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Original Article

Effects of positive end expiratory pressure during laryngeal mask airway anesthesia on respiratory parameters and abdominal pain in cataract surgery

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Abstract

Introduction: The purpose of this study was to evaluate the effects of positive end expiratory pressure (PEEP) on respiratory parameters and abdominal pain in patients ventilated with a laryngeal mask during cataract surgery.

Methods: This clinical trial study included 80 patients in need of cataract surgery (40 in the group without PEEP and 40 in the group with PEEP at 5 cmH2O) who underwent laryngeal mask ventilation during general anesthesia. The parameters of dynamic compliance, pressure peak (Ppeak), tidal volume, SpO2, EtCO2, heart rate, non-invasive blood pressure, and abdominal pain were recorded at intervals of 1, 5, 10, and 20 minutes after the start of anesthesia and were compared between the two groups.

Results: Respiratory parameters, heart rate and systolic and diastolic blood pressure were not significantly different between two groups, and only the mean tidal volume at 5, 10, and 20 minutes was significantly higher in the group without PEEP.

Conclusion: Application of 5 cmH2O PEEP during ventilation with laryngeal mask in patients undergoing cataract surgery had no significant effect on improving respiratory parameters and pain in the gastric area.

Introduction

Even in people with healthy lungs, general anesthesia can interfere with the mechanics of respiration.[1,2] Thus, ventilation and respiratory support are necessary for patients under general anesthesia.[3] In surgeries such as cataracts that do not require prolonged anesthesia, supraglottic devices and a laryngeal mask are usually used to manage the airway. Unlike tracheal tube, these devices do not enter the trachea and do not have many of the side effects of tracheal tube injury such as airway damage, however, they can cause gastric perfusion and as a result, abdominal pain, which can even aggravate hemodynamic problems.[2-5] Elderliness and the use of supraglottic devices for anesthesia are two risk factors that can increase the risk of pulmonary and cardiovascular problems during anesthesia in patients undergoing cataract surgery.[6] However, it has been suggested that positive end expiratory pressure (PEEP) as a standard strategy to protect the lungs during anesthesia can improve hemodynamic and oxygenation conditions in such patients.[6-8] The application of external PEEP is a pressure that is determined by an anesthesiologist at the beginning of the mechanical ventilation in the device settings and it is applied by the ventilator to the patient's airways at the end of exhalation until the beginning of the next breath. This positive pressure prevents the alveoli from overlapping at the end of the exhale and reduces the risk of pulmonary complications by minimizing alveolar traction at the end of the inhale and preventing possible inflammation or alveolar collapse.[9,10] It has been suggested that this parameter can improve oxygenation and reduce ventilator damage in patients under general anesthesia.[11] Numerous studies have been conducted to evaluate the effect of external PEEP on the improvement of pulmonary respiratory status during anesthesia, but the results of existing studies are very contradictory. However, the

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number of studies that has examined the application of this factor in patients undergoing cataract surgery is very limited. Therefore, this study compares two methods of volume-controlled ventilation with and without PEEP during anesthesia with a laryngeal mask, in terms of respiratory parameters and abdominal pain.

Methods

This is an interventional study of a clinical trial that has been done in the Nikukari Educational-Medical Center of Tabriz affiliated with the Tabriz University of Medical Sciences. Before starting the study, a written consent form was obtained from all participants.

Eighty patients, subjects for elective cataract surgery, were included in the study. The individuals were in the age range of 20-70 years with class I and II American Society of Anesthesiologists (ASA). Yet, those patients who were subject to local anesthesia or suffering from lung disease and sleep apnea, or had a record of gastroesophageal reflux, mental retardation, cardiac pacemaker, or a body mass index above 30 were excluded from the study.

The subjects of the study were randomly divided into two groups without PEEP (zero PEEP group (ZEEP)) and the group with PEEP application of 5 cmH2O (PEEP group). For anesthesia, patients in both groups underwent induction anesthesia with midazolam 1 mg, fentanyl 1 µg/kg, propofol 2 mg/kg, and atracurium 0.2 mg/kg. The confounding factors including the type of used laryngeal mask, the type of anesthesia machine, and ventilator settings were standardized. The MEDEC Saturn Evo anesthesia machine was used for patients in both groups.

The laryngeal mask airway (LMA) Classic was used to control the airway. For this reason, size 4 was used for patients weighing 50 to 70 kg and size 5 for patients weighing 70 to 100 kg. After placing the LMA, the cuff was filled with an air syringe so that no air leakage would occur in the cuff pressure ranging from 40 to 60 cmH2O. Then, MAC isoflurane 1 and a combination of 50% oxygen and N2O were used. The patients in both groups were under control in terms of pulse oximetry, electrocardiography, non-invasive blood pressure measurement, and capnography.

For the ZEEP group, volume-controlled ventilation without PEEP was started with a flow volume of 6 mL/kg based on ideal body weight and respiratory rate of 8-10 times per minute. Then, according to capnography and to maintain Et CO2 between 30 and 35 mm Hg, the number of breaths was changed as needed. In the PEEP group, volume-controlled ventilation was started with a flow volume of 6 mL/kg based on the ideal body weight with a respiration rate of 8-10 times per minute and with PEEP at a rate of 5 cmH2O. Then, based on capnography and to maintain Et CO2 between 30 and 35 mm Hg, the number of breaths was changed as needed. At intervals of 1, 5, 10, and 20 minutes after the start of anesthesia, the parameters of dynamic compliance, pressure peak (PPeak), tidal volume, expiratory flow volume (EtCO2), pulse oximetry (SpO2), heart rate, and non-invasive blood pressure for all patients were recorded by an anesthesiologist. After recovery of patient from the anesthesia and when patient's consciousness was increased to the point of ability to respond, he/she was asked about the abdominal pain. The patient's response was recorded as yes or no by an anesthesiologist other than the anesthesiologist of the patient.

Statistical Analysis: The obtained data were analyzed by SPSS software (version 20.0). The normality of the data was evaluated by *Kolmogorov–Smirnov* test. Parametric data with normal distribution were analyzed by using t-test and the non-parametric data were analyzed by using the χ^2 test or Fisher exact test. A P value of less than 0.5 was considered statistically significant.

Results

As shown in Table 1, no statistically significant difference was observed between the ZEEP and PEEP groups in terms of gender ($P=0.411$), age ($P=0.441$), weight ($P=0.259$), height ($P=0.489$), and BMI ($P=0.407$) (Table 1).

According to the data in Table 2, in terms of dynamic compliance parameters, Ppeak, SpO2, EtCO2, heart rate, and systolic and diastolic blood pressure in the studied time periods, no statistically significant difference was observed between the two groups ($P<0.05$ in all). There was no significant difference in mean tidal volume between ZEEP and PEEP groups in the first minute ($P=0.099$), but this difference in the fifth (484.63 ± 74.40 vs 430.81 ± 56.81, $P=0.001$), tenth (478.13 ± 74.73 vs 433.71 ± 63.32, $P=0.01$) and twentieth minutes (480.00 ± 72.10 vs 422.42 ± 83.57, $P=0.003$) were significant between the two groups.

The present study could not report a significant effect in terms of respiration, cardiac, and blood pressure parameters due to the application of 5 cmH2O PEEP and there was only a significant difference between the mean tidal volume between the two groups. In a 2019 study of patients undergoing robot-assisted laparoscopic prostatectomy, Shono et al reported that applying 15 cmH2O PEEP had a significant effect on improving ventilation in the dorsal gravity-dependent parts of the lungs and thus improved gas exchange and lung function, but the application of 5 cmH2O PEEP did not have this

Table 1. Personal characteristics of the studied groups

	ZEEP	PEEP	*P* value*
Gender, Male, No. (%)	18 (45%)	22(55%)	0.411
Age (y)	65.18±14.75	62.37±15.31	0.441
Weight (kg)	67.78±11.84	70.87±10.74	0.259
Height (cm)	175.80±94.79	163.87±12.16	0.489
BMI (kg/m^2)	25.54±5.78	26.56±4.03	0.407

Abbreviations: PEEP, positive end-expiratory pressure; ZEEP, Zero PEEP; BMI, body mass index.
*Difference is significant at the<0.05 levels (2-tailed).
Data are mean±SD.

Table 2. Changes in respiratory and hemodynamic variables during the intraoperative period

	T1			T2			T3			T4		
	ZEEP	PEEP	*P* value	ZEEP	PEEP	*P* value	ZEEP	PEEP	*P* value	ZEEP	PEEP	*P* value
Dynamic compliance	38.21 ± 8.89	35.00 ± 7.82	0.120	37.53 ± 8.70	34.90 ± 7.93	0.200	37.57 ± 8.76	34.77 ± 8.19	0.178	37.21 ± 9.11	33.68 ± 9.73	0.125
Ppeak	14.28 ± 4.11	14.52 ± 3.51	0.795	14.05 ± 3.88	14.45 ± 3.98	0.670	14.00 ± 3.76	14.58 ± 3.69	0.517	14.15 ± 4.19	14.80 ± 4.02	0.506
Tidal Volume	468.33 ± 96.14	435.48 ± 58.78	0.099	4784.63 ± 74.40	430.81 ± 56.81	0.001	478.13 ± 74.73	433.71 ± 63.32	0.010	480 ± 72.10	422.42 ± 83.57	0.003
SpO2	99.23 ± 1.44	99.48 ± 0.85	0.378	99.20 ± 1.01	99.23 ± 1.16	0.919	99.15 ± 1.44	99.32 ± 0.94	0.499	99.03 ± 1.31	99.19 ± 1.01	0.566
EtCO2	36.73 ± 5.34	36.05 ± 4.85	0.780	37.18 ± 4.95	36.45 ± 5.16	0.528	37.45 ± 5.04	36.62 ± 5.11	0.476	37.65 ± 5.01	36.99 ± 4.87	0.548
Heart Rate	69.65 ± 12.24	71.32 ± 10.45	0.521	69.10 ± 12.01	70.52 ± 9.46	0.594	67.43 ± 11.03	68.52 ± 9.35	0.661	68.20 ± 12.35	76.77 ± 9.35	0.874
Systolic blood pressure	109.48 ± 25.05	109.52 ± 20.37	0.994	113.88 ± 20.33	117.42 ± 17.46	0.442	116.45 ± 18.91	117.87 ± 15.28	0.734	116.78 ± 20.29	115.58 ± 22.77	0.816
Diastolic blood pressure	68.50 ± 14.97	72.35 ± 13.12	0.260	72.12 ± 12.45	77.71 ± 11.03	0.053	72.38 ± 11.45	76.74 ± 9.16	0.087	72.98 ± 13.62	75.16 ± 12.11	0.484

Abbreviations: PEEP, positive end-expiratory pressure; ZEEP, Zero PEEP.
T1, first minute; T2, Fifth minute, T3, Tenth minute, T4, Twenty minutes.
Data are mean ± SD. Difference is significant at the < 0.05 levels.

effect on improving lung function.[10-16] In the present study, due to the age of the patients and the possibility of underlying cardiovascular disease, higher PEEP pressure was not applied to prevent possible complications, and only 5 cmH2O pressure was applied for all individuals in the PEEP group. This might be the reason for not observing a significant difference between the two groups in the study parameters. In a 2013 study, using 5 cmH2O PEEP during ventilation with supraglottic devices Kim et al. failed to observe an effect on improving pulmonary oxygenation.[16] In 2016, on the effect of applying 15 cmH2O PEEP to individuals with healthy lungs who underwent robot-assisted laparoscopic prostatectomy, Ahn et al. reported that applying this amount of PEEP can improve arterial oxygenation, but this effect is very durable and cannot improve lung function.[9] However, in their study in 2018, Pereira et al stated that applying a standard and constant PEEP pressure to all people may not have a significant effect on improving respiration[3] because the appropriate amount of PEEP for each person can be different.

On the other hand, performing different surgeries which create different conditions for the patient, can impose a different respiratory burden on the patient, thus, the appropriate amount of PEEP in each person should be determined and applied according to the specific hemodynamic conditions of the person and the type of surgery.[2,7] Furthermore, the parameter of pain in the abdominal region was examined between the two groups in this study. The use of supraglottic anesthetics during induction of anesthesia might cause gastric perfusion and as a result, abdominal problems such as pain around the umbilicus and even pulmonary aspiration.[17] It was thought that the application of PEEP during anesthesia may resolve abdominal problems,[18] but the present study failed to confirm this hypothesis. In a similar study in 2019, Cajander et al stated that PEEP not only could not reduce abdominal problems but could even exacerbate abdominal problems in anesthetized patients.[17]

The present study had some limitations that are suggested to be removed in future studies. Among them, it is possible to mention the small number of studied samples, control of hemodynamic conditions only with non-invasive methods and, the impossibility of performing blinding. Also, as mentioned before, due to the age of patients and the possibility of cardiopulmonary problems, choosing higher amounts of PEEP could cause possible complications. As a result, this study was performed only by applying 5 cmH2O PEEP. Therefore, by adopting more stringent entry and exit criteria in subsequent studies, it will be possible to evaluate the effect of values above 5 cmH2O PEEP and even values above the physiological range on respiratory parameters and abdominal pain in these patients (Table 2).

There was no significant difference between the two groups in terms of pain in the abdominal area ($P = 0.07$; Table 3).

Table 3. comparison of pain between studies groups

		ZEEP No. (%)	PEEP No. (%)	*P* value*
Pain	YES	4 (10)	0 (0)	0.07
	No	36 (90)	40 (100)	

PEEP, positive end-expiratory pressure; ZEEP, Zero PEEP.
* Difference is significant at the < 0.05 levels.

Discussion

In the present study, no significant statistical and clinical differences were found in ventilation parameters and abdominal pain between the study groups. However, comparing the mean tidal volume of the two studied groups in the 5th, 10th and 20th minutes, there was a statistically significant difference, so the amount of tidal volume in the group without PEEP was higher than the group with PEEP. But it was not clinically significant. In the comparison of the pain sensation, in the group without PEEP (90%), 36 patients reported no pain, three patients (7.5%) reported moderate pain and one person (2.5%) reported severe pain. In the group with PEEP (100%), 40 patients did not feel pain, which statistically did not have a significant difference between the two groups.

PEEP has long been used as a standard strategy to protect the lungs during mechanical ventilation, especially in patients with acute respiratory distress syndrome who require intensive care. However, the results of some previous studies indicated the possible effect of PEEP during surgery and general anesthesia in reducing the complications of atelectasis and pneumonia.[10-14] In a 2019 study, Kim et al stated that the application of PEEP to about 7 cmH2O could improve arterial oxygenation and reduce atelectasis during the use of laryngeal masks in elderly patients in urological surgery.[6]

Two similar studies conducted in 2009 and 2019 in obese patients undergoing bariatric surgery reported that the application of 10 cmH2O of PEEP reduced the length of stay in recovery and complications such as respiratory distress, and increased oxygen saturation.[15-19] In a study in 2013, Golparvar et al[15] stated that increasing PEEP from zero to 15 cmH2O can improve oxygenation in both groups of patients with healthy and damaged lungs without having a significant effect on systolic and diastolic blood pressure, and heart rate.[19]

Conclusion

According to the results of this study, during ventilation with a laryngeal mask, the application of PEEP in the range of 5 cmH2O did not have a significant effect on respiratory, cardiac, and blood pressure parameters and only tidal volumes were significantly different between the two groups.

Strong points of this study

Numerous studies have been conducted to evaluate the effect of external PEEP on the improvement of pulmonary respiratory status during anesthesia, but the results of existing studies are very contradictory. However, the number of studies which examine the application of this factor in patients undergoing cataract surgery is very limited.

Weak g points of this study

- Small sample size: The effect of PdyEEP on ventilatory parameters of patients undergoing minor surgeries should be investigated in a larger statistical volume. Comments to the Editorial Office
- Short surgery time: According to the choice of cataract surgery for this study, and that most of the patients were old and had underlying cardiovascular diseases, the choice of higher PEEP values could have caused its possible complications, so it is possible to select patients from A different statistical population and the adoption of stricter entry and exit criteria investigated the effect of higher PEEP values, even higher than the physiological range, on respiratory parameters and abdominal pain.

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Competing Interests
The authors stated that they had no conflict of interest.

Study Highlights

What is current knowledge?

- Application of 5 cmH2O PEEP during ventilation with laryngeal mask in patients undergoing cataract surgery had no significant effect on improving respiratory parameters and pain in the gastric area.

What is new here?

- The number of studies which examine the application of this factor in patients undergoing cataract surgery is very limited.

Ethical Approval

This study was approved by the Regional Committee of Ethics in Research (Human Subjects Studies) under the code IR.TBZMED.REC.1398.766. In addition, it was registered at Iranian Registry of Clinical Trials (identifier: IRCT20190921044832N1) (https://en.irct.ir/trial/42497).

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