Comparative Study of Volume Controlled Ventilation Mode (VCV) and Pressure Controlled Ventilation Mode (PCV) Intra Operatively in Patient Undergoing Coronary Artery Bypass Graft Surgery

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ABSTRACT

Introduction: Despite numerous advances in anaesthesia, surgical techniques, and postoperative care for coronary artery bypass graft (CABG) surgery, postoperative pulmonary complications still account for postoperative morbidity. Primary aim of the study was to compare two modes of ventilation on gas exchange in form of PaO2/FiO2 ratio in intraoperative period at time of expected significant respiratory alterations during CABG surgery. We compared VCV and PCV mode intra operatively as both ventilation modes are standard of care. It was also intended to compare effects of these modes on lungs to diagnose significant respiratory changes with Chest X ray findings, and postoperative length of ICU stay.

Material and methods: 60 patients posted for elective coronary artery bypass graft surgery (CABG) were divided into two groups. Group 1 (VCV group) and group 2(PCV) group divided by sequentially numbered opaque sealed envelope method. Baseline PaO2/FiO2 was observed before induction, half hour after induction, post cardiopulmonary bypass (CPB) and at the end of surgery noted. Postoperative chest x ray findings, length of postoperative ICU stay also compared within two groups.

Results: In terms of demographic data both modes were comparable**.** After comparing both the modes it was observed that PaO2/FiO2 ratio was better in PCV group half hour after induction and after CPB the end of surgery while no significant difference between two modes on postoperative ray changes and length of ICU stay.

Conclusion: Both the modes of ventilation can be used for CABG surgery with CPB which are standard of care where PCV mode offers better oxygenation in terms of PaO2/FiO2 at the end of the surgery after CPB.

Keywords: Cardiopulmonary Bypass, PCV, VCV, Oxygenation, Respiratory Changes

INTRODUCTION

Patients undergoing coronary artery bypass graft (CABG) usually prone to develop pulmonary complications more frequently than in other surgical procedures. These complications mostly due to sternotomy that is done during the procedure, lung retractions and cardiopulmonary bypass. Postoperative pulmonary complications (POPC) mostly due to changes arising in pulmonary and chest wall mechanics, atelectasis, altered capillary bed and pulmonary parenchyma due to left ventricular failure, nature of surgery and anaesthesia, cardiopulmonary bypass (CPB), inflammatory response secondary to mechanical ventilation. Previous studies shown that PaO2-FIO2 ratios after CPB were significantly lower compared with baseline values mostly related to old age, obesity, reduced cardiac function, previous myocardial infarction, prolonged CPB time, persistent hypothermia.

Cardiopulmonary bypass associated with production of reactive oxygen species and oxidative stress. As CPB is negative catabolic state and associated with anaerobic metabolism also haemolysis, ischemia, and perfusion injury and neutrophils activation during CPB play a pivotal role in oxidative stress and the associated activation of pro inflammatory and pro apoptotic signalling pathways which can affect the function and recovery of multiple organs such as the myocardium, lungs, and kidneys and influence clinical outcomes. The improvement of oxygenation index intra operatively with adequate strategies of mechanical ventilation may reduce ROS burst and oxidative stress during CPB. So determination of mode of ventilation with better oxygenation index may be beneficial for patients undergoing CABG surgeries for better recovery.

Appropriate techniques of mechanical ventilation decreases the incidence of pulmonary complications.

Hence we designed a study to observe better ventilation technique in perioperative period to reduce perioperative pulmonary complications.

The primary aim of the study was to compare effects of VCV and PCV on gas exchange in form of PaO2/FiO2 ratio at time of expected significant respiratory alterations which was obtained from ABG (arterial blood gas) analysis in three different time periods (T1) half hour after induction, (T2)15 min post CPB after initiation of ventilation, (T3) at the end of surgery before shifting.

We compared VCV and PCV mode intra operatively as both

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ventilation modes are standard of care.

The secondary aim of our study was to observe chest x ray findings to diagnose significant respiratory changes, postoperative length of ICU stay in both VCV and PCV modes of ventilation.

MATERIAL AND METHODS

Ethics committee approval for study taken from institutional ethics committee. After valid consent and confirmation of NBM status patients were taken inside operation theatre.

-Standard protocol was followed for all patients

-Standard monitors which included NIBP, Electrocardiogram and SPO2 were attached. Baseline blood pressure and heart rate readings obtained first. And were given O_2 by poly mask @4L/min.

For all the patients premedication was given with Inj. midazolam 0.2 mg/kg, Inj. fentanyl 1-2mcg/kg, Inj. ondensetron 0.08 mg/kg, Inj. dexamethasone 8 mg.

After premedication; superficial cervical plexus block was given with inj. Lignocaine (preservative free) 2%, 5cc.

Under aseptic precaution right IJV was cannulated with 5fr triple lumen catheter and fixed to skin. Under aseptic precaution rt femoral artery was cannulated with 7fr single lumen catheter under local anaesthesia given with inj. lignocaine (preservative free).

Pre induction ABG was taken. After all preparation patients were induced with inj. Thiopentone sodium 2-3mg/kg till the loss of eyelash reflex, inj. Vecuronium 0.08-0.1mg/kg as muscle relaxant. Patients were intubated with ETT NO.8.5 in males and 7.5 in females. After induction patient were put on volume control or pressure control ventilation according to the randomization and Maintenance was provided with 50%O_2 and 50% air mixture, and Desflurane or Sevoflurane given with 0.5-1.0 MAC.

1) Post induction after half hour ABG was taken and PaO_2/FiO_2 ratio (T1) observed.
2) Before discontinuation of CPB, lungs were manually inflated until visible atelectasis got disappeared. CPB terminated with the same ventilator setting as before CPB. Then again ABG taken 15 min after initiation of ventilation post CPB and PaO_2/FiO_2 ratio (T2) noted.
3) At the end of surgery before shifting ABG was again taken with similar setting and PaO_2/FiO_2 ratio (T3) noted.
4) Postoperative chest x ray findings to diagnose significant respiratory changes and length of ICU stay was recorded.

Assessment parameters

Patient age, sex, weight, Height, BMI, operation planned, ASA grade, PaO2, FiO2, PaO2/FiO2 ratio, postoperative chest x ray findings within period of ICU stay, length of ICU stay in terms of no of days.

Inclusion criteria

1) Patients having proven coronary artery disease. CABG surgery was not done in patients without proven coronary artery disease.
2) Patients posted for elective CABG surgery.
3) Sex: male and female.
4) Age: 35 to 65 years.

Exclusion criteria

1) Patients with h/o COPD.
2) Patients with known pulmonary HTN.
3) Patients with EF<40% on 2D echo.
4) Patients with past or present CCF/RENAL FAILURE.
5) Patients with BMI >35.
6) Patients with significant h/o smoking addiction.

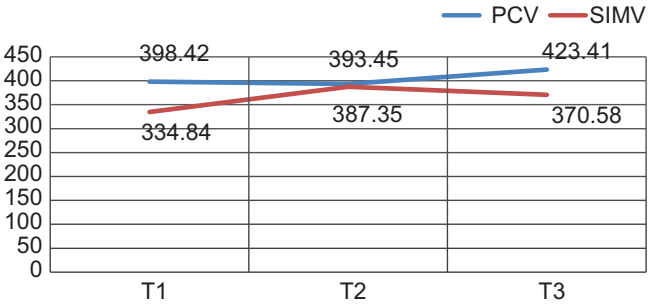
STATISTICAL ANALYSIS

After data entry data analysis was done with the help of statistical software package using parametric and nonparametric test. Quantitative data was represented using Mean ± SD and Median & IQR (Interquartile range) it include age, height, weight, BMI & PAO2/FIO2 ratio. Comparison of Quantitative data measured between groups done using unpaired t-test, if the data passes 'Normality test' or by Mann-Whitney test, if the data fails 'Normality' test. (E.g. Comparison of PAO2/FIO2 ratio between PCV & VCV cases).

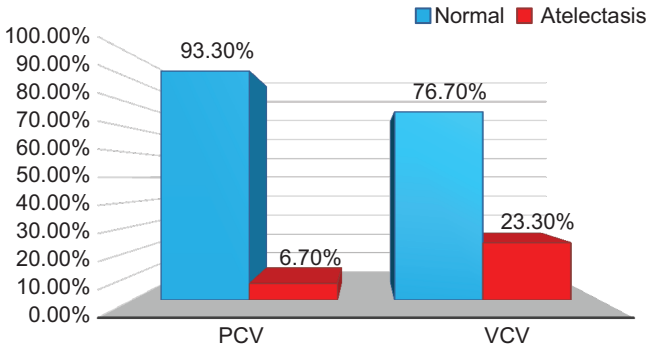
RESULTS

The demographic data was comparable. Total 60 cases were studied 30 in each group out of which 37 were below 60 years of age comprising 61.7% of study subjects, and 23 patients were 60 years or above comprising 38.3% of study subjects which includes 17 (28.3%) were Female and 43(71.7%) were male.

Data in table1 and graph1 shows comparison of PaO_2/FiO_2 within and between group PCV and VCV.



Graph-1: Comparison of PAO2/FIO2 within & between the group PCV and VCV.



Graph-2: Association between postoperative ray finding and mode of ventilation.

Sr. no.	T1	T2	T3	P-value#
PCV	398.42 (70.84)	393.45 (61.80)	423.41 (64.77)	<0.001
VCV	334.84 (74.02)	387.35 (67.25)	370.58 (76.62)	<0.001
P-value@	0.001	0.716	0.006	
P-value @ - for the Independent t test between PCV and VCV group. P-value # - for comparison within the group. (T1) time period half hour after induction (T2)15 min post CPB after initiation of ventilation, (T3) at the end of surgery before shifting				

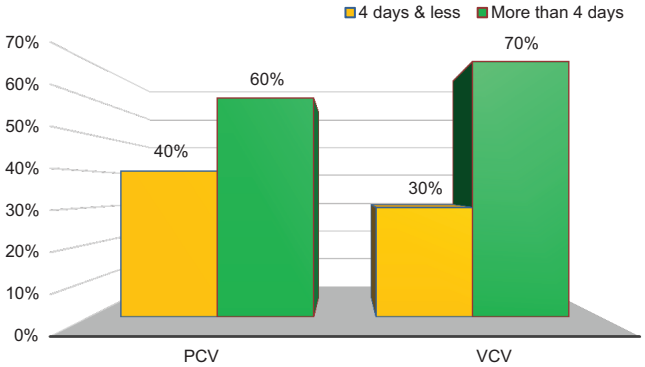
Table-1: Comparison of PAO2/FIO2 within & between the group PCV and VCV.

Post op x-ray finding	Ventilation mode		Total
	PCV	VCV	
NORMAL	28 (93.3%)	23 (76.7%)	51 (85%)
ATELECTASIS	2 (6.7%)	7 (23.3%)	9 (15%)
TOTAL	30 (100.0%)	30 (100.0%)	60 (100.0%)
(X2 = 3.268, p-value = 0.073)			

Table-2: Association between post OP X-ray finding & mode of ventilation

ICU stay	Ventilation mode		Total
	PCV	VCV	
4 Days & less	12 (40%)	9 (30%)	21 (35%)
More than 4 days	18 (60%)	21 (70%)	39 (65%)
Total	30 (100.0%)	30 (100.0%)	60 (100.0%)
(X2 = 0.659, p-value = 0.294)			

Table-3: Association between modes of ventilation & ICU stay of patients



Graph-3: Association between mode of ventilation and ICU stay of patients.

Patient who received PCV mode shown PaO_2/FiO_2 value mean (SD) at T1, T2, T3 as 398.42(70.48), 393.45(61.80), 423.41(64.77) respectively with (p<0.001) which is statistically significant, patients who received VCV mode shows PaO_2/FiO_2 value mean (SD) at T1, T2, T3 as 334.84(74.02), 387.35(67.25), 370.58(76.62) respectively with (p<0.001) which is also statistically significant. At time T1 when PCV and VCV groups compared (p=0.001) which was statistically significant. At T2 when PCV and VCV groups compared (p>0.05) which was statistically insignificant that means PaO_2/FiO_2 ratio value has no relation with mode of ventilation. At time T3 when PCV and VCV groups compared p value is 0.006 which is less than 0.05 which is statistically significant.

Out of 60 patients 51(85%) patients shows normal chest x ray findings out of which 28 (93.3%) patients were on PCV mode and 23 (76.7%) patients were on VCV mode. While 9 (15%) patients shows atelectasis out of which 2(6.7%) were on PCV mode and 7(23.3%) were on VCV mode.

When Chi square test is applied to these observations it showed result value of 3.268 with p value of 0.07 which is more than 0.05 and hence statistically not significant. Out of 60 patients 21(35%) patients have 4 days or less ICU stay, out if which 12 (40%) patients were on PCV mode and 9 (30%) were on VCV mode. While 39 patients have ICU stay more than 4 day, out of which 18 (60%) were on PCV mode and 21(70%) were on VCV mode. When Chi square test is applied to these observations it showed result value of 0.659 with p value of 0.29 which is more than 0.05 and hence statistically not significant.

DISCUSSION

This was a prospective observational study conducted to compare effects of pressure control ventilation mode (PCV) and volume control ventilation mode (VCV) intra operatively in patients undergoing CABG surgery and effects on gas exchange in terms of PaO_2/FiO_2 ratio. 60 study subjects with CAD posted of CABG on CPB fulfilling the eligibility criteria were included in the study after taking the written informed consent from the participants. Within duration of three year. Permission from the institutional ethics committee was obtained.

Out of these 60 (n=60) patients, 30 patients were divided in each group of ventilation.

PaO_2/FiO_2 values measured, we observed that both PCV mode and VCV mode are comparable in intraoperative period during CABG surgery. Patient who received PCV mode shown PaO_2/FiO_2 value mean (SD) at T1, T2, T3 as 398.42(70.48), 393.45(61.80), 423.41(64.77) respectively with (P<0.001) which is statistically significant, patients who received VCV mode shows PaO2/FiO2 value mean (SD) at T1, T2, T3 as 334.84(74.02), 387.35(67.25), 370.58(76.62) respectively. At time T1 (P=0.001) which was statistically significant. At T2 (P>0.05) which was statistically insignificant that means PaO_2/FiO_2 ratio value has no relation

with mode of ventilation. At time T3 (P=0.006) which is statistically significant.

Our PaO_2values were between the ranges (100-300mmHg) which would have better effects on organ function. According to the results of our study, although the PaO_2/FiO_2 ratio was found to be higher with PCV half an hour and most importantly at the end of the surgery. This feature can increase use of PCV by improving PaO_2/FiO_2, which is reported to be crucial in detecting mortality during the early postoperative period.

So better oxygenation achieved at the end of the procedure in PCV mode compared to VCV. As better oxygenation strategies are found protective to prevent surgical site infections which is commonest cause of mortality postoperatively.

Both ventilation modes not affect postoperative Xray changes in period of ICU stay, and postoperative Length of stay in ICU.

The differences between VCV and PCV are the flow pattern and the chosen target. VCV mode utilizes a constant flow (to deliver a target TV) and thus insures a satisfactory MV, PCV uses a decelerating flow which reaches the highest possible value at the beginning of inspiration, while having a preset pressure limitation but no minimum TV. Flow diminishes throughout inspiration according to the pressure target, and the resulting TV depends on the pressure limitation and on the chest compliance. It was suggested that the effect of PCV on improving oxygenation could arise from alveolar recruitment by forming intrinsic PEEP. We did not measure intrinsic PEEP level in our study. This could be one of limitations of our study. In some studies, however, better oxygenation with PCV was linked with improvement of the ventilation/perfusion ratio due to homogenous gas distribution to various regions of the lung. We have managed to achieve normal $ETCO_2$ levels with similar RR in both groups. Since we set FiO_2 at 0.5 for all the patients, and as FiO_2 and I/E were similar in both groups, we believe that the reason for better oxygenation with PCV can be homogenous distribution of various regions of the lung.

Mechanical ventilation in open cardiac surgery is always challenging. Cardiopulmonary bypass (CPB) initiates a systemic inflammatory response syndrome characterized by the activation of complement, neutrophils, endotoxin and the pro inflammatory cytokines and other inflammatory mediators. So at time T3 better oxygenation will improve postoperative lung functions and reduce inflammatory response post CPB. As CABG surgery requires a multidisciplinary approach beginning with induction of anaesthesia and continuing in the ICU especially in terms of ventilatory strategies. As a result, better oxygenation was achieved, PaO_2/FIO_2 ratio was increased in patients who underwent open heart surgery with PCV compared to VCV and while postoperative x ray changes and ICU length of stay were not affected with mode of ventilation.

As this study was conducted in a tertiary care hospital over a period of one year only which limits the sample size, also it is not representative for population and hence results of study cannot be applied directly**.** As we have taken patients within the age group of 35 to 65 years only, so patients more than 65 years not included in the study. As patients more than 65 years have more risk of developing lung pathologies and ARDS. So extensive study might be helpful.

CONCLUSION

We conclude that in patients undergoing CABG surgery while comparing PCV mode and VCV mode, both modes of ventilation can be used for CABG surgery with CPB which are standard of care while PCV mode offers better oxygenation in terms of PaO_2/FIO_2 at the end of the surgery after CPB which helps to prevent systemic inflammatory response syndrome as well as surgical site infections.

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