ORIGINAL RESEARCH PAPER

Anaesthesiology

KEY WORDS: prone position, pressure-controlled ventilation, volume-controlled ventilation, airway pressure, stress response

COMPARATIVE ANALYSIS OF PRESSURE CONTROLLED AND VOLUME CONTROLLED VENTILATION ON RESPIRATORY MECHANICS, HAEMODYNAMICS AND SYSTEMIC STRESS RESPONSE IN PATIENTS UNDERGOING SURGERY IN PRONE POSITION.

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ABSTRACT

BACKGROUND: General Anaesthesia in prone position is related with increased airway pressure, decreased pulmonary and thoracic compliance. **AIM:** Comparision of pressure controlled and volume controlled ventilation in patients undergoing lumbar spine surgery in prone position.**METHODS:** After ethics committee approval & written informed consent, a comparative randomized interventional study was conducted from July-December 2017. Randomization was done using random number tables. Patients of either sex, ASA grade I&II, age 25-55 yrs were included while those with severe pulmonary ,cardiovascular, endocrine disease & BMI> 30kg/m2 were excluded. Patients were randomly assigned to VCV group (n = 30), or PCV group (n = 30). Haemodynamic (HR,SBP,DBP,MAP), Respiratory (P-Peak,P-mean, C-dyn) variables, blood glucose, S.cortisol were measured and ABG analysis was done 10 minutes after intubation (T1), 30 minutes after prone positioning(T2) and 60 minuts after extubation(T3). **RESULTS:** Demographic parameters , perioperative hemodynamic values were comparable with no significant statistical difference. The P-Peak levels were lower and dynamic compliance was higher in PCV group during both T1 and T2 with p value of less than 0.05 Postoperative PaO2 level was significantly higher in Group PCV compared with Group VCV. The difference between post operative and preoperative serum cortisol and blood glucose levels was significantly less in patients ventilated with PCV mode.**CONCLUSION:** According to our study, PCV mode is associated with lower P-peak levels during prone position, better oxygenation postoperatively and lesser systemic stress response. We concluded that PCV mode might be more appropriate in prone position surgeries.

INTRODUCTION

Prone positioning of patients is desired for various surgical procedures like spine surgery, posterior fossa surgery , percutaneous nephrolithotomy etc. It provides an excellent view for surgery but is also associated with various important and potentially catastrophic complications which can result in permanent disability. These complications include haemodynamic changes resulting in hypoperfusion of vital organs, a range of ophthalmologic complications, central nervous system lesions, peripheral nerve compression injuries, compartment syndrome, and pressure ulcers. Reduction in stroke volume and cardiac index has been noted when the patients were turned to prone position.[1] Although it is widely used in Acute Respiratory Distress Patients (ARDS) for enhancing oxygenation, in anaesthetized patients, due to the loss of muscle tone, prone position can cause appreciable alterations in respiratory physiology.[2,3] Also, compression on thorax by the bolsters leads to exaggerated peak airway pressures (P-Peak) and decrease in respiratory compliance. Volume Controlled Ventilation(VCV) mode is by far the most common mode used for ventilation during anaesthesia. It has a constant flow pattern which delivers a fixed tidal volume, thus ensuring adequate minute ventilation.[4] But this flow pattern can generate high airway pressures in response to reduced thoracic compliance causing excessive stretch of lung tissue which ultimately leads to barotrauma and shear stress injury to the lung.[5] This will cause activation of the inflammatory cascade and increased stress response to surgery. Pressure Controlled Ventilation (PCV) mode can be used as an alternative to VCV as PCV, by design, limits the maximum airway pressure delivered to the lung. [6]Since the risk of barotrauma and acute lung injury is reduced in PCV, the systemic stress response which is characterized by elevated levels of serum cortisol and blood glucose perioperatively may also be less in patients ventilated with PCV mode.[7] PCV and VCV have been compared in ARDS patients in terms of improvement in oxygenation.[8]The literature comparing the two ventilation modes in prone position surgeries is very limited. Therefore, this prospective randomized study comparing PCV and VCV in terms of haemodynamics, respiratory mechanics and systemic stress response was conducted. We hypothesized that the peak airway pressures would be lower in patients ventilated with PCV mode in prone position.

MATERIAL AND METHODS

After approval from Research review board and ethics committee,60 ASA grade I and II patients posted for elective lumbar spine surgery and willing to give written informed consent were enrolled in the study. Patients older than 55yrs, BMI≥30kg/m^2, having pulmonary, cardiac or endocrine disease, history of thoracic surgery were excluded from the study. The randomization was done by computer generated random number table and the numbers were kept in sequentially numbered opaque envelopes. The envelope was opened and the patient was allocated to either VCV(n=30) or PCV(n=30)group . Patients were premedicated in the preoperative chamber with Intravenous Inj.Ranitidine (50mg), Inj.Metoclopramide (10mg), Inj.Midazolam (0.03mg/kg) and Inj.Glycopyrrolate (0.004mg/kg). Routine non-invasive monitors (NIBP, ECG, Pulse Oximeter) were attached and baseline parameters noted on arrival of the patient in operation theatre. Left Radial artery was cannulated with 20G I.V cannula under local anaesthesia. The anaesthesia technique was standardized for all the patients. Induction was done with Inj.Propofol (2mg/kg), Inj.Fentanyl (2mcg/kg), Inj.Rocuronium (0.9mg/kg). After securing the airway by endotracheal intubation, maintenance was done with 50% O_2 and 50% N_2O, Sevoflurane (end-tidal conc.0.8-1.2 vol.%), Inj.fentanyl (1mcg/kg/hr) continuous infusion and

Inj.Atracurium (0.1mg/kg). The Blease 900 series ventilator (Spacelabs Healthcare, USA) was used for ventilation. The tidal volume and pressure in VCV and PCV group respectively were set such that the tidal volume of 8ml/kg of ideal body weight was delivered to the patient. The respiratory rate in both the groups was adjusted to maintain end tidal carbon dioxide concentration ($EtC0_2$) between 30-35mmHg and I:E Ratio of 1:2. External positive end expiratory pressure (PEEP) of 5 mmHg was applied. After turning the patient to prone position, pressure support was adjusted to maintain same tidal volume. Haemodynamic (HR, SBP, DBP, MAP), Respiratory (P-Peak, P-mean, C-dyn) variables, blood glucose, S.cortisol were measured and ABG analysis was done 10min. after intubation (T_1), 30min. after prone position (T_2) and 60min. after extubation (T_3). Dynamic compliance was calculated using the formula: corrected tidal volume (ml)/ [peak insp. pressure-PEEP]cmH_2O where corrected tidal volume= Expired tidal volume-tubing volume. stress response was seen by calculating the difference between blood glucose and serum cortisol levels during prone and post-operative period from that of supine position after induction of anaesthesia. At the end of surgery, reversal was done with Inj. Neostigmine (0.05 mg/kg i.v.) and Inj.Glycopyrrolate (0.008mg /kg i.v.) after onset of spontaneous respiration. Statistical analysis was performed with the SPSS, version 21 for Windows statistical software package (SPSS inc., Chicago, IL, USA). The Categorical data was presented as numbers (percent) and were compared among groups using Chi square test. The quantitative data was presented as mean and standard deviation and were compared by students t-test. Anova/Kruskal Wallis Test were used to compare the medians of more than two sample. P-value was considered to be statistically significant if less than 0.05. Calculation of sample size was done based on a previous study.[15] The minimum sample size calculated was 18 in each group at 95% confidence and 80% power to verify the expected differences of 1.5(±1.4) in mean P-Peak value in both groups: VCV (12.9±1.4) vs PCV (11.6±1.4). This sample size was enhanced to 30 in each group. The primary objective of our study was peak airway pressure at 30min.after prone position. Secondary objectives included haemodynamic parameters (HR, SBP, DBP, MAP), Respratory parameters like mean airway pressure (P-mean),dynamic compliance (C-dyn), PaO_2, $PaCO_2$. Blood glucose and serum cortisol levels were measured to analyze stress response.

RESULTS

Demographic and perioperative haemodynamic variables were comparable between the two groups(Table 1).The P-Peak levels were lower in PCV group during both T_1 and T_2 with a p value of less than 0.05(p=0.002;p=0.0003 respectively) (figure 1).There was no statistically significant difference in mean airway pressure. Though, the C-dyn decreased in both the groups when patients were turned prone (11.3% in VCV and 3.4% in PCV),it was better preserved in group PCV. Dynamic compliance was found to be significantly higher at both T_1 and T_2 in group PCV(p=0.0003,p<0.0001 respectively).PaO_2 levels were significantly higher in group PCV at T_3(p=0.045)(figure 2) although no significant difference was observed in minute ventilation. Other respiratory and oxygenation parameters were not found to be statistically significant and are summarized in Table 2.Also,the rise in B.glucose and S.cortisol levels was lower in patients ventilated with PCV mode(p<0.05) (figure 3 and 4 respectively). Perioperative B.glucose and S.cortisol levels are shown in Table 3.

TABLE 1: Demographic and Haemodynamic parameters.

Variable	VCV(n=30)	PCV(n=30)	p-value
Age(yr)	40.6+12.24	41.9+12.95	0.69
Gender(M/F)	17/13	14/16	0.438
BMI(kg/m2)	23.03+2.44	24.24+2.41	0.059
Heart Rate(beats/min.)			
Baseline	83.26+13.85	84.67+17.06	0.726
T1	94.47+13.81	97.5+15.7	0.427
T2	91.9+14.02	91.27+15.12	0.867
T3	81.97+8.94	81.47+10.99	0.847
SBP(mmHg)			
Baseline	127.06+14.03	132.03+10.62	0.127
T1	126.8+13.65	118.27+29.88	0.159
T2	121.46+7.41	121.4+10.44	0.979
T3	125.06+10.07	123.4+11.56	0.55
DBP(mmHg)			
Baseline	81.86+10.64	85.73+8.67	0.128
T1	87.13+8.28	84.43+10.00	0.259
T2	85.43+8.11	83.57+8.97	0.403
T3	82.03+8.39	78.37+7.83	0.086
MAP(mmHg)			
Baseline	96.93+11.22	101.17+7.96	0.062
T1	100.37+9.39	94.71+13.14	0.119
T2	97.44+6.99	96.18+8.51	0.533
T3	96.38+8.46	93.38+8.01	0.163

TABLE 2:Ventilation and Oxygenation parameters.

Variable	VCV(n=30)	PCV(n=30)	p-value
P-Peak(cmH2O)			
T1	16.73+2.39	14.8+1.21	0.0002
T2	18.50+1.91	15.17+1.53	0.0003
P-Mean(cmH2O)			
T1	7.33+0.84	7.17+0.59	0.379
T2	7.47+0.73	7.30+0.47	0.296
C-dyn(ml/cmH2O)			
T1	28.21+5.8	34.06+5.83	0.0003
T2	25.01+4.74	32.88+5.86	<0.0001
SpO2(%)			
T1	99.63+0.49	99.74+0.51	0.397
T2	99.51+0.49	99.83+0.60	0.88
T3	97.22+1.96	97.49+2.21	0.619
MV(L/min)			
T1	7.17+1.1	7.51+0.74	0.173
T2	7.01+1.05	7.48+0.76	0.052
EtCO2(mmHg)			
T1	32.76+1.67	32.36+1.69	0.36
T2	32.73+1.46	32.16+1.62	0.157
PaO2(mmHg)			
T1	166.73+38.37	182.06+63.52	0.262
T2	185.37+28.10	196.8+33.84	0.16
T3	90+7.02	99.72+24	0.037
PaCO2(mmHg)			
T1	37.27+7.70	36.46+5.57	0.642
T2	36.52+4.83	32.85+6.15	0.055
T3	39.15+5.30	38.39+4.21	0.846

TABLE 3: Systemic Stress Response markers.

Variable	VCV(n=30)	PCV(n=30)	p-value
B.glucose			
T1	84.06+13.49	87.86+9.97	
T2	102.4+22.24	100.03+15.95	
T3	139.46+31.87	117.03+19.87	
T2-T1	17.33+13.42	12.16+12.76	0.132
T3-T1	54.4+24.41	29.17+17.74	<0.0001
S.cortisol			
T1	12.67+4.73	13.21+4.45	
T2	16.44+5.28	14.49+5.66	
T3	19.25+5.23	14.49+5.79	
T2-T1	3.77+2.93	1.28+4.64	0.031
T3-T1	6.58+3.79	1.75+4.34	<0.0001

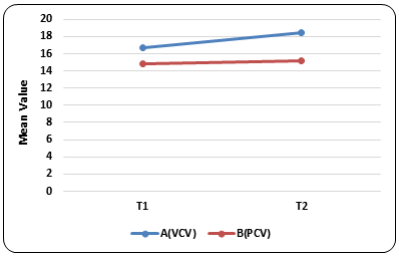

Figure 1: Peak airway pressure

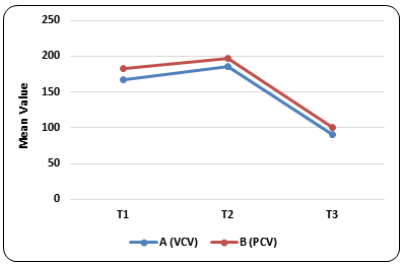

Figure 2 : PaO2 level

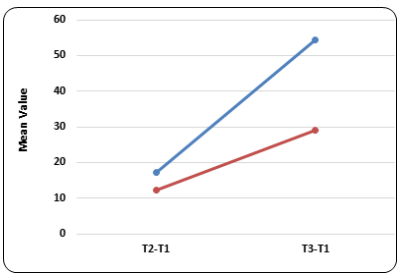

Figure 3: Rise in blood glucoselevels

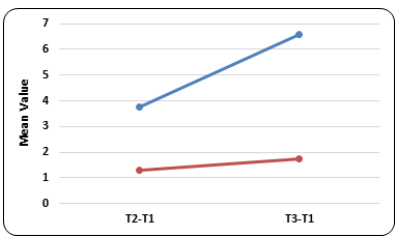

Figure 4: Rise in serum cortisol levels

DISCUSSION

Mechanical ventilation in patients receiving General anaesthesia should ensure adequate oxygenation with minimal trauma to the lung tissue. The position and ventilator parameters influence the pulmonary mechanics and systemic stress response peri-operatively. The principle finding of this study is the association of PCV mode with lower P-peak levels during prone position accompanied by a higher dynamic respiratory compliance. High airway pressure have been observed to be associated with the risk of acute lung injury post-operatively.[9] A study by Mirum Kim et al[10] to investigate the ventilation method effective in attenuating peak airway pressures also concluded in the favour of PCV mode but oxygenation was observed to be similar in both the modes as Oxygen saturation was maintained above 98% in all the patients. M.Carmen Unzueta et al[11] compared PCV and VCV mode during one lung ventilation for thoracic surgery. They found that main advantage of PCV mode was due to its affiliation with lower p-peak levels. PCV mode ensures lower respiratory airway pressures in laparoscopic surgeries also as studied by A.Tyagi [12] and Gupta et al[13]. With decrease in respiratory compliance, as seen during prone position a higher airway pressure is required to deliver the tidal volume. Therefore, lower airway pressures achieved using pressure mediated modes assures better lung protection in scenarios of decreased lung compliance. Palmon et al[14] observed 18% decrease in C-dyn on turning the patients being ventilated with VCV mode to prone position which is in accordance with our study where C-dyn decreased by 11.3% in VCV group and only 3.4% in PCV group after prone position. In our study, the post-operative PaO_2 levels were significantly higher in PCV group which is in concordance with a study by Oznur Sen et al.[15] A meta-analysis by Jiang et al [16] comparing PCV and VCV mode in different positions (supine, prone and lateral) was done which concluded that oxygen index was better and arterial oxygen difference ($A\text{-}aDO_2$) was minimized in PCV group implying better alveolar ventilation and possibly less alveolarde-recruitment. PCV mode results in more alveolar recruitment by relinquishing a considerable amount of tidal volume in the early inspiratory phase. It also affirms homogeneous dispensation of the tidal volume and efficacious removal of carbon dioxide. The rise in serum cortisol (mcg/dl) and blood glucose levels(mg/dl) was comparatively lower in patients ventilated with PCV mode. Though, the blood glucose levels increased in both the groups intraoperatively but the rise was higher in group VCV. Similarly, the serum cortisol levels remained elevated in VCV group in early post operative period while they approached the baseline values in group PCV. Our results are in confirmation with a similar study by oznur sen et al [15] conducted to analyze systemic stress response by assessing S.Cortisol, B.Glucose and S.Insulin levels.S.cortisol levels were observed to be higher in group VCV compared to group PCV. However, they did not report any significant difference in other two parameters. In their study, Hasan Senay et al[17] investigated the effect of the two ventilation modes on inflammatory markers. Interleukin 6 (IL-6), Interleukin 8 (IL-8), Interleukin 10 (IL-10), and Tumor necrosis factor alpha (TNF-) were measured to assess the inflammatory response.IL-6 and IL-10 levels increased significantly from baseline at 6th and 12th hour in both groups but the difference in 6th and 12th hour measurement of IL-10 was not signicant in group II(PCV). IL-8 increased significantly from baseline at 6th hour in group I(VCV) whereas the increase was not significant in group II. TNF- levels were not observed to rise significantly from baseline in either group except at the 6th hour in group I. However, they did not report any significant difference in inflammatory marker levels between the two groups. This may be attributed to the short duration of ventilation. A study by Memtsoudis et al[18] which compared low versus high tidal volume ventilation on inflammatory markers in the prone position by measuring plasma levels of IL-6,IL-8,urine desmosine could not infer any statistically significant difference.

CONCLUSION

According to the finding of our study, PCV mode is associated with lower P-peak levels and better Dynamic compliance during both supine and prone positions as compared to VCV mode and also better oxygenation postoperatively.The rise in systemic stress response markers is also comparatively less in PCV mode. Hence, PCV mode, which is now available with modern anaesthesia machines, should be preferred over the conventional VCV mode in patients undergoing surgery in prone position.

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