COMPARISON OF EFFECTS OF VOLUME-CONTROLLED AND PRESSURE-CONTROLLED VENTILATION DURING LAPAROSCOPIC SURGERIES IN BIRAT MEDICAL COLLEGE TEACHING HOSPITAL

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ABSTRACT

Introduction

The pneumoperitoneum created during laparoscopic surgery has numerous effects on the patient ranging from respiratory to hemodynamics. The two common methods of ventilator are volume control and pressure control. The volume control method has been commonly used during general anesthesia. Pressure control method has been used in intensive care unit for improving the respiratory mechanics. The study aims to compare the effects of pressure control to volume control ventilation in patients undergoing laparoscopic surgery.

The hypothesis of the study is that pressure control method improves the respiratory mechanics by decreasing the peak airway pressure and increasing the lung compliance.

Methodology

The total of 100 patients who underwent laparoscopic surgery were undertaken for this study. The 50 in each group (PCV and VCV) were allotted randomly. As per predicted body weight, the tidal volume was adjusted to 8 ml/kg, for both the modes of ventilation, peep 5 mm of Hg with fio2 of 100% and I:E-1:2,. The variations in peak airway pressure, mean airway pressure, lung compliance, SPO2 and hemodynamic parameters were observed at baseline (T1), at pneumoperitoneum (T2), after 10 minutes of pneumoperitonium (T3) and at 20 minutes after pneumoperitonium (T4).

Result

The pressure control group on comparison to volume control mode group showed significant decrease in peak airway pressure while increase in mean airway pressure and increase in lung compliance at different points of pneumoperitoneum. However there was no significant change in hemodynamics between the two groups in patient undergoing laparoscopic surgery.

Conclusion

We conclude that respiratory mechanics improve when the patient is on pressure control ventilation in compared to volume control method of ventilation. Whereas there is no difference in hemodynamic parameters between the two methods.

KEYWORD

pressure control ventilation,volume control ventilation, laproscopic surgery, pneumoperitoneum, lung compliance, peak airway pressure

INTRODUCTION

Laparoscopic surgery has become a very common method of operation due to its advantages like minimal postoperative pain, rapid recovery, and shorter duration of hospital stay of patients after the operation. Various systemic disadvantages have been noted to have occurred due to general anesthesia and intra-abdominal pressure[1]

The pneumoperitoneum created during such surgeries have various effects on the respiratory mechanics and hemodynamic parameters. It is very challenging to an anesthesiologist so as to maintain these parameters. The pneumoperitoneum causes limited diaphragmatic movement leading to increase in airway pressure, decrease in respiratory compliance and functional residual capacity.[2.]

There are different methods and modes of ventilation. Anesthesiologists prefer Volume control ventilation method as it is the most frequently used method of ventilation. Volume control ventilation method causes high airway pressure in laparoscopic surgery because it provides a target Tidal Volume (TV) and guarantee minute ventilation by using a consistent flow, this in turn increases the risk of lung injury.[3.]

Pressure Controlled Ventilation (PCV) has been used in intensive care unit for hypoxic patients to improve gas exchange. The intrapulmonary shunting caused during pneumoperitoneum may cause hypoxia. The pressure control ventilation generates a maximum pressure difference between the alveoli and proximal airway. The maximum tidal volume is reached during the early period of inspiratory phase .These effects are helpful in recruiting the alveoli which further improves the oxygenation.[4]

The results show lower airway pressure and reduce chances of barotrauma during pressure control in comparison to volume control, while the same set of tidal volume is being delivered.[5]

During volume control ventilation, the tidal volume and respiratory rate need changes to work efficiently due to increased airway pressure. Whereas pressure control uses the decelerating inspiratory flow pattern which helps in providing better control over the airway pressure. It is a less frequently used method of ventilation during surgeries despite these.[6]

The inconsistency of intrathoracic and intra-abdominal pressures during laparoscopic surgery could result in hypoventilation in pressure control ventilation.[7]

Despite the respiratory mechanics the different modes of ventilation does not seem to have significant differential effect in the hemodynamic of the patient.[8]

Our study compares the effect of pressure control and volume control on respiratory mechanics and hemodynamics of the patients undergoing laparoscopic surgery.

METHODOLOGY

The descriptive comparative cross sectional study was designed after the approval of IRC. The study was conducted on patients who were planned for laparoscopic surgery admitted in surgery department of Birat Medical College and teaching hospital. The patients who met the inclusion criteria marked as ASA 1-2 between the age group 20-50 were informed and written consent was taken.

After enrolling the patient into the operation theatre, all the patients received standard general anesthesia regime. All the important monitoring tools were connected to the patient. They then, received fentanyl (2mcg/kg), propofol (2mg/kg),rocuronium bromide(0.6mg/kg) during anesthesia. Anesthesia was maintained with 100% o2 +isoflurane @1.2% mac +rocuronium.The odd serial number patient were assigned into group 1 and even serial number into group 2.The group 1 was designed for pressure control ventilation and group 2 as volume control ventilation at the same work station(Datex Ohmeda,GE health care). As per predicted body weight ,for both the modes of ventilation, the tidal volume was adjusted as 8 ml/kg with fio 2 of 100%,I:E-1:2,peep 5 mm of Hg. The target peak airway pressure was set to 35 mm of Hg .Once the pneumoperitoneum establishes, the intraperitoneal pressure was adjusted to 14 mm of Hg.

Data was collected at following time:
T1 (i)-5 minutes after intubation (baseline)
T2 (p)-at pneumoperitoneum
T3 (10)-after 10 mins of creating pneumoperitoneum
T4 (20)-after 20 mins of creating pneumoperitoneum

The respiratory parameters such as SPO2, peak airway pressure, mean airway pressure, lung compliance were collected at marked times. Additionally Heart rate, Mean arterial pressure were also recorded at all the times.

After the end of surgery, the entire patients were shifted to post anesthetic care unit.

MS Excel was used for data entry and it was analyzed by IBM SPSS version 23.

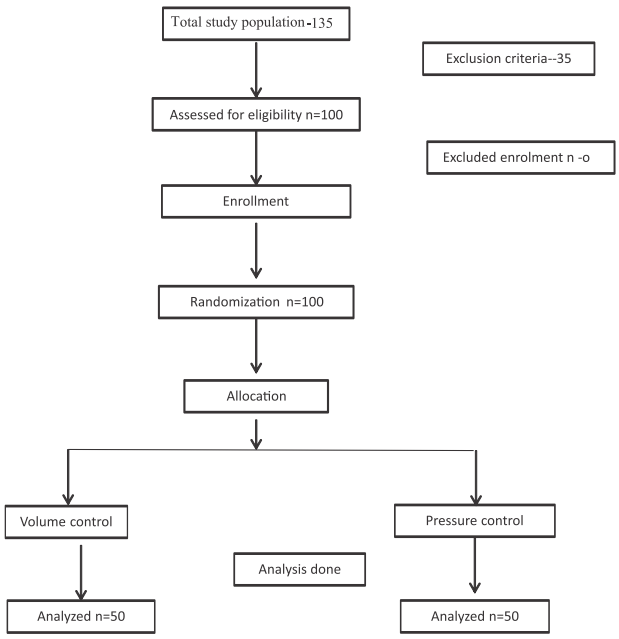
The mean and standard deviation was used for continuous data while frequency and percentage was used for categorized data. The chi-square test was used for categorized variables, while independent t test was used for the evaluation of continuous variables.
A p value of < 0.05 was considered as significant.

Sample size estimation:
Sample size estimation was performed on basis of pilot study.
In a similar study conducted by Melike Korkmaz Toker.[9]
Standard deviation (SD) was 6.5
Effect size (d) -- Mean difference of peak airway pressure at T3 was (28.4-24) =4.4
In our study power of 80% and type 1 error of 5% were taken and through z table values 1.96 and 0.84 were derived.
Sample size: 2(SD) 2 (1.96+0.84)2/d2
2(42.25) 7.84/ 19.36=35
40 in each group
Total 100 patients shall be included in the study.

RESULTS

A total study population of 135 enrolled. Out of which only 100 patient were allocated into the research. Both the

groups namely pressure control ventilation (PCV) and volume control (VCV) were equally divided with 50 on each side. The demographic data did not show any static significance between the two groups.



Variables	Group PCV	Group VCV	P value
AGE (Mean ± SD)	37.58±8.3	37.34±8.6	0.6
SEX (male/female)	10/40	13/37	0.2
ASA grade(1/2)	22/28	24/26	0.65

*PCV-pressure control ventilation
VCV-volume control ventilation

The hemodynamic parameters heart rate and men arterial pressure were measured at different times, between the two named groups did not show any significant difference. However the heart rate and mean arterial pressure did increase from T1 to T2 T3 T4.

	Heart rate		Mean arterial Pressure	
	PCV	VCV	PCV	VCV
T1	66.38±1.3	66.12±1.6	69.28±1.4	68.16±2.2
P value	0.43		0.04	
T2	74.14±2.6	71.86±2.6	73.56±7.2	74.53±1.9
P value	0.00		0.369	
T3	75.36±8.6	74.32±2.4	78.62±2.7	78.16±1.3
P value	0.416		0.294	
T4	76.20±1.4	75.76±1.5	80.12±3.2	79.88±1.6
P value	0.15		0.644	

T1-After intubation (baseline)
T2-at pneumoperitoneum
T3-10 mins after pneumoperitoneum
T4-20 mins after pneumoperitoneum
Data are presented as mean ± SD

The respiratory dynamics were measured at specified different times between the two groups. The peak airway pressure showed significant increase between the T1 and other groups .The peak airway pressure at T1 between the two groups did not show any significant difference (p-0.27),while peak airway pressure at T2(0.00), T3(0.00) T4(0.00) showed significant difference.

The mean airway pressure revealed increase in both the groups at T2 T3 T4 in compared to T1.the mean airway pressure between the two groups showed mixed statics as in significant differences only at T4(0.02) in compared to T1(0.08)T2(0.3)T3(0.72) highlighting not much of a difference. On observing the lung compliance, it showed decrease from T1 to T2, T3, and T4 in both the groups. The lung compliance showed statically significant difference between the two groups at T1 (0.00) T2 (0.00)

T3 (0.00) T4 (0.00). The oxygen saturation recorded, did not show much of a difference at different times of planned observation. However, it did reveal a difference statically at T3 (0.00) T4 (0.00) while no difference at T1 (1.38).

	Spo2 (%)		Peak airway pressure (cm of h20)		Mean airway pressure (cm of h2o)		Lung compliance ($ml.cm^{-1}h2o$)	
	PCV	VCV	PCV	VCV	PCV	VCV	PCV	VCV
T1	98.94±0.8	98.72±0.6	15.62±2.3	16.6±1.3	8.12±0.8	7.84±0.7	43.20±3.7	39.56±2.8
P value	1.38		0.297		0.082		0.00	
T2	98.96±0.7	98.94±0.8	24.6±1.5	28.6±2.4	8.98±1.0	9.18±1.0	24.74±1.4	19.92±2.0
P value	0.905		0.00		0.33		0.00	
T3	99.22±0.7	98.24±0.7	25.6±1.9	29.8±2.4	10.16±0.9	10.10±0.7	24.60±2.7	21.50±2.4
P value	0.00		0.00		0.72		0.00	
T4	99.06±0.7	98.28±0.7	25.6±1.9	29.8±2.0	10.90±1.0	11.38±0.9	25.06±3.0	20.72±2.1
P value	0.00		0.00		0.02		0.00	

T1-After intubation (baseline)
T2-at pneumoperitoneum
T3-10 mins after pneumoperitoneum
T4-20 mins after pneumoperitoneum
Data are presented as mean ± SD

DISCUSSION

This study was undertaken to compare the effects of PCV and VCV in laparoscopic surgery on the hemodynamic and pulmonary variables. The PCV method showed lower peak pressure, higher lung compliance and higher p mean suggesting better respiratory dynamics than VCV.

Similar to our study Gupta SD et al found that in patient undergoing laparoscopic surgery, the peak airway pressures were significantly lower for PCV group than VCV mode group. The decelerating flow pattern and earlier dissipation of flow resistance in PCV were considered to be the reason behind it. It is also suggested that the leading cause of lung injury is over distention of alveoli followed due to the increased peak airway pressure, the higher tidal volume in VCV mode. The property of PCV to limit the peak airway pressure, correlates with reduces chances of barotrauma.[10]

In order to reach the set tidal volume, PCV adjusts the inspiratory pressure after measuring dynamic compliance at each breath.PCV achieves desired tidal volume in lower peak airway pressure whereas a constant preset tidal volume and airway pressure in delivered by VCV mode. When comparing the VCV and PCV mode during robot-

assisted laparoscopic gynecologic surgery with Trendelenburg position, Lee JM et al. concluded that lower peak airway pressure, higher compliance and higher mean airway pressure were provided in PCV mode.[11]

On a study conducted by Toker et al showed the decrease in peak airway pressure in pressure control mode. The results were similar to our study, despite the study was conducted on obese patients undergoing gynecological laparoscopic surgery in Trendelenburg position. The main reason they pointed to be, how the pressure control mode is operated, as discussed by other authors[9].

Our study also revealed that PCV group had higher mean airway pressure than the VCV group. Despite the claims by Nichols D and Haranath S. that higher mean airway pressure is associated with higher oxygenation, our study did not show any significant difference in oxygenation. The higher oxygenation in PCV is because the bulk of tidal volume is delivered during the initial phase of respiratory cycle.[12]

Matching the results of our study, JM Lee et al. suggested that despite increasing the mean airway pressure after the pneumoperitoneum, the PCV mode does not improve the oxygenation while comparing with VCV.[13]

Assad et al. also noticed that PCV provides no significant improvement in oxygenation in compared to VCV but the study was conducted on patient with mean BMI of 23.4kg.m-2(PCV) and 24.5 kg.m -2(VCV) suggesting normal BMI. While, P Cadi et al conducted a study on morbidly obese patients undergoing laparoscopic gastric banding surgery, where they drew a conclusion that PCV improves arterial oxygenation in such patients.[14]

The Data of our study suggest that the lung compliance of PCV mode improves significantly in comparison to VCV mode group. Hiroven et al observed the ventilation effects of prolonged CO2 pneumoperitoneum and Trendelenburg position in their study and finally concluded that PCV may be beneficial in achieving higher compliance during laparoscopic surgery.[15]

Schick et al. collected data from nine studies which compared the lung compliances between PCV and VCV modes during the elective surgery. Their analysis revealed that there is a significant improvement in lung compliance of PCV mode on comparison to VCV mode.[16]

On comparing the pressure control group with volume control group in laparoscopic cholecystectomy surgeries Nethra et al concluded the data were not significantly significant but the pressure control group had slightly higher compliance .[8]

Irwin MG et al. have suggested that hemodynamic changes may be associated with creation of pneumoperitoneum during laparoscopic surgery, including the increase in cardiac workload.[17]

The increased airway pressure caused by pressure control and volume control may enhance the affect on the hemodynamic variables by its effect on pleural pressure. Statically similar to Tyagi et al. our study did not reveal any significant change in hemodynamic parameters between the two groups namely PCV and VCV. They suggest that the insignificant change in hemodynamic parameter is due to only a small magnitude of change in mean airway presuure.[6]

Balick Weber et al. also suggest that the significant but small change in mean airway pressure may be the cause of statistically similar hemodynamic parameters. With the help of Transesophageal echocardiography for systolic and diastolic function, they observed the hemodynamic parameters in patients undergoing laparoscopic urological procedures. They also measured the left ventricular wall stress as primary outcome.[18]

A study conducted on laparoscopic gynecological surgery by Ogrulu m et al. The pressure control mode was compared to volume control mode and they did not note any significant effect on hemodynamic parameters while using non invasive monitoring.[19]

LIMITATION OF THE STUDY

The limitation of the study is that we included all the types of laparoscopic surgery, because of this position of the patient, could not be taken into account. We did not take into account the lung atelectasis occurring post operatively.

FINICIAL DISCLOSURE

None

CONFLICTS OF INTEREST

There are no conflicts of interest

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