Comparison Between Volume Controlled Ventilation and Pressure Controlled Ventilation in Laparoscopic Cholecystectomy and their Effects on Hemodynamic and Respiratory Parameters

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Abstract

Background: Laparoscopic cholecystectomy is a minimally invasive surgical technique for amputation of an unhealthy gallbladder. This procedure has several advantages including shorter stay in hospital, minimal post-operative pain and fast recovery after procedure. The disadvantages of this procedure due to increase intra-abdominal pressure, patient position and general anesthesia. Many of anesthetist apply VCV in this procedure. VCV can deliver adequate minute volume but this is corresponded by an increase in airway pressure, so other alternative mode can be used to solve this problem like PCV.

Aim of the Study: To compare effect of volume controlled ventilation versus pressure controlled ventilation on respiratory and haemodynamic parameters during laproscopic cholycystectomy.

Patients and method: A prospective comparative observational study, conducted at the Department of general surgery in Baghdad Teaching Hospital/Medical city complex, from October 2019 - October 2020. Fifty participants underwent laparoscopic cholecystectomy within the inclusion criteria were included in the present study. Each group consist of 25 patients .one group received VCV and others receive PCV. peak airway pressure, mean airway pressure, MAP, and heart rate was recorded intraoperatively at 5,10 and 30 minute intervals. The collected data were analyzed by SSPS version 22 program.

Results: In pressure control group of patients, the peak airway pressure was significantly deceased after 10 and 30minutes after start of laparoscopy (20.2and 20.8) versus (24.3 and 24.1) respectively and mean airway pressure was significantly increased after same time (10.6 and10.6) versus (9.7 and 9.7) respectively relative to volume control group. No significant change in hemodynamic parameters. **Conclusion:** PCV mode is a safe alternative & offers protection to the lungs but there was no beneficial effect of PCV regarding mean airway pressures which reflect oxygenation, minute ventilation &ETCO2.

Keyword: laparoscopic surgery, Pneumoperitoneum, PCV, VCV, Peak airway pressure, mean airway pressure.

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Introduction

Laparoscopic surgery is a minimally invasive surgical technique where specialized tubes are inserted for surgical access. Small skin incisions are made, approximately 1 cm in length, to facilitate insertion of rigid tubes, called trocars. Trocars are sharp, multiport, one-way conduits used to insufflate gas and to guide various specialized surgical instruments. Intra-peritoneal viewing is conducted using a video-capable telescopic camera[1]. It is one of the most common surgical techniques and has several advantages over traditional surgery, including decreased postoperative pain, a shorter length of stay in the hospital, and cosmetic appeal, less postoperative pulmonary impairment, a reduction in postoperative ileus, laparoscopic surgery can provide substantial medical and economic advantages. Carbon dioxide is the most commonly used gas for insufflation because it is extremely soluble and diffuses easily through biological membranes. Intra-abdominal pressure (IAP) is raised from less than 5 mm Hg to approximately 15 mm Hg[2].

Although the procedure involves minimal invasion and tissue damage, it has potentially serious complications, including cardiopulmonary effects that result mainly from hypercarbia and raised intraabdominal pressure caused by pneumoperitoneum. Absorbed carbon dioxide from the peritoneal cavity tends to cause acidosis. Leakage of the gas into tissue spaces may induce subcutaneous emphysema, pneumothorax, pneumomediastinum and pneumopericardium. Cardiac effects include arrhythmias, hypotension, cardiac arrest, gas embolism, pulmonary edema,and myocardial ischemia or infarction. Some of these effects, though rare, are serious and potentially fatal. Physicians should anticipate these problems in their patients undergoing laparoscopic procedures[3]. A moderate-to-low intra-abdominal pressure (<12 mm Hg) can help limit the extent of the pathophysiological changes[4]. Patients who undergo laparoscopic cholecystectomy is operated on under general anesthesia, in a reverse Trendelenburg position, with 12–15-mmHg pneumoperitoneum. All of these factors can induce venous stasis of the legs, which may lead to postoperative deep-vein thrombosis (DVT) [5].

The gallbladder lives on the inferior aspect of the liver bed, more specifically under liver segments 4b and 5. The gallbladder can be up to 10 cm in length and physiologically can hold up to 50 cc of fluid (bile). A line from the gallbladder to the inferior vena cava separates the liver into right and left lobes. There are four anatomical sections to the gallbladder: fundus, body, infundibulum, and neck. There is great variation in the biliary ductal anatomy[6].The cystic duct most commonly arises from the common bile duct and inserts at the neck of the gallbladder. The branch point of the cystic duct from the common bile duct marks the beginning of the common hepatic duct superiorly. The blood supply to the gallbladder is from the cystic artery which originates approximately 90% of the time from the right hepatic artery. Again, there is great variation in the course and origin of the cystic artery. The hepatocytes triangle (triangle of Calot) is a surgical anatomical landmark created by the cystic duct laterally, the common hepatic duct medially, and the liver edge superiorly. This triangle is of surgical importance because this is the location for the most common path of the cystic artery to the gallbladder. There sentinel lymph node of the gallbladder resides within the hepatocytes triangle, also known as Lund's node (and erroneously referred to as the node of Calot) [7].

Aim of the study: To compare effect of volume controlled ventilation versus pressure controlled ventilation on respiratory and haemodynamic parameters during laproscopic cholycystectomy.

Patient and Method:A prospective observational study, conducted at the Department of general surgery in Baghdad Teaching Hospital/Medical city complex, from first of October 2019 to the first of october2020.

Inclusion criteria: Patients within the age between 18-65 years' old ;ASA physical status between I-II; BMI < 30; Those who indicated for laparoscopic cholecystectomy under general anesthesia and Those who agreed to participate in the study.

Exclusion criteria: Patient with any suspected abnormality in the airway or respiratory system ; Patient with cardio-pulmonary diseases and Patients who are heavy smoker.

50 participants underwent laparoscopic cholecystectomy within the inclusion criteria were included in the present study. History and physical examination for each participant, height and weight were measured and the BMI were calculated.

Laboratory investigations include complete blood count, viral screen, CXR, and ECG.Then patients were divided into 2 groups each group were included 25 patients:Group A: (VC group) and Group B: (PC group).

Methods

Patients were divided into two groups; each group receive different type of ventilator mode either PCV or VCV. Each group was including twenty-five patients, were admitted in Baghdad teaching hospital.

At the operative room, standard monitoring of non-invasive blood pressure measurement, ECG, pulse oximetry & capnograph. The patients were cannulated & received 500 ml ringer lactate or normal saline then the baseline mean arterial pressure, heart rate& SPO2 were recorded.

Induction of anesthesia was done after premedication which consist of midazolam 2mg, metoclopramide 10 mg, dexamethasone 8 mg and preoxygenation with 1mcg/kg of fentanyl, 0.5 mg/kg of ketamine,and sleeping dose of propofol (1.25-2.5mg/kg).endotracheal intubation was done after administration of 0.6mg per kg rocuronium.maintenance of anesthesia was done with isoflurane1.2% and rocuronium 0.1mg/kg.paracetomol 1gm and nefopam 20mg infusion was given.The anesthetist administered further drugs and fluids as clinically indicated.

In VC group, the ventilator parameters were: tidal volume 6-8 ml per kg, respiratory rate 12 beat per minute, inspiratory to expiratory ratio (I: E) was 1:2 and maximum alarm setting of airway pressure is 35 cmH2O, PEEP was 5 cmH2O. so, In PC group, inspiratory pressure was adjusted to obtain tidal volume of 6-8 ml per kg. other parameters similar to VCV mode.

During surgery; pneumoperitoneum was done with CO2 insufflation with patients in the supine position, to a maximum intra-abdominal pressure of 12 mmHg. Patients were then tilted head-up by 15–20 degree. The same position was maintained throughout the procedure.

At the end of operation, after skin closure, isoflurane was turned off and neuromuscular blockage was reversed with 0.2mg/kg neostigmine and 0.02mg/kg atropine.pateints were stimulated verbally or with gentle tactile stimulation and extubated safely when they meet standardized extubation criteria.

Data were recorded intra-operatively at three-time intervals: approximately 5 min after tracheal intubation and at 10 and 30 min after the beginning of laparoscopy.Data include peak airway pressure, mean airway pressure,MAP and heart rate.

Statistical analysis: The data were analyzed using statistical package for social sciences (spss) version (24). Chi-square test was used to assess the association between categorical variables, P. value less than 0.05 considered statistically significant.

Results

Fifty patients were involved in this study. Comparison between two groups each of them received either VCV or PCV then the results were analyzed by using SPSS program statistic student's independent sample T test for difference of mean these tests were further referenced for P value less than 0.05 were considered statisticallysignificant

Shows **Table (1)** that mean age of the VC group was 32±3.9 years old and 33±0.2 years for PC group. female was more prominent in both groups (21 and 22) in VC and PC respectively.So mean of BMI was 27±3 in VC and 26±4 in PC.

Figure(1) showed25 patients were found in each of the studied groups.

Table 1: Mean age and BMI for laparoscopic cholecystectomy patients.

Variables	VC (n=25)	PC (n=25)	P - Value
Age (mean)/years	32.3±3.9	33±0.2	0.3 Ns
BMI (mean)	27±3	26±4	0.3 Ns

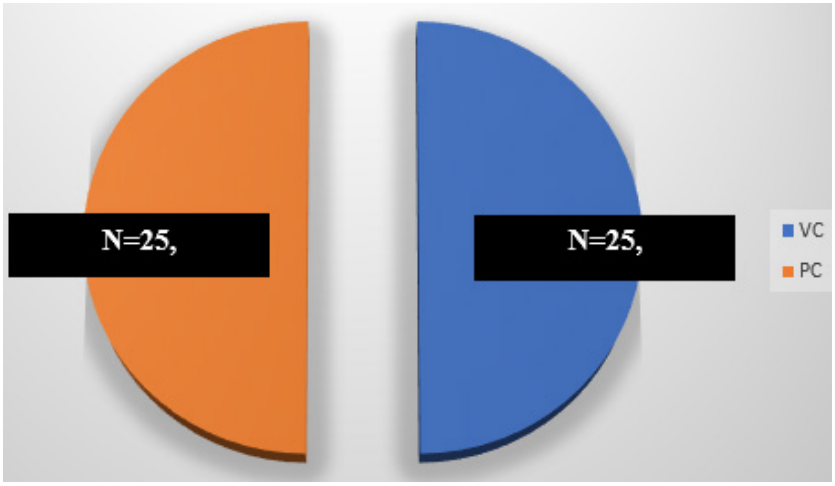


Figure 1: Distribution of the patients at the studied groups

The Baseline data for patients undergoing laparoscopic cholecystectomy was; heart rate of the studied groups was 92 with SD= 9 beats/min, mean arterial pressure was 100 and SD=12 mmHg, SPO2 was 98 with SD=4.

Table 2: Baseline data for laparoscopic cholecystectomy patients and patients undergoing laparoscopic cholecystectomy. Values are mean± SD.

Variables	laparoscopic cholecystectomy patients			patients undergoing laparoscopic cholecystectomy		
	Mean±SD	95% CI		VC (n=25)	PC (n=25)	P – Value
HR (beats/min) (mean)	92±9	88	91±11	91±11	93±16	0.6 Ns
MAP (mmHg) (mean)	100±12	95	102±10	102±10	98±18	0.3 Ns
SPO2(mean)	98±4	93	98±2	98±2	98±6	0.9 Ns

VC, volume-controlled ventilation; PC, pressure-controlled ventilation, MAP, mean arterial pressure; HR, heart rate; Ns, not significant.

The mean of heart rate was 91±11 beats/min in VC and 93±16 beats/min in PC, mean arterial pressure was 102±10 mmHg in VC and 98±18 mmHg in PC, SPO2 was 98±2 in VC and 98±6 in PC.

Table (3) showedin the two classes (VC and PC), both peak and mean airway pressures were the same at five minute after tracheal intubation. Nevertheless, the peak airway pressure decreased significantly after the start of laparoscopy at 10 and 30minutes and the mean airway pressure significantly increased in the PC group compared to VC group.

Table (3): Respiratory data results in the studied groups at different time interval. Values are mean± SD.

Variables		VC	PC	P. value
P_{peak}; cmH2O	5 min	18.2±1.42	17.8±1.1	0.2 Ns
	10 min	24.3±2.3	20.2±2.1	<0.001
	30 min	24.1±2.1	20.8±1.9	<0.001
P_{mean}; cmH2O	5 min	8.8±0.8	9±0.7	0.3 Ns
	10 min	9.7±1.01	10.6±1.5	0.01
	30 min	9.7±1.03	10.6±1.3	0.009

VC, volume-controlled ventilation; PC, pressure-controlled ventilation; P_{peak}, peak airway pressure; P_{mean}, mean airway pressure, Ns; not significant.

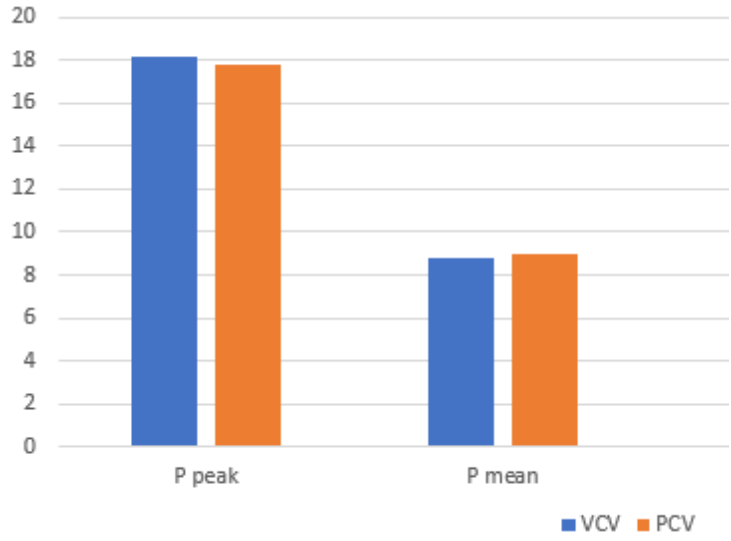


Figure (2): Comparison Between Respiratory Parameter After 5 minutes after tracheal intubation for both Modes

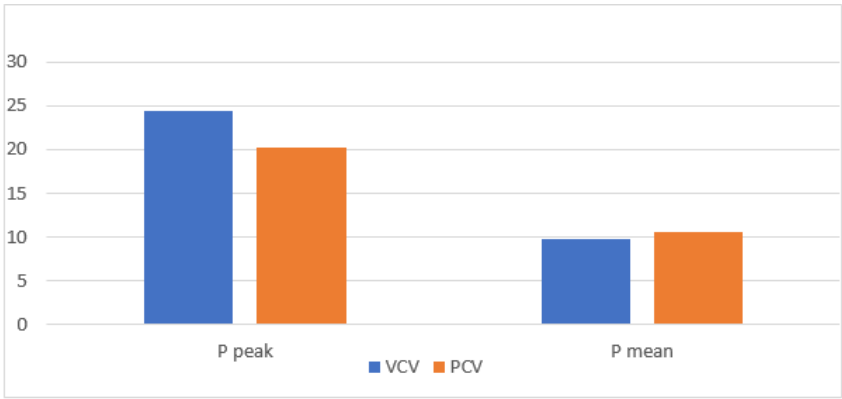


Figure (3): Comparison Between Respiratory Parameter After 10 Minutes after start of laparoscopy for both Modes

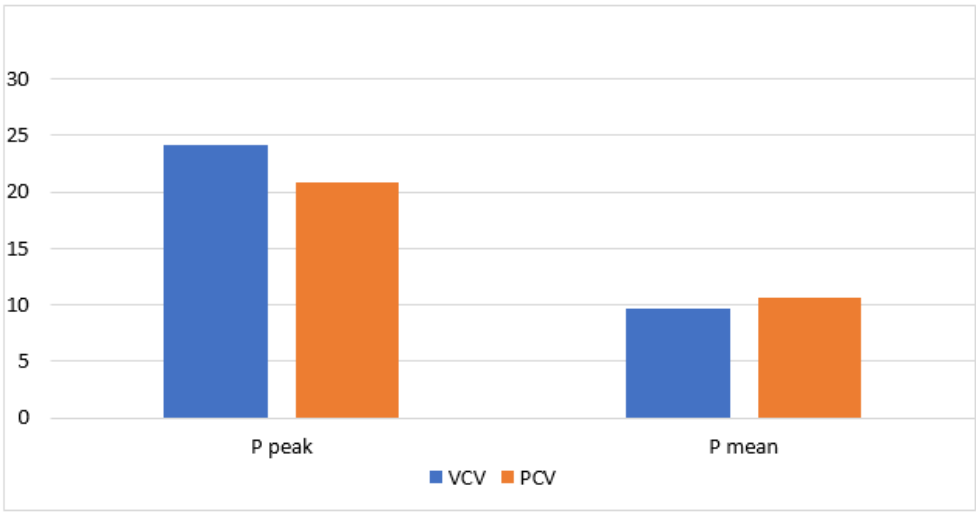


Figure (4): Comparison Between Respiratory Parameter after 30 minutes after start of laparoscopy for both Modes

No significant differences were found between VC and PC regarding heart rate, MAP.

Table (4): Hemodynamic data in the studied groups at various time interval; Values are mean ± SD. HR, heart rate;MAP,mean arterial pressure; Ns, not significant.

Variables		VC	PC	P – value
HR; beats/ min)	5 min	91±3	89±4	0.051 Ns
	10 min	84±2	85±3	0.17 Ns
	30 min	84±5	82±3	0.09 Ns
MAP; mmHg	5 min	88±8	85±3	0.08 Ns
	10 min	98±3	101±7	0.054 Ns
	30 min	94±1	97±9	0.1 Ns

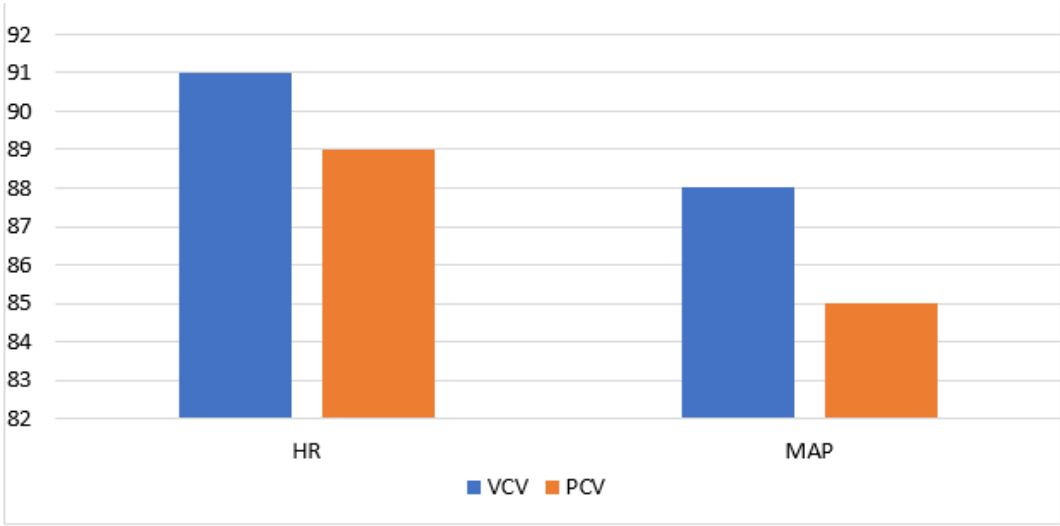
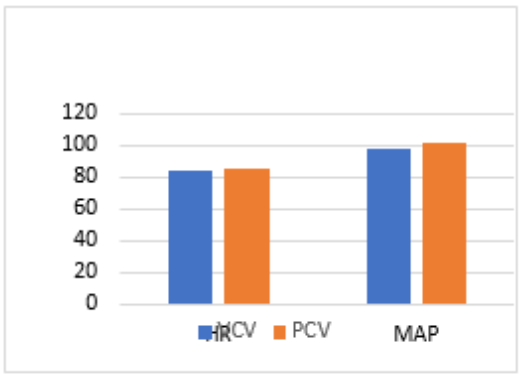
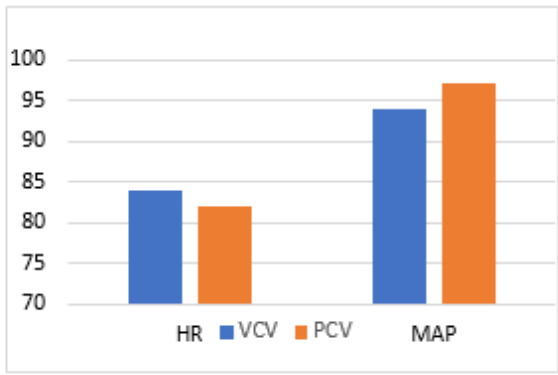


Figure (5): Comparison Between Hemodynamic Parameter After 5 minutes of tracheal intubation for both Modes





A- 10 Minutes after start of laparoscopy for both Modes

B-30 minutes after start of laparoscopy for both Modes.

Figure (6): Comparison Between Hemodynamic Parameter After10AND 30 Minutes after start of laparoscopy for both Modes.

Discussion

In this study we found statistical difference between two modes of ventilation in term of peak airway pressure and mean airway pressure at 10 and 30 minutes start of laparoscopy. Peak airway pressure at 10 and 30 minutes is (24.3 in VCV vs 20.2 in PCV, P = < 0.001) and (24.1 in VCV vs 20.8 in PCV, P value = < 0.001) respectively. Mean airway pressure at 10 and 30 minutes is (9.7 in VCV vs 10.6 in PCV. P, value = 0.01) and (9.7 in VCV vs 10.6 in PCV, P value = 0.009) respectively.

Balick *et al* and Oğurlu *et al.,* were found a significant decrease in the peak airway pressures to those for non-bariatric laparoscopic surgery[8 &9].

Davis K *et al.,* Mang *et al.,* and Hans *et al.,* Were found in other cases including acute pulmonary trauma / acute respiratory distress syndrome[10&11] and obese patients[12], a decrease in peak airway pressure due to PC ventilation has been observed.

In comparison, Cadi *et al.,* Baerdemaeker *et al.,* and Sinha *et al.,* were found that there are no ventilator changes between two groups in obese patient[13&14]. This can be explained by the physiological differences associated with obesity in the respiratory system that may impair mechanical ventilation regardless of the compromise caused by laparoscopy[15].

A variety of changes in the ventilatory strategy during laparoscopy have been evaluated for their effect on surgical conditions. The effect of mechanical ventilation was compared with spontaneous ventilation during laparoscopic gynecological surgery by Williams *et al.,*[16]. The use of mechanical ventilation was associated with substantially improved pneumoperitoneum (facilitating surgical access) and lower Intra-abdominal pressure.

Due to its decelerating inspiratory flow pattern the decrease in peak airway pressure correlated with PC ventilation is likely to be the consequence[10 &17], with the optimum value reached early in inspiration. This is then accompanied by a flow rate deceleration, resulting in its characteristic shape. The initial fast flow contributes to early alveolar inflation and PC ventilation thus associated with an increase in mean airway pressure[18].

Hemodynamic changes, including a rise in cardiac workload, can be associated with the development of a pneumoperitoneum during laparoscopic surgery[19]. Because of the increased mean airway pressure[20], pressure-controlled ventilation can yield an enhanced effect of the increased mean airway pressure, which may adversely affect hemodynamic variables by its effects on pleural pressure[8], Balik *et al.,* explain the hemodynamic effects of laparoscopic urological procedures using trans esophageal echocardiography to measure systolic and diastolic function as a primary outcome of left ventricular wall stress. The authors found that PCV and VCV ventilation were associated with statistically comparable hemodynamic outcomes[8].

Conclusion

PCV mode is a safe alternative & offers protection to the lungs but there was no beneficial effect of PCV regarding mean airway pressures which reflect oxygenation, minute ventilation &ETCO2.

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Conflict of Interest: non

Ethical clearance: non

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