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A Comparison between Volume - Controlled Ventilation and Pressure - Controlled Ventilation in Providing better Oxygenation in Obese Patients Undergoing Laparoscopic Cholecystectomy

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Abstract: ***Obesity is a well - established risk factor for cholelithiasis for which laparoscopic cholecystectomy is the routinely performed surgery [1]. During laparoscopy the respiratory mechanics are affected by obesity and pneumoperitoneum, but vary little with body position [2]. Hence maintenance of oxygenation is one of the main concern in the anaesthetic management of obese patients [3]. There are no specific guidelines for selection of ventilatory modes in morbidly obese patients [4]. Advancement in our understanding of pressure–volume curves and the recent demonstration of microscopic shear stress lung injury have changed the whole concept of safe range of pressure and volume in mechanical ventilation [5].***

Keywords: Volume - controlled ventilation, Pressure - controlled ventilation, Peak airway pressure, Minute ventilation, obesity, laparoscopic cholecystectomy

1. Introduction

Obesity is a well - established risk factor for cholelithiasis for which laparoscopic cholecystectomy is the routinely performed surgery [1]. During laparoscopy the respiratory mechanics are affected by obesity and pneumoperitoneum, but vary little with body position [2]. Hence maintenance of oxygenation is one of the main concern in the anaesthetic management of obese patients [3]. There are no specific guidelines for selection of ventilatory modes in morbidly obese patients [4]. Advancement in our understanding of pressure–volume curves and the recent demonstration of microscopic shear stress lung injury have changed the whole concept of safe range of pressure and volume in mechanical ventilation [5]. The traditional approach of using large tidal volumes in volume - controlled ventilation (VCV) during laparoscopic surgery in obese patients causes cardiovascular embarrassment, rise in peak inspiratory pressure and plateau pressure without significant improvement in arterial oxygenation [6]. Moreover, high tidal volume causes excessive stretch of nondependent lung regions and promotes alveolar rupture, leading to volutrauma [7]. On the contrary, the decelerating inspiratory flow used during pressure - controlled ventilation (PCV) generates high initial flow rate, causing more rapid alveolar inflation. This mechanical effect of PCV allows a homogeneous distribution of ventilation leading to better ventilation–perfusion matching. At the same time, pressure limits and uniform distribution of forces within the lung reduce the risk of volume and barotrauma [5]

In one of the crossover study in non - obese patients undergoing laparoscopic urological procedures did not find any significant short - term benefit of PCV over VCV with respect to pulmonary mechanics, gas exchange and cardiac functions [8]. Another study comparing PCV with VCV during laparoscopic gastric banding surgery in obese patients has revealed that PCV improves oxygenation without any side effects [9]. Considering these results, I opted this study to evaluate and compare the efficacy of VCV and PCV in maintaining adequate oxygenation in obese patients undergoing laparoscopic Cholecystectomy.

Aim:
To evaluate the efficacy of pressure - controlled ventilation in comparison with volume - controlled ventilation for maintaining oxygenation during laparoscopic cholecystectomy in obese patients.

2. Review of Literature

Ventilator is a simple machine designed to apply & transmit energy which serves to perform useful work, following a set scheme.

Three pressures that determine the flow and, therefore, the generation of volume; these are:

- The atmospheric pressure (Patm).
- The alveolar pressure, the pressure within the lungs (Palv).
- The pleural pressure, the pressure generated between the lungs and the thoracic cage (Ppl)

Classification of conventional modes of ventilstion:

Conventional modes are classified into 2 types based on the two components of a mode:

- Based on type of breath.
- C M V – Continuous Mandatory Ventilation.

- I M V - Intermittent Mandatory Ventilation.
- S I M V - Synchronous Intermittent Mandatory Ventilation.

Based on control variables modes are classified:
- Pressure control or pressure preset.
- Volume control or volume preset.

A mechanical ventilation mode is defined as "a specific combination of breathing pattern, control type, and operational algorithms". With the advent of microprocessor - controlled ventilators, the variety and complexity of modes has dramatically increased. It is important to understand mechanical ventilation modes in order to match breath delivery to specific clinical application and patient needs.

Volume controlled ventilation: Volume - controlled ventilation allows the clinician to set the volume to delivered with each breath with fixed volume delivery and variable pressure depending upon the patient's pulmonary compliance and airway resistance, Volume will remain constant in spite of changes in the patient's condition. The advantage of volume control is the ability to regulate both tidal volume and minute ventilation (a product of tidal volume and frequency).

Pressure controlled ventilation: The pressure - controlled mode allows the clinician to set a peak inspiratory pressure for each mechanical breath. Since pressure remains constant, volume and minute ventilation will vary with changes in the patient's pulmonary compliance or airway resistance. Should the patient's compliance worsen or airway resistance increase, the peak inspiratory pressure terminates soon and the tidal volume and minute ventilation decreases. The advantage of the 9 pressure - controlled mode is that the lungs can be protected from excessive pressures, preventing ventilator - induced lung injury (VILI)

3. Materials and Methods

Study Design: The proposed study is a cross - sectional study.

Study Area: Department of Anaesthesiology of GSL MEDICAL COLLEGE AND HOSPITAL.

Study Period: The study will be carried out from October 2019 to September 2021.

Sample Design: All patients will be randomly allocated in 2 equal groups [n=50] by simple randomization. Group - V: Patient will be kept on volume - controlled ventilation mode. Group - P: patient will be kept on pressure - controlled ventilation mode. Total number of patients taken under study are 100.

Inclusion Criteria:
1) Patients of both sex with physical status ASA 1 and ASA 2 of age between 18 - 50years undergoing laparoscopic cholecystectomy surgeries under general anaesthesia.
2) Patients with body mass index between 30 - 40 kg/m2.
3) Patients with no major obstructive or restrictive pulmonary disease.

Exclusion Criteria:
1) Patients having severe adverse reactions or allergy to any trial drug.
2) Patients with anticipated difficult intubation.
3) Patients with physical status ASA 3 and ASA 4.
4) Patients having major obstructive or restrictive pulmonary disease.
5) Patients inability to maintain stable ventilator settings of VCV for initial 30min of surgery.

Parameters to be studied:
- SPO2.
- Minute ventilation.
- PaO2.
- PaCo2.
- Peak airway pressure.

Plan for analysis of data:
The recorded data will be analyzed using standard statistical methods and the finding will be discussed in detail to any appropriate conclusion. Statistical analysis was performed by using SPSS software • The data will be presented as, mean and standard deviation. • The study is student t test and Annova test • p< 0.05 % will be statistically significant

Methodology
After obtaining approval of the Institutional Ethics Committee and written informed consent from the patients. All patients will receive intravenous inj. Ranitidine 50mg and inj. Ondansetron 4mg 2h pre - operatively, inj. Glycopyrrolate 0.2mg intravenously 30min preoperatively and inj. Fentanyl 2mcg/kg 5min before induction. After proper preoxygenation, patients will be induced with inj. Propofol 2mg/kg. After induction, will be intubated with a oral, cuffed endotracheal tube of appropriate size after achieving adequate relaxation with inj. Succinylcholine 1 - 2mg/kg. The lungs will be ventilated with 50% Air, 50% oxygen and isoflurane 0.9–1%. Muscle relaxation will be maintained with inj. vecuronium bromide 0.08 mg/kg followed by additional top up doses of 0.02 mg/kg as and when required. To start with, all patients will be using VCV with a tidal volume of 8 mL/kg and inspiratory/expiratory ratio of1: 2. Respiratory rate will be adjusted to obtain an end - tidalCO2 (EtCO2) of35–40mmHg. After pneumoperitoneum (intraabdominal pressure 10–12 mmHg), patients will be placed in a 250 head up position. Fifteen minutes after pneumoperitoneum, patients will be randomized with the help of simple randomization method to receive either VCV (Group V; n=50) or PCV (Group P; n=50). In Group V, ventilation will be continued with a tidalvolume of 8 mL/kg. The initial tidal volume can be increased by 1 mL/kg every 5min till 12 mL/kg, and the respiratory rate can be increased by 2/min every 5min till 20/min to maintain EtCO2 between 35and 40 mmHg. Following fall in EtCO235 cmH2O and respiratory rate >20/min to maintain normocarbia will be shifted to VCV and will be dropped from the study. Arterial blood samples will be drawn 15 min after establishment of pneumoperitoneum and at 20minintervals thereafter till the end of the surgery. Patients requiring conversion from laparoscopy to laparotomy were excluded from the study. Neuromuscular blockade will be reversed with inj. neostigmine 0.05mg/kg and inj. glycopyrrolate 0.01mg/kg.

The patient will be extubated after fulfilling the criteria of adequate reversal.

4. Results

A prospective interventional study was done among 100 patients who underwent laparoscopic cholecystectomy surgery satisfying inclusive and exclusive criteria under the department of anesthesia, GSL medical college, Rajahmundry during the study period of October 2019 to September 2021 after obtaining informed consent. All patients were randomly allocated into following groups:

- Group V: 50 patients each kept on volume - controlled ventilation mode.
- Group P: 50 patients each kept on pressure - controlled ventilation mode

Distribution of mean SPO2 among the study groups (n=100).

SpO2 %	Group V		Group P		P value
	Mean	SD	Mean	SD	
Baseline	99.04	0.81	99.14	0.83	0.543
15 min after pneumoperitoneum	98.9	0.81	99.2	0.86	0.758
35 min after pneumoperitoneum	98.66	0.89	98.8	0.76	0.401

Distribution of mean PaO2 among the study groups (n=100).

PaO2 mm of hg	Group V		Group P		P value
	Mean	SD	Mean	SD	
Baseline	90.82	3.28	90.68	3.09	0.827
15 min after pneumoperitoneum	165.86	16.69	164.58	15.17	0.689
35 min after pneumoperitoneum	160.8	16.69	171.66	17.52	0.002

Distribution of mean PaCo2 among the study groups (n=100).

PaCo2 mm of hg	Group V		Group P		P value
	Mean	SD	Mean	SD	
Baseline	39.38	2.91	39.88	1.87	0.935
15 min after pneumoperitoneum	37.62	4.72	37.62	3.93	0.783
35 min after pneumoperitoneum	42.9	3.61	43.44	3.29	0.437

Distribution of mean minute ventilation among the study groups (n=100).

Minute ventilation (I)	Group V		Group P		P value
	Mean	SD	Mean	SD	
15min after pneumoperitoneum	7.62	0.44	7.74	0.71	0.289
25min after pneumoperitoneum	7.86	0.69	7.49	0.43	0.002
35min after pneumoperitoneum	8.36	0.69	7.24	0.24	<0.0001

Distribution of peak airway pressure among the study groups (n=100).

PAP mm of hg	Group V		Group P		P value
	Mean	SD	Mean	SD	
15min after pneumoperitoneum	20.14	1.43	20.08	1.37	0.831
25min after pneumoperitoneum	20.72	1.19	19.06	0.89	<0.0001
35min after pneumoperitoneum	21.18	1.57	18.74	0.81	<0.0001

5. Summary

A cross - sectional study was done to evaluate the efficacy of volume - controlled ventilation and pressure - controlled ventilation and their comparison in providing better oxygenation for obese patients undergoing laparoscopic cholecystectomy. The present study was done among 100 patients who belong to ASA physical status 1 & 2 with ages from 18 years to 60 years underwent elective surgeries under general anesthesia. These 100 were grouped into 2 groups of 50 each:

Group - 1: kept on volume - controlled ventilation

Group - 2: kept on pressure - controlled ventilation

- In the current study, it was concluded that Volume controlled ventilation was compared with pressure controlled ventilation with significant peak airway pressure, minute ventilation during the laparoscopic surgery showing increased oxygenation.
- It was showed that pressure - controlled ventilation is a better choice when compared with volume - controlled ventilation among patients with obesity who underwent laparoscopic cholecystectomy due to the dual advantage of PCV.

6. Conclusion

According to current findings, volume - controlled ventilation was compared with pressure - controlled ventilation with significant peak airway pressure, minute ventilation during the laparoscopic surgery showing increased oxygenation. It was showed that pressure - controlled ventilation is a better choice when compared with volume - controlled ventilation among patients with obesity who underwent laparoscopic cholecystectomy due to the dual advantage of PCV.

1) Improved arterial oxygenation.
2) Limiting the chances of injury to lung.

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