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Original Research Article

Comparison of ventilation with and without positive end expiratory pressure during anesthesia for laparoscopic surgeries

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Background: Respiratory dynamics are significantly altered during laparoscopic surgeries. Anesthesiologists should be well versed with the benefits as well as limitations of positive end expiratory pressure (PEEP) during laparoscopy. They can then judiciously use the same in different patient populations. In this study we have compared the effects of ventilation with and without PEEP of 10 cm on blood gases, airway pressures and hemodynamic parameters during laparoscopy.

Materials and Methods: 60 patients, from American Society of Anesthesiologists (ASA) physical status I and II, in the age group of 18 to 60, posted for laparoscopic cholecystectomy were enrolled. They were randomized into two groups of 30 each. Group P received PEEP of 10 cm during laparoscopy and group C did not receive any PEEP. The vital parameters, arterial blood gases, and airway pressures were compared in both groups.

Results: The oxygenation, (PaO_2/FiO_2 ratio) was significantly higher in PEEP group (446. 4 ± 113.32 mm of Hg) as compared to the control group (404 ± 51.4 mm of Hg) after one hour of laparoscopy (P= 0.0037). The control group had higher arterial carbon dioxide tension (42.84 ± 2.38 mm of Hg) as compared to PEEP group (41.86 ± 2.33 mm of Hg), (P < 0.001). Both the findings suggest better ventilation perfusion matching in PEEP group. There was a no significant variation in mean arterial pressure and heart rate due to PEEP in our patient population. However the peak airway pressures were significantly higher in PEEP group.

Conclusion: 10 cm of PEEP helped in better oxygenation with no significant hemodynamic alterations, in otherwise healthy patients undergoing laparoscopic cholecystectomy.

1. Introduction

Laparoscopy has multiple benefits like quicker recovery and shorter hospital stay. However it poses significant challenges to the anesthetiologists. General anesthesia with paralysis causes cephalad shift of diaphragm leading to reduction in functional residual capacity and atelectasis leading to intrapulmonary shunt affecting gas exchange. This causes hypoxemia and post operative pulmonary complications. All these changes are more pronounced after pneumoperitoneum. These changes cause significant morbidity particularly in patients with preexisting respiratory pathology, obesity etc.

The usefulness of positive end expiratory pressure (PEEP) in improving arterial oxygenation during laparoscopy was evaluated by many authors.[1–3] However there seems to be no consensus on the amount of PEEP required. A ventilatory strategy should aim to improve the blood gas changes and prevent atelectasis associated with laparoscopy. We have carried out this study to evaluate the effects of 10 cm of PEEP in this situation.

2. Materials and Methods

After approval from institutional ethical committee, 60 patients from American society of Anesthesiologists (ASA)

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physical status I and II, in the age group of 18-60 years, posted for laparoscopic cholecystectomy, were recruited for the study. Patients having hypertension, obesity (BMI> 40 kg/ m^2), previous lung surgeries, chronic obstructive pulmonary disease, asthma, pregnancy, restrictive lung disease or any other cardiorespiratory comorbidities were excluded from the study. Written, valid and informed consent was obtained from all patients. They were randomized using opaque sealed envelope to either group P (n=30) who received PEEP during ventilation, or group C (n=30) who received conventional ventilation without PEEP.A thorough preoperative assessment was done for all patients including detailed history, general and physical examination and review of investigations.

On arrival in the operation theatre, standard monitors like electrocardiogram, non invasive blood pressure monitor and pulse oximetry were attached. Baseline values of pulse rate (PR) and mean arterial pressure (MAP) were noted. Premedication was given with Inj. Midazolam 0.03 $mg.kg^{-1}$ and Inj Fentanyl 2 $mcg.kg^{-1}$ intravenously. Patients also received Inj. Glycopyrrolate 4mcg. kg^{-1} & Inj. Ondansetron 0.08 $mg.kg^{-1}$ intravenously. General anaesthesia was induced with Injection Propofol 1-2 mg. kg^{-1} (till the loss of eyelash reflex) and Injection Vecuronium 0.1mg. kg^{-1} to facilitate intubation with appropriate sized cuffed entotracheal tube. Patients were ventilated with closed circuit with volume control mode. Patients in group P received a tidal volume of 8 $ml.kg^{-1}$ body weight with a PEEP of 10 cm of H2O and a respiratory rate of 12 per minute. Patients with group C were ventilated with a tidal volume of 8 ml. kg^{-1} body weight and a respiratory rate of 12 per minute. Anesthesia was maintained with oxygen and nitrous (50:50) and isoflurane. It was titrated according to hemodynamic response.

After giving reverse trendelenburg position, i.e. 30^0propped up position, T0 readings of peak pressure, end tidal CO2 (ETCO2) as obtained directly from ventilator were noted. MAP, PR and arterial blood gas sample for blood gas analysis were taken. After inflation of CO2 pneumoperitoneum with a 10-12 mm Hg intra-abdominal pressure, anesthesia was maintained to keep the PR and MAP within 20% of baseline. Respiratory rate was increased if ETCO2 increased above 40 mm of Hg. In those patients in whom peak airway pressure increased to more than 30 cm of H2O after giving PEEP and /or inflation of CO2 pneumoperitonium, the PEEP was lowered to bring peak airway pressure below 30 cm of H2O. Such patients were excluded from the study. T1 readings of arterial blood gases, ETCO2, peak pressure, PR and MAP were recorded one hour after pneumoperitoneum. Rest of the anesthesia, reversal and post operative care proceeded according to usual institutional protocols.

2.1. *Statistical analysis*

Sample size was calculated using α=0.05 with a power (1-β) of 0.8 with regards to the study conducted by Kim et al.,[2] considering partial pressure of oxygen as the primary variable. We studied 30 patients per group. Data was expressed as mean ± standard deviation. The statistical analysis was carried out with software program Ghaphpad Quick Calcs and Statistics Kingdom. Independent group variables were analyzed by unpaired t-test. Comparison of continuous variables within the group, pre and post intervention was carried out by paired t test. Categorical variables were compared by Chi square test. A p-value of <0.05 was considered significant.

3. Results

The demographic parameters like age, weight, body mass index and baseline vital parameters were comparable in both groups (table 1). PR, MAP, arterial blood gas changes, peak pressures and ETCO2 noted before (T0) and one hour after (T1) inflation of pneumoperitoneum are shown in table 2. Our study showed statistically significant, higher mean PaO2 and PaO2/FiO2 index after one hour of pneumoperitoneum in PEEP group than control group. However there was wide variation in the PEEP group with 15 patients (53%) showing a fall in PaO2, though the fall was less than control group, while others maintained their PaO2 after pnemoperitoneum. In two patients from PEEP group, peak airway pressures increased to more than 30 cm H2O. PEEP was reduced to bring the pressure below 30 cm H2O and they had to be excluded from the study.

4. Discussion

General anesthesia and pneumoperitoneum are both known to cause intrapulmonary shunting, hypoxemia, lung heterogeneities, atelectasis and post-operative pulmonary complications.[4,5] PEEP has been advocated by various authors to improve oxygenation, prevent atelectasis and related postoperative complications.[6,7] On the other hand some trials[8] concluded that high PEEP and lung recruitment did not afford any protection against pulmonary complications. There seems to be no agreement among different authors regarding optimal PEEP value. It should be understood that PEEP is not without complications like hypotension and alveolar over distension, which will be more pronounced in patients with compromised cardiac function and diseased lungs. We have found statistically significant differences in the two groups in oxygenation after one hour of pneumoperitoneum. PaO2/ FiO2 were higher in group P, 446.4 ± 113.32 mm of Hg as against 404 ± 51.4 mm of Hg in group C. However there was wide variation among the PEEP group with as many as 15 (53%) patients showing a fall in PaO2, though the fall was not as much as in the control group. Rest

Table 1: Demographic parameters

Parameter	Group P (n=28) (mean ± SD)	Group C (n=30) (mean ± SD)	P value
Age	48.6 ± 5.37	47.3 ± 7.64	0.4541
Weight	65.2 ± 5.61	62.4 ± 8.56	0.1437
BMI*	25.77 ± 9.31	26.33 ± 10.12	0.8271
Base line Pulse rate	82.8 ± 12.36	84.2 ± 10.46	0.6445
Baseline MAP#	95.76 ± 8.22	98.42 ± 9.54	0.2592
Male/ Female	13/17	15/13	0.267

*BMI- body mass index, # MAP- Mean arterial pressure

Table 2: Hemodynamic, respiratory and ABG findings before and one hour after pneumoperitoneum

	Group P (n=28)			Group C (n=30)			Comparison of group P vs. group C	
Parameter	T0(mean ± SD)	T1(mean ± SD)	P value	T0(mean ± SD)	T1(mean ± SD)	P value	P value(for T0 of group P vs. C)	P value(for T1 of group P vs. C)
Pulse rate	81.36 ± 8.53	83.44 ± 13.36	0.798	84.31 ± 9.42	88.42 ± 11.61	0.171	0.215	0.1346
MAP[1]	99.3 ± 6.48	94.36 ± 12.42	0.06	102.2 ± 14.11	104.62 ± 12.62	0.09	0.3234	0.002
ETCO2[2]	35.03 ± 2.69	37.41 ± 6.21	0.052	34.36 ± 3.05	38.2 ± 4.04	<0.001*	0.3801	<0.001*
Peak airway Pressure (cm of H2O)	15.63 ±1.60	24.23 ± 1.63	<0.001*	16.01 ± 2.01	18.42 ± 4.10	<0.001*	0.4312	<0.001*
PO2 (mm Hg)	262.46 ± 31.17	223 ± 56.66	<0.001*	264 ± 30.59	202 ± 45.38	<0.001*	0.8229	0.0437*
PO2/FiO2	524. 93 ± 62.35	446. 4 ± 113.32	<0.001*	529 ± 61.18	404 ± 51.4	<0.001*	0.8029	0.0037*
PCO2 (mmHg)	40.33 ± 2.59	41.86 ± 2.33	0.003*	39.76 ± 2.76	42.84 ± 2.38	<0.001*	0.4216	<0.001*
Ph	7.42 ± 0.04	7.40 ± 0.05	0.129	7.41 ± 0.03	7.37 ± 0.03	<0.001*	0.4616	0.007*

* Statistically significant, [1]MAP-mean arterial pressure, [2]ETC02-end tidal co2

patients maintained their PaO2 after peumoperitoneum. “Optimal” positive end-expiratory pressure (PEEP) is that PEEP which prevents collapse, avoids over-distension, and consequently, leads to optimal lung mechanics at minimal dead space ventilation.[9] Optimal PEEP is likely to be dependent on factors like patients body mass index (BMI),[10] chest wall dimensions, shape and pleural pressures.[8,11,12] In our study we have included patients who did not have any cardiac or pulmonary diseases and had comparable BMI as these factors were likely to influence results. However the wide variation in PaO2 / FiO2 in our PEEP group can be explained by recent studies that tried to find out optimal individual PEEP in patients undergoing laparoscopy using electrical impedance tomography.[10] They have found optimum PEEP that was a best compromise of lung collapse and hyper distension, ranged between 6-16 cmH2O among patients. Various patient factors mentioned above affect these values. It therefore seems important to stress that PEEP needs to be carefully adjusted to patients needs ,particularly in those susceptible to its cardiorespiratory adverse effects, rather than blindly adhering to a predetermined fixed value.

Laparoscopy uses carbon dioxide for creating pneumoperitoneum. Hence there is a rise in PaCO2 in these patients. In our study we increased the respiratory rate after creation of pneumoperitoneum to maintain ETCO2 between 35-40 in both groups. However we found the PaCO2 to be higher in the group without PEEP than in the PEEP group. This was also reflected in the lower pH values in the control group without PEEP. This is in line with the results from a study where 10 cm PEEP was found to be optimal in their patients population with lower PaCO2 values in the PEEP group reflecting better gas exchange with PEEP.[13]

Hemodynamically, we found that the PEEP group showed statistically lower mean arterial pressure though they did not require any vasopressor support. In our study the patients were of ASA physical status 1 and 2, without any pre existing cardiac morbidity. In another study PEEP of 12 cm of H2O caused hemodynamic instability requiring increased fluid administration.[8] On the other hand some studies showed no hemodynamic instability after giving PEEP.[7,10,14] Though PEEP did not demonstrate significant hemodynamic consequences in many studies, it is worth noting that all these studies were done on otherwise healthy patients from cardiac point of view. We recommend judicious use of PEEP titrated to minimum hemodynamic derangement, particularly in patients with preexisting cardiac disease.

The peak airway pressures were significantly higher in PEEP group as compared to control group. Two patients in the PEEP group had peak airway pressures more than 30 cm of H2O, where we reduced the PEEP and excluded them from the study. Rise in airway pressure can be detrimental in patients various respiratory pathologies, so it becomes important to limit PEEP in such patients.

We have not compared the effects of PEEP in obese patients or those having some cardiorespiratory morbidity. We have also not confirmed the actual evidence of atelectasis by post-operative imaging, as this was not feasible in our set up. These were the limitations of our study.

5. Conclusion

In our study we found that 10 CM of PEEP showed improvement in oxygenation, without causing significant hemodynamic compromise in otherwise healthy individuals. Since improvement in oxygenation indicates better ventilation perfusion mismatch, we may conclude that PEEP may be helpful to reduce intraoperative and postoperative pulmonary complications. However judicious use of PEEP is essential keeping in mind the problems related to excess of PEEP, particularly with cardiorespiratory comorbidities. More studies to determine, how to effectively select optimal PEEP for individual patient are needed considering that there is wide variation in the response of patients to a fixed PEEP.

6. Source of Funding

None.

7. Conflict of Interest

The authors declare that there is no conflict of interest.

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