A Comparison of the Effects of Postoperative CPAP and Nasal Oxygen Use on Arterial Blood Gas in Laparoscopic Cholecystectomy Performed in Obese Patients: A Prospective, Randomized Cinical Trial

Obez Hastalarda Yapılan Laparoskopik Kolesistektomide Postoperatif CPAP ve Nazal Oksijen Uygulamasının Arteriyel Kan Gazı Üzerine Etkilerinin Karşılaştırılması: Randomize, Prospektif Klinik Çalışma

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ABSTRACT Objective: This study was designed to compare the effects of continuous positive airway pressure (CPAP) and nasal oxygen use on postoperative blood gases in obese patients undergoing laparoscopic cholecystectomy. **Material and Methods:** A total of 40 patients with a body mass index (BMI) ranging between 30 and 40 were enrolled in this study. Patients were divided into two groups: Group C (n=20) = CPAP and Group N (n=20) = Nasal O_2. Baseline blood gas was sampled on spontaneous respiration (G_0). The blood gas sampling was repeated before patients were admitted to the postoperative care unit (PACU) (G_1). Following the operation, Group C received CPAP 5 cmH_2O and Group N received 5 l/min O_2 via nasal cannula for 60 minutes. Blood gas sampling was repeated after 60 minutes in both groups (G_2). **Results:** At the PACU, the SpO_2 values were higher in Group C relative to Group N at 30 minutes ($p<0.05$). In both groups, the in-group pH values at G_1 measurement time displayed a statistically significant reduction compared to those at the G_0 measurement time ($p<0.05$). At G_2, $PaCO_2$ was higher in Group N compared to Group C ($p<0.05$). In both groups, the in-group $PaCO_2$ values were significantly higher at G_1 relative to G_0 ($p<0.01$). In Group C, PaO_2 was higher at G_2 compared to Group N ($p<0.05$). **Conclusion:** Postoperative CPAP use may increase the PaO_2 more and provide a better CO_2 elimination compared to nasal oxygen use in obese patients undergoing laparoscopic cholecystectomy.

Key Words: Anesthesia, general; cholecystectomy, laparoscopic; blood gas analysis; continuous positive airway pressure

ÖZET Amaç: Bu çalışma, laparoskopik kolesistektomi yapılan obez hastalarda devamlı pozitif hava yolu basıncı (CPAP) ve nazal oksijen uygulamasının, postoperatif kan gazları üzerine etkilerini karşılaştırmak için tasarlandı. **Gereç ve Yöntemler:** Beden kitle indeksi (BKİ) 30 ile 40 arasında değişen toplam 40 hasta çalışmaya alındı. Hastalar iki gruba ayrıldı: Grup C (n=20): CPAP grubu ve Grup N (n=20): Nazal O_2 grubu. Spontan solunumda kan gazı örneği alındı (G_0). Hastalar postoperatif bakım ünitesine (POBÜ) alınmadan önce kan gazı örneklemesi tekrarlandı (G_1). Ameliyattan sonra, Grup C'ye 5 cmH_2O CPAP, Grup N'ye 60 dakika boyunca nazal kanülle 5 l/dak O_2 verildi. Her iki grupta 60 dakika sonra kan gazı örneklemesi tekrarlandı (G2). **Bulgular:** POBÜ'de 30 dakikada Grup C'de SpO_2 değerlerinin Grup N'ye göre daha yüksek olduğu gözlendi ($p<0,05$). Her iki grupta G_1 ölçüm zamanında grup içi pH değerleri G_0 ölçüm zamanına kıyasla istatistiksel olarak anlamlı azalma gösterdi ($p<0,05$). G_2'de $PaCO_2$'nin Grup N'de Grup C'ye göre daha yüksek olduğu saptandı ($p<0,05$). Her iki grupta grup içi $PaCO_2$ değerlerinin G_1'de G_0'a göre belirgin olarak daha yüksek olduğu gözlendi ($p<0,01$). Grup C'de PaO_2 G_2'de Grup N'ye göre daha yüksekti ($p<0,05$). **Sonuç:** Laparoskopik kolesistektomi operasyonu geçiren obez hastalarda, postoperatif CPAP uygulaması nazal oksijen uygulamasına göre PaO_2'yi daha fazla artırmakta ve CO_2 eliminasyonunu daha iyi sağlamaktadır.

Anahtar Kelimeler: Anestezi, genel; kolesistektomi, laparoskopik; kan gazı analizi; devamlı pozitif hava yolu basıncı

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During laparoscopic surgery, a large amount of gas, generally carbon dioxide (CO_2), is introduced into the peritoneal cavity. The CO_2 absorption from the peritoneal surface results in hypercapnia and acidosis during the pneumoperitoneum induced by intraperitoneal CO_2 insufflation.[1] The limitation of diaphragm movements, secondary to pneumoperitoneum, leads to a reduction in the functional residual capacity (FRC) and pulmonary compliance. Obese patients are particularly affected by this condition, more than non-obese patients.[2] Some studies showed that continuous positive airway pressure (CPAP) was effective on oxygenation after laparascopic cholecystectomy surgery.[3,4] However, studies investigating the effects of postoperative CPAP on blood gases in laparoscopic cholecystectomy surgery performed in obese patients are lacking. We hypothesized that postoperative CPAP would be more effective than nasal oxygen use on blood gasses in obese patients.

MATERIAL AND METHOD

A total of 40 patients aged between 18 and 65 years, with American Society for Anesthesiology status I and II, a body mass index (BMI) in the range of 30-40 and who were scheduled to undergo elective laparoscopic cholecystectomy were included in the trial after the approval of the Selçuk University Meram Medical Faculty Ethical Committee (June 26, 2009. 2009/348). All patients signed an informed consent form in accordance with the Helsinki Declaration. Patients with ischemic cardiac disease, congestive cardiac failure, liver or kidney dysfunction, respiratory disorder, psychiatric conditions and cooperation failures, and known hypersensitivity to the study medications were excluded.

On admission to the operating room, 0.9% sodium chloride infusion was initiated after peripheral vascular access was provided using an 18-gauge cannula. The patients were randomly assigned to two groups [Group C (n:20)= continuous positive airway pressure (CPAP), Group N (n:20)= Nasal O_2] and were given the Allen's test via the closed envelope method. After this, a 20G cannula was placed in the radial artery of the non-dominant arm under local anesthesia (20 mg %2 lidocaine) with sedation (midazolam 1 mg iv). Baseline blood gas was sampled on spontaneous respiration (G_0) for analysis. The blood gas sample was assayed using a blood gas device (Rapidlap® Healtcare-Bayer) in the operating room immediately after blood sample was drawn. The heart beat rate (HR), the mean arterial pressure (MAP), SpO_2 [t_0: Basal, t_1: post-induction, t_2: following intubation, t_3: 5 min, t_4: 10 min, t_5: 20 min, t_6: 30 min, t_7: 40 min, t_8: 50 min, t_9: postoperative care unit (PACU) Basal, t_{10}: PACU 30 min, t_{11}: PACU 60 min] and the end-tidal carbon dioxide pressure ($EtCO_2$) (t_2: Following intubation, t_3: 5 min, t_4: 10 min, t_5: 20 min, t_6: 30 min, t_7: 40 min, t_8: 50 min) (Drager Cappa – Infinity, Germany) were monitored. Invasive arterial monitoring was used to measure blood pressure.

For induction of anesthesia, all the patients received 2 mg/kg iv bolus propofol (Propofol® Fresenius Kabi-Sweden) and 1 μg/kg remifentanil (Ultiva™ GlaxoSmithKline-Italy) as a 60-second intravenous bolus (iv) administration.[5] After achieving loss of consciousness, endotracheal intubation was performed following 3 minutes after atracurium (Tracrium® GlaxoSmithKline) administration.[6] The drugs used in anaesthesia were calculated based on total body weight (TBW). Trachea was intubated by 9.0 (for males) or 8.0 (for females) mm diameter (ID) endotracheal tube. To prevent vomiting, 4 mg ondansetron was administered to all patients before the induction of anesthesia.

Ventilation was provided by using a mechanical ventilator (Drager Primus-Germany) at a tidal volume of 6-8 mL/kg (total body weight) and a respiratory rate of 10-14/min to achieve an $EtCO_2$ of 35±5 mmHg.[7] The maintenance of anesthesia was provided by 50/50% oxygen/air and 0.5 minimum alveolar concentration (MAC) sevofluran (Sevoflurane® Abbott-UK) and 0.25 μg/kg/min remifentanil infusion.[8] Pneumoperitoneum was kept constant at 12 cm H_2O pressure. Tramadol (Contramal®-Abdi İbrahim) was administered as an IV infusion, at a dose of 1 mg/kg, 30 minutes before the end of the surgery to achieve postoperative analgesia. Sevofluran and remifentanil infusion was terminated five minutes before the end of the surgery and the patients inhaled 100% oxygen. Upon initiation of spontaneous respiration, 0.04-0.08 mg/kg neostigmine (Neostigmine® Adeka-Turkey) and 0.02-0.04 mg/kg atropine were administered, thereby eliminating the muscle relaxant effect. After extubation, blood gas samples were obtained (G_1) and the patients were admitted to the PACU. CPAP was administered using the Drager Evita XL – Germany device by oronasal mask to achieve CPAP 5 cmH_2O, FiO_2 0.35 in Group C, while 4 l/min (FiO_2 0.31-0.38) O_2 was administered for 60 minutes via nasal cannula in Group N. Blood gas sampling was performed after 60 minutes in both groups (G_2). At the PACU, SpO_2 values were recorded every 10 minutes.

All the adverse effects (nausea, vomiting, CPAP incompliance, pain) and additional medications were recorded for all patients. Nausea was assessed on a 5-point scale (0: no 1: mild nausea, 2: moderate nausea, 3: severe nausea, 4: retching and vomiting). A 10 mg intravenous metoclopramide administration was planned for cases with a nausea-vomiting score ≥2. The pain was assessed with visual analogue scale (VAS) using a 10-cm line scale (0: no pain, 10=unbearable pain) before admitting to and after discharging from the PACU of the patient.

STATISTICAL ANALYSIS

Data obtained were analyzed by the SPSS 13.0 program. In this study including two groups and three recurrent measurements, a power analysis indicated that 95% confidence for 20 subjects in each group would be required to achieve a statistical power of 0.84 based on the standardized effect size of 0.5. Data were summarized using the frequency, arithmetic mean and ±standard deviation. A comparison of the distribution of the categorical data to the CPAP and nasal O_2 groups was performed using the "chi-square (χ^2) test". Sample means were tested for normality using the Kolmogorov - Simirnov test. To compare the values from the CPAP and the nasal O_2 groups of the analyzed variables, the independent Student's t test was used. A Two-way ANOVA test was used to compare the variables presented in repeated measurements with respect to the groups and time; the Student's t-test was used in independent groups with Bonferroni correction. The difference was considered statistically significant at $p<0.05$ ($p<0.01$ on Bonferroni correction) for all analyses.

RESULTS

The 40 patients included in the trial showed similarity in the demographic characteristics, anesthesia and duration of surgery (Table 1) ($p>0.05$). There was no significant difference between the two groups in the intraoperative $EtCO_2$ measurements ($P>0.05$) (Figure 1). At the PACU, the SpO_2 values at 30 minutes were significantly higher in Group C relative to Group N ($p<0.05$) (Figure 2). The comparison of the pH values in the blood gas samples at G_0, G_1 and G_2 revealed no significant difference in either group ($P>0.05$). The comparison of the intra group pH values revealed significantly lower values for G_1 compared to G_0 for both groups ($p<0.01$) (Table 2). While there was no significant difference between the $PaCO_2$ values on blood gas samples between the two measurement times, G_0 and G_1, the $PaCO_2$ value was significantly higher at G_2 in Group N relative to Group C ($p<0.05$). The in-group comparison of the $PaCO_2$ values at G_0 and G_1 revealed a statistically significant difference ($p<0.01$). The G_1 $PaCO_2$ values of Group C and Group N were higher than the G_0 values (Table 3). The finding that the PaO_2 value in the blood gas sample at G_2 in Group C was higher than that in Group N had statistical significance

TABLE 1: Patient demographics (Mean±SD).

	Group C (n=20)	Group N (n=20)	p
Age (years)	46.90±13.16	48.55±10.32	0.66
Height (cm)	164.75±8.91	162.60±5.63	0.36
Weight (Kg)	88.50±14.54	86.35±8.34	0.57
BMI (kg/height^2)	32.37±2.42	32.60±1.94	0.74
Duration of Anesthesia (min)	54.45±4.38	56.75±5.22	0.14
Duration of surgery (min)	50.20±4.47	52.40±5.48	0.17
Gender (F/M)*	15/5	14/6	0.72
ASA (I/II)*	10/10	6/14	0.19

* Numeric distribution.
Group C: Continuous positive airway pressure.
Group N: Nasal oxygen.
ASA: American Society for Anesthesiology; BMI: Body mass index; F: Female; M: Male.

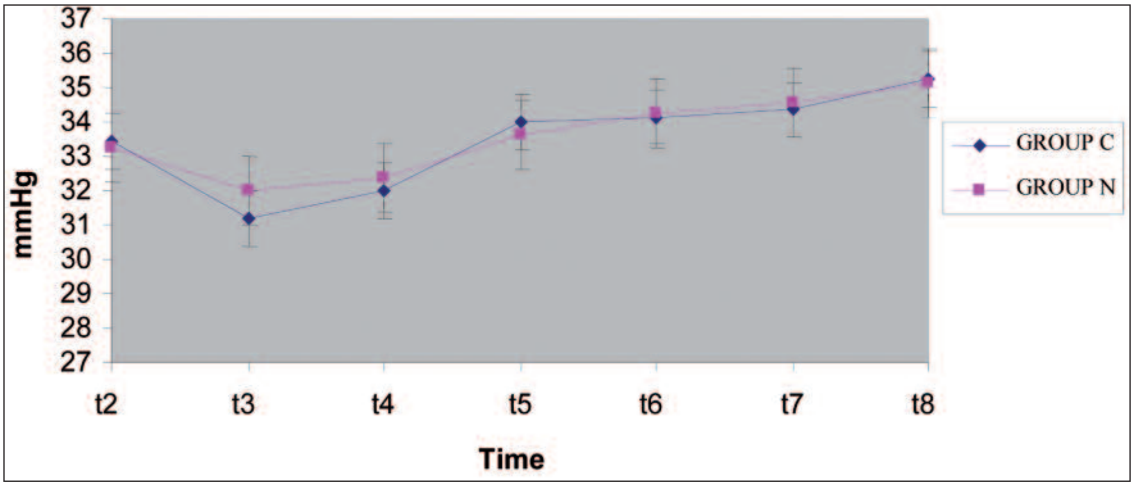

FIGURE 1: $EtCO_2$ values.

t_2: following intubation; t_3: 5 min, t_4: 10 min, t_5: 20 min, t_6: 30 min, t_7: 40 min, t_8: 50 min.

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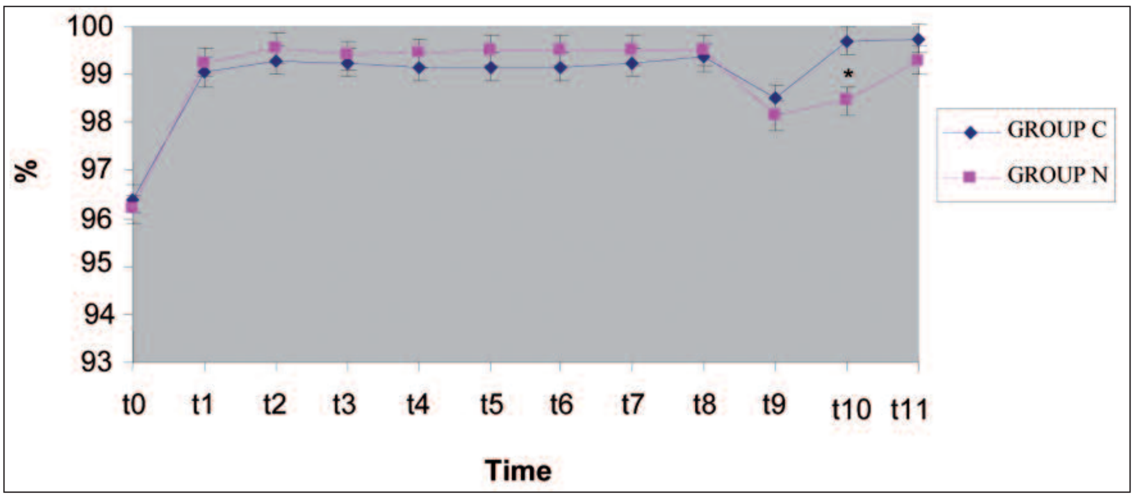

FIGURE 2: Comparison of SpO_2 values.

t_0: basal, t_1: post-induction, t_2: following intubation, t_3: 5 min, t_4: 10 min, t_5: 20 min, t_6: 30. min, t_7: 40 min, t_8: 50 min, t_9: postoperative care unit (PACU) Basal, t_{10}: PACU 30 min, t_{11}: PACU 60 min.

* Group C compared to Group N; p=0.04.

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($p<0.05$) (Table 4). The two groups showed similarity in nausea-vomiting rates ($p>0.05$) (Table 5). Metoclopramide 10 mg IV was administered to three patients in Group C and two patients in Group N due to a nausea-vomiting score ≥2. The pain score was similar between the two groups ($p>0.05$) (Table 6). Two patients were incompatible with CPAP.

DISCUSSION

The effects of CPAP and nasal oxygen use were compared on postoperative blood gases in obese patients undergoing laparoscopic cholecystectomy. Postoperative CPAP use increased the PaO_2 more and provided a better CO_2 elimination compared to nasal oxygen use.

Respiratory complications occurring after surgery represent the leading cause of prolonged hospitalization due to an increase in morbidity and mortality. The most significant risk factor affecting postoperative respiratory functions is obesity. Trials reported a respiratory complication incidence of 9-69% following non-thoracic surgery.[9] Most of the respiratory complications result from changes

TABLE 2: pH values.

	Group C (n=20)	Group N (n=20)	p
G_0 pH	7.45±0.02	7.44±0.03	0.48
G_1 pH	7.30±0.04*	7.30±0.04†	0.83
G_2 pH	7.38±0.03	7.37±0.03	0.38

* G_0 and G_1 comparison for Group C, p<0.01.
† G_0 and G_1 comparison for Group N, p<0.01.
Group C: Continuous positive airway pressure.
Group N: Nasal oxygen.
G_0: Baseline blood gas was sampled on spontaneous respiration, G_1: Patients were admitted to the postoperative care unit (PACU), G_2: PACU 60 min.

TABLE 3: $PaCO_2$ values.

	Group C (n=20)	Group N (n=20)	p
G_0 $PaCO_2$	32.55±2.50	33.82±2.96	0.15
G_1 Pa CO_2	48.15±5.62†	49.62±5.03‡	0.38
G_2 Pa CO_2	35.35±3.91	38.63±3.98*	0.01

Group C: Continuous positive airway pressure.
Group N: Nasal oxygen.
*Group C compared to Group N; p <0.05.
† G_0 $PaCO_2$ and G_1 $PaCO_2$ comparison for Group C p<0.01.
‡ G_0 $PaCO_2$ and G_1 $PaCO_2$ comparison for Group N p<0.01.
G_0: Baseline blood gas was sampled on spontaneous respiration, G_1: Patients were admitted to the postoperative care unit (PACU) ,G_2: PACU 60 min.

TABLE 4: PaO_2 values.

	Group C (n=20)	Group N (n=20)	p
G_0 PaO_2	79.30±9.15	75.86±11.48	0.30
G_1 PaO_2	84.19±8.21	86.99±8.58	0.29
G_2 PaO_2	115.93±12.95*	92.28±10.58	0.00

Group C: Continuous positive airway pressure.
Group N: Nasal oxygen.
* Group C compared to Group N p<0.0.
G_0: Baseline blood gas was sampled on spontaneous respiration, G_1: Patients were admitted to the postoperative care unit (PACU), G_2: PACU 60 min.

in the pulmonary volume secondary to disorder of the chest wall mechanics and dysfunction of the respiratory muscles. Following abdominal and thoracic surgery, a marked reduction in vital capacity and a less marked reduction in functional residual capacity occur. The CO_2 insufflated during laparoscopic surgery is rapidly absorbed from the peritoneal cavity, thereby resulting in hypercapnia and acidosis.[10,11] Another factor involved in the occurrence of complications is the increase in Closure Volume (CV). If CV, accounting for 30% of the total lung capacity, increases to the point where it exceeds FRC, some of the alveoli which are normally required to remain open are closed, thus leading to decreased ventilation and atelectasia. [9]

Berström et al induced pneumoperitoneum in laparoscopic surgery in pigs with CO_2 in one group and with helium in another group; the comparison of the pH values between the two groups revealed a lower value in the CO_2 group compared to the helium group.[12] A trial by Iwasaka et al including patients receiving laparoscopic cholecystectomy reported an increase in $PaCO_2$ and $EtCO_2$ during the CO_2 insufflation and a secondary reduction in the pH value.[1]

Reviewing the impact of the CO_2 pneumoperitoneum induced for laparoscopic surgery on the postoperative blood gas in our trial, a significant reduction was observed in both groups following laparoscopy in line with the results from the previous trials. The $PaCO_2$ value was higher than the control values. The absence of a significant change in the $EtCO_2$ value was attributed to the fact that the ventilator setting was corrected to $EtCO_2$ 35±5.

Obese patients have a higher requirement for postoperative respiratory support.[13] The methods commonly used to prevent pulmonary complica-

TABLE 5: Postoperative nausea and vomiting score (n %).

Nausea and vomiting score	Group C (n=20) (%)	Group N (n=20) (%)
0- No	12 (60%)	12 (60%)
1- Mild nausea	5 (25%)	6 (30%)
2- Moderate nausea	2 (10%)	1 (5%)
3- Severe nausea	1 (5%)	1 (5%)
4- Retching and vomiting	-	-

Group C: Continuous positive airway pressure.
Group N: Nasal oxygen.

TABLE 6: Visual analogue scale.

	Group C (n=20)	Group N (n=20)	p
VAS 1	4.10±1.29	4.55±0.75	0.18
VAS 2	2.45±0.51	2.45±0.51	1.00

Group C: Continuous positive airway pressure.
Group N: Nasal oxygen.
VAS; visual analogue scale.
VAS 1: Before admitting the patient to the PACU,
VAS 2: After discharging the patient to the PACU.

tions include respiratory physiotherapy, pulmonary expansion techniques, oxygen administration via nasal route or by mask, and non-invasive mechanical ventilation (NIMV).[14-16]

Ayhan et al monitored the oxygen administered via postoperative nasal cannula and mask by using a pulse oximeter and demonstrated that the patients' BMI and ASA class were involved in the low saturation observed and that nasal oxygen application was more effective than the mask application.[17] Gift et al. suggested that postoperative nasal oxygen application was more convenient and effective relative to mask application.[18] Nasal intermittent mandatory ventilation (NIMV) is a method used to provide positive-pressure respiratory support by mask without using an endotracheal tube. Recently, the use of NIVM in cases of chronic obstructive pulmonary disease (COPD), cardiogenic pulmonary edema, extubation or postoperative respiratory failure has gradually increased.[19] NIMV is designed to correct ventilation to relax the respiratory muscles, thereby correcting hypercapnia and secondary acidosis.[20]

NIMV is being used increasingly in the care of patients suffering acute respiratory failure. High-level evidence supports the use of NIMV to treat COPD exacerbations. NIMV has also been successfully used in selected patients suffering acute hypoxemic respiratory failure.[21] Although both masks performed similarly with regard to improving vital signs and gas exchange and avoiding intubation, the nasal mask was less well tolerated than the oronasal mask in patients with acute respiratory failure.[22]

A meta-analysis by Ferreyra et al. suggested that CPAP decreased the postoperative pulmonary complications, and recommended its use in the treatment of post-abdominal-surgery respiratory complications.[23] In a trial by Ursavas et al investigating the factors affecting the success of NIMV in patients with acute hypercapnic respiratory failure, the improvement in $PaCO_2$ and pH was detected to be a good predictor for success or failure.[24] Our results showed no difference between the two groups in pH values based on the comparison of the blood gas values. The CPAP group had a lower $PaCO_2$ value compared to the nasal oxygen group. In addition, Group C had a higher PaO_2 value relative to that in Group N.

In a trial by Meng et al. investigating the impact of CPAP following a laparoscopic gastric bypass operation on postoperative nausea-vomiting, no significant difference was detected between the groups receiving and not receiving CPAP.[25] In our trial, we also could not detect any difference between the two groups in nausea and vomiting based on the assessment of postoperative nausea and vomiting. Two patients, incompatible with CPAP were excluded from the study. Smith RA et al showed in their study that CPAP use by an external mask (mask or nasal CPAP) has been increasing for the treatment of patients with severe hypoxaemia who have adequate carbon dioxide elimination. Good candidate for mask or nasal CPAP are patients with severe hypoxaemia requiring more than 80% oxygen to achieve PaO_2 above 60 mmHg. They must have a normal $PaCO_2$, not have severe respiratory distress and be awake and alert.[26]

Bolus dose recommendations are generally based on total body weight (TBW), a valid approach for non-obese subjects of varying sizes. However, in morbidly obese subjects, the increase in lean body weight (LBW) is not proportional to the increase in adipose tissue.[27] The volume of fat tissue increases proportionally with TBW and BMI. The absolute value of LBW increases in morbidly obese subjects; however, the percentage of lean body tissue relative to TBW actually decreases. In addition, increased CO and stroke volume are proportionately greater in the individual whose increased size is due to increased lean tissue rather than adipose tissue.[28] Because these changes in body composition and distribution of blood flow alter a drug's distribution, obese patients need doses individualized according to other dosing scalars.[29]

One of the limitations of this study is that the drugs used for anesthesia were based on TBW.

Postoperative CPAP application can increase the PaO_2 more and provide a better CO_2 elimination compared to the nasal oxygen application in obese patients undergoing laparoscopic cholecystectomy.

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