(International Print/Online Journal)

SJIF IMPACT FACTOR: 5.565
PUBMED-National Library of Medicine ID-101739732

ISSN (Print): 2209-2870
ISSN (Online): 2209-2862

IJMSCR

International Journal of Medical Science and Current Research (IJMSCR)
Available online at: www.ijmscr.com
Volume4, Issue 2, Page No: 953-959
March-April 2021

Evaluation of pressure controlled (PCV) Vs volume controlled ventilation (VCV) in obese patients undergoing upper abdominal laproscopic surgeries

Aruna Gupta[1] Ajaiz Rasool[2] Raja Suhail Shounthoo[3] Vivek Sharma[4] Showkat Ahmad Gurcoo[5]
[1]Postgraduate Resident, [2,3]Senior Resident, [3]Senior Resident, [4]Assistant Professor, [5]Professor
[1, 2, 3, 5]Department of Anesthesiology & Critical Care, Sher-i-kashmir Institute of Medical Sciences, SKIMS,Srinagar, Jammu & Kashmir, India-190011
[4]Gautam Buddha Chikitsalya, Mahavidhalya, Dehradun, India

***Corresponding Author:**
Raja Suhail Shounthoo
Department of Anesthesiology & Critical Care, Sher-i-kashmir Institute of Medical Sciences, SKIMS,Srinagar, Jammu & Kashmir, India-190011

Type of Publication: Original Research Paper
Conflicts of Interest: Nil

ABSTRACT

Background: Obesity is a global pandemic and is usually associated with other co-morbidities, it's implications on pulmonary physiology are well documented. Hence, obesity carries additional risks during laparoscopic surgery under general anaesthesia due to special respiratory mechanics associated with obesity and difficulty in maintenance of oxygenation in these patients. Currently, there is no gold standard method for intra operative ventilation in obese patients and in practice, appropriate strategy of ventilation is based on anesthesiologist's preferences. Keeping in view these facts we observed and evaluated volume controlled and pressure controlled modes of ventilation in obese patients undergoing laproscopic upper abdominal surgery under general anesthesia.

Settings & Design: A prospective, observational Study, comprising of 60 obese patients (BMI≥30kg/m²), who were distributed into PCV group and VCV group based on the mode of ventilation comprising 30 patients in each group.

Materials & Methods: The participants were either put on volume controlled or pressure controlled mode of ventilation during the intra-operative period ,the vitals of the patients were monitored and oxygenation and ventilator parameters were recorded. After completion of surgery patients were extubated after fulfilling all extubation criteria.

Statistical Analysis: The data was analyzed statistically with the help of statistical software SPSS and Microsoft excel. All the continuous variables were shown in terms of descriptive statistical and categorical variables in terms of frequency and percentage. All the results were discussed on 5% level of significance. i.e. p value<0.05 was considered significant.

Results: The baseline characteristics of the patients were similar between the two groups. Mean Spo_2, pH, PaO_2 were higher in PCV group, however, average $PaCO_2$, tidal volume and peak airway pressures were lower in PCV group with statically significant difference($p<0.05$). Mean respiratory rate, $EtCO_2$, peak inspiratory pressure, plateau presssure and dynamic total compliance were similar between the two groups($p>0.05$).

Conclusion: Pressure control mode is relatively a better mode of ventilation in obese patients undergoing laparoscopic upper abdominal surgeries as it provides better oxygenation and gas exchanges by improving ventilation perfusion ratio at lower peak airway pressures.

Keywords: Obesity, laproscopic surgery, pressure controlled ventilation, volume controlled ventilation, general anesthesia

INTRODUCTION

The implications of obesity on pulmonary physiology are well known.[1] Obese patients often present with additional pulmonary comorbidities including airway hyperactivity, sleep apnea and pulmonary hypertension.[2] Most lung capacities are decreased, primarily the Functional Residual Capacity (FRC) and Expiratory Reserve Volume (ERV).[3]All these changes are more prominent when patients are in supine position because increased intra-abdominal pressure restricts diaphragmatic movement and lung expansion.[2] Laparoscopic surgery is a relatively modern minimally invasive surgical technique for carrying out various abdominal surgeries.[4]Despite its many advantages, laparoscopic surgery is not totally free of risk and complications.[5] Carbon dioxide (CO_2) pneumoperitoneum commonly used for laparoscopic surgeries increases intra-abdominal pressure, and thus, may alter respiratory mechanics, by decreasing lung volume and increasing airway pressure and end-tidal CO_2 tension.[6] Obesity carries additional risks during laparoscopic surgeries.[7] Because of the special respiratory mechanics associated with obesity, maintenance of oxygenation is one of the most difficult problems in the anesthetic management of obese patients. Moreover, pneumoperitoneum causes 30% lower static compliance and 68% higher inspiratory resistance in supine anesthetized obese patients.[8] In obese patients undergoing upper abdominal laparoscopic surgery, studies so far have not been conclusive to prove any significant difference in airway pressure and compliance between P.C.V and V.C.V modes[9]and no guidelines regarding the preferred mode of ventilation are recommended till now.[10] In practice appropriate strategy of ventilation is based on anesthesiologist's preferences. Keeping these facts into consideration, this study was undertaken to observe and evaluate V.C.V and P.C.V modes in obese patients undergoing laparoscopic upper abdominal surgery under general anesthesia after intra-abdominal CO_2 insufflation.

The primary aim of this study was to evaluate the effects of pressure controlled and volume controlled ventilation in obese patients undergoing laparoscopic upper abdominal surgeries in terms of lung mechanics and oxygenation status.

Materials & methods

This study was undertaken in the Department of Anesthesiology of a tertiary care hospital in Northern India. This prospective, observational, cross-sectional study was conducted in obese patients who underwent laparoscopic upper abdominal surgeries from 1st August 2018 to 31st July 2020. Approval from the institutional ethics committee was taken prior to the conduct of this study, and a written informed consent was obtained from all the patients whose data were collected for the study.

In our study, 60 obese patients (BMI ≥ 30 kg/m^2) of either gender, age 18 to 60 years, with ASA status II and III undergoing laparoscopic upper abdominal surgeries were included. Patients with ASA status >III, or with severe cardio-pulmonary disease, and pregnant ladies were excluded from the study.

The patients were subsequently divided into two groups of 30 patients each:

Group P.C.V i.e. pressure-controlled ventilation group

Group V.C.V i.e. volume-controlled ventilation group

Body mass index (BMI) was defined as total body weight in kg divided by height in meter square and ideal body weight (IBW) was calculated using Devine's formula.[42]

In males, IBW = 50 kg (110 lb) +0.91 kg (2.0 lb) x (height in cm-152.4).

In females, IBW = 45.5 kg (100 lb) +0.91 kg (2.0 lb) x (height in cm-152.4).

Once the patients were shifted to the operating room (OR), standard monitoring (ECG, non-invasive arterial pressure, pulse oximetry and end tidal CO_2) was attached. Anesthesia was standardized for all the patients. Pre-oxygenation was done in every patient with 100% oxygen for 3 minutes. Induction of anesthesia was performed with 2mg/kg of propofol and fentanyl 2µg/kg. Tracheal intubation was facilitated with rocuronium 1.2 mg/kg. The dosages of all the drugs were calculated based on the ideal body weight.

Anesthesia was maintained with oxygen (50%), nitrous oxide (50%) and isoflurane (1.0 to 1.2 MAC).

Volume 4, Issue 2; March-April 2021; Page No 953-959

Patients were positioned head up (25 degree) after creation of pneumoperitoneum with intra-abdominal pressures maintained between 10-12 mmHg.

In V.C.V group, ventilation was started with a tidal volume of 8 ml/kg, and in order to maintain the $ETCO_2$ in the range of 35-40 mmHg, tidal volume was increased incrementally by 1 ml/kg upto 10 ml/kg each five minutes and respiratory rate was increased incrementally by 2 breaths/min each 5 minutes upto 25 breaths/min. If the target $ETCO_2$ could not be achieved with this setting, patient was excluded from the study.

In P.C.V group, pressure was set to target tidal volume of 8 ml/kg and respiratory rate was increased incrementally by 2 breaths/min each 5 minutes to maximum of 25 breaths/minute to reach targeted $ETCO_2$ and respiratory rate was decreased by 2 breaths/min each 5 minutes, if $ETCO_2$ was less than the target value. If a patient needed respiratory rate more than 25 breaths/min, or the target $ETCO_2$ could not be achieved, they were excluded from the study.

Arterial blood gas analysis was performed after induction through an arterial line inserted in radial artery, and every 20 minutes thereafter till the end of surgery. Oxygenation and lung dynamic parameters were noted for all patients during the study. In addition, SpO_2, $ETCO_2$, respiratory rate, tidal volume, peak airway pressure, plateau pressure, PEEP, peak inspiratory flow, intra-abdominal pressure and dynamic total compliance were recorded.

After surgery any residual neuromuscular blockade was reversed with neostigmine 60 µgm/kg and glycopyrrolate 10 µgm/kg. Before extubation, FIO_2 was increased to 1.0 and patients were extubated after fulfilling the extubation criteria. Patients were shifted to recovery area and monitored there for two hours.

Statistical analysis

The data was analyzed statistically with the help of statistical software SPSS and Microsoft excel. All the continuous variables were shown in terms of descriptive statistical and categorical variables in terms of frequency and percentage. Also, the categorical variables were analyzed with the help of Chi square, Mann-Whitney, U-test & Fisher's Exact test. All the results were discussed on 5% level of significance. i.e. p value less than 0.05 was considered significant.

Results

The total number of patients included in the study was 60 (n=60). They were distributed equally between V.C.V group (n=30) and P.C.V group (n=30). All patients were obese patients taken for upper abdominal laparoscopic procedures. Demographic characteristics (age, gender, weight, BMI), ASA class, and comorbidities are summarized in Table 1.

Table 1: Demographic characteristics & medical history of patients

Parameters	**VCV Group**	**PCV Group**
Age (years)	41.30 (18-60)	42.17 (21-60)
Gender (M/F)	46.67% (14) / 53.33% (16)	43.33% (13) / 56.67% (17)
Weight (Kg)	50.79 (43.32-60.56)	50.91 (43.32-61.47)
BMI (Kg/m^2)	42.63 (37.22-54.10)	42.14 (35.25-49.95)
Medical History		
Hypothyroidism	20.00% (6)	16.67% (5)
Hypertension	16.67% (5)	13.33% (4)
Diabetes Mellitus	20.00% (6)	20.00% (6)
ASA (II/III)	40.00% (12) / 60.00% (18)	50.00% (15) / 50.00% (15)

Volume 4, Issue 2; March-April 2021; Page No 953-959

The hemodynamic, blood gas and ventilatory parameters are summarized in Table 2. During the entire intraoperative period, the hemodynamic variables (HR, MAP) were comparable between the two groups. The respiratory rate increased from the baseline values in both the groups, but remained comparable between VCV group and PCV group during the entire intraoperative period. Tidal volumes were significantly increased in VCV group (406.28-473.72), compared to PCV group (407.26-445.92) at 40mins, 60mins and 80mins intraoperatively (p-value<0.05). The oxygenation was relatively better in PCV group (95.70%-98.63%)) compared to VCV group (95%-97.13%)) with better SPO_2 in PCV group during the entire intraoperative period (p-value<0.05). $PaCO_2$ values were better controlled in PCV group (36.83-38.43) than in VCV group 39.27-40.64 , and the difference was statistically significant (p value<0.05).

The peak airway pressures tended to be greater in VCV group (26.67-30.36) compared to PCV group (18.80-21.43) at all intraoperative time intervals (p value<0.05). However, there was no impact on the dynamic compliance depending upon the mode of ventilation employed.

Table 2: Results of analyzed parameters

Parameters	**VCV Group**	**PCV Group**	**P-Value**
MAP (mmhg)	(88.87-91.47)	(85.90-92.29)	> 0.05
HR (/min)	(80.33-85.86)	(79.43-86.50)	> 0.05
RR (Cycles/min)	(15.83-17.13)	(15.86-17.07)	> 0.05
Tidal Volume (ml)	(406.28-473.72)	(407.26-445.92)	< 0.05
SpO_2 (%)	(95%-97.13%)	(95.70%-98.63%)	< 0.05
pH	(7.38-7.40)	(7.38-7.42)	< 0.05
pCo_2	(39.27-40.64)	(36.83-38.43)	< 0.05
HCo_3^-	(23.73-24.36)	(23.55-24.17)	> 0.05
Lactate	(0.93-1.32)	(1.01-1.25)	> 0.05
Pressure (CmH_2O)			
Peak	(26.67-30.36)	(18.80-21.43)	< 0.05
Plateau	(25.27-27.50)	(24.77-27.14)	> 0.05
Dynamic Compliance	(24.93-31.57)	(25.21-31.40)	> 0.05

Discussion

Difficulties in mechanical ventilation are frequently encountered in patients with morbid obesity. These difficulties can be related to difficult intubation, mask ventilation and abnormal ventilation mechanisms especially during laparoscopic surgery. Although there are many strategies for intra-operative management of patients with obesity, it is not clear which ventilation strategy is optimal.[11]

This prospective observational study was conducted in order to evaluate and compare the effects of V.C.V and P.C.V in obese patients, a sample size of 60 patients was selected. Patients undergoing upper abdominal laparoscopic surgeries with B.M.I more than 30 kg/m^2 admitted from 1st August 2018 to 31st July 2020 at our institute were enrolled. Based on the mode of ventilation employed, they were allocated into group V.C.V and group P.C.V with 30 patients each.

It was observed that SpO_2 was maintained between 98.63 ± 1.43 % at 40 minutes and 97.21 ± 1.67 % at 120 minutes post-intubation in all patients in P.C.V group, but variable number of patients in VCV group had SpO_2 between 97.13 ± 1.87 % at 1st minute to 95.00 ± 1.66 % at 120 minutes post-intubation. The

Volume 4, Issue 2; March-April 2021; Page No 953-959

differences recorded between the two groups, was significant (p value < 0.05). Intra-operative Respiratory rate progressively increased in V.C.V group and highest average respiratory rate achieved was 17.13 ± 3.64 breaths/min at 80 minutes. Highest average respiratory rate reached in P.C.V group was 17.07 ± 1.95 breaths/minute at 120 minutes (p value 0.087 to 0.9617). Arterial pH was maintained between 07.38 ± 0.01 to 07.45 ± 0.02 in all patients in P.C.V group, but patients in VCV group had arterial pH between 07.38 ± 0.02 to 07.40 ± 0.02 at different intra-operative times. It was 7.38 ± 0.02 in V.C.V group and 7.41 ± 0.02 in P.C.V group at 20 minutes (P value=0.00000353). The statistical difference remained significant until 120 minutes intra-operatively (p value=0.00000080 to 0.0218). Arterial PCO_2 remained lower in P.C.V group, with mean intra-operative PCO_2 reaching 36.83 ± 1.74 mmHg at 60 minutes. However, mean arterial PCO_2 in VCV group remained higher at all time intervals. Lowest mean arterial PCO_2 recorded in V.C.V group was 39.27 ± 1.98 mmHg at 1 minute and 39.88 ± 2.49 mmHg at 20 minutes. The difference was statistically significant from 20 minutes till 120 minutes (p value=0.00 to 0.00098). Arterial PO_2 was notably higher in P.C.V group intra-operatively, with mean arterial PO_2 of 210.33 ± 100.57 mmHg at 40 minutes, but average arterial PO_2 was lower in VCV group at all intraoperative times (p value< 0.05). The highest mean $ETCO_2$ noted in P.C.V group intra-operatively was 35.93 ± 2.07 mmHg at 40 minutes, and that in V.C.V group was 35.25 ± 1.62 mmHg at 80 minutes. The differences recorded between two groups, were found to be non-significant (p value>0.05).

There was no significant difference in SpO_2 between the PCV group and VCV group as reported by other similar studies.[12,13,14] **Cadi P et al.**[15] reported slightly better SpO_2 values in PCV group, but the difference was marginal and statistically non-significant between the two groups. Intra-operatively ventilator settings were altered and the respiratory rate was adusted to achieve the $ETCO_2$-$PaCO_2$ gradient within the normal range, there was no significant difference in the respiratory rate between the two groups as reported by many studies, and it was in agreement with our study.[15,14] However, **Movassagi R et al.,**[12] reported a significantly higher intraoperative respiratory rate in VCV group (p value=0.004). Atrerial pH was maintained within normal limits between the two groups as reported by various studies, the difference between the groups was reported to be statistically non-significant at all intraoperative time intervals (p value > 0.05).[12,14] **Cadi P et al.**[15] reported a significantly higher intraoperative pH in PCV group (7.40±0.03) compared to VCV group (7.38±0.02), however the pH was maintained within normal physiological limits in both the groups (p value=0.041), this observation was in agreement with our study. Observations made by **Movassagi R et al.**[12] **and Ozyurt E et al.**[14] in their respective studies did not show any significant difference in $PaCO_2$ values between the two groups (P value >0.05). Similar to our study, **Cadi P etal.**[15] reported significantly lower $PaCO_2$ values in PCV group (39.00±3.00) compared to VCV group (40.50±2.25) attributable to better gas exchange in PVC group (p value <0.05). A higher PaO_2 was reported in PCV group by **Cadi P et al.**[15] and **Movassagi R et al.**[12] and the results of their studies were in agreement with our study (p value <0.05). However, **Ozyurt E et al.**[14] did not report any significant difference in oxygenation values between the two groups (p value>0.05). These observations can be attributed to better ventilation achieved in P.C.V group with more effective gaseous exchange owing to better ventilation perfusion ratio. Intraoperative $ETCO_2$ values were similar between the two groups as reported by many other similar studies(p value>0.05).[15,12,13]

The average tidal volumes were higher in V.C.V group compared to P.C.V group at all time periods. Highest mean tidal volume maintained in V.C.V group was 473.72 ± 59.37 ml at 40 minutes and in P.C.V group it was 445.92 ± 55.60 ml at 20 minutes. The differences recorded between the groups, was found to be significant (p value=0.00131 to 0.03681). Peak airway pressures tended to be persistently lower in P.C.V group, with average peak airway pressure reaching 18.80 ± 3.16 cmH_2o at 60 minutes. Whereas, average peak airway pressures were higher in V.C.V at all time periods. The differences recorded between the two groups, was found to be significant (p value=0.0000 to 0.00000003).

The plateau pressures were comparable in both groups intra-operatively, with mean plateau pressure maintained at minimum 25.27 ± 2.75 CmH_2o at 20 minutes to maximum 27.50 ± 3.25 CmH_2o at 100

Volume 4, Issue 2; March-April 2021; Page No 953-959

minutes in V.C.V group and minimum 24.77 ± 2.85 CmH_2o at 20 minutes to maximum 27.14 ± 2.77 CmH_2o at 120 minutes in P.C.V group (p-value=0.37 to 0.91). The dynamic total compliance was maintained between 24.93 ± 5.64 ml/CmH_2o at 100 minutes to 31.57 ± 7.19 ml/CmH_2o at 40 minutes in V.C.V group and between 25.21 ± 5.94 ml/CmH_2o at 120 minutes to 31.43 ± 7.74 ml/CmH_2o at 20 minutes in patients in P.C.V group (p value=0.85 to 0.95).

Similar to our study intraoperative tidal volumes were reported to be higher in VCV group compared to PCV group in studies conducted by **MovassagiR et al[12] and OzyurtE et al.[14]**(p<0.05). **Cadi P et al.[15]**did not report any significant difference in tidal volumes between the two groups(P >0.05). **Movassagi R et al[12]** reported higher peak pressures in VCV group (25.05±4.79) compared to PCV group (20.22±4.32) and remained higher in VCV group during entire intraoperative period (p value <0.05). **Ozyurt E et al.[14]** similarly reported significantly higher peak pressures in VCV group at all intraoperative times. Similar to our study many other studies did not show any significant difference in the plateau pressure between the two groups(p value >0.05).[15,12] The dynamic compliance was reported to be similar between PCV and VCV groups in our study and this observation was in accordance with other similar studies.[15,14]

Conclusion

Based on the analysis of recorded data it can be concluded that P.C.V is better mode of ventilation than V.C.V in obese patients undergoing laparoscopic upper abdominal surgeries as it provides better oxygenation and gas exchanges by improving ventilation perfusion ratios at lower peak airway pressures. P.C.V generates higher instantaneous flow peaks by using decelerating inspiratory flow thus allowing a better alveolar recruitment and thus better oxygenation in obese patients.

Bibliography

1 Obesity and anesthesia. In B. Bucklin, A. B. Fernandez, P. Barash, B. Cullen, and R. Stoelting (Eds.), Clinical anesthesia (7 ed., pp. 1274-1293). Philadelphia: Wolters Kluwer/LippincottWilliams and Wilkins, 2013.

2 BustamanteAF and HashimotoS. Perioperative lung protective ventilation in obese patients. BMC Anesthesiology, 2015; 15:56.

3 ParameswaranK, ToddDC, SothM. Altered respiratory physiology in obesity. Canadian Respiratory Journal, 2006; 13(4): 203-210.

4 Himal HS. Minimally invasive (laparoscopic) surgery. Surgical Endoscopy and Other Interventional Techniques, 2002; 16: 1647–1652.

5 HaydenP, CowmanS. Anaesthesia for laparoscopic surgery. Continuing Education in Anaesthesia Critical Care & Pain, 2011; 11(5): 177-180.

6 JoYY and KwakHJ. What is the proper ventilation strategy during laparoscopic surgery? Korean Journal of Anesthesiology, 2017; 70(6): 596–600.

7 Al-MulhimAS, Al-HussainiHA, Al-MoagalRO. Obesity Disease and Surgery. International Journal of Chronic Diseases. 2014; doi:https://doi.org/10.1155/2014/652341.

8 KunduSB, GuptaSD, GhoseT, MajiS, MitraK, MukherjeeM. A comparison between volume-controlled ventilation and pressure-controlled ventilation in providing better oxygenation in obese patients undergoing laparoscopic cholecystectomy. Indian Journal of Anesthesia, 2012; 56(3).

9 HuXY. Effective Ventilation Strategies for Obese Patients Undergoing Bariatric Surgery: A Literature Review. American Association of Nurse Anesthetists Journals, 2016; 84(1): 35-45.

10 AldenkorttM, LysakowskiC, TramerMR, EliaN, BrochardL. Ventilation strategies in obese patients undergoing surgery: a quantitative systematic review and meta-analysis. British Journal of Anaesthesia, 2012; 4(109): 493-502.

11 ShahU, WongD, WongJ. Preoxygenation and intra-operative ventilation strategies in obese

patients: a comprehensive review. Current Opinion in Anesthesiolgy, 2016; 29: 109-118.

12 MovassagiR, MontazerM, MahmoodpoorA, FattahiV, IranpourA. Comparison of pressure vs. volume controlled ventilation on oxygenation parameters of obese patients undergoing laparoscopic cholecystectomy. Pakistan Journal of Medical Sciences, 2017; 33(5): 1-6.

13 HelouMR, GhabachMB, MoussallyJT. Comparison of pressure-controlled and volume-controlled ventilation in obese patients undergoing laparoscopic bariatric surgery: a prospective cross-over cohort study. M.E.J. Anesth, 2018; 25(1).

14 OzyurtE, KavakliAS, OzturkNK. Comparison of volume-controlled and pressure-controlled ventilation on respiratory mechanics in laparoscopic bariatric surgery: randomized clinical trial. RevistaBrasileira de Anestesiologia, 2019; 69(6): 546-552.

15 CadiP, GuenounT, JournoisD, ChevallierJM, DiehlJI, SafranD. Pressure-controlled ventilation improves oxygenation during laparoscopic obesity surgery compared with volume-controlled ventilation. British Journal of Anaesthesia, 2008; 5(100): 709–716.