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# Comparative Study of the Efficacy of Volume Control Ventilation vs Pressure Control Ventilation on Patients Undergoing Laparoscopic Surgeries Under General Anaesthesia-An Observational Cross-Sectional Study

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#### **KEYWORDS**

Pressure control ventilation, volume control ventilation, laparoscopic surgeries, pneumoperitoneum, general anaesthesia.

### ABSTRACT: Background:

A variety of disorders are surgically treated with laparoscopy. Its benefits are frequently considered as being less intrusive, giving superior cosmetic outcomes, and needing a shorter hospital stay because they are based on surgical knowledge and cutting-edge technology. However, laparoscopic surgery under general anaesthesia and pneumoperitoneum may result in adverse pulmonary physiological alterations. This study will make choosing between volume control ventilation and pressure control ventilation for patients having sedated laparoscopic procedures feasible.

#### Methodology:

82 participants of both male and female gender and of the age between 18 and 70, with 41 in each group, will be randomly allotted with pressure control or volume control ventilation. The hemodynamic parameters and ventilatory parameters will be assessed. Data collection and analysis will be done.

### **Expected outcomes**:

To conclude if volume control ventilation or pressure control ventilation is effective in laparoscopic surgeries and which has less hemodynamic responses and better patient outcomes.

#### Introduction:

#### **Background and Rationale:**

Analgesia, or the inability to feel pain, is one of the many goals of general anaesthesia, along with immobility (loss of reflexes), paralysis, amnesia (loss of memory), and unconsciousness (loss of awareness) (muscle relaxation).

The main ventilation mode used during surgery is volume-controlled ventilation (VCV). However, when dealing with elevated peak airway pressure, it is crucial

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to establish the tidal volume and respiratory rate beforehand to ensure effective ventilation. Although pressure-controlled ventilation offers better management of airway pressure, it is not the preferred choice for intraoperative use. (1)

Lung compliance, functional residual, and essential lung capacity decrease during general anaesthesia. The pneumoperitoneum can increase intra-abdominal and intrathoracic pressure, whereas the Trendelenburg position, favoured during laparoscopic surgery, can further reduce these values. Atelectasis may result from recurrent minor airway closures. The majority of patients should be able to adapt to these changes without too much trouble if they are otherwise healthy, but obese patients and those with long-term respiratory issues are more likely to experience issues with intraoperative hypoxia, barotrauma. and volutrauma during laparoscopic procedures. (2)

With more surgeries being performed laparoscopically in the previous ten years our understanding of the effects of pneumoperitoneum on the cardiopulmonary physiology has also increased. Among the most noticeable ventilatorv effects. along with cardiovascular consequences, is increased peak airway pressure (Ppeak). The anaesthesiologist (PC) could change the ventilation control mechanism from volume-controlled (VC) to pressure-controlled (PC) for the patient's respiratory rate (RR), tidal volume, or both. PC ventilation is being employed regularly in operating rooms to handle patients with elevated Ppeak, despite a paucity of knowledge about its ventilatory and hemodynamic effects and potential downsides. (3)

The objective of this study is to compare volume control ventilation (VCV) and pressure control ventilation (PCV) in laparoscopic surgery patients, specifically examining their impact on ventilatory and hemodynamic responses. In PCV, the ventilator is responsible for regulating inspiratory flow and flow waveform to maintain a square inspiratory pressure profile while the physician adjusts the inspiratory pressure based on the measured tidal volume.

VCV is commonly used in general anaesthesia to maintain steady minute ventilation during pulmonary resistance and compliance impact airway pressure. Volume-controlled ventilation (VCV) utilizes a steady flow to administer tidal volume. Nevertheless, this method can result in elevated airway pressures.(4)

During laparoscopic surgeries, the presence of pneumoperitoneum can lead to decreased tidal volumes in patients. This is attributed to the increased pressure within the abdomen, which negatively affects the compliance of the chest wall and lungs. Consequently, the functional residual capacity decreases, leading to a reduction in alveolar ventilation.(5)

The study will assess the efficacy of ventilation by measuring various parameters such as end-tidal carbon dioxide (ETCO2), mean airway pressure (Pmean), peak inspiratory pressure (Ppeak), and expiratory tidal volume. Its primary goal is to determine whether VCV or PCV offers superior ventilation and preserves hemodynamic stability in patients undergoing laparoscopic procedures with pneumoperitoneum.

#### Protocol:

### Aim:

This observational cross-sectional study's objective is to compare the efficacy of volume control ventilation with pressure control ventilation in patients undergoing laparoscopic surgery while sedated.

#### **Objectives**:

- 1. The primary goal is to assess the effectiveness of ventilation by examining expiratory tidal volume, high peak pressure, and mean inspiratory pressure (Ppeak) (Pmean).
- 2. The secondary goal is to compare the efficacy of hemodynamic response by evaluating variables such as heart rate (HR), oxygen saturation (SPO2), systolic blood pressure, diastolic blood pressure, and mean arterial pressure (MAP).

#### Methods and analysis:

- Study design:
- 1. Study duration: Two years of research.
- 2. Study area: JNMC and AVBRH's anaesthesia department.
- 3. Research design: An observational cross-sectional study.
- 4. Patients of either gender between the ages of 18 and 70 make up the study population.

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#### Study setting

The research study has obtained ethical approval from the Ethics and Screening Committee of The Jawaharlal Nehru Medical College (JNMC) ,Datta Meghe Institute of Higher Education and Research, to be carried out at Acharya Vinoba Bhave Rural Hospital (AVBRH), Sawangi (M), Wardha. The study will involve 82 participants, and prior to their surgical procedures, all patients will be requested to provide written consent after receiving comprehensive information about the study.

Participants:

Criteria for inclusion:

1. Patients of any gender, ages 18 to 70.

2. Patients in ASA Classes I and II.

3. All patients who are willing to provide written, fully informed permission.

4. The surgery duration is between 60 and 120 minutes.

Criteria of exclusion:

1.ASA Class III and higher

- 2. Patients' rejection
- 3. Male or female, between the ages of 18 and 70.
- 4. Patients who shouldn't have laparoscopic procedures

5. People who experience allergic responses to anaesthetics

- Data analysis:
- 1. Haemodynamic parameters, including heart rate, blood pressure, and blood oxygen level
- 2. Mean inspiratory pressure (Pmean), Tidal volume, High peak pressure (Ppeak), and End-tidal CO2 (etco2)
- Materials requirement:
- 1. Appropriately sized cuffed endotracheal tubes and masks.
- 2. Anaesthesia workstation Drager
- 3. Monitors with ECG, pulse oximetry, and noninvasive blood pressure.
- Sample Design & Size:

The study will be conducted among 82 adult patients of both sexes (41 patients in each group) fulfilling all

inclusion criteria. They will be allotted randomly using a computer generated sequence:

•GROUP A (n=41): Patients receiving pressure control ventilation

•GROUP B (n=41): Patients receiving volume control ventilation

• Rationale for selected sample size:

The formula for sample size from difference between two means was used to calculate the sample size of this study. The MAP after 15 mins of tracheal intubation was chosen to calculate the sample size. (2)

$$N = (Z\alpha + Z\beta)^2 (\delta_1^2 + \delta_2^2/K)$$

$$\Delta^2$$

Z alpha: level of significance at 5%- 95% confidence level

 $Z\beta$  is the power of test =80% =0.84

 $\delta_1 = SD \text{ of MAP in PCV} = 15$ 

 $\delta_2 = SD$  of MAP in VCV = 10

K = 1

 $\Delta =$  Difference between two means

In order to calculate sample size for comparing two means, data that was inputted are(fig 1)

- Confidence Interval (2-sided): 80%
- Power: 80%
- The ratio of sample size (Group 2/Group 1): 1
- MAP :97 mmHg (Group A), 91mmHg (Group B)
- Standard deviation: 15 (Group A), 10 (Group B)

Substituting:

- $Z\alpha = 1.28$
- $Z\beta = 0.84$
- $\delta_1 = 15$
- K = 1
- $\delta_2 = 10$
- $\Delta = (97-91=6)$

$$N = (1.28 + 0.84)^2 (15^2 + 10^2)$$

$$6^{2}$$
  
= 40.57  
= 41

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#### Methodology:

After giving written informed consent, 82 patients between the ages of 18 and 70 who will have laparoscopic surgery under general anaesthesia will be enrolled in the study. An intravenous line with an 18gauge cannula will be started as soon as the patient enters the operating room, and monitors will be linked to them for continuous monitoring of their heart rate, ECG, noninvasive blood pressure, breathing rate, and oxygen saturation (Spo2). The baseline vitals will be noted. As part of a typical premedication protocol, patients will get 0.2 mg of glycopyrrolate (0.004 mg/kg), 1 milligram of intravenous midazolam (0.05 mg/kg), and 1 milligram of butorphanol (0.04 mg/kg). Vecuronium 6 milligram intravenous (0.1 mg/kg) and propofol 100 milligram (0.2 mg/kg) injections will be used to induce anaesthesia in the patient.

The patient will be connected to a ventilator after being intubated with an acceptable internal diameter cuffed endotracheal tube. A total of 41 people will receive PCV (Group A), and a total of 41 people will receive VCV (Group B). Regular monitoring will be done periodically using the ET CO2 Pmean and Ppeak, NIBP, ECG, and pulse oximetry. Systolic blood pressure, Diastolic blood pressure, respiratory parameters like respiratory rate, and saturation will be measured at the time of induction and every five minutes post-induction till 45 minutes. (Table 1)

#### **Statistics methods:**

The statistical analysis conducted in this study will encompass both inferential and descriptive statistics. Inferential statistics, such as the chi-square test and unpaired t-test, will be utilized to analyze the data and make inferences about the broader population. Descriptive statistics, including measures like the mean, standard deviation, and standard error of the mean, will be computed to summarize and describe the data. A significance level of 5% will be applied to evaluate the statistical significance of the results.

#### Discussion:

In 2011 Tyagi et al. did a study titled "A comparison between volume control and pressure control ventilation for laparoscopic cholecystectomy", where they randomly assigned volume control ventilation and pressure control ventilation. The ventilator settings were assigned accordingly to match the parameters. The initial 5 minutes had no difference in peak and mean airway pressure. The peak airway pressure decreased after 10 and 30 minutes, and the mean pressure increased in PCV more than in VCV. This, they explained, is due to decelerating inspiratory flow rate. However, they could not see any differences in the ETCO2, gas exchange, or PaCO2.(1)

In a 2017 study conducted by Mihalj et al., the effects of pressure-controlled ventilation (PCV) and volumecontrolled ventilation (VCV) on respiratory and hemodynamic parameters were examined during laparoscopic cholecystectomy. The study included 60 patients aged 18 to 70, with ASA scores ranging from 1 to 3, a body mass index (BMI) below 35 kg/m<sup>2</sup>, and no history of chronic respiratory disorders. The patients were randomly divided into two groups: one receiving protective pressure-controlled mechanical ventilation and the other receiving volume-controlled mechanical ventilation.

Initially, no significant differences in respiratory and hemodynamic measures were observed between the two groups. However, when specifically comparing patients with a BMI of 25, it was found that the PCV group exhibited significantly lower peak inspiratory pressure (Ppeak) at 15, 30, and 45 minutes after tracheal intubation. Similar trends were observed in other measured parameters. The study concluded that PCV and VCV effectively maintained appropriate ventilation, oxygenation, and hemodynamic stability in the observed patient groups. (2)

In a 2007 study conducted by Balick et al., titled "Respiratory and hemodynamic effects of volumecontrolled vs. pressure-controlled breathing during laparoscopy: a cross-over study with echocardiographic assessment," the objective was to compare the respiratory and hemodynamic effects of volumecontrolled (VC) and pressure-controlled (PC) ventilation in laparoscopic urological procedures. The study included twenty-one patients who underwent VC ventilation initially and then switched to PC ventilation. Tidal volume, respiratory rate, and fraction of inspired oxygen (FIO2) were maintained constant across both ventilation modes. The study findings indicated that pressure-controlled (PC) ventilation resulted in better outcomes in peak airway pressure, peak inspiratory flow,

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and dynamic compliance compared to volume-controlled (VC) ventilation. However, no significant differences were observed in static airway pressure, static compliance, or arterial oxygenation. The systolic and diastolic heart performance assessment also showed no notable changes. Therefore, the study concluded that PC ventilation had no immediate benefits over traditional VC ventilation in patients undergoing laparoscopic procedures with pneumoperitoneum. (3)

In a 2020 study conducted by Salah et al. titled "Comparison Between Volume Controlled Ventilation and Pressure Controlled Ventilation in Laparoscopic Bariatric Surgeries," the researchers aimed to investigate how different ventilation modes impact respiratory parameters and the need for postoperative ventilation in laparoscopic bariatric surgeries.

The study revealed that pneumoperitoneum during these surgeries led to a significant increase of 68% in inspiratory resistance and a decrease of 30% in compliance among obese patients compared to normalweight patients. These changes reduced arterial oxygenation due to decreased functional residual capacity, pulmonary shunting, ventilation-perfusion mismatch, and increased atelectasis, particularly in obese patients. However, no significant differences in oxygenation levels between volume-controlled and pressure-controlled ventilation modes were observed.

Interestingly, the study showed that pressure-controlled ventilation resulted in significantly lower levels of arterial carbon dioxide (PaCO2) after pneumoperitoneum, at the end of the surgery, and in the postoperative period. This was the case despite similar preoperative PaCO2 levels between the two groups.

In another study from 2014 titled "Comparison of volume-controlled ventilation pressure and in laparoscopic cholecystectomy operations," researchers specifically examined the effects of pressure-controlled ventilation (PCV) and volume-controlled ventilation (VCV) during the surgery. The study concluded that based on patient characteristics, surgical procedures, anaesthesia, pneumoperitoneum, and recovery period there were no significant changes. Hemodynamic data and blood gas values were also similar. However, both groups experienced decreased lung compliance after pneumoperitoneum, with a more pronounced effect observed in the PCV group. The VCV group showed a significant increase in tidal volume at 10 and 20 minutes after insufflation. According to the study, the group pressure-controlled ventilation receiving (PCV) exhibited higher values of alveolar dead space ventilation to tidal volume ratio before pneumoperitoneum and a higher alveolar-arterial oxygen gradient after pneumoperitoneum compared to the group receiving volume-controlled ventilation (VCV). However, the dynamic compliance of the respiratory system was similar between the two groups.

The study results showed that by using volumecontrolled ventilation for laparoscopic surgeries required tidal volumes to be on higher side and alveolar-arterial oxygen was less after pneumoperitoneum. These findings suggest that VCV may offer improved alveolar ventilation compared to PCV in laparoscopic cholecystectomy procedures. (5)

Pelosi et al.'s (1998) study, "The Influence of Body Mass on Gas Exchange, Lung Volumes, and Respiratory Mechanics," looked at how body mass index (BMI) impacts respiratory variables under general anaesthesia. Their method entailed analysing compliance, resistance, gas exchange, and the effort needed to inhale one litre of air using the oesophageal balloon technique and rapid airway obstruction. At the same time, functional residual capacity (FRC) was calculated using the helium dilution technique. The study included 24 participants randomly selected in a supine position before surgery, divided into three groups based on BMI: normal BMI (<25 kg/m<sup>2</sup>), moderately obese (BMI between 25 and 40 kilograms per square metre), and severely obese (BMI >40 kilograms per square metre). The results of the study revealed the following changes as BMI increased:

The compliance of the chest wall was marginally impacted, while the compliance of the lung and the overall respiratory system dropped dramatically. (6)

Haemodynamic and respiratory outcomes for pressurecontrolled ventilation versus volume-controlled ventilation in patients undergoing laparoscopic surgery was a study by Martinez et al. conducted in 2007. This study involved 40 Class I/II ASA patients with elective laparoscopic surgery. The patients were given fentanyl (2 mg/kg), propofol (2 mg/kg), and atracurium (150 mg/kg) to produce anaesthesia while they fasted starting at midnight the night before the procedure. Following a thorough relaxation assessment, endotracheal intubation

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was carried out and scored with a train of four (TOF). Sevoflurane (1 MAC) was used to keep the anaesthesia in place. PCV or VCV was administered to patients at random. Both groups' hemodynamic parameters during the various period records were comparable. Mean, systolic, and diastolic pressures were comparable. In comparison to 97.25 + 1.2 for VCV, SpO2 increased during pneumoperitoneum up to 97.61 + 1.29 for PCV. SpO2 levels for both groups remained identical ten minutes after insufflation. Both PCV and VCV were well-tolerated treatment options for individuals undergoing laparoscopic surgery. (7)

In a study by Gupta et al., the effects of volumecontrolled ventilation (VCV) and pressure-controlled ventilation (PCV) on oxygenation in obese patients undergoing laparoscopic cholecystectomy were investigated. The study included 102 adult patients with a 30-40 kg/m<sup>2</sup> BMI. Initially, all patients received VCV, but after pneumoperitoneum, they were randomly assigned to continue with VCV or switch to PCV. The results showed that the PCV group had significantly higher arterial oxygen partial pressure (PaO2) levels and lower alveolar-arterial oxygen gradient (PAO2-PaO2) values than the VCV group. The VCV group required higher tidal volume and minute ventilation to maintain appropriate CO2 levels. In contrast, the PCV group improved lung ventilation by using higher flow rates in the early inspiratory phase. Despite lower tidal volume and minute ventilation in the PCV group, adequate carbon dioxide elimination was achieved. PCV was found to reduce the adverse effects of high tidal volumes. Another study by Sen et al. also compared VCV and PCV in patients undergoing laparoscopic cholecystectomy and found that the PCV group had lower peak airway pressure levels, reduced systemic stress response, and improved oxygenation compared to the VCV group. Overall, these findings indicate that PCV might be an improved option for laparoscopic surgery in terms of oxygenation and lowering stress reaction. (9)

By comparing the effects of pressure-controlled ventilation (PCV) and volume-controlled ventilation (VCV) on oxygenation parameters in obese patients having laparoscopic cholecystectomy, Movassagi et al. conducted a randomised prospective trial. Seventy patients with ASA physical status I-II and a BMI of 30 to 40 were enrolled in the study.

Initially, VCV was used, and after pneumoperitoneum was established, patients were randomly assigned to either the PCV or VCV group. The results revealed that the VCV group required larger tidal volumes and respiratory rates to maintain the necessary CO2 levels at specific intervals. Following pneumoperitoneum, the VCV group exhibited significantly higher peak airway pressure compared to the PCV group. However, the two groups had no significant changes in plateau pressure and mean airway pressure. Oxygenation parameters, such as PO2, PCO2, and pH, showed no significant differences between the two groups, except for a few instances after pneumoperitoneum, where the PCV group displayed higher PO2 levels.

The study concluded no clinically significant differences between PCV and VCV in obese patients undergoing laparoscopic cholecystectomy. Although PCV demonstrated some improvements in plateau pressure, mean airway pressure, and oxygenation parameters, it may be beneficial to consider using a dual-mode strategy to mitigate complications effectively.(10)

#### **Ethical considerations:**

The ethics and screening committee has approved the research proposal at Jawaharlal Nehru Medical College. Prior to their involvement in the study, each participant will receive a thorough explanation of the research's objectives and procedures from a member of the research team. The participants have the right to withdraw during any time of the study and for any reason without any consequences. Written informed consent will be obtained from all participants to ensure their understanding and voluntary participation in the research.

#### REF NO.: DMIMS(DU)/IEC/2022/90

Date: 20/07/2022

#### **Dissemination:**

The findings of the study will be shared with participants and relevant organisations, as well as published in an acceptable scholarly journal.

#### Study status:

Control group data collection is ongoing.

#### Data availability:

No data are associated with this article.

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#### **Competing interests:**

No competing interests were disclosed.

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TIME	HR	SYSTOLI	DIASTOLI	MEAN	SPO	PMEAN	PEAK	ET CO2	
AFTER INDUCTIO N	(BPM )	C BP (mmHg)	C BP (mmHg)	ARTERIA L PRESSUR	2 (%)	(cmH2O )	(cmH2O )	(mmHg )	VTe (mL
11				F					)
				L					,
				(mmHg)					
0 MINS									
15 MINS									
30 MINS									
45 MINS									

Table:

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