"STUDY OF AIRWAY PRESSURE CHANGES IN VOLUME CONTROLLED VENTILATION AND PRESSURE CONTROLLED VENTILATION IN PATIENTS UNDERGOING LAPAROSCOPIC HYSTERECTOMY"

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Sub: Institutional Ethical Clearance for the study.

With reference to the above, we wish to inform you that your proposed research project titled **"STUDY OF AIRWAY PRESSURE CHANGES IN VOLUME CONTROLLED VENTILATION AND PRESSURE CONTROLLED VENTILATION IN PATIENTS UNDERGOING LAPAROSCOPIC HYSTERECTOMY"**, is ethical and justifiable. The proposed research project has been cleared by the JNMC Institutional Ethics Committee on Human Subjects Research.

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LIST OF ABBREVIATIONS USED

ASA - American society of Anaesthesiologists

CNS - Central nervous system

CO_2 - Carbon dioxide

O_2 - Oxygen

N_2O - Nitrous Oxide

CVS - Cardiovascular system

RS - Respiratory system

PCV- Pressure control ventilation

VCV- Volume control ventilation

PAP- Peak airway pressure

Pplateau- Plateau pressure

WOB- Work of breathing

ALI- Acute lung injury

IAP- Intra abdominal pressure

PVR- Pulmonary vascular resistance.

GA- General Anaesthesia.

TLH- Total Laparoscopic Hysterectomy.

MAP- Mean Arterial Pressure

PIP- Peak Inspiratory Pressure.

CMV- Continuous Mandatory Ventilation.

PCV-VG- Pressure Control Ventilation Volume Guaranteed.

Cdyn- Dynamic Compliance.

SVR- Systemic Vascular Resistance.

PVR- Pulmonary Vascular Resistance.

FRC- Functional Residual Capacity.

CPP- Cerebral Perfusion Pressure.

IOP- Intra Ocular Pressure.

CBF- Cerebral Blood Pressure.

ABSTRACT

BACKGROUND: Pneumoperitoneum achieved in laparoscopic surgeries can cause adverse effects on different systems**.** PCV and VCV are the two modes used for GA. PCV provides fixed airway pressure with varying tidal volume which decreases the chance of barotrauma.

AIM: Comparison of airway pressure changes and haemodynamic changes in PCV and VCV mode of ventilation.

METHOD:-The study included 56 patients in total who underwent TLH under GA. Patients were divided into two groups at random; group 1 was given VCV with a tidal volume of 10 ml/kg, while group 2 was given PCV, peak airway pressure is adjusted to get a tidal volume of 10 ml/kg. a variation of 5% is accepted. Peak airway pressure, plateau pressure and other haemodynamic variables are monitored after induction of GA, post pneumoperitoneum, lithotomy position, trendelenburg position and 15min after Trendelenburg position. Data were analyzed using student's paired and student's unpaired t test.

RESULT: In all five time periods, PCV offered a clinically significant drop in PAP and P plateau compared to Volume controlled mode, but no clinically significant change in heart rate. However, there was a considerable rise in MAP in PCV in the lithotomy position, Trendelenburg position, and 15 minutes following Trendelenburg position.

CONCLUSION: PCV provides better respiratory mechanics by providing decreased peak and plateau pressure compared to VCV. Therefore, PCV is preferable to VCV in individuals undergoing total laparoscopic hysterectomy.

KEYWORDS:

Pressure control ventilation (PCV), Volume control ventilation (VCV), Peak airway pressure (PAP)

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INTRODUCTION

Laparoscopic gynaecologic surgery frequently employs Trendelenburg positioning and carbon dioxide (CO_2) pneumoperitoneum to enhance surgical access.

However, these techniques can occasionally cause a number of cardiopulmonary side effects, such as elevated MAP, reduced pulmonary compliance and FRC, elevated PAP, and respiratory acidosis due to hypercarbia. [1,2].

The most popular technique for ventilating patients under general anaesthesia is VCV. It provides constant minute ventilation, affecting airway pressure. This mode provides a steady flow to supply tidal volume but can lead to increased airway pressures, especially during laparoscopic operations due to pneumoperitoneum.

Adjusting the necessary PIP in PCV allows for the maintenance of fixed airway pressure. With a predetermined pressure, PCV uses decelerating type of flow that achieves its maximum value at the start of inspiration.This is achieved with a delivery method that employs high initial flow rates to quickly reach and maintain the required inspiratory pressure before rapidly decelerating flow. With a higher initial rate of flow, the lung is ventilated more evenly, which improves the ventilation/perfusion mismatch and allows faster alveolar inflation. The increased pressure that occurs with pneumoperitoneum, however, might result in patients receiving low or inadequate tidal volumes. Low peak pressures and a lower incidence of barotraumas are produced while using this mode.

Blood pressure, heart rate, and cardiac output can all be affected by CO_2 pneumoperitoneum in the Trendelenburg position[3]. This is because variations in airway pressure have an impact on intra-thoracic pressure and the heart's own functionality. [2].

In this randomised trial, we want to monitor the variations in airway pressure in the Trendelenburg position during laparoscopic hysterectomy in the VCV and PCV modes.

OBJECTIVES

Primary-

Comparison of airway pressure changes in VCV and PCV.

Secondary-

To compare the hemodynamic changes in two modes of ventilation.

REVIEW OF LITERATURE

The development of iron lung, a type of non-invasive negative pressure ventilator that became popular during the time of polio epidemics in 20th century following the inventions of "Drinker respirator" in 1928, John Haven Emerson's improvements in 1931, and the 'Both respirator' in 1937, is where the history of mechanical ventilation begins[4,5]. Biphasic Cuirass Ventilation , relatively rudimentary positive pressure equipment and the rocking bed are other non-invasive ventilators that are frequently utilised for polio patients.

The Continuous Mandatory Ventilation mode was the earliest type of current ventilation mode (CMV). It was designed to provide the patient with positive pressure artificial breathing, but only within the ventilator's predetermined limits. The patient's actions or "request for" were not detected by the ventilator. In other words, the ventilator would not produce a quicker respiratory rate than what was programmed if the patient started to trigger breaths. In terms of the patient, it was totally blind.

Different modes of ventilation evolved over time for minimal physiological derangement and better patient comfort.

Jung Min Lee,2020: At random, 60 patients were compared for VCV, PCV, or PCV-VG. They reached to the conclusion that, while doing a Trendelenburg position robotic laparoscopic gynaecologic surgery, PCV and PCV-VG have lower P peak, higher Pmean, and increased Cdyn.While demonstrating no noticeable alterations in hemodynamic parameters or arterial blood gas readings.[6]

Toker MK and Altiparmak B.,2019: Examined how well obese patients posted for laparoscopic hysterectomy could maintain acceptable airway pressures, oxygenation and lung compliance by using volume-controlled ventilation (VCV) and pressure-controlled volume-guaranteed (PCV-VG) modes of ventilation.Mean inspiratory pressure, plateau pressure, driving pressure, and peak inspiratory pressure of the PCV-VG group were all considerably lower than VCV group. Furthermore, its dynamic compliance was greater. The mean PaO2 values in PCV-VG group were significantly higher than those in VCV group at each time point in Trendelenburg position with pneumoperitoneum.[7]

Rishabh Jaju et al 2017: Researchers examined the effects of VCV mode and PCV mode on the respiratory mechanics and hemodynamic in patients who undergo robotic surgery while positioned in the steep Trendelenburg position. Heart rate, mean blood pressure, and central venous pressure were measured together with respiratory (peak and mean airway pressure, dynamic lung compliance, and arterial blood gas analyses). Since PCV mode offers better ventilation-perfusion matching, greater Cdyn, and lower airway pressures for the same MV, they came to the conclusion that it is a safe alternative in robotic pelvic surgeries.[8]

Sangbong Choi and So Young Yang., 2019: Compared the effects of two mechanical ventilation modes after laparoscopic colectomy in colorectal cancer patients to determine the association between postoperative respiratory problems, airway mechanics, and biomarkers. Peak airway pressure, postoperative respiratory problems, plasma sRAGE levels, and S100A12 levels were lower in PCV than in the VCV.[9]

Yin J et al., 2019: Patients with abdominal compartment syndrome were compared between pressure control mode ventilation (PCV) and pressure-regulated volume control mode ventilation (PR-VCV). The partial pressure of carbon dioxide, the peak inspiratory pressure, the mean inspiratory pressure, the central venous pressure, the heart rate, and the extravascular lung water index all significantly decreased during mechanical ventilation using PR-VCV (Pressure regulated volume control ventilation) compared to PCV (Pressure control ventilation) mode. [2]

Tyagi A, Kumar R, Sethi AK, and Mohta M. A.,2011: Compared individuals with BMI of less than 30 kg/m^2 who were posted for laparoscopic cholecystectomy with PCV mode and VCV mode. At 10 minutes and immediately after the surgery started, pressure-controlled ventilation significantly increased mean airway pressure. At 10 minutes and 30 minutes, it significantly decreased mean (SD) peak airway pressure. They come to the conclusion that pressure-controlled mode ventilation, when used during laparoscopic cholecystectomy in non-obese patients, is a safe alternative to volume-controlled mode breathing and has certain advantages over it.[10]

Kallet RH and Campbell AR,2000: In patients with acute lung injury and acute respiratory distress syndrome, the effects of pressure control vs volume control mode ventilation were compared. The work of breathing of 18 mechanically ventilated adult patients ALI or ARDS was measured using a BICORE CP-100 monitor (with a Campbell

Diagram). Compared to VCV, PCV dramatically decreased patient WOB in the presence of ALI and ARDS.[11]

F. Kalmar, 2010: Studied oninfluence of steep Trendelenburg posture and CO2 pneumoperitoneum on cardiovascular, cerebrovascular, and respiratory homeostasis during robotic prostatectomy. They concluded that extended steep Trendelenburg posture along with the CO(2) pneumoperitoneum were both well tolerated. The pulmonary and hemodynamic parameters stayed within acceptable ranges. Regional cerebral oxygenation was well conserved, and CPP stayed within the range that is typically thought to be the range where cerebral autoregulation maintains cerebral blood flow.[12]

Osama M. Assad's 2016: Study to examine how airway pressures, respiratory and circulatory indicators, and volume-controlled mode ventilation affect these variables in laparoscopic surgery while the patient is in Trendelenburg position. They found that the PCV-VG group had considerably lower peak inspiratory pressure and higher dynamic compliance than VCV.[13]

Zhendan Peng and Jiangyan Xia,2021: compared the impact of pressure-controlled versus volume-controlled mode ventilation on hemodynamic and respiratory parameters in lumbar spine fusion surgery patients. They found that throughout all research time periods, the PCV group had a lower peak pressure than the VCV group and a higher dynamic compliance than the VCV group. Additionally, dynamic compliance and CO showed a positive association.[14]

Mona gad et al., 2019: On obese patients posted for laparoscopic hysterectomy, the effects of PCV-VG vs VCV mode with equal ventilation ratio were compared.They found that PCV-VG outperformed VCV with ERV because it offered higher dynamic compliance and lower peak inspiratory pressure, which may be preferable, especially in those whose cardiopulmonary function may be more prone to decline.[15]

Seok young song et al., 2014: compared the two techniques for ensuring one lung ventilation in patients undergoing thoracic surgery patients: VCV mode and PCV mode. They came to the conclusion that whereas exhaled TV was much higher with PCV-VG than with VCV, airway pressure was significantly decreasedand arterial oxygen tension was not significantly enhanced.[16]

BASIC SCIENCES

Laparoscopic surgeries have been approved widescale in various surgical fields, due to its advantages such as minimal incision, lower response to stress and lower blood loss. During laparoscopic surgery, pneumoperitoneum with CO_2 is commonly used along with Trendelenburg mode to provide adequate exposure to surgical visualization and space.[17] These methods have a significant impact on the cardiovascular system and pulmonary systems such as increased mean arterial pressure, increased peak airway pressure, decreased lung compliance and pushes the abdominal contents towards diaphragm whichincreases the risk of barotrauma. Increased airway pressure or excessive tidal volume may do harm to alveolar epithelial cells during mechanical ventilation, which leads to the destruction of lung parenchyma. Above effects may produce serious consequences especially in patients with morbid obese or chronic lung disease.[10] Therefore, it is necessary to seek for appropriate lung-protective ventilation strategies to reduce cardiopulmonary complications for patients undergoing laparoscopic surgeries in Trendelenburg position.

Physiologic Effects of Laparoscopy.

CARDIOVASCULAR CHANGES:

Cardiovascular changes in laparoscopic surgeries are variable and dynamic. These effects are well tolerated by healthy patients, but significant intraoperative cardiac dysfunction can occur in older patients and in patients with cardiopulmonary diseases.

Cardiovascular changes during laparoscopy due to the increase in intra-abdominal pressure (IAP) associated with carbon dioxide insufflation, effects of positioning, and of absorption of CO_2, as follows:

Effects of pneumoperitoneum – Pneumoperitoneum and the associated increase in IAP result in neuroendocrine and mechanical effects on cardiovascular physiology.

Neuroendocrine effects – Increase in IAP results in release of catecholamine and activation of the renin–angiotensin system with vasopressin release. This increases MAP in most patients and may contribute to increases in SVR and pulmonary vascular resistance (PVR). Vagal stimulation, from insertion of the Veress needle or peritoneal stretch with gas insufflation, can result in bradyarrhythmia. Bradycardia is common in this setting, while atrioventricular dissociation, nodal rhythm, and asystole have been reported.

Effects of positioning:

Head up – The head up position (reverse Trendelenburg) leads to venous pooling, tends to reduce venous return to the heart, and may result in hypotension, especially in patients who are hypovolemic.

Head down – The head down position (Trendelenburg) increases venous return and cardiac filling pressures.

Effects of hypercarbia – Absorption of CO during laparoscopy can have direct and indirect cardiovascular effects. The direct effects of hypercarbia and associated acidosis include decreased cardiac contractility, sensitization to arrhythmias, and systemic vasodilation. Indirect effects are the result of sympathetic stimulation, and include tachycardia and vasoconstriction, which may counteract vasodilation.

PULMONARY CHANGES:

Pneumoperitoneum causes cephalad displacement of the diaphragm and mediastinal structures, which reduces functional residual capacity (FRC) and pulmonary compliance, resulting in atelectasis and increased peak airway pressures. These effects are exacerbated with steep Trendelenburg positioning and are reduced with reverse Trendelenburg positioning.

CO2 is highly soluble and is rapidly absorbed into the circulation during insufflation for laparoscopy. CO2 absorption increases quickly and reaches a plateau at approximately 60 minutes of insufflation. Ventilation must be increased to maintain normal end tidal and arterial partial pressure of CO_2.

Ventilation/perfusion mismatching – The reduction in FRC and atelectasis associated with laparoscopy leads to shunting and ventilation/perfusion mismatch.

Endotracheal tube – Pneumoperitoneum and Trendelenburg positioning may cause cephalad movement of the carina, which can result in mainstem endobronchial migration of the endotracheal tube, hypoxia, and high inspiratory pressure.

REGIONAL CIRCULATORY CHANGES

Splanchnic blood flow – The mechanical and neuroendocrine effects of pneumoperitoneum can decrease splanchnic circulation, resulting in reduced total hepatic blood flow and bowel perfusion.

Renal blood flow – The creation of a pneumoperitoneum results in reduction in renal perfusion and urine output associated with renal parenchymal compression, reduced renal flow, and increased levels of vasopressin. When IAP is kept under 15 mmHg, renal function and urine output generally normalize soon after pneumoperitoneum deflation, without histologic evidence of pathologic changes.

Cerebral blood flow – Increased intraabdominal and intrathoracic pressures, hypercarbia, and Trendelenburg positioning can all increase cerebral blood flow (CBF) and intracranial pressures.

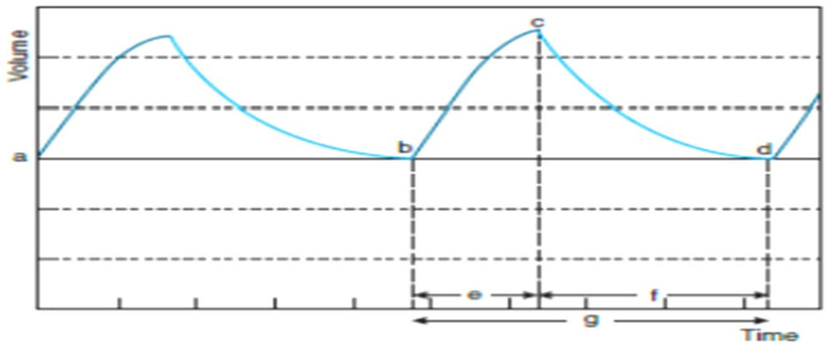
Intraocular pressure – Intraocular pressure (IOP) increases with pneumoperitoneum and increases further when the patient is positioned in Trendelenburg.

VENTILATION MODES

A mechanical ventilation mode is explained 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.

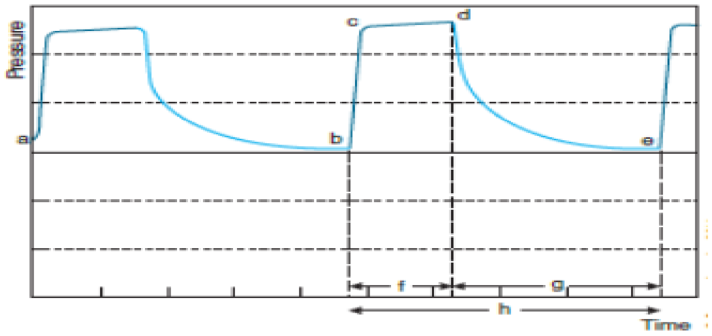
Volume-controlled ventilation helps the clinician to regulate the volume to be delivered with each breath with constant volume delivery and variable pressure depending on patient's pulmonary compliance and airway resistance. Volume will remain fixed in spite of changes in the patient's condition. The advantage of volume control is the aptitude to regulate both tidal volume and minute ventilation.



Volume time scalar in volume control mode (a: beginning inspiration, b: end-expiration/beginning inspiration, c: end-inspiration/beginning expiration, d: end-expiration, e: inspiratory time, f: expiratory time, g: total cycle time.)

Pressure-Controlled Ventilation

The pressure-controlled mode helps the clinician to regulate peak inspiratory pressure for each mechanical breath. Since pressure remains constant, volume and minute ventilation changes with changes in patient's pulmonary compliance or airway resistance. If so the patient's compliance worsen or airway resistance increase, the peak inspiratory pressure ends soon and the tidal volume and minute ventilation decreases. The advantage of the pressure-controlled mode is that the lungs can be protected from excessive pressures, preventing ventilator-induced lung injury.



A pressure-time scalar in pressure-controlled mode. A pressure-time scalar in pressure-controlled mode. a: beginning inspiration, b: end-expiration/beginning inspiration,c to d: pressure plateau, d: end-inspiration/beginning expiration, e: end-expiration, f: inspiratory time, g: expiratory time, h: total cycle time

Airway resistance

Airway resistance is the airflow obstruction in the airways. In mechanical ventilation, the degree of airway resistance is affected by the length, size, and patency of the airway, endotracheal tube, and ventilator circuit.

Factors Affecting Airway Resistance

Obstruction of airflow is due to:

(1) increased secretions in the airway.

(2) Due to any tumours or growth compressing the airway.

(3) Due to any neoplasm of bronchial muscle structure.

Any of these above mentioned condition can cause decrease in the size of airway, the radius of the airway decreases and airway resistance increases. According to the simplified form of Poiseuille's Law, the driving pressure (DP) to maintain the same airflow (V#) must increase by a factor of 16-fold when the radius (r) of the airway is reduced by only half of its original size.

Other factors that increase the airway resistance are the diseases like chronic obstructive pulmonary disease, chronic bronchitis, asthma and bronchiectasis.

Airway resistance can also increase due to kinking of endotracheal tube post intubation and in foreign particle aspiration.

Some infections in airway like croup, epiglottitis and bronchiolitis can also result in increased airway resistance.

Conditions that increase airway resistance

TYPE	CLINICAL CONDITIONS
COPD	Emphysema Chronic bronchitis Asthma Bronchiectasis
Mechanical obstruction	Post intubation obstruction Foreign body aspiration Condensation in mechanical circuit
Infections	Croup Epiglottitis Bronchiolitis

In a normal healthy adult airway resistance is about 0.5 to 2.5 cm of H2O.

It is higher in intubated patients due to reduction in diameter of airway.

Airway resistance is directly proportional to the length and inversely proportional to the diameter of the airway or ET tube.

Largest size ET tube appropriate to the patient must be used so that airway resistance can be minimised.Once the ET tube is in place its patency should be maintained, as secretions inside the ET tube increase airway resistance. Besides the ET tube, the ventilator circuit may also impose mechanical resistance to airflow and contribute to total airway resistance. This is particularly important when there is a significant amount of water in the ventilator circuit due to condensation.

Lung compliance.

Lung compliance is volume change (lung expansion) per unit pressure change (work of breathing), and it is calculated by

C = DV/DP,

where C = compliance,

DV = volume change, and

DP = pressure change.

Most ventilators can measure and show the static and dynamic compliance values on the data or graphic display.

TABLE 1-2 Method to Measure Static and Dynamic Compliance
(1) Obtain corrected expired tidal volume.
(2) Obtain **plateau pressure** by applying inspiratory hold or occluding the exhalation port at end-inspiration.
(3) Obtain **peak inspiratory pressure.**
(4) Obtain positive end-expiratory pressure (PEEP) level, if any. $\text{Static Compliance} = \frac{\text{Corrected Tidal Volume}}{(\text{Plateau Pressure} - \text{PEEP})}$ $\text{Dynamic Compliance} = \frac{\text{Corrected Tidal Volume}}{(\text{Peak Inspiratory Pressure} - \text{PEEP})}$

Low Compliance

Low compliance (high elastance) means that the volume change is small per unit pressure change.

In this condition, the lung is stiff or noncompliant. The work of breathing is more when the compliance is low.

It is seen in conditions like ARDS and lung fibrosis.

Low lung compliance can cause refractory hypoxemia.

Low lung compliance are seen in patients who have conditions causing reduced functional residual capacity.

These patients usually have restrictive lung defect, low lung volumes and decreased minute ventilation.

It is compensated by increasing the frequency.

High Compliance.

Volume changes large for unit pressure change results in higher compliance.

In higher compliance exhalation is incomplete due to decreased elastic recoil of lungs.

The conditions that cause higher compliance resulting impaired gas exchange are diseases like emphysema which results in air trapping, destruction of lung tissues and enlargement of terminal and respiratory bronchioles.

High compliance lungs have increased functional residual capacity and total lung capacity.

Patient can cause airflow obstruction, air trapping and poor gas exchange.

TYPES OF COMPLIANCE	CLINICAL CONDITIONS
Static compliance	ARDS
	Atelectasis
	Tension pneumothorax
Dynamic compliance	Bronchospasm
	Kinking of ET tubes
	Airway obstructions

STATIC COMPLIANCE

Static compliance is calculated by dividing the volume by the pressure (i.e., plateau pressure), measured when the flow is momentarily stopped.

When airflow is absent, airway resistance becomes a non-factor. Static compliance reflects the elastic resistance of the lung and chest wall.

Dynamic Compliance.

It is ratio of volume and pressure (peak inspiratory pressure) when air flow is present, airway resistance is a factor in dynamic compliance.

Dynamic compliance therefore reflects the condition of airway resistance (nonelastic resistance) as well as the elastic properties of the lung and chest wall (elastic resistance).

Plateau and Peak Inspiratory Pressure.

Conditions that cause differences in P plateau and static compliance makes same kind of difference in peak inspiratory pressure and dynamic compliance.

Conditions like Atelectasis of lungs increases peak and plateau pressures. This increase in above mentioned pressures, causes a decrease in the measurement of static and dynamic compliance.

When this atelectasis condition is reversed, the changes in the pressures return to normal.

The other respiratory problems in which the flow resistance is more like in bronchospasm, there is only increase in peak airway pressures. The plateau pressure remains unchanged.

As there is only change in peak airway pressure the dynamic compliance decreases and the static compliance remains unchanged as there is no variation in plateau pressure.

When the pathology of the condition causing is resolved, both type of compliance returns to normal.

VOLUME CONTROLLED VERSUS PRESSURE CONTROLLED MODE VENTILATION

Volume control and pressure control are different control variables within a mode.

	PCV	VCV
TIDAL VOLUME	Variable	Constant
P Plateau	Constant	Variable
Peak inspiratory pressure	Constant	Variable
Peak flow	Variable	Set
Flow pattern	Variable	Set
Inspiratory time	Set	Set
Minimum rate	Set	Set

In VCV tidal volume and minute ventilation is pre-set and we can appropriately set the flow waveform, inspiratory flow and inspiratory time.

Increase in airway pressure can occur due to reduced complianceand increased resistance, which can increase the risk of ventilator induced lung injury.

In PCV airway pressure can be limited but tidal volume and minute volume is variable. User can titrate the inspiratory pressure to the measured tidal volume, but the inspiratory flow and flow waveform are determined by the ventilator as it attempts to maintain a square inspiratory pressure profile.

Pressure control modes of ventilation.

• In a pressure-controlled mode of ventilation, the inspiratory pressure is the control variable, and is maintained during the inspiratory phase.

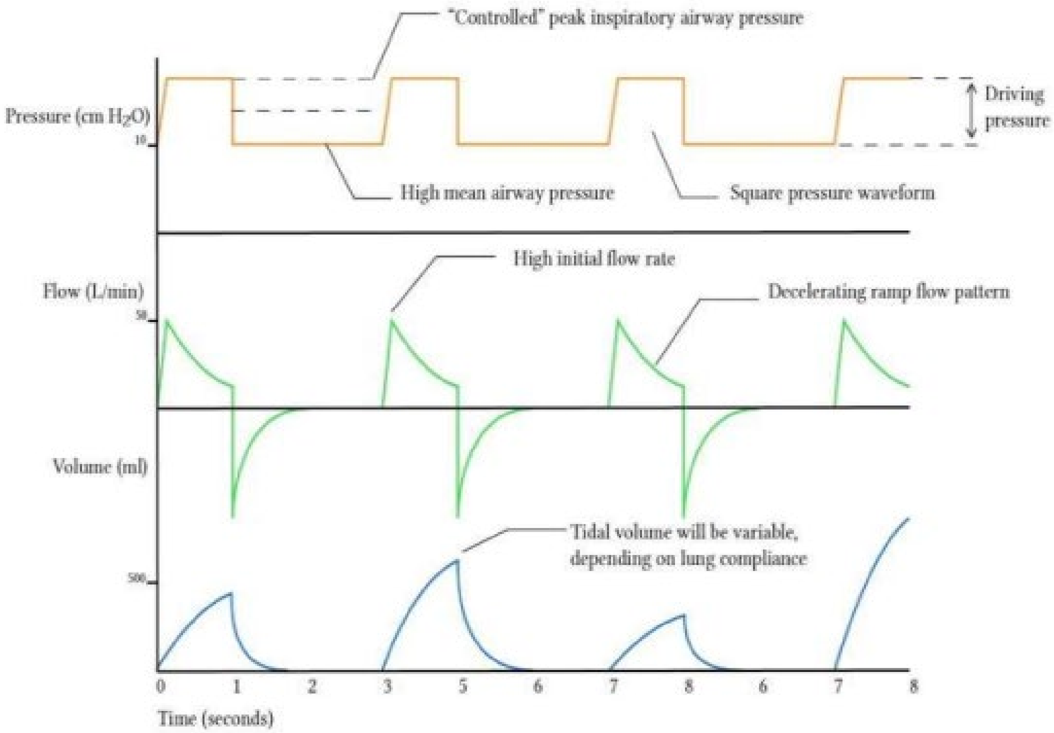
Because of this, the pressure waveform is “square”. This increases the mean airway pressure (i.e., the area under the pressure/time graph is greater).

During the early inspiratory phase, the ventilator generates a high inspiratory flow rate to rapidly achieve the pressure limit variable.

To maintain this pre-set pressure, the flowrate needs to decelerate during the course of inspiration and usually it is a down sloping ramp.

The flow will reach zero if the inspiratory time is long.

In the absence of flow, the constant prescribed pressure is in equilibrium with the peak alveolar pressure at the end of the breath and equals the plateau pressure.



Advantages of PCV

PCV protect the lungs against barotrauma as the pressure level is controlled and patient will never suffer from extreme high pressures.

Work of breathing and patient comfort may be improved because the initial high flow rate prevents the "flow starvation", a type of patient-ventilator desynchrony, where the patient's demand for fresh gas flow goes unmet by the ventilator's inappropriate low flow limit.

Significant leak is present in pressure control variable, the ventilator will automatically adjust the inspiratory flow for even a significant leak to maintain the pre-set pressure.

Disadvantages of PCV.

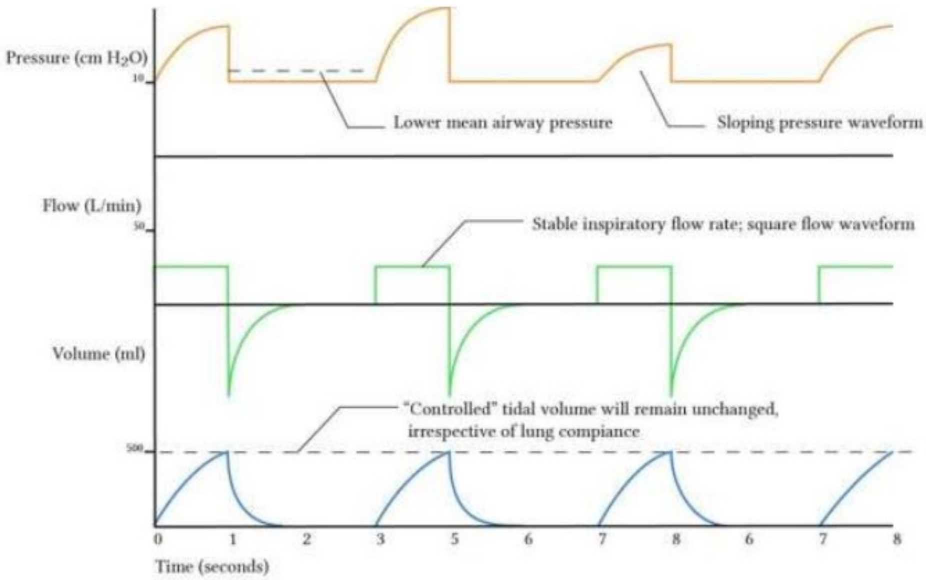
Tidal volume is dependent on respiratory compliance; and it may vary substantially over the course of mechanical ventilation, requiring frequent adjustments.

With PCV, without constant attention to the ventilator settings tight control of PaCO2 may be difficult to achieve.

High initial inspiratory flow may breach the pressure limit, if airway resistance is high. In such cases, a gentle inspiratory flow rate might be beneficial.

Volume control modes of ventilation

The volume control mode is usually a constant flow mode, the ventilator delivers the flow which is constantand it will stop the flow as soon as the pre-set volume is achieved. Since pressure is not controlled and regulated, the pressure waveform forms a parabolic sloping shape as the lungs distend during a breath**.** The pressure waveform changes during volume control ventilation, changing shape depending on lung compliance and airway resistance.



Advantages of volume control ventilation

Guaranteed tidal volume produces a more stable minute volume. The reliability of the minute volume makes this mode of ventilation more appropriate in situations where careful control of PaCO2 is important. Volume controlled mode is the standard of care for patients with severe traumatic brain injury, where tight PaCO2 control is necessary.

The minute volume remains stable over a range of changing pulmonary characteristics. If airway resistance fluctuates significantly (eg. in the course of therapy for status asthmaticus) this mode has the advantage of maintaining a reliable minute volume.

The initial flow rate is lower than in pressure-controlled mode. This is an advantage if airway resistance is high, blowing more slowly into the tight bronchi does not produce a high resistance-related early pressure peak and potentially prevents an early termination of the breath by the pressure alarm limit.

Disadvantages of volume control ventilation

Since the peak airway pressure is a variable in VCV for the fixed tidal volume it is not suited for surgeries where we are suspecting increased intra thoracic pressures as it can cause barotrauma.

The mean airway pressure is lower with volume control ventilation, due to the slopy shape of the pressure waveform. This can theoretically be a disadvantage in patients who have severe hypoxia.

Recruitment may be poorer in lung units with poor compliance. Units with a long time constant and poor compliance may remain unrecruited until very late in the inspiratory phase when pressure approaches its maximum value. These units will have little time for gas exchange before the ventilator cycles to expiration. From this, one might expect that with a volume-controlled mode the degree of atelectasis will be greater than with a pressure-controlled mode, peak airway pressures being equal.

In the presence of a leak, the mean airway pressure may be unstable. The constant flow used during VCV may not be able to compensate for an intermittent leak. Consider: if the leak flow rate is equal to the inspiratory flow rate, there will be no volume delivered.

MATERIALS & METHODS

Patients belonging to ASA grade I and II, posted for elective laparoscopic total abdominal hysterectomy under general anaesthesia at KLE's Dr. Prabhakar Kore charitable Hospital And Medical Research Centre, Nehru Nagar, Belagavi -10 during the period from January 2021 to December 2021.

a) Study design:

A One Year Hospital Based randomized control trial.

b) Sample size:

Total sample size:56

c) Sample size calculation:

The prevalence rate-based formula for the minimal sample size is

$$\text{Finite population: } n' = \frac{n}{1+\frac{z^2\times\hat{p}(1-\hat{p}}{\varepsilon^2 N}}$$

Total number of recruits is 56

where P is the prevalence percentage and d is the likelihood of the prevalence difference in percentage.

z_α is linked with the level of significance. For 5% level of the significance $z\alpha = 1.96$.

P.05 error=10% n=500,confidence level 95% margin of error 10% Population proportion 80% Population size=500

Ref:

With P = 59.8% and d = 20% of P, the sample size is 56

d) Place:

KLES Dr. Prabhakar Kores Hospital and Medical Research Centre, Jawaharlal Nehru Medical College, Belagavi.

e) Selection Criteria:

Inclusion Criteria:

1) Informed written Consent

2) Age between 20 and 60 years.

3) ASA status I and II.

4) Patients Undergoing laparoscopic abdominal hysterectomy surgery under general anaesthesia.

Exclusion Criteria:

1) Difficult airways

2) Intracranial pathology

3) Severe obstructive pulmonary disease

4) Uncontrolled Asthma.

5) Any patients contraindicated in regional anaesthesia.

METHODOLOGY

Written informed consent will be sought at the preanaesthetic check-up after receiving clearance from the institutional ethical committee. A thorough preanaesthetic evaluation is done. Patients are kept Nil per oral 8hrs before surgery

On day of surgery, 18G / 20G IV cannula will be secured.

After taking the patients to operation theatre, all standard monitors will be attached.Baseline electrocardiograms, heart rates, mean arterial pressure readings, and saturation will all be recorded in the operating room. All patients will receive preloaded lactated Ringer's solution 20 ml/kg after an intravenous access has been established. In the L3-L4 interspace, SA will be administered while the patient is seated using a 27 G Whitacre needle and 3.5 cc of 0.5% heavy bupivacaine solution.Patients immediately after being made supine, a pin prick test will be used to determine when sensory anaesthesia began. General anesthesia is administered at least 15minutes after spinal anaesthesia when patient is stable haemodynamically.

Patients will be premedicated with Glycopyrolate 0.005mg/kg, Inj Midazolam 0.05mg/kg and Inj fentanyl 1-2 mcg/kg

Induction of anaesthesia will be carried out with IV Thiopentone sodium 5 mg/kg and IV Atracurium 0.5 mg/kg after 3 minutes of pre-oxygenation with 100% oxygen. The trachea will then be secured with an appropriate size endo-tracheal tube, and a nasogastric tube will be inserted to decompress the stomach. Two groups of patients were randomly allocated (VC or PC ventilation). In both groups, the initial tidal volume setting is 10ml/kg. In the PCV group, the ventilator's settings will be changed until the target tidal volume is reached (a fluctuation of 5% is acceptable). A PEEP of 5 cmH2O was used, and both groups had the same ratio of inspiratory to expiratory time (1:2) and Fraction of inspired oxygen (0.5).Variations in respiratory rate as well as tidal volume were allowed to maintain normocapnia (end-tidal carbon dioxide 30–40mmHg).. The FiO2 will be titrated from 0.5 to maintain Saturation more than 97%. Once the pneumoperitoneum achieved following settings are set VCV: tidal volume=7ml/kg or 350ml PCV: pressure set so that tidal volume=7ml/kg or 350mlRR=20/min, I:E=1:2,FiO2=0.5,PEEP=5cm H2O in order to avoid barotrauma and volutrauma to the lungs. Operation is carried out in steep head low with trendelenburg position till uterus is freed in the abdomen. The pressure changes in the airway related to trendelenburg position noted.

Anaesthesia will be maintained with low flow mixture of O_2 and N2O, along with 0.2% to 0.4% isoflurane.In order to keep the patient's heart rate and blood pressure within 20% of baseline, the anaesthetist will give them medications and fluids as clinically necessary.

At the aforementioned measurement periods, data collection is carried out:

Time 1 (T1): Post induction- supine position .

Time 2 (T2): In lithotomy position.

Time 3 (T3): Immediately After pneumoperitoneum.

Time 4 (T4): After Trendelenburg position with pneumoperitoneum.

Time 5(T5): 15 minutes after Trendelenburg position and pneumoperitoneum.

Ventilatory parameters, such as

1)peak airway pressure (PAP)

2) plateau pressure (P plateau)

3)tidal volume

4) et-CO 2

Hemodynamic parameters like

1)oxygen saturation (SpO_2)

2) Heart rate (HR)

3) MAP

Patient will be transferred to the post-anaesthetic recovery room after surgery.

STATISTICAL ANALYSIS

The study's main objective is to compare the two groups. We will compute the mean and standard deviation for the continuous quantitative data. The appropriate statistical methods, such as unpaired students t tests, used to compare the intergroup continuous variables. Using the students' paired t test, three quantitative variables within a group will be compared. Median will be used to represent discrete variables. The comparison will be shown using the appropriate graphs.The categorical data will be expressed in rates, ratios, and percentages. The association between the outcome's clinical and demographic characteristics will be investigated using the chi-square test or fisher's exact test.

A value of p less than 5% (0.05) will be regarded as significant for all tests.

RESULTS

The present study was conducted for comparing the efficacy of VCV mode and PCV mode in laparoscopic hysterectomy.

56 patients were recruited for the study, keeping in mind the inclusion and the exclusion criteria. 28 patients in volume control group (VC) and 28 patients in pressure control group (PC).

We observed the respiratory and haemodynamic parameters in five different time periods.

Time 1 (T1): Post induction-supine position.

Time 2 (T2): In lithotomy position.

Time 3 (T3): Immediately After pneumoperitoneum.

Time 4 (T4): After trendelenburg position with pneumoperitoneum.

Time 5 (T5): 15 min after positioning.

Intergroup comparison.

In the following tables intergroup comparison was done using Students unpaired t test.

Abbreviations:

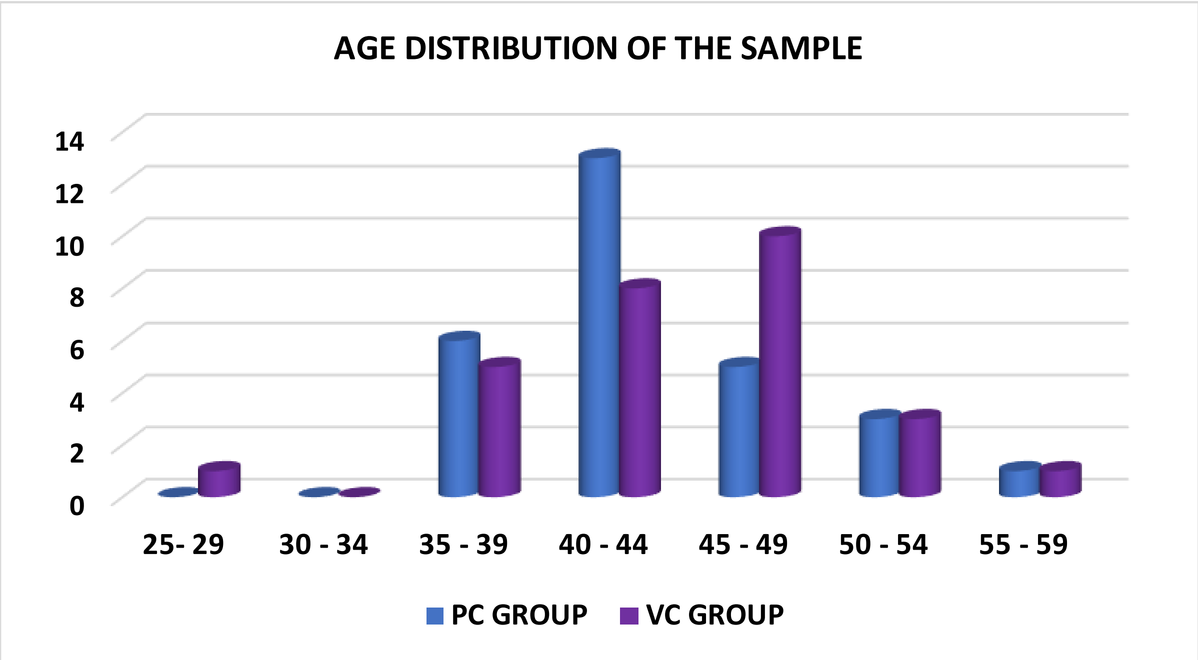
NS:- Not Significant, S:- Very Significant, VS:- Very Significant, HS:- Highly Significant

DEMOGRAPHIC DATA

Table 1 : Age

	PC GROUP		VC GROUP	
AGE	**NUMBER**	**%**	**NUMBER**	**%**
25- 29	0	0.00	1	3.57
30 - 34	0	0.00	0	0.00
35 - 39	6	21.43	5	17.86
40 - 44	13	46.43	8	28.57
45 - 49	5	17.86	10	35.71
50 - 54	3	10.71	3	10.71
55 - 59	1	3.57	1	3.57
TOTAL	28	100.00	28	100.00

Graph 1



Above graph depicts age group of patients involved in this study, in which more patients belonging to 40 to 49 years age.

	PC GROUP				VC GROUP					
	MEAN	S.D.	MIN	MAX	MEAN	S.D.	MIN	MAX	p VALUE	INFERENCE
AGE	43.68	5.14	36	55	43.61	6.01	25	58	0.9621	NS

In this study analysis, no statistically significant variation in mean age between volume control and pressure control group (43.68 and 43.61 respectively).

The p value (0.9621) is calculated using student's unpaired t test.

Table 2 : Peak Airway Pressure

	PC GROUP				VC GROUP					
	MEAN	S.D.	MIN	MAX	MEAN	S.D.	MIN	'MAX'	p VALUE	INFERENCE
T1	17.75	3.10	12	22	20.79	3.83	14	28	0.0019	VS
T2	18.04	2.89	12	22	21.14	3.24	15	26	0.0004	HS
T3	20.39	3.10	15	25	25.32	4.06	18	36	<0.0001	HS
T4	21.50	3.02	16	28	26.11	3.87	19	36	<0.0001	HS
T5	21.36	2.42	16	26	26.00	4.11	17	35	<0.0001	HS

The p value for PAP was compared using student's unpaired t test. The mean PAP at time T1 was 17.75 in PC group and 20.79 in VC group which shows statistically very significant with p-value 0.0019.

The mean PAP at T2, T3, T4 and T5 was 18.04,20.39,21.50 and 21.36 respectively in PC group and 21.14,25.32,26.11 and 26.00 respectively in VC group, which is statistically highly significant with increase PAP in VC group.

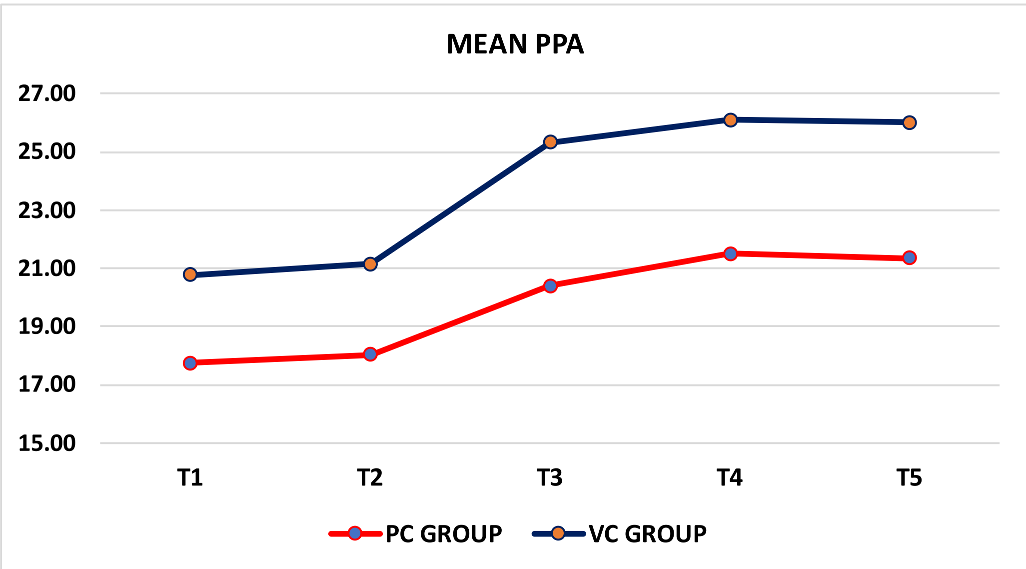
FOR COMPARING THE MEANS WITHIN A GROUP (INTRA GROUP COMPARISON) STUDENTS PAIRED t TEST IS USED.

	PC GROUP					
	MEAN	S.D.	MIN	MAX	p VALUE	INFERENCE
T1	17.75	3.10	12	22	--	--
T2	18.04	2.89	12	22	0.3612	NS
T3	20.39	3.10	15	25	0.0012	VS
T4	21.50	3.02	16	28	< 0.0001	HS
T5	21.36	2.42	16	26	< 0.0001	HS

In the intra group comparison in PC group the p value in T3 was 0.0012 which is very significant. P value in T4 and T5 was <0.0001 which was highly significant.

	VC GROUP					
	MEAN	S.D.	MIN	MAX	p VALUE	INFERENCE
T1	20.79	3.83	14	28	--	--
T2	21.14	3.24	15	26	0.3540	NS
T3	25.32	4.06	18	36	< 0.0001	HS
T4	26.11	3.87	19	36	< 0.0001	HS
T5	26.00	4.11	17	35	< 0.0001	HS

In the intra group comparison in VC group the p value in T3,T4 and T5 was <0.0001 which was highly significant.



The above graph depicts the PAP in two modes of ventilation PC and VC. The PAP was found to be more in VC mode ventilation in all time periods.

Table: 3 Plateau Pressure

FOR P PLATO:

	PC GROUP				VC GROUP					
	MEAN	S.D.	MIN	MAX	MEAN	S.D.	MIN	MAX	p VALUE	INFERENCE
T1	17.54	3.02	12	22	19.54	3.67	12	26	0.0302	S
T2	17.82	3.80	11	30	19.86	3.41	13	25	0.0395	S
T3	20.46	3.94	15	31	23.89	3.77	16	33	0.0016	VS
T4	21.04	3.39	15	30	24.64	3.76	18	34	0.0004	HS
T5	20.89	2.59	16	26	24.46	4.20	14	33	0.0003	HS

Mean Plateau pressure in VC mode is found to be more in all time periods with p value highly significant in T4 and T5.

INTRA GROUP COMPARISON

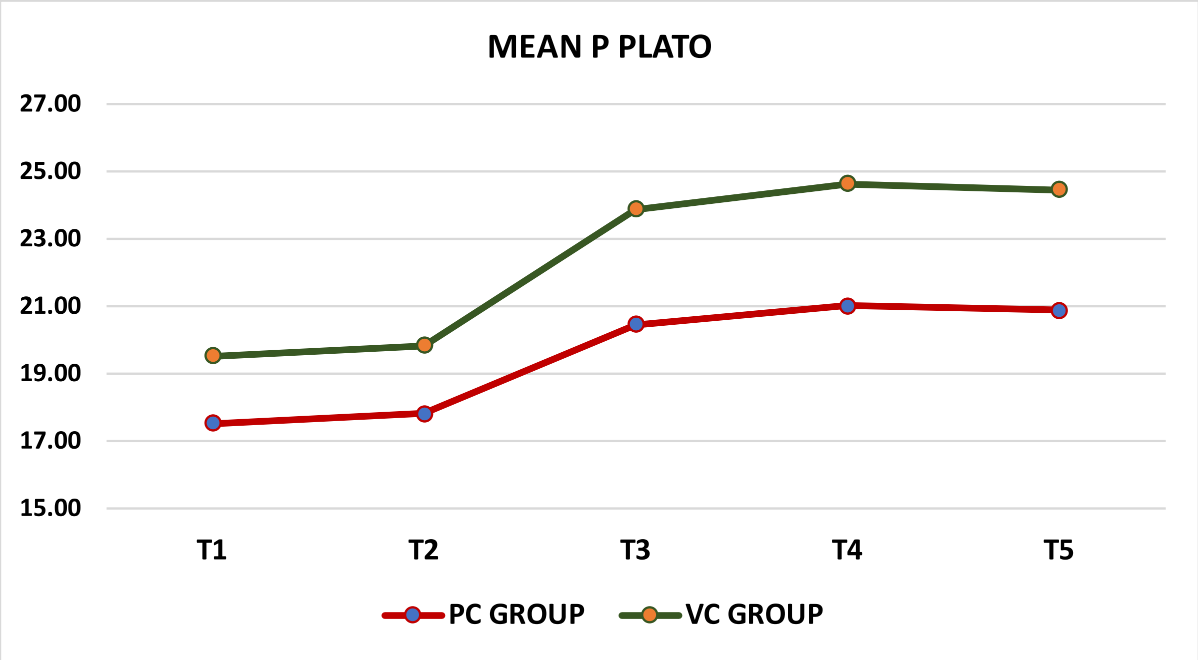
	PC GROUP					
	MEAN	S.D.	MIN	MAX	p VALUE	INFERENCE
T1	17.54	3.02	12	22	--	--
T2	17.82	3.80	11	30	0.3784	NS
T3	20.46	3.94	15	31	0.0014	VS
T4	21.04	3.39	15	30	0.0001	HS
T5	20.89	2.59	16	26	<0.0001	HS

Mean P plateau was more in T4 with p value 0.0001 which is highly significant.

	VC GROUP					
	MEAN	S.D.	MIN	MAX	p VALUE	INFERENCE
T1	19.54	3.67	12	26	--	--
T2	19.86	3.41	13	25	0.3677	NS
T3	23.89	3.77	16	33	< 0.0001	HS
T4	24.64	3.76	18	34	< 0.0001	HS
T5	24.46	4.20	14	33	< 0.0001	HS

Mean P plateau was more in T4 with p value <0.0001 which is highly significant.

Graph 2



The above graph depicts the plateau pressure in two modes of ventilation in different time periods which is found to be more in volume control ventilation.

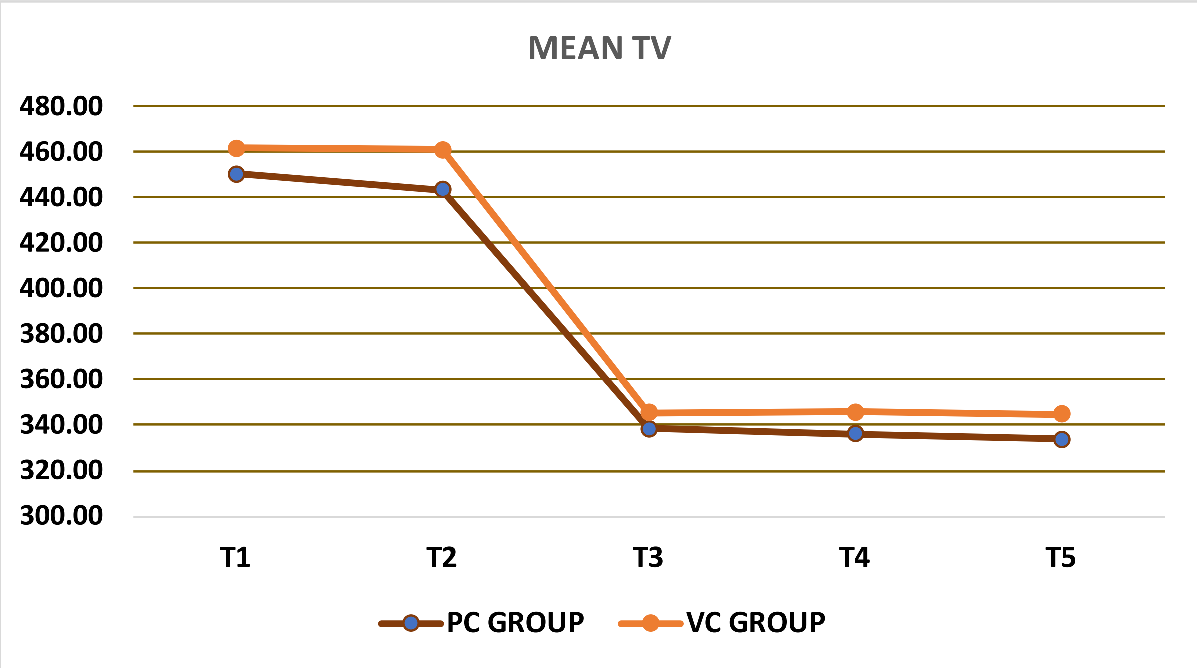
Table: 3 Tidal Volume

FOR TV:

	PC GROUP				VC GROUP					
	MEAN	**S.D.**	**MIN**	**MAX**	**MEAN**	**S.D.**	**MIN**	**MAX**	**p-VALUE**	**INFERENCE**
T1	450.46	37.80	360	557	461.79	26.36	404	500	0.1991	NS
T2	443.57	29.21	380	522	461.00	27.37	397	500	0.0251	S
T3	338.39	13.33	310	370	345.46	11.91	303	350	0.0411	S
T4	336.29	14.26	301	371	345.75	10.21	315	350	0.0061	VS
T5	333.86	12.84	300	360	344.96	9.37	320	350	0.0005	HS

Tidal volume was found to be more in VC mode in all time periods but a difference of 5% was acceptable in our study.

Graph: 3



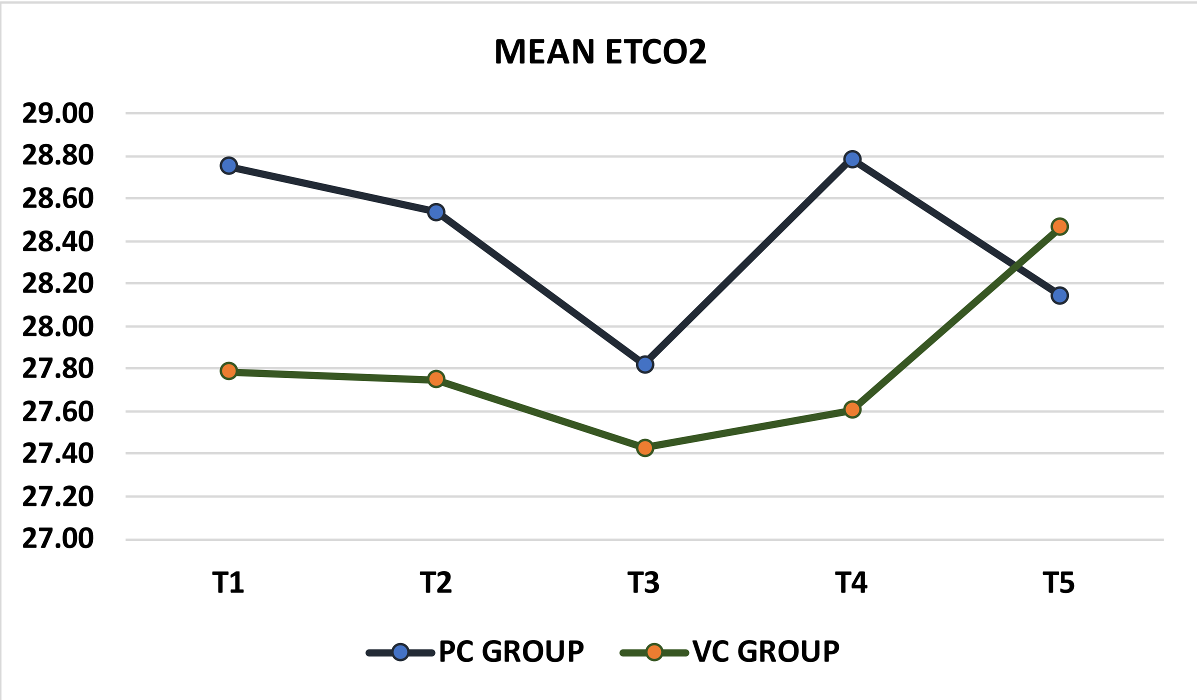
Above graph depicts the tidal volume in two modes od ventilation in different time periods.

Table:4 EtCo2

	PC GROUP				VC GROUP					
	MEAN	S.D.	MIN	MAX	MEAN	S.D.	MIN	MAX	p-VALUE	INFERENCE
T1	28.75	3.17	22	35	27.79	4.53	15	42	0.3603	NS
T2	28.54	3.06	21	34	27.75	4.48	15	41	0.4467	NS
T3	27.82	3.01	17	32	27.43	4.35	16	40	0.6958	NS
T4	28.79	2.39	25	34	27.61	4.49	18	42	0.2258	NS
T5	28.14	2.21	22	32	28.46	4.42	22	42	0.7319	NS

Comparison of two groups have shown no statistical significance.

Graph: 4



Above graph depicts EtCo2 in two modes of ventilation in different time period.

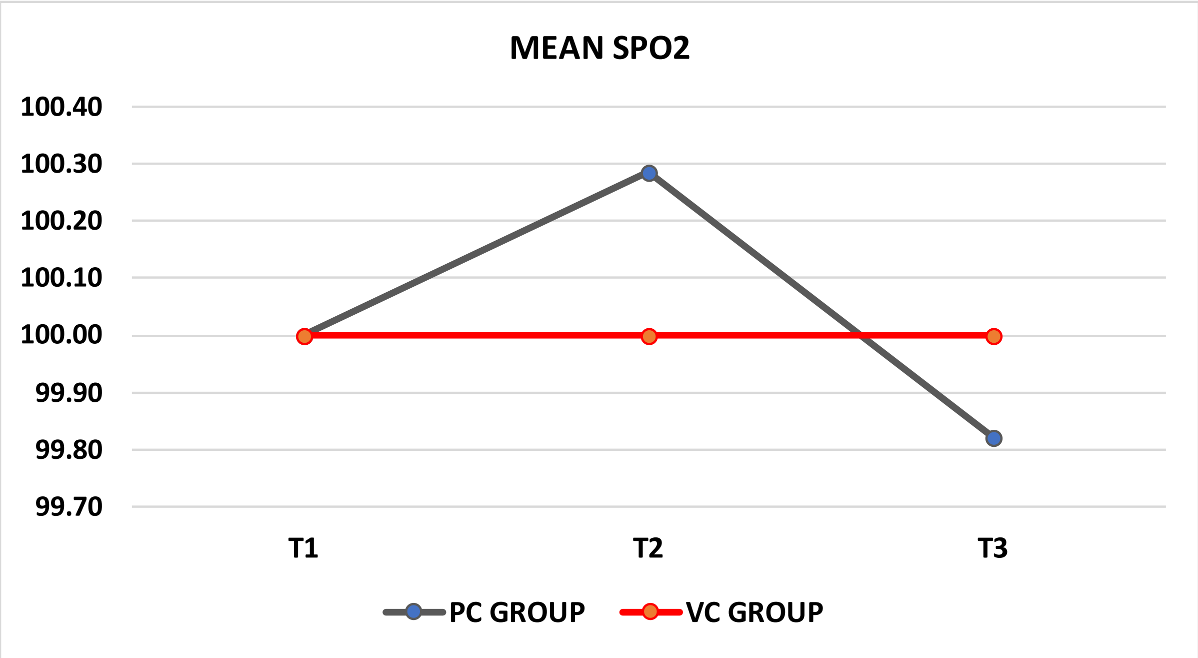
FOR SPO2:

	PC GROUP				VC GROUP					
	MEAN	S.D.	MIN	MAX	MEAN	S.D.	MIN	MAX	p-VALUE	INFERENCE
T1	100.00	0.00	100	100	100.00	0.00	100	100	--	--
T2	100.29	1.51	100	108	100.00	0.00	100	100	0.3218	NS
T3	99.82	0.94	95	100	100.00	0.00	100	100	0.3218	NS
T4	100.00	0.00	100	100	100.00	0.00	100	100	--	--
T5	99.25	3.97	79	100	100.00	0.00	100	100	0.3218	NS

Table: 5 Saturation.

SPO2 in the two groups during the various time periods does not differ statistically significantly from one another.

Graph: 5



The above graph depicts the SPO2 in different time periods in VC and PC modes of ventilation.

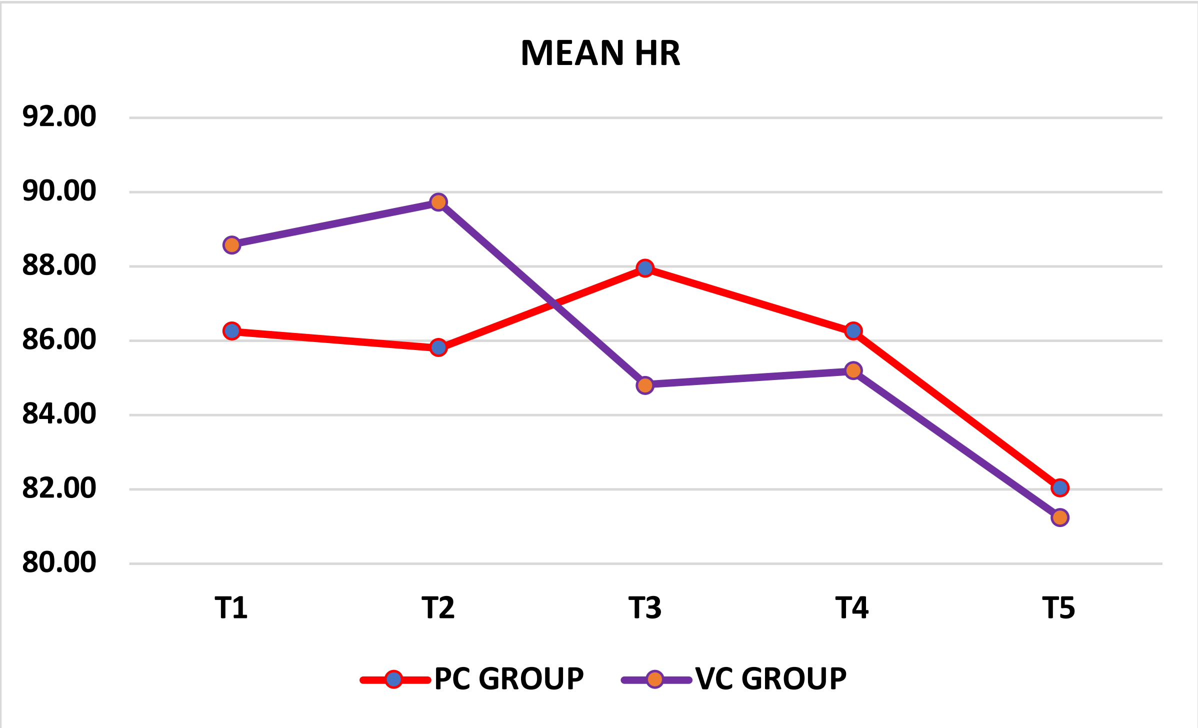
Table: 6 Heart Rate

FOR HR:

	PC GROUP				VC GROUP					
	MEAN	S.D.	MIN	MAX	MEAN	S.D.	MIN	MAX	p VALUE	INFERENCE
T1	86.25	12.02	63	122	88.57	13.19	68	113	0.4942	NS
T2	85.79	11.90	58	112	89.71	13.04	68	115	0.2441	NS
T3	87.93	10.93	69	110	84.79	11.96	64	116	0.3092	NS
T4	86.25	9.70	66	103	85.18	12.26	62	108	0.7183	NS
T5	82.04	9.70	55	98	81.25	13.31	58	107	0.8017	NS

There is no statistically significant difference in heart rate between two groups.

Graph: 6



FOR MAP:

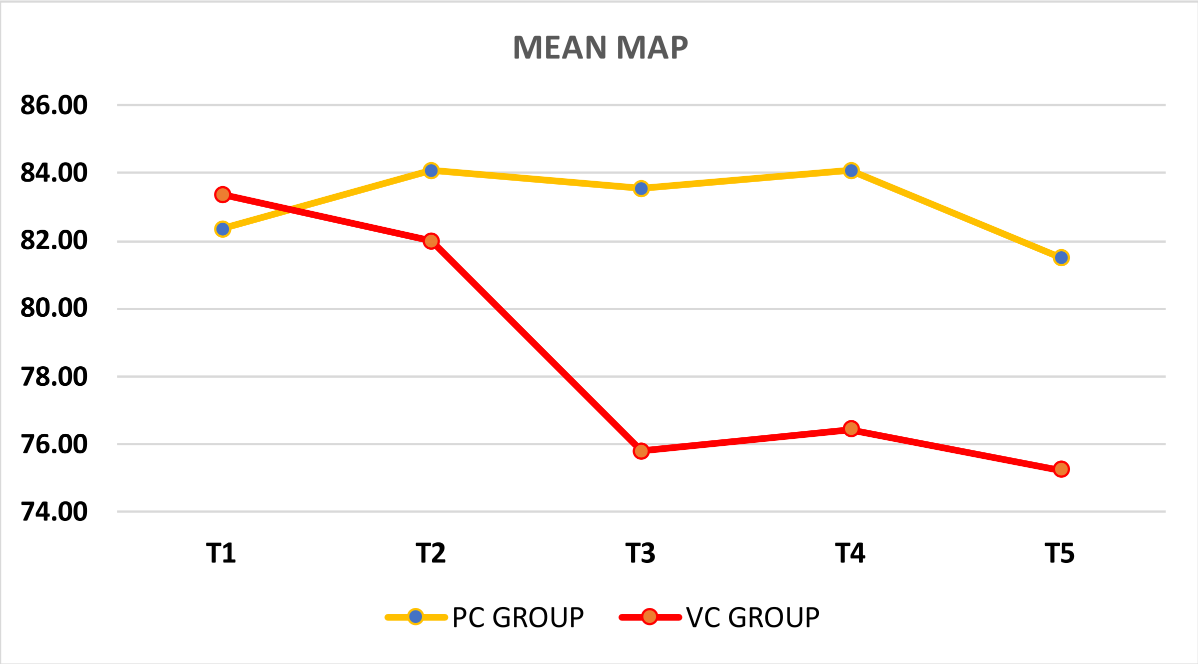
	PC GROUP				VC GROUP					
	MEAN	S.D.	MIN	MAX	MEAN	S.D.	MIN	MAX	p VALUE	INFERENCE
T1	82.36	9.22	57	98	83.36	14.87	62	111	0.7635	NS
T2	84.07	8.06	66	96	82.00	11.81	62	108	0.4467	NS
T3	83.54	9.68	63	98	75.79	10.65	58	93	0.0062	VS
T4	84.07	7.63	67	98	76.43	7.24	63	89	0.0003	HS
T5	81.50	8.17	65	96	75.25	7.19	64	94	0.0037	VS

The above graph depicts the heart rate of patient in VC and PC mode of ventilation.

Table: 7 Mean Arterial Pressure

Mean arterial pressure is found to be more in PC mode ventilation in time periods T2, T3, T4 and T5. MAP is statistically very significant in T3 and T5 with p value 0.0062 and 0.0037 and highly significant in T4 with p value 0.0003.

Graph: 7



The above graph depicts the MAP in VC and PC mode ventilation which is found to be more in PC group in T2, T3, T4 and T5.

DISCUSSION

Laparoscopic gynaecological surgeries are conducted under general anaesthesia for patients in the Trendelenburg position using mechanical ventilation and CO2 pneumoperitoneum. However, the Trendelenburg posture and CO2 pneumoperitoneum have been shown to enhance the likelihood of postoperative pulmonary problems.

Furthermore, after general anaesthesia, patients with normal lungs could conceivably develop ventilator induced lung injury (VILI) with improper mechanical ventilation settings [18][19]. It is crucial for anaesthesiologists to use the best lung-protective ventilation strategies during laparoscopic surgery with Trendelenburg position in order to lessen lung damage and reduce the post operative respiratory complications [9][20].

In recent years, laparoscopic gynaecologic surgery has become more common.Because VCV keeps an adequate tidal volume and effectively eliminates CO2, most anaesthesiologists are more familiar with it, VCV is typically used without considering alternative ventilation modes. When CO2 cannot be removed efficiently even with increased respiratory rate and increased tidal volume, which may lead to a higher peak airway pressure and decrease in mean airway pressure [10].

In this Randomized control trial, we compared PCV mode and VCV mode ventilation. Compared to other which involved both male and female patients, our study involved only female patients posted for total laparoscopic hysterectomy. When in pneumoperitoneum in Trendelenburg position, we saw that PCV maintained sufficient ventilation with decreased peak airway pressures and greater lung compliance.

The present randomized clinical study was conducted in 56 patients posted for total laparoscopic hysterectomy under general anaesthesia at KLE'S Dr. Prabhakar Kore Hospital and Medical Research Centre Nehru Nagar, Belagavi. Patients of ASA I and II aged between 20 and 60 years who were divided into two groups VC and PC by computer generated randomization table.

Peak airway pressures, plateau pressure and haemodynamic parameters were assessed during various time intervals after combined spinal and general anaesthesia.

Time 1 (T1): Post induction-supine position.

Time 2 (T2): In lithotomy position.

Time 3 (T3): Immediately after pneumoperitoneum.

Time 4 (T4): After trendelenburg position with pneumoperitoneum.

Time 5 (T5): 15 minutes after lithotomy, pneumoperitoneum and trendelenburg position.

According to our research on the age factor, the majority of patients in VC group and PC group, respectively, are 43.61 and 43.68 years old. P value (0.9621) was not statistically significant.

In group VC 82.14% patients were ASA grade I and 17.86% were ASA grade II. In group PC 85.71% patients were ASA grade I while 14.29% were ASA grade II. Both the groups had similar demographic characteristics. No statistical significance found when we compared with student`s unpaired t test.

Age of the patients enrolled in the study was compared, no statistically significant variation in mean age between volume control and pressure control group (43.68 and 43.61 respectively).

EtCo2 was compared, increased EtCo2 was noted in T4 in PC mode (mean 28.79) and T5 in VC mode (mean 28.45).[21]There was no statistically significant difference between two groups in all five time periods.

When heart rate was compared, increased heart rate in PC mode was noted in T3(mean87.93) and in VC mode in T2(mean 89.7) but there was no statistically significant difference between both groups.

There is no statistically significant difference in mean SpO2 between the two groups.
The tidal volume generated in PC group and tidal volume kept in VC group was also compared. A difference of 5% with permissible leak was accepted in our study. It was found that mean TV at T1 in PC was 450.46 and in VC 461.79 which was found to be statistically not significant. At T2 time period mean TV in PC was 443.57 and in VC 461 which has statistical significance with p-value 0.0251. At T3 mean TV in PC was 338.39 and in VC was 345.46 which has statistical significance with a p-value of 0.0411. At T4 mean TV in PC was 336.29 and in VC 345.75 which was statistically very significant with p-value of 0.0061. At T5 mean TV in PC was 333.86 and in VC 344.96 which was statistically highly significant with a p-value of 0.0005.

In our study mean TV was noted to be more in VC group than PC group, but 5% variation was accepted in our study and it came within that difference.

The mean arterial pressure (MAP) at T1 and T2 was statistically not significant, but it is noted that mean MAP in PC at T3 was 83.54 and in VC was 75.79 which was statistically very significant with p value 0.0062. At T4 mean MAP in PC was 84.07 and in VC 76.43 which was statistically highly significant with p value 0.0003 and at T5 MAP in PC was 81.50 and in VC 75.25 which was statistically very significant with p-value 0.0037. Other research with similar findings regarding higher MAP in PC ventilation compared to VC ventilation were also observed. [14]

Coming to airway changes, we have studied Peak airway pressure (PAP) changes in various time periods that is T1, T2, T3, T4 and T5 as explained in the methodology. Both PCV and VCV groups received subarachnoid block with 3.5 ml of bupivacaine heavy in order to achieve good relaxation and post operative analgesia.

Coming to T1 that is immediately after completion of general anaesthesia procedure we found that mean of PAP at T1 in PC group was 17.75 and in VC group was 20.79 which has come statistically very significant with p value 0.0019. In some studies, comparing VCV and PCV-VG they have found that there is no statistically significant difference in peak inspiratory pressure between two modes of ventilation after the induction of GA before pneumoperitoneum.[7] [22]

In time period T2 that is in lithotomy position, the mean of PAP in PC group was 18.04 and in VC group was 21.14 which is statistically highly significant (p-value 0.0004).

In time period T3 that is after pneumoperitoneum, the mean of PAP in PC was 20.39 and in VC was 25.32 which is statistically highly- significant with p-value of <0.0001. Similar results like our study are observed after pneumoperitoneum in other studies.[13][23]

In time period T4 that is in Trendelenburg position the mean of PAP in PC is 21.50 and in VC is 26.11 which is statistically highly significant with p value <0.0001. Comparable results are observed in Trendelenburg position in other studies which substantiate the current result[8].

In time period T5 that is 15 min after the Trendelenburg position the mean of PAP in PC mode was 21.36 and in VC mode was 26.0 which is statistically highly significant with p-value <0.0001. In some other studies peak airway pressure was more in VCV mode 30min and 60min after pneumoperitoneum in trendelenburg position.[7][24]

Hence, in our study we found that PAP is high in volume control mode of ventilation than pressure control mode in all the time intervals.

In the intra group comparison of PAP in PC group, it is found that more PAP was found in T4 time with mean of 21.50 which was statistically highly significant with p-value <0.0001.
In intragroup comparison in VC group PAP was found to be more in T4 time period with mean 26.11 which was statistically highly significant with p-value <0.0001.

When doing Trendelenburg position robot-assisted laparoscopic gynaecologic surgery, PCV and PCV-VG offered lower P peak, higher P mean, and enhanced dynamic compliance [8][25]. In our study we also got the same result, the peak airway pressure was more in VC mode compared to PC mode. The time period of measuring the airway pressures was different in two studies which substantiate the fact that peak airway pressure is reduced in PC mode ventilation throughout the intraoperative period.[26][27]

When plateau pressure was compared it was found that mean plateau pressure at T1 in PC group was 17.54 and in VC group was 19.54 which has statistical significance with p value 0.0302 and in T2 mean in PC was 17.82 and in VC was 19.86 which was statistically significant with p-value 0.0395. At T3 mean in PC was 20.46 and in VC mean was 23.89 which was very significant statistically with p value 0.0016. At T4 and T5 mean in PC was 21.04 and 20.89, in VC 24.64 and 24.46 respectively which was statistically highly significant with p-value 0.0004 and 0.0003 respectively.

In our study we found that plateau pressure was more in VC group in all fivetime intervals.
In the intra group comparison of plateau pressure in PC group, it is found that more plateau pressure was found in T4 interval with mean of 21.04 which was statistically highly significant with p value 0.0001.

In the intra group comparison of plateau pressure in VC group, it is found that more plateau pressure was found in T4 time with mean of 24.64 which was found to be statistically highly significant with p-value <0.0001.

The plateau pressure increases in trendelenburg position compared to supine position in patients undergoing surgery in general anaesthesia[12]. In our study we found that plateau pressure was more in T4 compared to T3 in both VC and PC mode, and we also found that plateau pressure was more in VC mode compared to PC mode.

LIMITATION OF THE STUDY

Patients included in our study doesn’t have any underlying cardiac or pulmonary diseases which may can alter the results. So our result may not be applicable to population with underlying cardiac or pulmonary diseases.

CONCLUSION

So we found in our study that pressure control ventilation is the better lung protective mode of ventilation compared to volume control ventilation in patients undergoing laparoscopic hysterectomy surgeries.

SUMMARY

The present study was conducted in the Department of Anaesthesiology, KLES Dr. Prabhakar Kore Hospital and MRC, Nehru Nagar, Belagavi after getting approval from institutional ethics committee and written informed consent.

Total laparoscopic hysterectomy was performed on 56 patients with an ASA I or II between the ages of 20 and 60 under combined spinal and general anaesthesia. Thorough pre anaesthetic evaluation was done. Computer generated randomization table was used to allocate the patients into 2 groups (VC and PC).In both groups, the tidal volume is initially fixed at 10 ml/kg. In the PCV group, the ventilator will be adjusted so that the pre-set pressure reached the target tidal volume (a fluctuation of 5% will be permitted). Both groups had the same ratio of inspiratory to expiratory time (1:2) and FiO_2 (0.5), and all patients received a positive end-expiratory pressure (PEEP) of 5 cmH_2O. To maintain normocapnia (end-tidal carbon dioxide levels of 30–40 mmHg), variations in respiratory rate and tidal volume were permitted. To keep SpO_2 over 97%, the FiO_2 will be titrated higher from 0.5 as needed. Following parameters are set in the VCV once pneumoperitoneum has been achieved: tidal volume=7ml/kg or 350ml. In PCV: pressure set so that tidal volume=7ml/kg or 350mlRR=20/min, I:E=1:2,FiO_2=0.5,PEEP=5cm H_2O.

Peak airway pressure and other haemodynamic changes are recorded in following time periods

Time 1 (T1): Post induction-supine position.

Time 2 (T2): In lithotomy position.

Time 3 (T3): Immediately after pneumoperitoneum.

Time 4 (T4): After trendelenburg position with pneumoperitoneum.

Time 5 (T5): 15 minutes after lithotomy, pneumoperitoneum and trendelenburg position.

The PAP was found to be less in PC group compared to VC group in all time periods T1,T2,T3,T4 and T5 with p value significant in T1 and T2 , very significant in T3 and highly significant in T4 and T5.

Plateau pressure was found to be less in PC group in all the time periods T1,T2,T3,T4 and T5 with p value significant in T1 and T2 , very significant in T3 and highly significant in T4 and T5.

There is no statistically significant change in the SpO2,HR and EtCo2 in both the groups in all the time periods.

MAP was found to be more in VC group than in PC group in T1 with mean of 82.36 in PC group and 83.36 in VC group which was statistically not significant with p-value 0.7635. But in other time periods mean MAP is found to be more in PC group which was statistically not significant in T2 with p value 0.4467, very significant in T3 and T5 with p-value 0.0062 and 0.0037 respectively and highly significant in T4 with p value 0.0003.

Thus based on the result we concluded that pressure control ventilation was beneficial in maintaining adequate intra operative respiratory mechanics and oxygen parameters in patients undergoing total laparoscopic hysterectomy under combined spinal and general anaesthesia.

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ANNEXURE I - INFORMED CONSENT FOR PARTICIPATION IN RESEARCH STUDY

Mr./Mrs.______________________________ we are requesting you to enroll in study titled "STUDY OF AIRWAY PRESSURE CHANGES IN VOLUME CONTROLLED VENTILATION AND PRESSURE CONTROLLED VENTILATION IN PATIENT UNDERGOING LAPAROSCOPIC HYSTERECTOMY" AT Dr. Prabhakar Kore Charitable Hospital, Belagavi, 590010." conducted by REG NO : BA0120013 Post Graduate in M.D. Anaesthesiology under the guidance of Dr. ____________________ Professor, Department of Anaesthesiology, J.N. Medical College, Belagavi under KLE University, Belagavi.

Respected Sir/Madam We request you to participate in our study as he/she is eligible for participating in the study. During the study you will be asked some questions regarding the present complaints that you are having.

Your participation in this research is voluntary. Your decision whether or not to participate in the study will not affect your relationship with J.N. Medical College. If you decide to participate you are free to withdraw at any time.

Purpose of the study:

- The purpose of research is to compare the effectiveness of VCV and PCV to maintain adequate peak inspiratory pressure in patients who underwent laparoscopic hysterectomy in the Trendelenburg position.

Procedure Involved:

If you agree to enroll in my study, I will ask you the present and past medical history and family history. Then you will be clinically examined in detail. Spinal anaesthesia and General anaesthesia will be given by senior anaesthesiologist and each patient is randomly assigned to one of two groups of ventilation modes (PCV or VCV) in the same anaesthesia machine and will be monitored throughout the procedure.

Voluntary Participation/Withdrawal:

Taking part in the study is voluntary. You may choose not to enroll in this study. Your decision will not change present or future health care services offered to you or your ward at K.L.E. S Hospital & MRC

Alternatives: Even if you decline the participation in the study, your ward will get the routine line of management.

Privacy and Confidentiality: The only people to know that you are a research subject is you and the members of the research team. No information provided by you during the research will be disclosed to other without your written permission except:

- In emergency to protect your rights and welfare.
- If required by law.

Authorization to Publish Results:

When the results of the research are published or discussed, in a conference, no information will be displayed that would disclose your identity. Any information that is obtained in connection with this study and that can be identified with your identity remaining confidential.

Financial Incentives for participation: No financial incentives are being offered to enrolled patients. It is purely being done with the idea of research and all the cost of the study will be borne by the investigator.

Compensation: In the event of injury related to the study, treatment will be made available through KLES Hospital and MRC, Belagavi. There is no compensation or payment for such medical treatment by law. If you get injured you may contact REG NO : BA0120013 at Department of Anaesthesiology, KLES Hospital and MRC.

Questions: In case you have any questions related to the study, in future or in case of study related injury or illness, you can contact REG NO : BA0120013, Department of Anaesthesiology, KLES Hospital and MRC, Belagavi phone no: 9526240025 or Dr. _______________________., Professor, Dept. Of Anaesthesiology, KLES Hospital and MRC, Belagavi ph. no :9886375154.

If you have any queries about your rights as a study subject, you may call **DR. HARSHA HEGDE M.D** chairperson, J.N. medical college, IEC & scientist department, icmr, national institute of traditional medicine, Belagavi - 9480422500.

Informed Consent for participation in research trial

"STUDY OF AIRWAY PRESSURE CHANGES IN VOLUME CONTROLLED VENTILATION AND PRESSURE CONTROLLED VENTILATION IN PATIENT UNDERGOING LAPAROSCOPIC HYSTERECTOMY." at Dr. Prabhakar Kore Charitable Hospital, Belagavi, 590010."

I, Mr. /Mrs. ______________________________ voluntarily agree for the participation of my ward as a subject of study. By signing this consent form, I am not giving up any of my legal rights, I may withdraw my ward from the study anytime. I am signing the consent form after having read or been read for me in vernacular language, including the risks and the benefits and having all my questions answered.

Subject Name: ____________________

Guardian Name: ____________________

Signature or the Left Thumb Print

of Guardian: _____________________

Date:

Witness Name: _________________ Signature: ______________

Investigators Name: ______________ Signature:______________

Date:

Place : ______________

ANNEXURE II-PROFORMA

Title: "STUDY OF AIRWAY PRESSURE CHANGES IN VOLUME CONTROLLED VENTILATION AND PRESSURE CONTROLLED VENTILATION IN PATIENT UNDERGOING LAPAROSCOPIC HYSTERECTOMY."AT Dr. Prabhakar Kore Charitable Hospital, Belagavi, 590010.**"**

Patients Name : I.P No. :

Age :

Date of operation :

Address : Anaesthesiologist :

Preanaesthetic evaluation

Chief complaints

Past History

- H/o recent upper respiratory infections
- H/o previous surgery/(s)

Family History

General physical examination

Weight (Kg): Pallor :

Cyanosis : Clubbing :

PR : RR :

Systemic examination

RS : CNS :

CVS : GIT :

Airway Assessment

Spine

Investigations

Hb (gm/dl): TLC: Platelet count:

Diagnosis

Proposed surgery

Preoperative physical status AMERICAN SOCIETY OF ANAESTHESIA

Grade I II

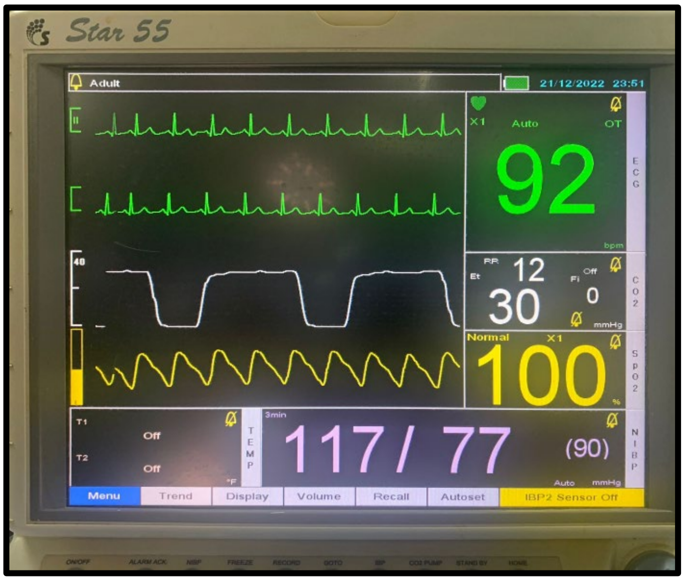
Mode of Ventilation:

	T1	T2	T3	T4	T5
PAP					
P plateau					
TV					
EtCo2					
SATURATION					
HR					
MAP					

ANNEXUREIII- PHOTOGRAPHS

PHOTOGRAPH I- VCV

PHOTOGRAPH II- PCV

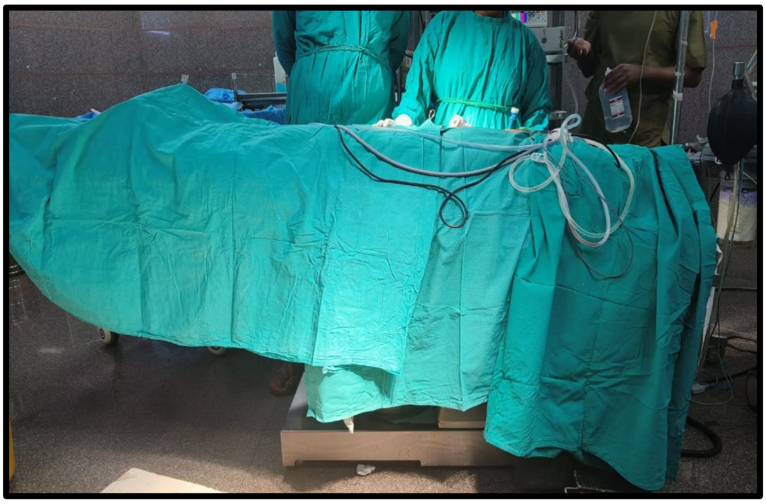


PHOTOGRAPH III- MONITOR

PHOTOGRAPH IV- AFTER INDUCTION OF GA

PHOTOGRAPH V- AFTER PNEUMOPERITONIUM

PHOTOGRAPH VI- LITHOTOMY POSITION



PHOTOGRAPH VII- TRENDELENBURG POSITION

ANNEXURE IV – MASTER CHART GROUP-VC

				T 1							T 2							T 3							T 4							T 5						
SL.NO	AGE	MPG	ASA	PAP	P PLAT0	TV	ETCO2	SPO2	HR	MAP	PAP	P PLAT0	TV	ETCO2	SPO2	HR	MAP	PAP	P PLAT0	TV	ETCO2	SPO2	HR	MAP	PAP	P PLAT0	TV	ETCO2	SPO2	HR	MAP	PAP	P PLAT0	TV	ETCO2	SPO2	HR	MAP
1	45	2	1	26	24	500	28	100	94	74	26	25	500	26	100	90	76	30	28	350	24	100	92	80	30	28	350	25	100	84	76	28	26	350	23	100	70	94
2	48	2	2	23	20	430	32	100	82	70	24	22	423	29	100	82	70	27	23	303	31	100	75	63	22	20	336	32	100	74	71	23	21	334	30	100	73	65
3	46	2	2	24	23	450	32	100	71	76	24	23	450	33	100	72	78	30	28	350	31	100	68	74	32	30	350	32	100	65	79	34	32	350	27	100	60	66
4	47	2	1	28	24	450	32	100	74	69	23	20	450	32	100	72	73	27	26	320	33	100	72	66	24	23	320	34	100	70	67	25	23	320	36	100	66	68
5	39	2	1	20	18	450	24	100	100	88	22	19	450	24	100	102	84	29	24	350	26	100	88	72	30	27	350	26	100	90	76	28	27	350	25	100	84	72
6	43	2	1	14	12	450	26	100	78	76	15	13	450	26	100	80	72	24	23	350	28	100	84	80	25	24	350	25	100	82	70	17	14	350	25	100	82	70
7	41	2	1	16	15	450	24	100	100	90	18	18	450	25	100	92	86	27	24	350	26	100	64	70	28	24	350	25	100	62	76	29	28	350	27	100	58	74
8	40	2	1	20	19	450	32	100	83	72	20	17	450	33	100	86	80	25	23	350	31	100	83	74	26	24	350	30	100	78	66	24	24	350	30	100	76	70
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11	45	2	2	18	16	500	30	100	78	66	17	15	500	30	100	76	66	22	20	350	31	100	82	62	21	19	350	32	100	88	64	21	19	350	33	100	86	79
12	58	2	2	25	22	500	27	100	84	64	26	25	500	27	100	75	62	36	33	350	23	100	75	64	36	34	350	24	100	85	73	35	33	350	25	100	82	80
13	47	2	2	16	15	450	28	100	75	76	17	17	450	27	100	84	84	22	20	350	33	100	90	88	20	18	350	29	100	92	85	18	15	350	26	100	82	76
14	41	2	1	22	20	500	15	100	113	78	22	17	500	15	100	112	78	23	23	350	16	100	108	79	24	23	350	18	100	108	79	30	26	350	32	100	94	86
15	46	2	1	22	21	440	30	100	95	98	22	22	442	30	100	90	88	27	26	330	32	100	98	93	27	26	315	28	100	86	80	27	26	325	25	100	76	74
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19	50	2	1	22	22	450	23	100	78	82	22	21	446	24	100	78	82	24	24	350	24	100	82	86	24	23	340	26	100	80	78	24	23	340	25	100	78	76
20	40	2	1	20	19	450	26	100	85	111	20	20	450	24	100	88	87	25	25	350	24	100	88	87	29	28	350	24	100	88	87	29	28	340	26	100	85	83
21	43	2	1	18	18	450	27	100	110	110	19	19	450	27	100	103	99	24	22	350	24	100	85	91	25	22	350	21	100	100	85	25	24	350	22	100	80	76
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25	39	2	1	17	15	500	29	100	108	110	17	16	500	29	100	115	108	18	18	350	27	100	89	64	23	22	350	30	100	106	81	24	22	350	32	100	107	80
26	45	2	1	26	26	450	30	100	106	100	25	24	450	31	100	110	98	28	28	350	27	100	92	80	30	30	350	28	100	90	84	28	26	350	34	100	106	82
27	38	2	1	24	24	450	25	100	76	78	24	24	450	24	100	86	84	26	25	350	27	100	76	86	26	25	350	28	100	84	80	25	25	340	26	100	82	74
28	40	2	1	25	24	450	24	100	74	76	25	25	450	26	100	88	86	25	24	350	26	100	78	88	24	23	350	26	100	86	84	25	24	350	28	100	80	76

MASTER CHART GROUP-PC

				T 1							T 2							T 3							T 4							T 5						
SN	AGE	MPG	ASA	PAP	P PLAT0	TV	ETCO2	SPO2	HR	MAP	PAP	P PLAT0	TV	ETCO2	SPO2	HR	MAP	PAP	P PLAT0	TV	ETCO2	SPO2	HR	MAP	PAP	P PLAT0	TV	ETCO2	SPO2	HR	MAP	PAP	P PLAT0	TV	ETCO2	SPO2	HR	MAP
1	39	2	1	13	13	480	28	2	63	73	13	13	416	30	100	84	74	16	16	334	31	100	84	74	22	21	336	32	100	88	80	20	20	338	31	100	86	76
2	43	2	2	20	19	557	32	100	85	75	20	19	522	33	100	72	66	24	24	355	30	100	73	63	26	26	346	34	100	66	84	26	26	353	32	100	67	80
3	51	2	2	15	15	370	34	100	100	57	17	17	380	34	100	58	22	22	31	310	100	95	69	25	25	330	30	32	100	75	25	25	26	360	100	79	60	70
4	39	2	1	15	15	520	33	100	101	89	15	15	500	30	100	91	78	17	17	370	27	100	84	79	20	20	365	28	100	70	79	20	19	351	29	100	71	77
5	55	2	2	15	15	360	32	100	122	6017	17	390	30	100	108	72	25	25	320	30	29	100	104	67	27	27	371	27	100	85	67	26	26	353	26	100	80	65
6	41	2	1	20	19	413	28	100	78	92	21	20	412	28	100	80	93	22	22	336	26	100	80	96	23	22	334	26	100	82	94	22	22	332	28	100	88	94
7	41	2	1	16	16	452	29	100	100	86	16	16	436	29	100	112	96	19	18	310	28	100	98	79	19	19	301	28	100	98	79	19	19	305	27	100	83	73
8	43	2	1	18	18	450	30	100	78	80	18	18	446	30	100	76	82	22	21	346	28	100	80	76	21	21	340	28	100	82	78	22	22	340	26	100	88	76
9	44	2	1	15	13	400	35	100	82	79	16	13	400	33	100	80	75	17	16	330	29	100	84	76	20	20	330	30	100	100	75	22	20	320	31	100	90	78
10	48	2	2	16	16	450	25	100	74	70	17	16	446	24	100	79	78	16	18	17	350	28	100	83	78	19	350	30	100	75	72	21	20	330	30	100	55	73
11	44	2	1	15	14	460	24	100	80	76	15	15	458	25	100	82	78	15	15	348	25	100	81	80	17	16	330	28	100	83	82	18	18	323	27	100	82	85
12	44	2	1	19	19	438	30	100	78	80	20	20	440	31	100	84	82	23	22	346	32	100	88	86	22	21	338	31	100	90	90	22	22	340	30	100	82	92
13	39	2	1	12	12	470	26	100	70	86	13	12	462	26	100	70	88	15	15	326	28	100	72	93	16	15	324	30	100	74	93	16	16	326	30	100	76	90
14	52	2	1	22	21	490	28	100	84	92	22	22	486	28	100	88	94	24	23	336	30	100	92	96	24	23	326	32	100	94	98	24	23	332	30	100	90	96
15	53	2	1	12	12	460	22	100	98	96	12	11	456	21	100	98	96	18	17	330	24	100	108	98	18	17	334	25	100	103	92	20	19	340	22	100	92	73
16	36	2	1	16	18	460	28	100	88	74	18	16	460	26	100	88	74	17	16	350	26	100	89	80	17	15	363	26	100	82	78	19	18	343	28	100	80	79
17	36	2	1	22	22	430	28	100	98	92	22	22	448	30	100	102	90	24	23	346	28	100	104	92	23	23	336	28	100	100	92	23	23	336	28	100	98	96
18	49	2	1	22	21	446	30	100	82	86	20	20	436	31	100	84	84	22	22	340	30	100	78	85	24	24	332	28	100	78	88	23	23	330	28	100	80	90
19	36	2	1	19	19	453	29	100	91	79	16	16	436	29	100	110	96	18	19	320	28	100	110	85	19	19	310	28	100	98	79	19	19	300	28	100	83	73
20	47	2	1	18	18	446	28	100	90	92	19	18	444	28	100	96	94	21	21	336	28	100	94	90	22	22	330	30	100	96	88	22	21	332	29	100	96	82
21	40	2	1	22	22	448	31	100	98	90	22	20	436	32	100	102	92	24	23	346	32	100	98	92	23	23	336	32	100	98	92	23	22	332	31	100	90	90
22	40	2	1	22	21	448	30	100	82	80	21	21	446	28	100	84	78	23	23	340	28	100	86	76	22	22	332	28	100	82	78	23	22	328	26	100	80	80
23	46	2	1	20	20	450	32	100	95	98	20	19	442	30	100	90	85	22	21	346	28	100	90	94	21	21	332	26	100	88	90	22	21	330	26	100	80	88
24	48	2	1	20	20	456	30	100	82	88	21	20	440	30	100	84	86	22	21	330	32	100	86	90	21	21	336	32	100	86	92	21	20	332	28	100	78	82
25	42	2	1	20	20	450	28	100	78	76	21	20	446	28	100	80	78	22	21	346	26	100	82	78	22	22	338	27	100	88	80	21	21	336	28	100	90	82
26	42	2	1	19	19	454	26	100	82	88	19	18	446	26	100	88	90	22	21	336	27	100	92	96	22	22	340	26	100	90	92	21	20	332	26	100	84	86
27	43	2	1	18	18	448	23	100	78	82	18	17	440	24	100	80	84	21	20	346	25	100	78	82	21	21	336	26	100	80	80	21	21	332	25	100	84	78
28	42	2	1	16	16	454	26	100	78	80	16	15	450	25	100	88	86	18	17	346	27	100	78	88	17	17	340	28	100	84	82	17	16	342	28	100	84	78

ANNEXURE V- KEY TO MASTER CHART

MPG–Mallampati Grading

ASA–American Society of Anaesthesiologists

PAP – Peak Airway Pressure

P plateau–Plateau Pressure

TV – Tidal Volume

EtCo2– End tidal carbon dioxide

SpO2 –Saturation

HR – Heart Rate

MAP – Mean Arterial Pressure