Effect of Pressure Versus Volume In Controlled Ventilation In Overweight And Obese Patients During Laparoscopic Cholecystectomy

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ABSTRACT

Objectives: Proper ventilation techniques are debatable for laparoscopy procedures in high body mass index (BMI) participants. We compared respiratory outcomes between pressure and volume ventilations in high (BMI) participants, assigned to laparoscopic cholecystectomy.

Methods: Our prospective and double blinded investigation involved 103 patients of both sexes, aged 34–58 years, BMI between 27 and 36 kg/m^2 with ASA I–II assigned for laparoscopic cholecystectomy at Prince Hashem Hospital, Zarqa and Queen Alia Hospital, Amman, Jordan, between (June 2018- July 2019). General anaesthesia was initiated using volume ventilation, but after 10 min of pneumoperitoneum with 8–10 mmHg intra-abdominal pressure, patients were randomly divided. Group I patients (n=51) received pressure controlled ventilation and group II patients (n=52) received volume controlled ventilation. Ventilation was manipulated to achieve an end tidal CO_2 between 30 and 35 mmHg. Mean and peak airway pressure data were collected.

Results: Patients in group II required more (TV) and respiratory rates to attain an $ETCO_2$ of 30–35 mmHg, at 25–60 min after pneumoperitoneum. There were no significant discrepancies between both groups regarding mean airway pressures, but peak airway pressures at 25–60 min after pneumoperitoneum were higher in group II than group I.

Conclusions: Although some positive effects were observed in terms of mean airway pressures using pressure ventilation, there were no significant discrepancies between pressure and volume ventilations in high body mass index patients, scheduled for laparoscopic cholecystectomy.

Keywords: Laparoscopy cholecystectomy; Obese; Pressure ventilation; Volume ventilation.

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Introduction

Adequate mechanical ventilation during surgery may minimise the frequency of respiratory complications after surgery, thereby enhancing outcomes in obese patients.[1,2] The volume ventilation mode has been commonly used during surgery, with a stable flow to maintain tidal volume, but with increased airway pressures during laparoscopy to avoid pneumoperitoneum. [3]

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Pneumoperitoneum causes reduced lung and chest wall compliance, and decreases functional residual capacity (FRC), leading to disturbed alveolar ventilation with ventilator associated lung insults. (1)

Increased primary flow rates are maintained to rapidly attain inspiratory pressure, followed by a rapidly decelerating flow. (1) Patients may receive low tidal volumes during pneumoperitoneum due to high pressure. Pressure controlled ventilation causes low peak pressures, and reduces the frequency of barotraumas in overweight and obese patients. Volume controlled ventilation may induce increased alveolar ventilation, when compared to pressure controlled ventilation during laparoscopic cholecystectomy.(4)Nevertheless, pressure controlled ventilation did not appear to enhance outcomes in a previous investigation.(4) Pressure controlled ventilation had more favourable compliance, and less peak pressures than volume controlled ventilation, with no benefits over volume controlled ventilation.(5)

The goal of our investigation was to compare respiratory and oxygenation outcomes between pressure controlled and volume ventilation in overweight and obese patients, assigned for laparoscopic cholecystectomy.

Methods

This prospective, double blinded investigation involved 103 patients of both sexes, aged 34–58 years, BMI between 27 and 36 kg/m^2 with ASA I–II. All were scheduled for laparoscopic cholecystectomy at Prince Hashem Hospital, Zarqa and Queen Alia Hospital, Amman, Jordan, between June 2018 and July 2019. We received approval from our local ethical and research committee and written informed consent from all participants. Participants with lung disease, converted to laparotomy and with an inability to sustain adequate end tidal CO_2 volumes were excluded.

General endotracheal anaesthesia was initiated using volume controlled ventilation for all patients, but after 10 minutes of pneumoperitoneum, with 10–12 mmHg of intra-abdominal pressure, patients were randomly divided. Group I participants (n=51) received pressure ventilation and group II participants (n=52) received volume ventilation. Ventilation was manipulated to achieve an end tidal CO_2 volume between 30–35 mmHg using a tidal volume of 8 ml/kg and inspiratory/expiratory ratio of 1/2. Respiratory data such as mean and peak airway pressures were recorded for all participants. Standard monitoring included pulse oximetry and end tidal CO_2.

In group II, ventilation was achieved using a tidal volume of 8 ml/kg and was increased gradually by 1 ml/kg to 10 ml/kg every five minutes, and respiratory rates were increased gradually by two every five minutes to 25/min. In group I, pressure was designated to a tidal volume of 8ml/kg and the respiratory rate was designated according to an $ETCO_2$ range of 30–35 mmHg. Respiratory rates were increased gradually by two every five minutes to maximum of 25/min, and respiratory rates were reduced by two every 5 min. If $ETCO_2$ was less than optimum, PEEP was designated on 5 cm H_2O in both groups.

Statistics

Quantitative parameters were evaluated and categorical parameters were assessed using the chi square test. P-values less than 0.05 were considered statistically significant.

Results

There were no significant discrepancies between the two groups regarding demographic data (Table I).

Table I: Patient demographics.

		Group I	Group II
Numbers		51	52
Age(years) (median)		41.34	42.12
Gender(numbers)			
M		31	31
F		20	21
BMI(kg/m^2) (median)		31.24	32.54
ASA	***I***	33	32
	II	18	20

Patients in group II required statistically more tidal volumes (P<0.05 at 25 minutes and P<0.005 at 60 minutes), and respiratory rates (P<0.005 at 25 and 60 minutes) to maintain $ETCO_2$ at 25 and 60 minutes after pneumoperitoneum (Table 2). Patients in group II required more minutes of ventilation than patients in group I at 25 and 60 minutes after pneumoperitoneum. There were no discrepancies between both groups in terms of mean airway pressures, but peak airway pressures at 25 and 60 minutes after pneumoperitoneum were greater in group II than group I (P<0.05) (Table II).

There were no discrepancies regarding initial pCO_2 levels, and at 10, 25 and 60 minutes and postoperatively.

Table II: Ventilation and respiratory parameters (median).

	Group I			POSTOP.	Group II			POSTOP.
Base $ETCO_2$		34.61		------		34.64		------
Minutes	**10**	**25**	**60**	------	**10**	**25**	**60**	------
$ETCO_2$	34.61	35.07	35.01	------	34.69	35.04	35.07	------
Base pCO_2		39.05		------		38.98		------
pCO_2	39.18	40.21	40.25	42.18	39.30	40.49	40.55	42.41
RR	10.32	10.67	10.13		10.75	11.45	11.26	
VT	590	562.14	559.63		577.22	595.11	597.45	
***PAP**	19.84	19.34	18.26		19.31	24.13	23.44	
****MAP**	8,14	8.65	8.73		7.46	8.23	8.66	

*10 Minutes after pneumoperitoneum; *PAP: peak airway pressure; **MAP: mean airway pressure.*

Discussion

No discrepancies were found in terms of ventilation variables in laparoscopic cholecystectomy, between pressure and volume ventilations, except at 25 minutes and 1 hour following pneumoperitoneum. Reduced pulmonary compliance in high body mass index patients have been shown to minimise FRC with ventilation perfusion mismatch and hypoxia.(6) As anaesthesia and pneumoperitoneum lead to exaggerated diminutions in these cases, the proper ventilation technique to avoid ventilator associated lung insult with enhanced oxygenation, must be selected as anaesthesia and pneumoperitoneum can lead to increased reductions in FRC.(7)

No discrepancies were observed between volume and pressure ventilations, according to ventilation variables.(8) An enhancement was observed in oxygenation indices for all patients in the first hour of ventilation. The enhancement in oxygenation index was increased in volume ventilation at the second hour of ventilation because of a reduced mean airway pressure.(9) Pressure ventilation causes increased mean airway pressure during time with better oxygenation at end of anaesthesia. During inspiration, the mean airway pressure governs ventilation patterns. Pressure ventilation is better during cholecystectomy in a head down position, according to less peak inspiratory pressure.(10) There were no discrepancies between the two techniques with using PEEP with high BMI patients in intraoperative and post-operative period.(11)

During laparoscopic cholecystectomy, there were less peak pressure, more compliance and mean airway pressure with pressure ventilation and with the high BMI patients.(12) Volume ventilation is correlated with reduced oxygenation and more alveolar-arterial oxygen differences.(13)Pressure ventilation may increase mean airway pressures during pneumoperitoneum.(14) CO_2 elimination is greater with volume controlled ventilation, when compared to pressure controlled ventilation due to various minute ventilation.(1)

The advantages of pressure controlled ventilation are reduced work for breathing, due to decelerating flow waveforms. The advantages of volume controlled ventilation are due to decreasing volutrauma.(15,16)

Pressure controlled ventilation is not superior to volume controlled ventilation, if there is no spontaneous respiration, and volume controlled ventilation has decelerating flows. We believe that complications for each mode will not occur if dual modes are used, with improved lung oxygenation and minimisation of ventilator associated lung insult.(17,18) Our results do not apply to patients with lung or cardiac issues.

Conclusions

Although there were advantages in terms of mean airway pressure for pressure ventilation, no clinical discrepancies were observed between pressure and volume ventilation in high BMI patients. Using dual modes may be the ideal approach, as it may involve fewer complications.

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