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ORIGINAL ARTICLE

Comparative Study of Two Different Positive End Expiratory Pressure Strategies in Laparoscopic Bariatric Surgery: Effect on Cardiopulmonary Function

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ABSTRACT

Background: Obesity causes a reduction in the functional residual capacity (FRC), significant atelectasis and shunting in dependent lung regions. In bariatric surgery under general anesthesia the application of positive end expiratory pressure (PEEP) improves the arterial oxygen tension (PaO_2) via increasing function residual capacity and prevention of surfactant aggregation which reduces alveolar collapse.

Methods: In our prospective randomized controlled comparative study, a total of 69 patients who were non-smoker, ASA II and scheduled for laparoscopic sleeve gastrectomy were included. Patients were randomly allocated to three groups, 23 patients each, group C: control group including patients on mechanical ventilation without any PEEP applied, group A: in which an ascending pattern of PEEP was applied till the end of surgery and group D: in which a descending pattern of PEEP was applied till the end of surgery.

Results: Regarding oxygen saturation (SPO_2) and PaO_2 distribution from time 30 till 90 minutes, group A and group D were significantly higher than group C, while arterial carbon dioxide tension ($PaCO_2$) and End tidal CO2 ($ETCO_2$) in both group A and group D were significantly lower than group C but at different times. Mean airway pressure and PIP were significantly higher in groups A and D than group C.

Conclusions:

PEEP 7 cmH_2o is the best ventilation strategy among the studied strategies regarding hemodynamic parameters and lung mechanics, but oxygenation and ventilation improve with any PEEP level.

Keywords: PEEP: Bariatric: Ventilation: Laparoscopic Sleeve Gastrectomy

INTRODUCTION

Obesity causes a reduction in the functional residual capacity (FRC), significant atelectasis and shunting in dependent lung regions but the resting metabolic rate, work of breathing and minute oxygen demand are increased **[1].** This means that, following the cessation of breathing, arterial oxygen levels decrease rapidly. Positive pressure in the lungs at the end of each exhalation known as PEEP improves arterial oxygen tension PaO_2 via increasing the functional residual capacity (FRC), prevention of surfactant aggregation which reduces alveolar collapse, increasing alveolo-capillary interface available for gas exchange and displacing extra-vascular lung water from the alveolar interstitium to peribronchial interstitium **[2]**.

The application of extrinsic PEEP will have both a direct impact on oxygenation and an indirect impact on ventilation. By opening up airways, the alveolar surface increases, creating more areas for gas exchange and hence improving ventilation **[3].**

The National Institutes of Health Consensus Statement specifies gastrointestinal surgery as a treatment alternative for patients with high Body mass index **[3]**. Bariatric surgery is associated with an improved rate of sustained weight loss and a reduction of comorbidities **[4]**.

General anesthesia has a golden rule in Laparoscopic surgery as it facilitates decompression of the gastrointestinal tract (GIT), provides optimal muscle relaxation, and makes pneumoperitoneum and Trendelenburg position rather tolerable. These circumstances provide a good environment for abdominal organs manipulation and minimize the risk of operative mechanical combat injury **[5].**

METHODS

This prospective randomized controlled comparative study was carried out at the Anesthesia Department of Zagazig University Hospital from December 2016 to December 2018.

Ethical Clearance

Approval from the local Ethics committee was obtained and written informed consent from each patient, the work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Our sample was 69 patients calculated by Epi info and with a CI 95%, power 80% based on a mean value of PaO2 of 269±59 mmHg in a control group 335±52 mmHg in a descending group and 271±62 mmHg in an ascending group **[6].** And it included a total of 69 patients who were non-smokers, American Society of Anesthesia (ASA) class II, aged between 21 and 50 years, both sexes, body mass index (BMI) >35 and up to 39.99 kg/m^2 and scheduled for laparoscopic sleeve gastrectomy. Our exclusion criteria were patient refusal, ASA III &IV patients, ages < 21 and > 50 years, patients with anticipated difficult airway, patients with any medical conditions causing arterial desaturation or hypercarbia (Chronic obstructive pulmonary disease, Coronary Artery Disease, Cerebrovascular disease and intracranial hypertension) and if the surgical time was less than 90 minutes or extended more than 2.5 hours from starting of PEEP.

Patients were randomly allocated to one of three groups:

Control group (Group C): Patients on mechanical ventilation without any PEEP applied.

Ascending group (Group A): Ascending pattern of PEEP is applied starting from 5 cm H_2O and increased by 2 cm H_2O every 30 minutes up to a maximum of 9 cm H_2O PEEP value which was continued till the end of surgery.

Descending group (Group D): Descending pattern of PEEP is applied starting by 9 cm H_2O and decreased every 30 minutes by 2 cm H_2O to a minimal level 5 cm H2O PEEP value which was continued till the end of surgery.

Randomization was done using a computer-generated number tables and concealed using sealed opaque envelopes. Patients and data collectors were blind to group assignments.

Preoperative:

Complete history and physical examination were done by the anesthetist, history and physical examination of obesity related co morbidities and airway were stressed on. Routine laboratory investigations (CBC, coagulation profile, kidney function, liver function, lipid profile, fasting blood glucose, blood type) in addition to cardiopulmonary evaluation (ECG, CXR, echocardiography, lower limb duplex when indicated) were also done. Patients were then referred to endocrine evaluation for diabetes, thyroid disease, pregnancy counseling and psychosocial-behavioral evaluation by specialist in each of those fields. Patient approval was obtained after detailed explanation of the procedure. Documentation of the medical cause for bariatric surgery was done. All patients received H_2 receptor antagonist 150 mg/day on the night before surgery.

Intraoperative:

In the operating room, routine monitors will be applied (ECG, noninvasive blood pressure (NIBP) with an appropriate cuff size, pulse oximetry and capnography). Two 18-gauge Intravenous lines were inserted as well as an arterial line inserted after subcutaneous infiltration of 1 ml lidocaine 2% and under complete aseptic precautions.

Basal line parameters for all patients were recorded [mean arterial blood pressure (MAP), systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), end tidal CO_2, oxygen saturation (SpO_2%), arterial carbon dioxide tension ($PaCO_2$) and arterial oxygen tension (PaO_2)]

All Patients were Preoxygenated with 100% O_2 for 3 minutes in a ramping position (An elevation of 25-degree of the head and neck until the external auditory meatus and the sternal notch were in the same plane) with pulse oximetry monitoring. Induction of general anesthesia (GA) with propofol up to 2.5 mg/kg (1 %) up to 350 mg, fentanyl 1-2µg/kg up to 250µg, then patients were smoothly intubated using succinyl choline 1.5-2mg/kg actual body weight for muscle relaxation. Maintained muscle relaxation was done using cisatracurium in the form of an initial bolus dose of 0.15mg/kg ideal body weight and a maintenance dose of 10% of the loading dose every 30 minutes. Rescue analgesia was in the form of fentanyl 1ug/kg when inadequate analgesia was suspected by an increase in the heart rate and/or blood pressure > 20% from the recorded baseline.

All Patients were mechanically ventilated with Volume controlled ventilation (VCV) using conservative tidal volumes of 8 ml/kg ideal body weight. Inspired oxygen fraction (FiO_2) was 100% throughout the procedure. Ascending, descending pattern or no PEEP applied according to our random allocation. Hemodynamic parameters, PaO_2, $PaCO_2$, SpO_2 %, end tidal CO_2, peak airway pressure and peak inspiratory pressure were recorded at basal time as well as before and after the application each PEEP.

Patients were extubated following reversal from muscle relaxants, using neostigmine 50 ug/kg adjusted body weight and atropine 20 ug/kg, and under neuromuscular monitoring using a nerve stimulator. After extubation, continuous positive airway pressure (CPAP) value of 5 cm H_2O was added and hemodynamic parameters, end tidal CO_2, SpO_2 were recorded after 10 minutes (CPAP1) then after another 10 minutes (CPAP2). Patients were transferred from operating theatre to post-anesthesia care unit (PACU) when the modified Aldrete score was ≥9 **[7].**

Post-operative

Pain was assessed using visual analogue scale (VAS) aiming to maintain VAS < 3. On extubation, ketorolac 30 mg/dose was given and maintained in the form of 30 mg/kg every 8 hours. VAS was reassessed after 30 minutes and if ≥3 opioid supplementation in the form of pethidine 0.5mg/kg ideal body weight was given if needed.

Data collection:

During mechanical ventilation, hemodynamic parameters (HR, SBP and DBP) along with PaO_2, $PaCO_2$, SpO_2 %, end tidal CO_2, mean airway pressure and peak inspiratory pressure were recorded at basal time. PEEP was altered every 30 minutes and the parameters mentioned above were measured before and 10 minutes after the application of each PEEP.

During spontaneous breathing after extubation, apart from the mean and peak airway pressures, the same parameters were recorded every 10 minutes after extubation.

Statistical analysis

Data were checked, entered, and analyzed using SPSS version 20. According to the type of data qualitative represent as number and percentage, quantitative continues group represent by mean ± SD, the following tests were used to test differences for significance, difference and association of qualitative variable by Chi square test (X2)., multiple by ANOVA or Kruskal Wallis, P value was set at <0.05 for significant results &<0.001 for high significant result.

RESULTS

Regarding the respiratory parameters, there was no statistically significant difference between the studied groups regarding the baseline PaO_2. On the other hand, there was a statistically significant difference between them regarding PaO_2 at 30, 60 and 90 minutes. The difference was significant between the control group and each of the other groups: ascending group and descending group had significantly higher PaO_2 compared to the control group **Figure [1].**

There was no statistically significant difference between the studied groups regarding the baseline $PaCO_2$. On the other hand, there was a statistically significant difference between them regarding $PaCO_2$ at 30, 60 and 90 minutes. The difference is significant between the control group and each of the other groups: ascending group and descending group had significantly lower $PaCO_2$ than control group **Figure [2].**

There was no statistically significant difference between the studied groups regarding the baseline peak inspiratory pressure (PIP). On the other hand, there was a statistically significant difference between them regarding PIP at 30, 60 and 90 minutes. Compared to the control group, the ascending and descending groups had a significantly higher PIP. **Figure [3].**

Regarding the hemodynamic parameters (SBP and DBP), there was no hemodynamic instability at PEEP value of 7 cmH_2O in ascending and descending pattern at (60min) but there was a significant decrease of SBP and DBP at PEEP values of 9 cmH_2O in both ascending group at (90min) and descending group at (30min). On the other hand, $PaCO_2$ and end tidal CO_2 were significantly lower within the non-control groups and so either ascending or descending pattern were beneficial compared to no PEEP application.

There was no statistically significant difference between the studied groups regarding the baseline systolic blood pressure, at 60 minutes, continuous positive airway pressure (CPAP1 and CPAP2). SBP at 30 minutes was significantly lower the descending group when compared to the other groups. SBP was also significantly lower in the ascending group at 90 minutes **Table [1]**.

There was no statistically significant difference between the studied groups regarding the baseline heart rate, at 60 minutes, CPAP1 and CPAP2. On the other hand, there was a statistically significant difference between them regarding heart rate at 30 and 90 minutes. The difference is significantly higher between the control group and each of the other groups concerning heart rate at 30- and 90-minutes **Table [2].**

Table (1): Comparison between the studied groups regarding heart rate over time

		N	Mean	Standard Deviation	F	P
HR_0	**Control group**	23	83.17	4.68		
	Ascending group	23	90.30	11.69	2.773	0.070
	Descending group	23	88.48	13.52		
HR_30	**Control group**	23	94.98	8.04		
	Ascending group	23	94.13	8.81	2.867	0.064
	Descending group	23	100	9.99		
HR_60	**Control group**	23	101.78	11.5		
	Ascending group	23	99.78	10.27	2.219	0.112
	Descending group	23	99.57	9.8		
HR_90	**Control group**	23	99.99	7.94		
	Ascending group	23	102.82	8.88	2.532	0.087
	Descending group	23	96.89	9.89		
HR_CPAP1	**Control group**	23	98.78	8.85		
	Ascending group	23	98.35	13.36	2.506	0.095
	Descending group	23	100.09	7.01		
HR_CPAP2	**Control group**	23	101.2	8.61		
	Ascending group	23	100.00	5.65	0.155	0.857
	Descending group	23	100.59	7.35		

Data were expressed as mean ± Standard deviation (SD).
N: number. F: One way ANOVA $p<0.05$ is statistically significant $p\leq0.001$ is statistically highly significant
HR: heart rate (bpm) CPAP: continuous positive airway pressure

Table (2): Comparison between the studied groups regarding systolic blood pressure (SBP):

		N	Mean	Standard Deviation	F	P
SBP_0	**Control group**	23	115.087	15.297		
	Ascending group	23	113.87	15.348	3.001	0.061
	Descending group	23	114.39	19.35		
SBP_30	**Control group**	23	98.65	9.2		
	Ascending group	23	97.39	8.1	22.269	<0.001**
	Descending group	23	81.78	7.83		
SBP_60	**Control group**	23	100.75	10.06		
	Ascending group	23	101.130	8.52	0.35	0.706
	Descending group	23	102.391	10.378		
SBP_90	**Control group**	23	115.65	7.88		
	Ascending group	23	82.61	10.95	83.201	<0.001**
	Descending group	23	114.35	10.41		
SBP_CPAP 1	**Control group**	23	139.565	9.75997		
	Ascending group	23	136.087	16.443	2.280	0.110
	Descending group	23	137.435	16.646		
SBP_CPAP 2	**Control group**	23	142.652	12.368		
	Ascending group	23	141.30	11.8	2.932	0.085
	Descending group	23	143.04	7.65		

Data were expressed as mean ± Standard deviation (SD) and range
N: number F One way ANOVA $p<0.05$ is statistically significant $^{**}p\leq0.001$ is statistically highly significant
SBP: Systolic blood pressure (mmHg) CPAP: continuous positive airway pressure

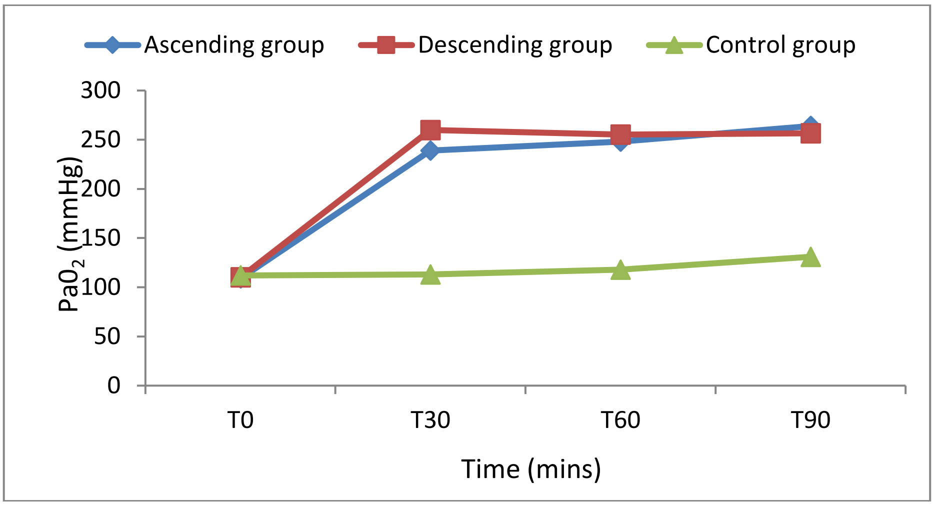

Figure (1): Comparison between the studied groups regarding PaO_2 over time**.**

- **PaO2: arterial oxygen tension (mmHg)**
- **Time: measured in minutes (mins)**

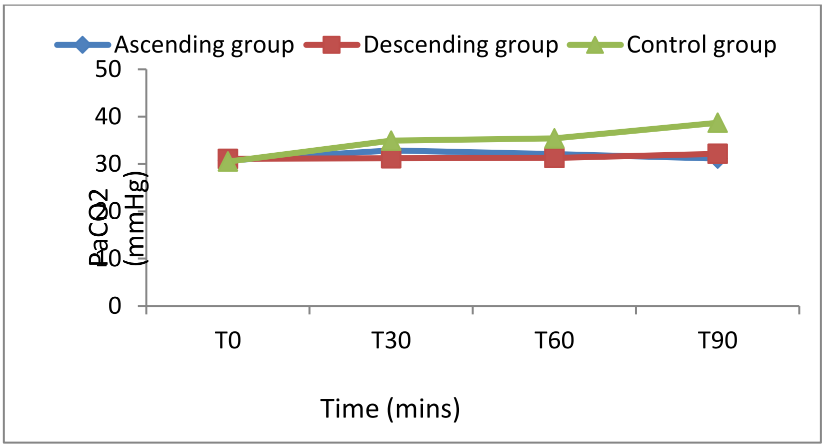

Figure (2): Comparison between the studied groups regarding $PaCO_2$ over time.

- **$PaCO_2$: arterial carbon dioxide tension (mmHg)**
- **Time: measured in minutes (mins)**

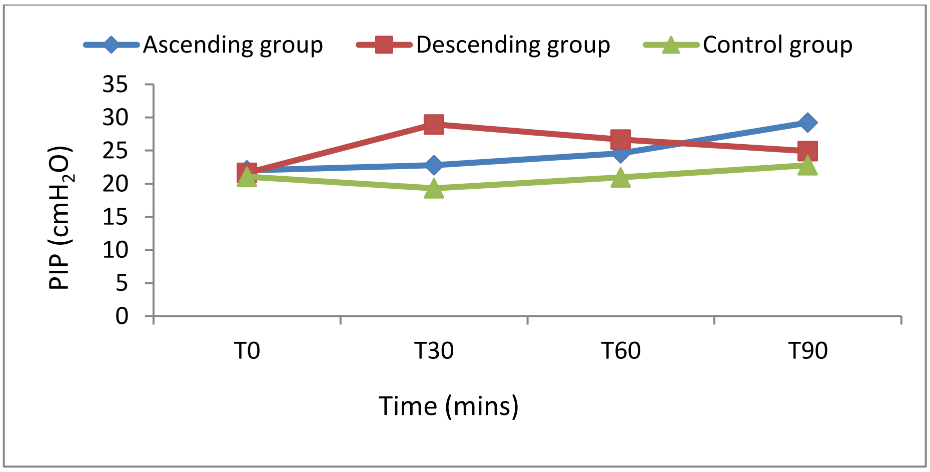

Figure (3): Comparison between the studied groups regarding PIP over time.

- **PIP: Peak inspiratory pressure (cmH_2O)**
- **Time: measured in minutes (mins)**

DISCUSSION

Obesity is considered as a major humanity health problem as it increases the hazard for all-cause mortality. Various intraoperative ventilatory strategies have been studied to improve gas exchange in these patients including large tidal volume, high ventilatory frequency, PEEP, and reverse Trendelenburg position, however, the effects of these interventions have been variable **[8].**

PEEP (defined as: positive pressure in the lungs at the end of each exhalation) improves PaO_2 **[1].** Yet, no randomized trial compared the intraoperative application of PEEP with no PEEP application. Previous studies did not unanimously show a beneficial effect of PEEP alone Thus, the widely believed beneficial effect of PEEP in obese surgical patients is still not based on strong evidence **[9].**

The present study was designed to detect the level and pattern of PEEP which will be more beneficial for patient with normal cardiopulmonary performance undergoing laparoscopic bariatric surgery to provide optimal care for patient.

As regard the pulmonary effects, the present study recorded that PaO_2 and SpO_2 have significantly increased in descending and ascending groups patients with normal pulmonary performance. So, the application of PEEP either descending or ascending pattern is believed to have a beneficial effect on oxygenation.

This finding agrees with **Tusman et al. [10],** who found that in morbidly obese patients, induction of anesthesia and paralysis of muscles reduced end expiratory lung volume, promoted atelectasis in dependent lung regions and causes a marked fall in arterial oxygenation. And the addition of PEEP alone leads to an increase the normally aerated lung fraction, decreased atelectasis caused by general anesthesia, and decreased hypoxic pulmonary vasoconstriction. So, oxygenation was significantly improved.

Regarding $PaCO_2$ and end tidal CO_2, they were significantly lower within the non-control groups and so either ascending or descending pattern were beneficial compared to no PEEP application.

This agrees with **Rossi et al. [11],** who found that PEEP alone resulted in a decrease in $PaCO_2$ to near baseline values after its initial increase due to improvement of ventilation perfusion matching and the increase in capillary-alveoli interface for gas exchange. The finding in our current study is also in accordance with **Higa and his colleagues [12].** They found the application of extrinsic PEEP had a direct impact on oxygenation and an indirect impact on ventilation.

Regarding lung mechanics (PIP and mean airway pressure), it was established that the effects of the applied PEEP during laparoscopic bariatric surgery depend on lung mechanics of the patient, thus PIP as well as mean airway pressure were carefully monitored, in our study we recorded an increase in PIP and mean airway pressure in both the ascending and descending pattern and this agrees with **Fellahi et al. [13]**, who found that during CO_2 pneumoperitoneum elevated intra-abdominal pressure lead to a cephalic shift of the diaphragm increasing airway pressures and reducing respiratory compliance.

Regarding the hemodynamics parameters (SBP and DBP), there was no hemodynamic instability at PEEP value of 7 cmH_2O in ascending and descending pattern at (60min) but there was a significant decrease of SBP and DBP at PEEP values of 9 cmH_2O in both ascending group at (90min) and descending group at (30min) and this result agrees with **Viquerat et al. [14],** who found that positive pressure generated by the ventilator, transmitted to the upper airways and finally to the alveoli which were reflected on the alveolar space and thoracic cavity, creating positive pressure (or at minimizing the negative pressure). This increased the right atrial pressure and decreased the venous return, generating a decrease in preload.

Regarding the heart rate there was no statistically significant difference between the studied groups at baseline, 30, 60, 90 minutes, CPAP1 and CPAP2. This agrees with **Eboe et al. [15],** who stated that heart rate usually does not change with PEEP.

Regarding the application of CPAP and its cardio pulmonary effects immediately post extubation, an improvement in both oxygenation and ventilation with no hemodynamic instability. This finding agrees with **Eboe et al. [15],** who stated that post extubation period was hazardous due to the risk of airway obstruction, narcosis, and residual effect of muscle relaxant and application of positive airway pressure during this period improved spirometric lung function and recruited collapsed alveoli.

The main limitations in our study are the limited number of cases, the use one mode of ventilation (VCV) and one surgical procedure are done (sleeve gastrectomy).

CONCLUSIONS

Both ascending and descending patterns of PEEP application showed no difference regarding the hemodynamic impact and its effect on lung mechanics, however, a PEEP value of 7 cmH_2O, regardless the pattern, was associated with no hemodynamic instability and more optimal lung mechanics compared to other values.

DECLARATION OF INTEREST

The authors report no conflicts of interest. The authors along are responsible for the content and writing of the paper.

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None declared

REFERENCES

1. Pelosi P, Croci M, Ravagnan I, et al. (1998): The effects of body mass on lung volumes, respiratory mechanics, and gas exchange during general anesthesia. Anesthesia and Analgesia;87: 654–60.
2. Maracajá-Neto LF, Verçosa N, Roncally AC, Giannella A, Bozza FA, Lessa MA. Beneficial effects of high positive end-expiratory pressure in lung respiratory mechanics during laparoscopic surgery. Acta AnaesthesiologicaScandinavica2009;53(2):210-7.
3. Rossi A, Santos C, Roca J, Torres A, Félez MA, Rodriguez-Roisin R. Effects of PEEP on VA/Q mismatching in ventilated patients with chronic airflow obstruction. Am. J. Respir. Crit. Care Med 1994;149(5): 1077-84.
4. Julia C, Ciangura C, Capuron L, Bouillot JL, Basdevant A, Poitou C, et al. Quality of life after Roux-en-Y gastric bypass and changes in body mass index and obesity-related comorbidities. Diabetes Metab 2013; 39:148–54.
5. Smith I. Anesthesia for laparoscopy with emphasis on outpatient laparoscopy. AnesthesiolClin North Am2001;19:21-41.
6. Waly S, Nasr Y , Shahin M. Does the pattern of PEEP applied during one-lung ventilation affect oxygenation? ZUMJ 2009; 15: 346-53.
7. Aldrete JA: The postanesthesia recovery score revisited, J Clin Anesth 7; 1995: 89-91.
8. Ogden CL, Carroll MD, Kit BK, Curtin LR, McDowell MA, Tabak CJ, et al. Prevalence of obesity in the United States. NCHS Data Brief 2012; 82:1-8.
9. Futier E, Constantin JM, Petit A, Jung B, Kwiatkowski F, Duclos M. Positive end expiratory pressure improves end-expiratory lung volume but not oxygenation after induction of anesthesia EurJAnaesthesiol 2010; 27:508-13.
10. Reinius H, Jonsson L, Gustafsson S, Sundbom M, Duvernoy O, Pelosi P. Prevention of atelectasis in morbidly obese patients during general anesthesia and paralysis: a computerized tomography study. Anesthesiology 2009; 111:979–87.
11. Tusman G, Bohm SH, Suarez-sipmann F, Turchetto E. Alveolar recruitment improves ventilator efficiency of the lungs during anesthesia. Can j anaesth2004; 51: 723-7.
12. Rossi A, Santos C, Roca J, Torres A, Félez MA, Rodriguez-Roisin R. Effects of PEEP on VA/Q mismatching in ventilated patients with chronic airflow obstruction. Am. J. Respir. Crit. Care Med 1994 ;149(5):1077-84.
13. Higa KD, Boone KB, Ho T. Complication of the laparoscopic Roux-en-Y gastric bypass: 1.040 patients-what have we learned? Obes Surg 2000; 10:509-13.
14. Fellahi JL, Valtier B, Beauchet A, Bourdarias JP, Jardin F.Does positive end-expiratory pressure ventilation improve left ventricular function? A comparative study by transesophageal echocardiography in cardiac and noncardiac patients. Chest 1998;114(2):556-62.
15. Viquerat CE, Righetti A, Suter PM.Biventricular volumes and function in patients with adult respiratory distress syndrome ventilated with PEEP. Chest 1983;83: 514-59.
16. EbeoCT,Benotti PN, Byrd RP, Elmaghraby Z, Lui J. The effect of positive air way pressure on postoperative pulmonary function following gastric surgery for obesity, Respir. Med. 2002; 96: 672-6.

Fahmy, A., elhossary, Z., Abaza, K., shaheen, M. COMPARATIVE STUDY OF TWO DIFFERENT POSITIVE END EXPIRATORY PRESSURE STRATEGIES IN LAPAROSCOPIC BARIATRIC SURGERY: EFFECT ON CARDIOPULMONARY FUNCTION. *Zagazig University Medical Journal*, 2022; (659...665): -. doi: 10.21608/zumj.2020.21000.1649