Al-Azhar Med. J . (Medicine). *Vol. 51(2), April, 2022, 1199 – 1208*
DOI: 10.21608/amj.2022.230482
https://amj.journals.ekb.eg/article_230482.html

EFFECT OF VOLUME, PRESSURE AND PRESSURE CONTROL-VOLUME GUARANTEED VENTILATION ON CARDIOVASCULAR PARAMETERS AND PULMONARY MECHANICS IN OBESE PATIENTS UNDERGOING LAPAROSCOPIC SLEEVE GASTRECTOMY

By

Hisham Mohammed Ahmed, Maamoun Mohammed Ismael and Mohammed Ali Salem

Department of Anesthesia and Intensive Care, Faculty of Medicine, Al-Azhar University

Corresponding auther: Hisham Mohammed Ahmed;

Mobile: 01143024590, **E-mail:** hisham19901014@gmail.com

ABSTRACT

Background: Optimization of intraoperative mechanical ventilation can decrease the incidence of pulmonary postoperative complications and improve outcome in obese patients.

Objective: To study the effect of different modes of ventilation [volume control, pressure control and pressure control volume-guaranteed] with pneumoperitoneum on pulmonary mechanics and cardiovascular parameters and the incidence of post-operative pulmonary complications.

Patients and methods: This study was carried out on 90 patients subjected to laparoscopic sleeve gastrectomy operation at Al-Azhar University Hospitals from March 2020 till October 2020. The participants were divided into 3 equal groups according to mode of mechanical ventilation: Group Ⅰ: Volume control ventilation, Group Ⅱ: Pressure control ventilation and Group Ⅲ: Pressure control volume-guaranteed ventilation. Intraoperative parameters (SaPo2, EtCO2, PaCO2, Ppeak, Pplateau, dynamic compliance, exhaled tidal volume, oxygenation index, heart rate, mean ABP) were measured before pneumoperitoneum, 15 minutes after pneumoperitoneum and 5 minutes after desufflation. Postoperative parameters (SaPo2 and PaO2/FiO2 ratio) were measured for 24 hours, every hour during the first six hours, then every 2 hours during the next six hours and every 4 hours during the next 12 hours.

Results: Volume control group was the highest group in peak airway pressure, and the lowest group in dynamic compliance before and after pneumoperitoneum and after desufflation. The difference between volume control group and the other two groups [pressure control group, pressure control volume-guaranteed group] was statistically significant.

Conclusion: Pressure control ventilation and pressure control volume-guaranteed was lower in peak airway pressure and higher in dynamic compliance compared to volume control ventilation.

Keywords: Sleeve gastrectomy, obese patients, volume guaranteed, laparoscopic, pulmonary mechanics.

INTRODUCTION

Obese patients having an increased risk of post-operative pulmonary complications *(Schultz et al., 2017)*. The rising prevalence of obesity, along with high numbers of non-responders to medical weight-reduction programs, has

led to the evolution and success of bariatric surgery. Although this treatment was initially conceived purely for weight loss, bariatric surgery has since evolved into a treatment for health gain *(Funk et al., 2016)*. Laparoscopic bariatric surgery is the most effective long-term treatment of severe obesity *(Kostecka and Bojanowska, 2017)*.

General anesthesia produces muscle relaxation and consequently reduces lung volumes, especially the functional residual capacity. This leads to repeated closure of small airways and constitution of atelectasis. Repeated closure of small airways and atelectasis not only alter gas exchanges, but also contribute to ventilator-induced lung injury *(Dresse et al., 2012)*. Maintenance of oxygenation is one of the many problems in the anesthetic management of obese patients *(Gupta et al., 2012)*. Optimization of intraoperative mechanical ventilation can decrease the incidence of pulmonary postoperative complications and improve outcome especially in obese patients *(Ball et al., 2015)*.

The present study aimed to compare the effect of different modes of (ventilation volume control, pressure control and pressure control volume-guaranteed) with pneumoperitoneum on pulmonary mechanics, and cardiovascular parameters, and to detect the incidence of post-operative pulmonary complications.

PATIENTS AND METHODS

The present study was a prospective randomized trial carried out on 90 patients were subjected to laparoscopic sleeve gastrectomy operation from March 2020 to October 2020 at Al-Azhar University Hospitals, and performed after ethical committee approval and informed consents from the patients at Al-Azhar University Hospitals. Patients divided into 3 equal groups: Group I: Volume control ventilation, Group Ⅱ: Pressure control ventilation, and Group III: Pressure control volume-guaranteed ventilation. The study included patients with age from 18 to 60 years, BMI from 35 to 40 kg/m2, and ASA II clinical status. We excluded patients who refused to be studied, patients with respiratory tract infection within last three weeks, patients with pre-existing lung diseases, cases converted from laparoscopic surgery into open surgery and patients with history of alcohol or substance abuse, psychological disorders, ischemic heart diseases, hypothyroidism and hyperthyroidism.

Measurements:

Intraoperative SaPo2, EtCO2, PaCO2, peak airway pressure, plateau airway pressure, dynamic compliance, exhaled tidal volume, oxygenation index, heart rate, mean ABP, was measured before pneumoperitoneum, 15 minutes after pneumoperitoneum and 5 minutes after desufflation.

Postoperative SaPo2 and PaO2/FiO2 ratio was measured for 24 hours postoperatively every hour during the first six hours then every 2 hours during the next six hours and every 4 hours during the next 12 hours.

Statistical analysis:

The measured data were collected and tabulated to be statistically analyzed qualitative data as percentage (%) and quantitative data as mean and standard deviation. The recorded data were

analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA).

A one-way analysis of variance (ANOVA) test was used when comparing between more than two means, Chi-square (x2) test of significance was used in order to compare proportions between qualitative parameters. The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant when P-value < 0.05.

RESULTS

There was no statistically significant difference between the three groups according to their demographic data regarding age, gender and BMI **(Table 1)**.

Table (1): Comparison between groups according to demographic data

Groups / Demographic data	Group Ⅰ (n=30)	Group Ⅱ (n=30)	Group Ⅲ (n=30)	P-value
Age (years) **Mean ±SD**	43.50±5.66	42.63±5.54	44.76±5.43	> 0.05
Gender (**Male/ Female ratio)**	11/19	13/17	10/20	> 0.05
BMI (kg/m^2) **Mean ±SD**	38.25±1.25	38.1±1.25	38.4±1.2	> 0.05

Using: F-One Way Analysis of Variance; x2: Chi-square test; p-value>0.05 NS

There was a statistically significant higher peak airway pressure (Ppeak), and significant lower dynamic compliance in group - compared to group - and group III at T1 (before pneumoperitoneum), T2 (15 mint. after pneumoperitoneum) , and T3 (5 mint. after desufflation) P value was < 0.05. There was no statistically significant difference between the other parameters **(Table 2)**.

Table (2): Comparison between respiratory parameters

Groups / Parameters	Time	Group Ⅰ (n=30)	Group Ⅱ (n=30)	Group Ⅲ (n=30)	p-value
$SaPO_2$%	T1	99.8±0.2	99.9±0.2	99.8±0.2	> 0.05
	T2	99.5±0.5	99.6±0.4	99.5±0.5	> 0.05
	T3	99.8±0.2	99.8±0.2	99.7±0.2	> 0.05
$PaCO_2$ (mmHg)	T1	36.5±1.5	36.8±2	36.7±2.2	> 0.05
	T2	40.1±4	39.9±3.01	38.2±3.6	> 0.05
	T3	38±7.5	34±6.1	35±5.8	> 0.05
$EtCO_2$	T1	35.1±0.9	35.5±1.1	35.4±0.8	> 0.05
	T2	36.7±1.2	36.2±1.5	35.8±1.45	> 0.05
	T3	34±1.28	33±2.8	33.5±1.67	> 0.05
Oxygenation index	T1	1.95±0.38	2.03±0.78	2.02±0.97	> 0.05
	T2	2.02±1.08	2.15±0.87	2.14±0.95	> 0.05
	T3	2.09±0.98	2.07±0.88	2.02±1.04	> 0.05
P_{Peak} (cmH_20)	T1	19.77±2.45*	18.35±2.2	18.31±2.85	**< 0.05***
	T2	22.58±3.10*	20.57±3.21	20.8±2.75	**< 0.05***
	T3	21.31±3.34*	19±2.91	18.78±3.25	**< 0.05***
$P_{Plateau}$ (cmH_20)	T1	16.1±3.25	17.7±3.1	17.5±3.37	> 0.05
	T2	19.6±3.32	20.1±2.61	19.35±2.47	> 0.05
	T3	17.81±3.08	18.2±3.28	18.1±2.8	> 0.05
Dynamic compliance (mL/cmH_2O)	T1	38.98±8.85*	44.2±10.25	45.34±9.91	**< 0.05***
	T2	27.30±7.28*	32.48±8.34	31.02±7.15	**< 0.05***
	T3	35.43±9.80*	42.35±8.81	42.61±9.82	**< 0.05***
Exhaled tidal volume	T1	453.91±68.7	448.16±48.9	457.25±47.21	> 0.05
	T2	452.13±69.3	439.65±50.12	450.31±47.31	> 0.05
	T3	456.12±68.35	448.6±48.65	455.19±47.75	> 0.05

Using: F-One Way Analysis of Variance

There was a statistically significant higher peak airway pressure (Ppeak) in group I compared to group II and group III at T1 (before pneumoperitoneum), T2 (15 mint. after pneumoperitoneum) and T3 (5 mint. after desufflation). P value was < 0.05 **(Figure 1)**.

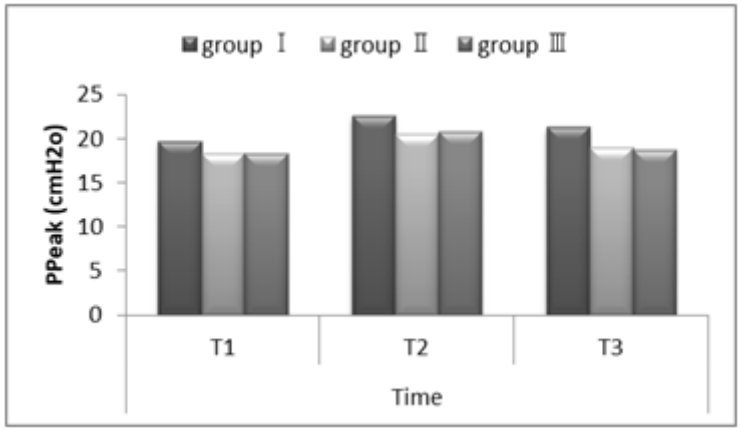

Figure (1): Comparison between groups according to peak airway pressure (cmH20)

There was a statistically significant lower dynamic compliance in group I compared to group II and group III at T1 (before pneumoperitoneum), T2 (15 mint. after pneumoperitoneum) and T3 (5 mint. after desufflation) . P value was < 0.05 **(Figure 2)**.

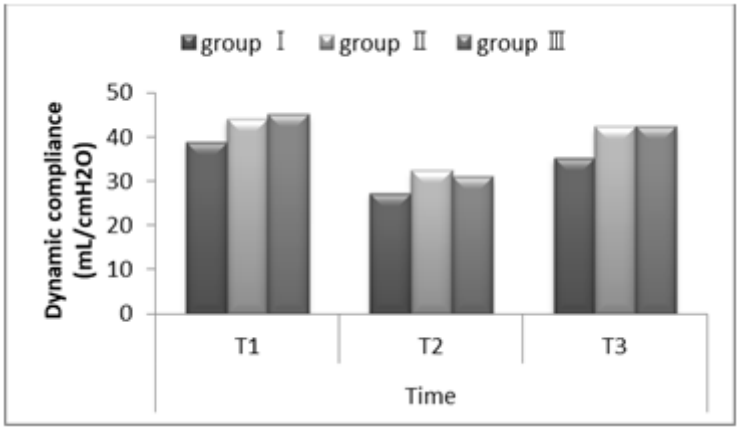

Figure (2): Comparison between groups according to dynamic compliance (mL/cmH2O)

There was no statistically significant difference between groups according to their cardiovascular parameters at T1 (before pneumoperitoneum), T2 (15 mint. after pneumoperitoneum) and T3 (5 mint. after desufflation). P value was > 0.05 **(Table 3)**.

Table (3): Comparison between cardiovascular parameters

Groups / Parameters	Time	Group Ⅰ (n=30)	Group Ⅱ (n=30)	Group Ⅲ (n=30)	p-value
Heart rate (beat/min)	T1	88.44±9.12	85.45±10.25	83.62±10.5	> 0.05
	T2	84.31±11.12	86.36±12.1	81.58±11.41	> 0.05
	T3	84.27±10.81	85.41±9.67	82.65±6.55	> 0.05
Mean ABP (mmHg)	T1	102.85±15.32	98.52±14.75	100.13±12.46	> 0.05
	T2	110.32±16.31	111.21±15.72	108.34±16.74	> 0.05
	T3	101.52±14.25	98.12±15.12	98.21±14.61	> 0.05

Using: F-One Way Analysis of Variance

There was no statistically significant difference between groups according to their postoperative SaPO2% and PaO2/FiO2 ratio **(Table 4)**.

Table (4): Comparison between postoperative respiratory parameters

Time	Groups / Parameters	Group Ⅰ (n=30)	Group Ⅱ (n=30)	Group Ⅲ (n=30)	p-value
1st hr.	$SaPO_2$%	96.85±1.61	97.21±1.37	97.45±1.13	> 0.05
	PaO_2/FiO_2 ratio	388±31	380±53	384±26	> 0.05
2nd hr.	$SaPO_2$%	96.74±1.58	97.22±1.36	97.44±1.21	> 0.05
	PaO_2/FiO_2 ratio	389±30	380±55	385±25	> 0.05
3rd hr.	$SaPO_2$%	96.65±1.62	97.23±1.34	97.43±1.22	> 0.05
	PaO_2/FiO_2 ratio	389±29	378±53	385±24	> 0.05
4th hr.	$SaPO_2$%	96.61±1.81	97.24±1.35	97.46±1.31	> 0.05
	PaO_2/FiO_2 ratio	389±30	378±52	385±24	> 0.05
5th hr.	$SaPO_2$%	96.6±1.87	97.24±1.28	97.45±1.37	> 0.05
	PaO_2/FiO_2 ratio	390±31	378±52	386±23	> 0.05
6th hr.	$SaPO_2$%	96.6±1.93	97.26±1.29	97.44±1.36	> 0.05
	PaO_2/FiO_2 ratio	391±31	380±51	387±25	> 0.05
8th hr.	$SaPO_2$%	96.6±2.01	97.31±1.15	97.46±1.48	> 0.05
	PaO_2/FiO_2 ratio	395±30	384±51	391±24	> 0.05
10th hr.	$SaPO_2$%	96.53±2.18	97.32±1.13	97.46±1.51	> 0.05
	PaO_2/FiO_2 ratio	396±28	384±51	392±23	> 0.05
12th hr.	$SaPO_2$%	96.52±2.82	97.34±1.12	97.46±1.57	> 0.05
	PaO_2/FiO_2 ratio	394±27	387±49	390±25	> 0.05
16th hr.	$SaPO_2$%	96.51±2.41	97.33±1.14	97.48±1.32	> 0.05
	PaO_2/FiO_2 ratio	397±29	388±48	393±24	> 0.05
20th hr.	$SaPO_2$%	96.61±2.21	97.34±1.15	97.52±1.21	> 0.05
	PaO_2/FiO_2 ratio	404±32	393±49	400±25	> 0.05
24th hr.	$SaPO_2$%	96.68±2.06	97.34±1.16	97.58±1.05	> 0.05
	PaO_2/FiO_2 ratio	409±29	396±47	405±21	> 0.05

Using: F-One Way Analysis of Variance

DISCUSSION

In the present study, there was no statistically significant difference between the three groups as regards demographic data (age, gender, BMI), intraoperative (SaPO2, PaCO2, EtCO2, PPlateau, Exhaled tidal volume, oxygenation index, Heart rate, mean ABP), and postoperative (SaPO2, PaO2/FiO2 ratio).

In accordance to the present study, *Gupta, et al. (2012)* compared between the effect of volume control ventilation and pressure control ventilation in 20 obese patients of body mass index range from 30 to 40 kg/m2 were subjected to laparoscopic cholecystectomy operation. They found no significant difference in demographic data, SaPo2, heart rate, mean ABP between volume control ventilation and pressure control ventilation.

The study of *Movassagi et al. (2017)* coincided with our results, which compared between the effect of pressure control and volume control ventilation in obese patients of body mass index range from 30 to 40 kg/ m2 were subjected to laparoscopic cholecystectomy operation. They found that there was no significant difference in the rise of PaCo2, EtCo2 and PPlateau after abdominal insufflation between volume control and pressure control ventilation.

Matching with this study, *Hassan et al. (2020)* who compared between volume

control ventilation and pressure control ventilation in obese patients with BMI between 45-60 kg/m2, and were subjected to laparoscopic sleeve gastrectomy. They noticed that there was no significant difference in postoperative oxygenation between volume control ventilation and pressure control ventilation.

As regards peak airway pressure, we found that peak airway pressure was statistically higher with volume control ventilation before and after pneumoperitoneum and after desufflation compared to pressure control and pressure control volume guaranteed ventilation. There was no statistically significant difference between pressure control and pressure control volume guaranteed ventilation.

In accordance to the present study, *Kothari and Baskaran (2018)* compared between pressure control volume guaranteed ventilation, pressure control ventilation and volume control ventilation in obese patients with BMI > 30 kg/m2 subjected to laparoscopic cholecystectomy. They found a significant difference in the rise of peak airway pressure in volume control ventilation and both of pressure control ventilation and pressure control volume guaranteed ventilation, there was no significant difference between pressure control ventilation and pressure control volume guaranteed ventilation.

As regards dynamic compliance, we found that dynamic compliance was statistically lower with volume control ventilation before and after pneumoperitoneum and after desufflation compared to pressure control and pressure control volume guaranteed ventilation. However, there was no statistically significant difference between pressure control and pressure control volume guaranteed ventilation.

In contrast to the present study, *Aydin et al. (2016)* compared between pressure control ventilation and volume control ventilation in patients with body weight from 61 to 92 kg and subjected to laparoscopic cholecystectomy operation. They found that the decrease in dynamic compliance value after abdominal insufflation was insignificant between volume control ventilation and pressure control ventilation. The difference between these results and our results may be related to body weight of the patients.

CONCLUSION

Pressure control and pressure control volume guaranteed ventilation increasing dynamic compliance and lowering peak airway pressure when compared with volume control ventilation.

REFERENCES

1. **Aydın, V., Kabukcu, H. K., Sahin, N., Mesci, A., Arici, A. G., Kahveci, G. and Ozmete, O.(2016):** Comparison of pressure and volume-controlled ventilation in laparoscopic cholecystectomy operations. The clinical respiratory journal, 10(3): 342-349.
2. **Ball, L., Dameri, M. and Pelosi, P. (2015):** Modes of mechanical ventilation for the operating room. Best Practice & Research Clinical Anaesthesiology, 29(3): 285-299.
3. **Dresse, C., Joris, J. L. and Hans, G. A. (2012):** Mechanical ventilation during anaesthesia: Pathophysiology and clinical implications. Trends in Anaesthesia and Critical Care, 2(2): 71-75.
4. **Funk, L.M., Jolles, S.A., Greenberg, C.C., Schwarze, M.L., Safdar, N., McVay, M.A., Whittle J.C., Maciejewski, M.L. and Voils,**

C.I. (2016): Primary care physician decision making regarding severe obesity treatment and bariatric surgery: a qualitative study. Surgery for Obesity and Related Diseases, 12(4): 893-901.

5. **Gupta, S.D., Kundu, S.B., Ghose, T., Maji, S., Mitra, K., Mukherjee, M., Mandal, S., Sarbapalli, D., Bhattacharya, S. and Bhattacharya, S. (2012):** A comparison between volume-controlled ventilation and pressure-controlled ventilation in providing better oxygenation in obese patients undergoing laparoscopic cholecystectomy. Indian journal of anaesthesia, 56(3): 276-282.
6. **Hassan, B.E.D.E., El-Shaer, A.N., Elbeialy, M.A.K. and Ismail, S.A.M. (2020):** Comparison between volume-controlled ventilation and pressure-controlled volume-guaranteed ventilation in postoperative lung atelectasis using lung ultrasound following upper abdominal laparotomies: a prospective randomized study. Ain-Shams Journal of Anesthesiology, 12(1): 1-11.
7. **Kostecka, M. and Bojanowska, M. (2017):** Problems in bariatric patient care–challenges for dieticians. Videosurgery and Other Miniinvasive Techniques, 12(3):207-215.
8. **Kothari, A. and Baskaran, D. (2018):** Pressure-controlled volume guaranteed mode improves respiratory dynamics during laparoscopic cholecystectomy: a comparison with conventional modes. Anesthesia, essays and researches, 12(1):206-212.
9. **Movassagi, R., Montazer, M., Mahmoodpoor, A., Fattahi, V., Iranpour, A. and Sanaie, S. (2017):** Comparison of pressure vs. volume controlled ventilation on oxygenation parameters of obese patients undergoing laparoscopic cholecystectomy. Pakistan journal of medical sciences, 33(5): 1117-1122.
10. **Schultz, M.J., Hemmes, S.N., Neto, A.S., Binnekade, J.M., Canet, J., Hedenstierna, G., Jaber, S., Hiesmayr, M., Hollmann, M.W., Mills, G.H., Vidal Melo, M.F. and Tasoulis, M. K. (2017):** Epidemiology, practice of ventilation and outcome for patients at increased risk of postoperative pulmonary complications: LAS VEGAS-an observational study in 29 countries. European Journal of Anaesthesiology, 34 (8):492–507.

تأثير التنفس الصناعي بالتحكم في الحجم و الضغط و الضغط بضمان الحجم على المعايير القلبية والتنفسية في المرضى البدناء أثناء تكميم المعدة بالمنظار

هشام محمد أحمد، مأمون محمد اسماعيل، محمد علي سالم

قسم التخدير والرعاية المركزة، كلية الطب، جامعة الازهر

E-mail: hisham19901014@gmail.com

خلفية البحث: يؤدي استخدام التنفس الصناعي أثناء التخدير للعمليات بأحسن الطرق إلى تقليل نسبة المضاعفات التنفسية بعد العمليات خاصة في المرضى البدناء الذين هم اكثر عرضة للمضاعفات التنفسية.

الهدف من البحث: دراسة تأثير التنفس الصناعي باستخدام ثلاثة أنظمة مختلفة (التحكم بالحجم ،التحكم بالضغط، التحكم بالضغط بضمان الحجم) على أدء الجهاز القلبي والتنفسي وعلى نسبة حدوث مضاعفات رئوية بعد العملية الجراحية بالمنظار.

المرضى وطرق البحث: شملت الدراسة 90 مريضًا خضعوا لعملية تكميم المعدة بالمنظار الجراحي في مستشفيات جامعة الأزهر في الفترة من مارس 2020 الى أكتوبر2020، وقد تراوحت أعمارهم بين18 الى 60 سنة، ومعامل كتلة الجسم من 35 الى 40 كجم/ م2، ولايعانون من أمراض مزمنة متقدمة، و لم تشمل المرضى الذين رفضوا الانضمام للدراسة أوالذين تعرضوا لعدوى بالجهاز التنفسي في خلال 3 اسابيع قبل العملية أوالمصابين بأمراض مزمنة في الجهاز التنفسي أو مشاكل في القلب أوالغدة الدرقية، ولم تشمل أيضا الحالات الذين تحولت العملية فيها من المنظار إلى جراحة مفتوحة. وقد تم تقسيم المرضى إلى 3 مجموعات متساوية في العدد، وكل مجموعة خضعت لنظام معين من انظمة التنفس الصناعي (التحكم بالحجم، التحكم بالضغط، التحكم بالضغط بضمان الحجم)، وتم تسجيل نسبة تشبع الدم بالكسجين ونسبة غاز ثاني اكسيد الكربون بالدم وضغط الهواء الجوي بالجهاز التنفسي والمطاوعة الحركية للجهاز التنفسي وحجم المد والجزر للرئتين ومعامل توصيل الاكسجين للدم ومعدل ضربات القلب و ضغط الدم. وقد تم تسجيل هذه البيانات 3 مرات: قبل نفخ الغشاء البريتوني بخمس دقائق وبعد نفخ الغشاء البريتوني ب 15 دقيقة وبعد تفريغ الغاز من الغشاء البريتوني

بخمس دقائق، وتم أيضا تسجيل نسبة تشبع الدم بالأكسجيين ونسبة (ضغط غاز الاكسجين بالدم نسبة المستنشق) بعد العملية لمدة 24 ساعة كالتالي: كل ساعة خلال اول 6 ساعات ثم كل ساعتين خلال ثاني 6 ساعات ثم كل 4 ساعات خلال ال12 ساعة التالية.

نتائج البحث: أظهرت الدراسة أن التنفس الصناعي بالتحكم بالحجم يؤدي إلى إرتفاع ضغط الهواء في الجهاز التنفسي ويؤدي إلى تقليل المطاوعة الحركية مقارنة بالتنفس الصناعي عن طريق التحكم بالضغط أو عن طريق الضغط بضمان الحجم.

الإستنتاج: إستخدام التنفس الصناعي عن طريق التحكم بالحجم يؤدي إلى ارتفاع ضغط الهواء و تقليل المطاوعة الحركية بالجهاز التنفسي.

الكلمات الدالة: تكميم المعدة، المرضى البدناء، المنظار الجراحي، الميكانيكية الرئوية، التنفس الصناعي بالتحكم بالحجم، التنفس الصناعي بالتحكم بالضغط، التنفس الصناعي بالتحكم بالضغط وضمان الحجم.