2< 80mmHg on inhaled oxygen) requiring high concentration oxygen through re-breathing mask ornon-invasive ventilation (Duo PAP)were also noted. Also ICU ventilation time (in hours ± SD), re-ventilation and ICU length of stay (in days ± SD) was recorded for all patients in both groups.Collected data was analyzed by using SPSS version 20.

RESULTS

Results were available for all 100 patients. The male female ratio was different in both groups (2.13:1 in group 1 vs 11.5:1 in group II demographics of the patients in two groups incidence of hypertension & similarly 22 (44.0%)

in group I & 18 (36.0%) in group II 34(68.0%) in group I & 28 (56.0%) in group II (p=0.21V, p=0.41. There was no significant difference in the demographics of the patients in the two groups (table-I). Patients in both groups had similar incidence of hypertension and diabetes mellitus (p-values 0.21& 0.41 respectively), however, there were significantly less smokers in Group I (table-II). Patients in both groups had no significant difference in the duration of CPB time. Significant difference was observed in oxygenation status at the time of arrival in ICU and immediately after extubation among both groups (p-values 0.01 and 0.03 respectively).Patients in GroupII had a significantly longer post-operative mechanical ventilation time (p=0.02); longer ICU LOS (p<0.01) and more requirement of oxygen (O2) therapy (p<0.01). There was no significant difference in post-operative pulmonary complicationsin terms of pleural effusions but patients in GroupII had significantly higher incidence of post-operative consolidation and collapse and 3 out of 50 patients had to be re-ventilated due to persistent hypoxemia compared to none in Group I (table-III).

Table-I: Demographics of groups I and II (100 patients).

Variables	Group I (n=50)	Group II (n=50)	*p*-value
Age (in years)	57 ± 12.2	57.0± 12.5	0.97
Gender Male Female	 34(68.0%) 16(32.0%)	 46(92.0%) 4(8.0%)	
Weight (in Kgs)	65.21 ± 7.7	72.7± 20.81	0.01
Height (in Ft)	5.48 ± 0.30	5.46 ± 0.28	0.73

Table-II: Co-morbids observed in both groups.

Co-morbids		Group I (n=50)	Group II (n=50)	*p*-value
Hypertension	Yes	34(68.0%)	28(56.0%)	0.21
Diabetes	Yes	22(44.0%)	18(36.0%)	0.41
Smoking	Yes	12(24.0%)	24(48.0%)	0.01

Table-III: Comparison of Outcome in both Groups.

Outcome variable	Group I (n=50)	Group II (n=50)	*p*-value
CPB time (in minutes) (Mean ± SD)	119.21 ± 54.21	123.71 ± 55.72	0.68
PaO2 / FiO2 on arrival in ICU (Mean ± SD)	304.01 ± 10.21	299.11 ± 10.05	0.01
Post-extubationPaO2 / FiO2 (Mean ± SD)	298.21 ± 15.61	290.51 ± 20.17	0.03
ICU ventilation time (in hours) (Mean ± SD)	2.8 ±1.06	4.6 ± 4.11	0.01
ICU length of stay (in days) (Mean ± SD)	1.28 ± 0.54	1.84 ± 0.98	0.01
Incidence of Post-operative Pulmonary Complications			
Collapse	Yes	2 (4.0%)	8(16.0%)	0.04
Consolidation	Yes	Nil	10 (20.0%)	0.04
Pleural Effusion	Yes	6 (12.0%)	8 (16.0%)	0.56
Requirement of Duo PAP	Yes	4 (8.0%)	8 (16.0%)	0.21
Need of High Conc O2	Yes	Nil	10 (20.0%)	0.01
Re-ventilation	Yes	Nil	3 (6.0%)	0.07

DISCUSSION

During cardiopulmonary bypass venous return is diverted from heart through right atrium or vena cava cannulation. The aortic

outflow is provided through aortic cannula applied distal to cross clamp so circulation to heart and lung is totally bypassed[1]. The blood supply to lungs occur through bronchial artery which is subjected to vasoconstriction in the absence of ventilation and can lead to ischemic injury to lungs[13-16]. Ischemic reperfusion injury is also initiated after restoration of blood supply[17].

Postoperatively, it is reported that there is reduction of 30-50% in FEV1 and FVC among adults with coronary bypass procedures[17]. Among the many strategies studied continuous ventilation during CPB is least studied methodology because of the concerns of interference with surgical field[18].

Sandeep etal conducted prospective study including 45 patients divided in two groups based on receiving low volume ventilation or not and concluded improvement in oxygenation and inspiratory capacity after low volume ventilation during CPB[1].A randomized controlled trial of 100 patients by Aamir etal. concluded that there is improved PaO2/FiO2 ratio, decreased A-a O2 gradient and incidence of atelectasis in patients who received low tidal volume ventilation during CPB[3]. Muzaffar etal conducted prospective randomized study on 100 patients undergoing elective CABG and concluded that there is significantly decreased incidence of atelectasis (0.08) and NIV requirement (0.07) among the patients receiving low tidal volume ventilation, however the incidence of postoperative lung complications was found to be equivocal[18].

It is also found in published studies that ventilation with low tidal volume (3ml/kg) without PEEP per CPB could not significantly change pulmonary vascular resistance index (PVRI), mean pulmonary artery pressure (MPAP), pulmonary complications, PaO2/FiO2 ratio and total length of stay[12-14]. A retrospective case control study conducted at Miami in 2009-2013 on 274 patients concluded that continued ventilation and pulmonary perfusion during CPB is not associated with improved postoperative outcomes[19].

We designed this study to evaluate the effect of low volume ventilation during bypass period on prospective pulmonary outcome in patients undergoing coronary artery bypass grafting. The earlier statement was based on the concept that continued ventilation on CPB could lead to reduction in postoperative pulmonary complications.To avoid interference with surgical field we kept tidal volume low (TV=2ml/kg). The postoperative lung functions were predicted by the measurements of PaO2, need of oxygen supplementation andextubation time and ICU stay.We reported significant oxygenation improvement and less postoperative pulmonary complications in patients receiving low volume ventilation in our study. One of the reasons for this reduction may be postoperative PEEP application and exclusion of all patients with respiratory diseases. Also it can be due to less number of patients who smoke in group which received ventilation during Cardiopulmonary bypass.

Our study reported significant decrease in the incidence of lung collapse and consolidation when low volume ventilation applied during Cardiopulmonary bypass.

There was significant improvement in PaO2/FiO2ratio with significantlydecreased requirement of high concentration oxygen mask, less ICU ventilation time and shorter hospital stay for the ventilated group. The extubation time was significantly shorter in our findings for the ventilated group. This is similar to the study result by Lindsay et al.and Salama etal[20].

Indeed we found significant association between the continued low tidal volume ventilation on CPB and its effects on postoperative pulmonary outcomes.

CONCLUSION

Our study reports that continued low tidal volume ventilation during CPB improved postoperative pulmonary outcome.

CONFLICT OF INTEREST

This study has no conflict of interest to declare by any author.

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