

Effect of two different levels of positive end-expiratory pressure (PEEP) on oxygenation and ventilation during pneumoperitoneum for laparoscopic surgery in children: A randomized controlled study

ABSTRACT

Background: Positive end-expiratory pressure (PEEP) is used to attenuate the changes in respiratory parameters because of pneumoperitoneum during laparoscopic (LAP) surgery. As the ideal level of PEEP during LAP in children is not known, this study compared the effect of 5- and 10-cm H₂O of PEEP on oxygenation, ventilator, and hemodynamic parameters during pediatric LAP.

Method: After obtaining approval from the Institute Ethics Committee and written informed parental consent, 30 American Society of Anesthesiologists (ASA) I and II children aged 2–10 years, undergoing LAP were randomized to receive PEEP of 5- or 10-cm H₂O during pneumoperitoneum. Baseline hemodynamic and ventilatory parameters, PaO₂, and PaCO₂ were measured 2 min after tracheal intubation, 2 min and 1 h after pneumoperitoneum, and after deflation of pneumoperitoneum. Oxygenation index, dynamic compliance, and alveolar-arterial oxygen gradient (D (A-a) O₂) were calculated at the above-mentioned time points. Data were analyzed using Student's *t*-test and repeated measures ANOVA with Bonferroni correction.

Results: The oxygenation index and D(A-a)O₂ decreased in PEEP 5 Group and increased in PEEP 10 Group after pneumoperitoneum, the difference between the two groups being statistically significant ($P = 0.001$). The dynamic compliance decreased in PEEP 5 Group and increased or remained the same in PEEP 10 Group after pneumoperitoneum, the difference between the two groups being significant ($P = 0.001$). There were no significant changes in the hemodynamic parameters in the two groups.

Conclusion: Use of 10-cm H₂O PEEP during pneumoperitoneum in children improves ventilation and oxygenation, without significant hemodynamic changes.

Key words: Alveolar-arterial oxygen gradient, dynamic compliance, laparoscopic surgery, oxygenation index, positive-end-expiratory pressure

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Introduction

Laparoscopic (LAP) surgery has emerged as the treatment modality of choice not only in adults but also in pediatric patients because of its many advantages over conventional surgery.^[1-5] Carbon dioxide (CO₂) pneumoperitoneum, an integral component of LAP surgery, decreases functional residual capacity (FRC) and dynamic compliance (C_{dyn}), causing atelectasis and an increase in ventilation–perfusion (V/Q) mismatch.^[6] Children are prone to develop more hypercarbia, acidosis, and hypoxia during pneumoperitoneum because of smaller airway caliber, increased shunt, and dead space ventilation.^[7-9] Positive end-expiratory pressure (PEEP) has been used to attenuate the decrease in partial pressure of arterial oxygen (PaO₂) that accompanies pneumoperitoneum. However, in children, there is no consensus regarding the ideal level of PEEP for improving oxygenation without adverse effects.

It has been found in children that during LAP appendectomy, pressure-controlled ventilation (PCV) with 5-cm H₂O PEEP provides better dynamic compliance in comparison to volume-controlled ventilation (VCV) with 5-cm H₂O PEEP.^[10] However, there has been no comparison of the effect of various levels of PEEP on oxygenation and dynamic compliance in children. Based on the previous study of Sen and Erdogan Doventas^[8] in adult LAP cholecystectomy, this study hypothesized that during pneumoperitoneum, 10-cm H₂O PEEP would provide better compliance and oxygenation, without significant hemodynamic and respiratory complications in comparison to 5-cm H₂O PEEP.

The primary objective of this study was to compare and assess the effect of 5- and 10-cm H₂O PEEP on oxygenation index, and the secondary outcomes were assessment of ventilation and hemodynamic parameters in children undergoing LAP surgery under general anesthesia (GA).

Materials and Methods

This prospective single-blinded randomized study was conducted after institutional ethics committee approval (INT/IEC/2017/1245), registration in Clinical Trials Registry of India (CTRI/2017/11/010592), and written informed parental consent and patient assent in 36, American Society of Anesthesiologists (ASA) physical status I or II children, aged 2–10 years undergoing LAP surgeries. Children with an anticipated difficult airway, acute respiratory tract infection, and any cardiopulmonary disease were excluded. The patients were randomly allocated to receive either external PEEP of 5-cm H₂O (*n* = 18) or 10-cm H₂O (*n* = 18) using <http://www.randomizer.org> and simple randomization. A serially numbered opaque sealed envelope method was used

for the concealment of random allocation. The investigators were aware of the allocated group, but participants and data analysts were blinded to group allocation.

Anesthesia management

The children received premedication with 0.5 mg/kg of oral midazolam about 30 min before surgery. They were pre-oxygenated with 100% oxygen and anesthesia was induced with sevoflurane at a fresh gas flow of 4 L/min. Intubation was done with an appropriate size-cuffed endotracheal tube (ETT) after administering atracurium (0.5 mg/kg). Anesthesia was maintained with oxygen in the air (FiO₂ 0.5) and isoflurane (MAC >1.1) and morphine 0.1 mg/kg was administered to provide analgesia. Immediately after intubation, an arterial cannula preferably in the radial artery was placed for arterial blood gas analysis.

All children received identical ventilation after induction of anesthesia consisting of PCV with an I: E ratio of 1:2. Peak airway pressure (P_{peak}) was set initially to deliver a tidal volume (VT) of 8 ml/kg and then changed after pneumoperitoneum with an intra-abdominal pressure (IAP) of 10 mmHg in supine position to match the baseline-expired VT. The respiratory rate (RR) was adjusted to maintain the end-tidal carbon dioxide (ETCO₂) between 35 and 40 mmHg. PEEP of 5- or 10-cm H₂O was added after pneumoperitoneum as per the group allocation.

Intraoperative monitoring included ECG, non-invasive blood pressure (NIBP), oxygen saturation (SpO₂), and ETCO₂. Ventilatory parameters, such as P_{peak}, mean airway pressure (P_{mean}), RR, and VT were recorded from the ventilator. C_{dyn} was calculated as VT/(P_{peak} – PEEP). An arterial blood sample was taken to measure PaO₂, PaCO₂, and pH at T1 (Baseline value after intubation), T2 (2 min after pneumoperitoneum with an IAP of 12 mmHg), T3 (60 min after application of PEEP during pneumoperitoneum), and T4 (after deflation of pneumoperitoneum) time points. From these readings, oxygenation index (PaO₂/FiO₂) and alveolar-arterial oxygen gradient (PAO₂ – PaO₂) were calculated. The alveolar PO₂ (PAO₂) was measured using the alveolar gas equation.

Ondansetron (0.15 mg/kg) was administered at the end of surgery for prophylaxis against postoperative nausea and vomiting (PONV). Residual neuromuscular blockade was reversed with neostigmine (0.05 mg/kg) and glycopyrrolate (0.01 mg/kg). The patients were monitored in the Post-Anesthesia Care Unit for pain, heart rate (HR), NIBP, SpO₂, and PONV.

Sample size calculation

The sample size was estimated based on the findings of a

study by Sen and Erdogan Doventas^[8] in which the PEEP 10 Group had a mean PaO₂ of 176.1 (37.9) mmHg after 30 min of pneumoperitoneum, whereas in the PEEP 5 Group, the mean PaO₂ was 135.2 (36.9) mmHg. To detect the same difference in PaO₂, with 80% power and α error of 0.05, a sample size of 14 per group was calculated. To adjust for attrition, a total of 36 children were enrolled.

Statistical analysis

The results were analyzed by the Windows Program SPSS 15.0. Descriptive statistics were provided in terms of numbers and percentages for categorical variables and in terms of the mean and standard deviation for continuous variables. The variables were compared between the two groups using the Student's *t*-test (continuous variables) and Chi-square test (categorical variables). Within-group comparison at different time points was done by Repeated Measures ANOVA with Bonferroni correction. Statistical significance level was accepted with a *P* value less than 0.05.

Results

Thirty-six patients were enrolled and randomized in this study. Six patients were excluded as LAP surgery was converted to open surgery on three occasions and the duration of surgery was less than 60 min in three instances. Finally, data from 30 patients were analyzed with 15 patients in each group [Figure 1, Table 1]. The demographic parameters are shown in Table 2.

The oxygenation index decreased in PEEP 5 Group and increased in PEEP 10 Group after the creation of

pneumoperitoneum, the difference between the two groups being statistically significant [Table 2, Figure 2a]. The oxygenation index continued to be low immediately after deflation of pneumoperitoneum in the PEEP 5 Group [Figure 3a]. The dynamic compliance decreased in PEEP 5 Group and increased or remained the same in PEEP 10 Group after pneumoperitoneum [Figure 3b], the difference between the two groups being significant [Figure 2b]. The alveolar-arterial oxygen gradient increased [Figure 3c] and arterial oxygen tension decreased [Figure 3d] in PEEP 5 Group after pneumoperitoneum, and reverse changes occurred in PEEP 10 Group, with the differences between the two groups being significant [Figure 2c].

In both PEEP 5 and PEEP 10 Groups the peak [Figure 3f] and mean [Figure 3g] airway pressures increased significantly at T2 (*P* = 0.02), T3 (*P* = 0.001) and T4 (*P* = 0.015, 0.007) time points when compared to baseline.

There were no significant differences in the PaCO₂ [Figure 3e], HR [Figure 3h], and mean arterial pressure (MAP) [Figure 3i] in the two groups after pneumoperitoneum [Table 3, Supplementary Table 1].

Discussion

This study demonstrated that PCV with the application of 10-cm H₂O PEEP during pneumoperitoneum facilitates

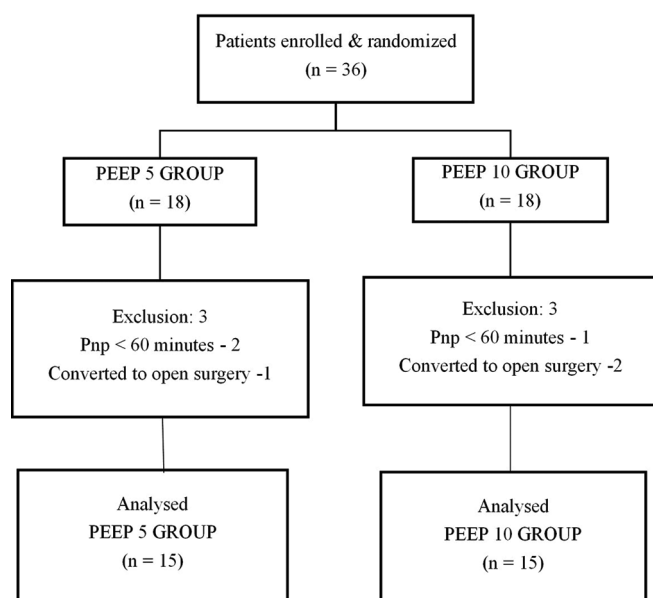


Figure 1: CONSORT flow chart

Table 1: Surgical procedures performed in both the groups

Surgery	PEEP 5 Group (n=15)	PEEP 10 Group (n=15)
Appendectomy	4	3
Choledochal cyst excision and repair	3	2
Cholecystectomy	3	4
Heller Myotomy (Achalasia cardia)	2	1
Pyeloplasty	2	2
Splenectomy	1	1
Nephrectomy	0	1
Bilateral undescended testes	0	1

PEEP=positive end-expiratory pressure

Table 2: Demographic variables

	PEEP 5 Group (n=15)	PEEP 10 Group (n=15)	<i>P</i>
Age (years)	7.7 (1.7)	6.3 (2.9)	0.118
Gender (M/F)	6/9 (40/60)	12/3 (80/20)	0.025
Weight (kg)	23 (5.2)	18 (4.9)	0.013
ASA (1/2)	14/1 (93.3/6.7)	14/1 (93.3/6.7)	1.0
Duration of Pnp (min)	153.3 (62.4)	129.5 (36.7)	0.215

PEEP=positive end-expiratory pressure, Pnp=pneumoperitoneum, ASA=American Society of Anesthesiologists. Categorical variables described by number (percent) and analyzed using Chi-square test, Numerical variables described by mean (SD) and analyzed using Student's *t* test

better oxygenation and ventilation in children undergoing LAP procedures without any significant hemodynamic changes.

Carbon dioxide pneumoperitoneum causes an increase in IAP, airway pressure, and ETCO₂ tension. The cephalic shift of the diaphragm during pneumoperitoneum reduces FRC by inducing basal lung collapse. It increases intrapulmonary shunt, the alveolar-arterial oxygen tension gradient, and V/Q mismatch.^[9] Bannister *et al.*^[6] also reported a decrease in C_{dyn} by 48%, a reduction in VT delivery by 33% with raised ETCO₂ by 13%, and a fall in oxygen saturation by 41% in infants undergoing LAP procedures.

Multiple ventilatory strategies have been introduced to minimize the respiratory and hemodynamic effects of carbon dioxide pneumoperitoneum during LAP. VCV guarantees delivery of targeted TV with the risk of increased airway pressures. On the other hand, PCV delivers an appropriate volume, independent of circuit compliance, changes in the fresh gas flow, and leaks around ETT by using a decelerating flow, which compensates for any potential reduction in ventilation caused by pressure limitation. It enables a more homogenous distribution of the VT in all ventilated alveoli, reducing the amount of atelectasis by improved alveolar recruitment.^[7] The airway pressure also rises significantly during pneumoperitoneum. In this situation, PCV is

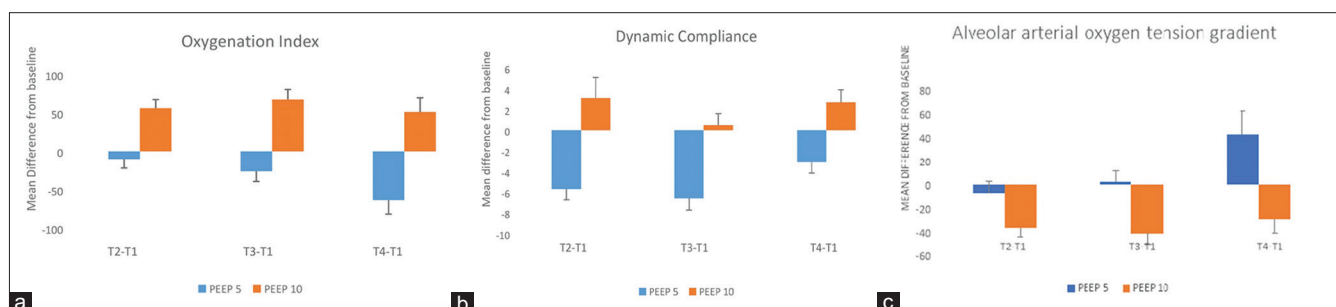


Figure 2: (a) Mean difference in oxygenation index compared from baseline (b) mean difference in dynamic compliance compared from baseline (c) mean difference in alveolar-arterial oxygen gradient compared from baseline

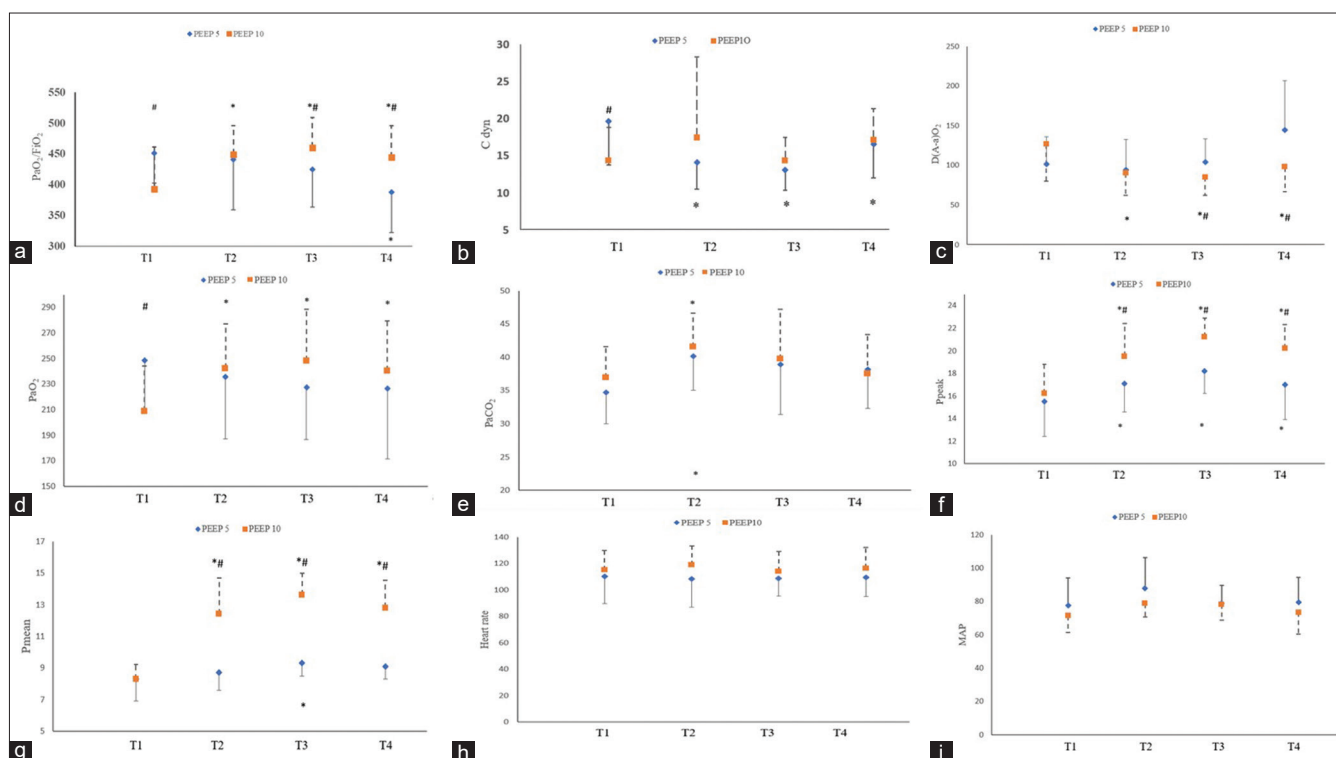


Figure 3: (a) PaO₂/FiO₂ – oxygenation index mean (SD) at different time points (b) Dynamic compliance mean (SD) at different time points (c) Alveolar-arterial oxygen gradient mean (SD) at different time points (d) PaO₂ mean (SD) at different time points (e) PaCO₂ mean (SD) at different time points (f) Peak airway pressure mean (SD) at different time points (g) Mean airway pressure mean (SD) at different time points (h) Heart rate mean (SD) at different time points. (i) Mean arterial pressure mean (SD) at different time points. #(*P*<0.05) intergroup comparison using Students *t* Test; *(*P*<0.05) within group comparison using Repeated Measure ANOVA with Bonferroni correction

Table 3: Changes from baseline (T1) at different times after pneumoperitoneum

Parameters	Time points	PEEP 5	PEEP 10	Mean difference (95% Confidence Interval)	P (Student's t Test)
Oxygenation index	T2	-10.4	56.1	66.5 (26.1-107.1)	0.001
	T3	-26.0	67.3	93.3 (53.7-132.8)	0.001
	T4	-63.4	51.3	114.7 (58.8-170.6)	0.001
Dynamic compliance	T2	-5.6	3.06	8.7 (3.5-13.8)	0.001
	T3	-6.6	-0.03	6.3 (3.0-9.5)	0.001
	T4	-3.1	2.7	5.8 (2.5-9.1)	0.001
Alveolar-arterial oxygen tension gradient	T2	-7.0	-36.2	29.2 (2.7-55.6)	0.001
	T3	2.7	-40.9	43.6 (16.9-70.2)	0.001
	T4	42.9	-28.7	71.6 (24.6-118.5)	0.002
PaO ₂	T2	-13.0	33.3	46.3 (26.3-66.3)	0.001
	T3	-21.4	39.3	60.7 (36.3-85.0)	0.001
	T4	-22.1	31.3	53.4 (24.8-81.9)	0.001
PaCO ₂	T2	5.3	4.6	0.7 (-3.0-4.4)	0.339
	T3	4.3	2.8	1.5 (-2.6-5.6)	0.241
	T4	3.5	0.6	2.9 (-1.4, 7.2)	0.091
Heart rate	T2	-1.6	3.7	5.3 (-8.8, 19.4)	0.223
	T3	-1.5	-0.8	0.7 (-11.1, 12.5)	0.458
	T4	-0.5	1.3	1.8 (-13.4, 17.1)	0.402
Mean arterial pressure	T2	10.2	7.3	2.9 (-7.6, 13.4)	0.290
	T3	1.1	6.9	5.8 (-3.8, 15.4)	0.110
	T4	1.7	2.0	0.3 (-9.2, 9.8)	0.471

T2=change in parameter two minutes after pneumoperitoneum from the baseline, T3=change in parameter one hour after application of PEEP during pneumoperitoneum from the baseline. T4=change in parameter after deflation of pneumoperitoneum from the baseline, PaO₂=partial pressure of oxygen in arterial blood, PaCO₂=partial pressure of carbon dioxide in arterial blood, PEEP=positive end-expiratory pressure

theoretically preferred as the Ppeak is limited and there is a lesser chance of barotrauma. In a study on children undergoing LAP appendectomy, significantly higher dynamic compliance and Pmean were demonstrated with the use of PCV with 5-cm H₂O PEEP compared to VCV with 5-cm H₂O PEEP.^[7] This study, therefore, used PCV as the ventilatory mode on children undergoing LAP surgeries.

Depending on the degree of PEEP used, PCV during LAP produces different ventilatory effects. PEEP improves pulmonary compliance, ventilation-perfusion abnormalities, and pulmonary oxygen exchange by preventing the collapse or closure of airways and redistributing the pulmonary blood flow.^[10,11] By keeping the airway open at the end of the expiratory period, PEEP helps in maintaining adequate gas exchange.^[12] The increase in Ppeak and Pmean leads to decreases in dynamic compliance during pneumoperitoneum. In the Trendelenburg position, these changes became more prominent.^[6,13] It has been established in different studies that the application of PEEP improves oxygenation during LAP surgery under GA. This study also showed the benefit of the application of PEEP in terms of oxygenation and dynamic compliance. However, there is no consensus in the literature regarding the ideal amount of PEEP that should be used for optimum benefit.

Various authors have found 10-cm H₂O PEEP to be beneficial in terms of oxygenation without hemodynamic complications

in adults.^[8,14,15] Lee *et al.*^[14] found that PEEP of 10-cm H₂O resulted in higher oxygenation compared to those with lower PEEP levels in adult patients undergoing robot-assisted LAP radical prostatectomy. Sen and Erdogan Doventas also concluded that PEEP of 10-cm H₂O increases oxygenation and compliance, without hemodynamic and respiratory complications, compared to a PEEP of 5-cm H₂O during LAP cholecystectomy.^[8] In another study, the application of 10-cm H₂O PEEP helped in obtaining a better oxygenation index and CO₂ elimination during LAP cholecystectomy compared to 0- and 5-cm H₂O PEEP, without any significant hemodynamic changes.^[15] Schibler *et al.*^[12] described better preservation of FRC with 10 PEEP [302.2 (160.4)] in comparison to application of 5 PEEP [280.0 (201.1)] and no PEEP 256.9 (178.6)] with better homogenous ventilation and improved PaO₂ in mechanically ventilated children.

Similar to the above-mentioned studies on adults, the oxygenation index increased significantly during pneumoperitoneum, and after deflation of pneumoperitoneum, compared to the baseline in the PEEP 10 group in this study. On the other hand, in the PEEP 5 group, the oxygenation index decreased at all time points when compared to baseline.

It has been found that in comparison to zero PEEP, application of a PEEP of 10-cm H₂O during pneumoperitoneum

significantly improves the respiratory system elastance and resistance.^[16] An electrical impedance tomographic study during LAP cholecystectomy has shown that recruitment manoeuvre and application of 10-cm H₂O PEEP provides better respiratory compliance and oxygenation by providing homogenous ventilation distribution in comparison to zero PEEP.^[17] A comparative study on 0-, 5-, and 8-cm H₂O PEEP during LAP cholecystectomy demonstrated that application of 8-cm H₂O PEEP increases compliance and causes less impairment of postoperative pulmonary function compared to 0- and 5-cm H₂O PEEP.^[18] Similarly, Spadaro *et al.*^[19] found that application of PEEP of 5-cm H₂O during LAP surgery is not satisfactory to counterbalance the effect of raised IAP during pneumoperitoneum, compared to 10-cm H₂O PEEP. They also described a significant reduction in pulmonary shunts (13% vs 6%; $P = 0.001$) with only 10-cm H₂O PEEP in comparison to zero PEEP.

This study also demonstrated a significant decrease in dynamic compliance during pneumoperitoneum (T2, T3) and after deflation of pneumoperitoneum (T4) compared to baseline (T1) in PEEP 5 group. On the other hand, the compliance in PEEP 10 group improved from baseline during other time points and was better than PEEP 5 group.

In this study during pneumoperitoneum and after deflation, the Ppeak increased from baseline in both groups. But the increase in Ppeak and Pmean were more in PEEP 10 group compared to the PEEP 5 group. This is expected because an increase in PEEP will proportionately increase the Ppeak and Pmean. Sen and Erdogan Doventas also found similar changes in airway pressures during LAP cholecystectomy in the adult population.^[8]

The application of PEEP of 10-cm H₂O during pneumoperitoneum was associated with the lowest alveolar-arterial oxygen gradient (D (A-a) O₂), better ventilation because of the formation of comparatively less atelectasis in the dependent portions of lungs compared to groups with lower level PEEP. The D (A-a) O₂ was significantly lower after 1 h of pneumoperitoneum in the PEEP 10 group but no significant changes were noted in other PEEP groups by Lee *et al.*^[14] Similarly in this study, the alveolar-arterial gradient was significantly lower during pneumoperitoneum and after deflation in PEEP 10 group compared to PEEP 5 group.

This study found a significant rise of PaO₂ at all the time points from baseline in the PEEP 10 group. On the contrary, it decreased from baseline at other time points in PEEP 5 group. The PaCO₂ level increased significantly from baseline at the onset of pneumoperitoneum in both groups and was comparable. A similar significant increase in PaO₂ from baseline

after 1 h of pneumoperitoneum in the 10 PEEP group was noted by Lee *et al.*^[14] with no significant change in other groups. Sen and Erdogan Doventas found significantly increased PaO₂ and decreased PaCO₂ in PEEP 10 group compared to PEEP 5 group.^[8] However, Lee *et al.*^[14] described an increase in PaCO₂ from baseline at the onset of pneumoperitoneum in all the groups. After 3 h of pneumoperitoneum, the PaCO₂ levels in the 5, 7, and 10 PEEP groups were significantly higher in comparison to lower PEEP groups. This difference in results may be related to the duration of pneumoperitoneum that was 30 min in the study of Sen and Erdogan Doventas,^[8] 3 h in the study of Lee *et al.*,^[14] and was 60 min in this study.

The most common concern for the application of PEEP during LAP surgery is hemodynamic changes and barotrauma. Theoretically, the raised IAP during pneumoperitoneum increases intra-thoracic pressure, thereby decreasing the venous return and cardiac output (CO), and application of PEEP may further worsen the condition. Kundra *et al.*^[15] found no significant difference in HR, MAP, and CO between 0-, 5-, and 10-cm H₂O PEEP groups during LAP cholecystectomy. Similarly, Sen and Erdogan Doventas^[8] also reported no significant hemodynamic changes associated with the application of PEEP 10 in comparison to the PEEP 5 group. This study population, comprising of healthy ASA I and II children aged 2–10 years, also demonstrated no significant changes in HR and MAP associated with PEEP 10 group in comparison to the PEEP 5 group. There was no incidence of respiratory complications in the patients of this study.

Limitations

The assessment of outcomes in this study was limited to 1 h of pneumoperitoneum and restricted to intraoperative period only. Assessing the parameters for a longer period would have been more informative.

Conclusion

PCV with 10-cm H₂O PEEP during pneumoperitoneum in children aged 2–10 years produces better oxygenation, by maintaining higher compliance and lower alveolar-arterial oxygen gradient, in comparison to 5-cm H₂O PEEP.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Supplementary Table 1: Intraoperative ventilatory, arterial blood gas, and hemodynamic parameters

Time points	PEEP 5 group (n=15)				PEEP10 Group (n=15)			
	T1	T2	T3	T4	T1	T2	T3	T4
Ppeak	15.5 (3.1)	17.1 (2.5)*	18.2 (2.0)*	17.0 (3.1)*	16.2 (2.6)	19.5 (2.9)*#	21.2 (1.7)*#	20.2 (2.1)*#
Pmean	8.3 (1.4)	8.7 (1.1)	9.3 (0.8)*	9.1 (0.8)	8.3 (0.9)	12.4 (2.2)*#	13.6 (1.4)*#	12.8 (1.7)*#
Cdyn	19.6 (5.9)#	14.1 (3.5)*	13 (2.7)*	16.5 (4.5)*	14.3 (4.4)	17.4 (10.9)	14.3 (3.1)	16.8 (4.3)
VT	194.5 (45.4)#	166.3 (37.2)*	171.1 (40.1)*	190.4 (44.1)	152.4 (25.3)	143.1 (37.9)	158.1 (34.9)	173.4 (53.3)
ETCO ₂	34.3 (3.9)	39.4 (3.1)*	39.3 (2.80)*	37.3 (2.4)*	35.6 (4.9)	40.8 (2.2)*	38.3 (3.3)	34.8 (3.1)#
RR	16.3 (1.9)	16.7 (2.2)	19.1 (2.9)	18.8 (5.4)	15.6 (2.5)	16.7 (3.5)	19.2 (3.1)	18.8 (2.3)
PaO ₂ /FiO ₂	451.3 (48.8)#	440.8 (81.7)	425.2 (61.5)	387.8 (65.5)*	393.4 (68.1)	449.4 (46.4)*	460.6 (48.8)*#	444.7 (51.1)*#
D (A-a) O ₂	101.1 (34.5)	94.1 (38.4)	103.8 (29.5)	144.1 (62.6)	126.1 (46.1)	89.9 (27.4)*	85.2 (22.7)*#	97.5 (30.6)*#
PaO ₂	248.6 (40.5)	235.6 (48.6)	227.2 (40.7)	226.5 (55.1)	208.8 (35.5)#	242.2 (34.8)*	248.2 (40.2)*	240.2 (39.2)*
PaCO ₂	34.7 (5.1)	40.1 (4.3)*	38.9 (4.6)	38.2 (5.7)	36.9 (4.7)	41.5 (5.1)*	39.7 (7.5)	37.5 (5.9)
HR	110 (20.3)	108.4 (21.5)	108.5 (13.4)	109.5 (14.8)	115 (14.7)	118.7 (14.4)	114.1 (14.9)	116.3 (15.7)
MAP	77.6 (16.3)	87.8 (18.3)	78.7 (10.9)	79.3 (14.9)	71.3 (9.9)	78.7 (8.1)	78.3 (9.7)	73.4 (12.9)

Values are in mean (SD). #($P<0.05$) intergroup comparison using Student's t Test; *($P<0.05$) within group comparison using Repeated Measure ANOVA with Bonferroni correction. PEEP: Positive end expiratory pressure; Ppeak: Peak airway pressure; Pmean: Mean airway pressure; Cdyn: Dynamic compliance; VT: Tidal volume; ETCO₂: End-tidal carbon dioxide tension; RR: Respiratory rate; PaO₂/FiO₂: Oxygenation Index; PaO₂: Partial pressure of oxygen in arterial blood; PaCO₂: Partial pressure of carbon dioxide in arterial blood; HR: Heart rate; MAP: Mean Arterial blood pressure. T1: baseline, T2: two minutes after pneumoperitoneum (Pnp), T3: one hour after application of PEEP during Pnp, T4: after deflation of Pnp