Comparison of the efficiency of different techniques used in the prevention of pain after laparoscopic sleeve gastrectomy surgery

Laparoskopik tüp mide ameliyatı sonrası ağrının önlenmesinde kullanılan farklı tekniklerin etkinliğinin karşılaştırılması

Abstract

Aim: The main purpose of this study is to investigate the effect of different methods that may affect pain after laparoscopic sleeve gastrectomy surgery.

Methods: Patients who were treated for morbid obesity in our clinic between January 2016 and January 2020 were analyzed retrospectively. The 90 patients who participated in the study were divided into three groups: Group 1: The active aspiration group, Group 2: The pulmonary recruitment maneuver (PRM) group, and Group 3: The intraperitoneal normal saline infusion (INSI) group. After completion of the operative procedures, residual gas was aspirated in Group 1. In the Group 2, the patients were placed in the Trendelenburg position (30°), and a pulmonary recruitment maneuver consisting of 5 manual pulmonary inflations was performed with a maximum pressure of 40 cm H2O. In the Group 3, the upper part of the abdominal cavity was even and bilaterally filled with isotonic normal saline (1000 mL), which was then left in the abdominal cavity. The patients (in all groups) were then placed in the level position, the trocar was removed, and the abdominal incisions were closed.

Results: There was no statistical difference between the groups in terms of the duration of surgery, duration of hospital stay, and return to normal activity. Although pain levels were found to be high in all groups within 4 hours, no statistical differences were observed. Despite this, the pain levels at 24 hours, 48 hours, and 3 days showed no difference between Groups 1 and 2, while Group 3 was lower. The amount and frequency of analgesics used are less in Group 3. This situation is statistically significant.

Conclusion: The INSI maneuver seemed to be much more effective in reducing upper abdominal and shoulder pain caused by laparoscopy, and the effect lasted longer.

Keywords: Abdominal pain; gastrectomy; obesity; peritoneal cavity; postoperative pain; shoulder pain

Öz

Amaç: Bu çalışmanın temel amacı laparoskopik tüp mide ameliyatı sonrası ağrıya etki edebilecek farklı yöntemlerin etkisini araştırmaktır.

Yöntemler: Kliniğimizde Ocak 2016 ile Ocak 2020 tarihleri arasında morbid obezite tedavisi gören hastalar geriye dönük olarak incelendi. Çalışmaya katılan 90 hasta üç gruba ayrıldı: Grup 1: Aktif aspirasyon grubu, Grup 2: PRM (pulmoner rekrütman manevrası) grubu ve Grup 3: INSI (intraperitoneal normal salin infüzyonu) grubu. Sleeve gastrektomi tamamlandıktan sonra Grup 1'de kalan gaz aspire edildi. Grup 2 hastalara Trendelenburg pozisyonu (30°) getirilerek maksimum 40 cm H2O basınçla 5 manuel pulmoner şişirmeden oluşan pulmoner rekrütman manevrası uygulandı. Grup 3 karın boşluğunun üst kısmı eşit ve iki taraflı olarak izotonik normal salin (1000 mL) ile doldurulduu ve daha sonra karın boşluğuna bırakıldı. Daha sonra hastalar (tüm gruplarda) düz pozisyona getirildi, trokar çıkarıldı ve karın kesileri kapatıldı.

Bulgular: Ameliyat süresi, hastanede kalış süresi ve normal aktiviteye dönüş süresi açısından gruplar arasında istatistiksel fark yoktu. 4 saat içerisinde tüm gruplarda ağrı düzeyleri yüksek bulunmasına rağmen istatistiksel olarak herhangi bir farklılık gözlenmedi. Buna rağmen 24 saat, 48 saat ve 3. gündeki ağrı seviyeleri Grup 1 ve 2 arasında fark göstermezken, Grup 3 daha düşüktü. Grup 3'te kullanılan analjezik miktarı ve sıklığı daha azdır. Bu durum istatistiksel olarak anlamlıdır.

Sonuç: INSI manevrası, laparoskopinin neden olduğu üst karın ve omuz ağrısını azaltmada etkili görünüyordu ve etki daha uzun sürdü.

Anahtar Sözcükler: Gastrektomi; karın ağrısı; obezite; omuz ağrısı; peritoneal kavite; postoperatif ağrı

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INTRODUCTION

Obesity in Western countries is an epidemic health problem that shows no signs of abating. The incidence of this disease is also increasing in low- and middle-income countries (1). Laparoscopic Sleeve Gastrectomy (LSG) is the most commonly used bariatric surgical technique today and is a restrictive procedure in which the stomach volume is reduced (2,3). The popularity of the LSG technique is increasing day by day among surgeons, and it has a promising future because its applicability is technically easy. The surgeon's training period is short and it is easier to perform procedures. In recent years, it has taken its place in obesity surgery as a confidential surgery through increasing patient satisfaction of patients (4).

Pain treatment is difficult in morbidly obese patients (5). There is a significant risk of opioid-induced ventilatory impairment (OIVI) in these patients since opioids are the first drug type of choice for postoperative pain control (6). In addition, the prevalence of obstructive sleep apnea (OSA) is high in the morbidly obese population (7,8).

The main purpose of this study is to investigate the effect of different methods that may affect pain after laparoscopic sleeve gastrectomy surgery.

MATERIALS AND METHODS

Patients who were treated for morbid obesity in our clinic between January 2016 and January 2020 were analyzed retrospectively. Ethical approval for this study was obtained from the Non-Interventional Research Ethics Committee of İzmir Kâtip Çelebi University (date: 22.09.2022, decision no: 0404). Data were obtained from the records in the archive of the hospital (operation notes, epicrisis, and polyclinic records). Exclusion criteria were an American Society of Anesthesiologists score of 3 or 4, a history of drug dependence/abuse, a history of opioid intake or chronic pain disorder, coagulopathy, infections, and previous abdominal surgery. All patients were given a liquid diet before the operation. In addition, the night before the operation, all patients were administered low molecular weight heparin (Enoxaparin, Sanofi, Paris, France) subcutaneously for deep venous thrombosis prophylaxis and were dressed in pneumatic compression stockings. All patients underwent upper GIS endoscopy under sedation to evaluate anatomical anomalies and gastric mucosal pathologies before surgery. All surgeries were completed laparoscopically.

Anesthesia technique

After monitoring, the vascular tract was opened with an 18G intravenous (IV) cannula. The patient's adjusted weight (ABW) was calculated and all drug dose adjustments were made according to ABW. Premedication was achieved with midazolam 0.03 mg/ kg midazolam. Anesthesia induction was performed with fentanyl 2 μg/kg, propofol 2 mg/kg, rocuronium 0.6 mg/kg, and orotracheal intubation after two minutes. Ventilation was started in pressure control mode with positive end-expiration pressure (PEEP) and above-PEEP pressure at a level that would create sufficient tidal volume (6-8 mL/kg). Maintenance of anesthesia was achieved with total IV anesthesia (TIVA) accompanied by 0-200 μg/kg/min decoction of propofol and 0.1-0.3 μg/kg/min infusion of remifentanil at a level that will provide ±20% of blood pressure baseline between BIS 40 and 60. To reduce postoperative nausea and vomiting, ranitidine 50 mg, metoclopramide 20 mg, and tramadol 100 mg, and 1 g of paracetamol IV were administered for analgesia. At the end of the operation, the reversal of neuromuscular blockade was achieved using atropine 0.02 mg/kg and neostigmine 0.04 mg/kg followed by tracheal extubation.

After completion of the operative procedures, residual gas was aspirated in Group 1 (Active aspiration group). Aspiration was performed with a flexible cannula that was inserted through the most lateral accessory port and positioned in the subdiaphragmatic space. In the PRM group (Group 2), the patients were placed in the Trendelenburg position (30°) and a pulmonary recruitment maneuver consisting of 5 manual pulmonary inflations was performed with a maximum pressure of 40 cm H2O. The anesthesiologists held the fifth positive-pressure inflation for 5 seconds. During these maneuvers, the surgeon was instructed to ensure that the trocar sleeve valve was fully open to allow the carbon dioxide to escape the abdominal cavity. In the INSI group (Group 3), the upper part of the abdominal cavity was even and bilaterally filled with isotonic normal saline (1000 mL), which was then left in the

abdominal cavity. During this procedure, the surgeon was instructed to ensure that the trocar sleeve valve was fully open to allow the carbon dioxide to escape the abdominal cavity. The patients (in all groups) were then placed in the level position, the trocar was removed, and the abdominal incisions were closed. The demographic data, body mass index, Preoperative Findings (comorbidity), operation time, intraabdominal pressure, insufflated CO_2 volume during the operation, hospitalization period, return to normal activity, and follow-up (months) were recorded.

All patients in our study had general anesthesia using propofol, fentanyl, rocuronium, and isoflurane. Postoperatively, the pain severity score was recorded by using a visual analog pain scale between 0 and 10 (0=no pain; 10=most severe pain). Diclofenac (75 mg/kg) was given intramuscularly as rescue analgesia when visual analog pain scale of at least 3 and repeated after 12 h if needed. An additional breakthrough, meperidine was given intramuscularly at 50 mg/dose each time, if necessary. Time to the first analgesic request, diclofenac consumption (mg), and the number of patients who needed additional breakthrough meperidine in each group were recorded. Following surgery, pain assessments were measured by the patient's bed at the end of 4 hours, 24 hours, 48 hours, and 3rd day. However, the pain levels between males and females in each group were compared.

Statistical analysis

The statistical analysis was performed using SPSS (Statistical Package for the Social Sciences ver. 10.0, SPSS Inc, Chicago, Illinois, USA) computer program. One-way analysis of variance (ANOVA) was done to compare between groups from 4 hours to day 3. Continuous variables were examined by one-way analysis of variance with Scheffe's post hoc test and are expressed as the mean ±standard deviation (SD). The categorical variables were expressed as a number and percentage for each item and analyzed using a chi-square test or Fisher's exact test. The normal distribution test of the quantitative data using the Kolmogorov-Smirnov test and comparisons between groups were analyzed using The Independent t-test(parametric data), Mann-Whitney U test (nonparametric data), and ANOVA. For all statistical analyses, $p<0.05$ was accepted as significant.

RESULTS

There was no statistical difference between the groups in terms of gender, age, BMI, and preoperative comorbidity. Hypertension attracts attention as the most common disorder in all groups. The demographic and clinical data of the three groups are summarized in Table 1.

Pain levels increased significantly in all groups at 4 hours and then decreased by the 3rd day. There was no statistical difference between the groups in terms of the duration of surgery, duration of hospital stay, and return to normal activity. The amount and frequency of analgesics used are less in group 3. This situation is statistically significant (Table 2). There was no statistical difference between the groups in terms of the time elapsed for the first analgesic requirement (Table 2).

Pain levels increased significantly in all groups at the 4th hour, and then they decreased on the 3rd day. Although pain levels were found to be high in all groups within 4 hours, no statistical differences were observed. Despite this, the pain levels at 24 hours, 48 hours, and 3 days showed no difference between groups 1 and 2, while group 3 was lower. Pain levels were consistently lower in the 3rd group, and the 2nd group and the 1st group followed this. The differences were statistically significant in three-time intervals (p=0.001*) (Table 3).

In all groups, statistically significant differences in pain levels between male and female patients in group 1 (p= 0.017*), group 2 (0.016*), and group 3 (0.017*) were observed. The mean period for returning to daily activities and to work for patients was 3,8 days.

DISCUSSION AND CONCLUSION

In laparoscopic surgeries, due to gas insufflation and increased intraperitoneal pressure, there is a linear relationship between peritoneal inflammation and neuronal exposure, abdominal cavity compliance, and the severity of postoperative pain (9).

The pain pattern after laparoscopic surgeries is multifactorial. It has three separate components: incisional pain (somatic pain), visceral pain (deep intra-abdominal pain), and shoulder pain (reflected somatic pain). Visceral pain is responsible for most of the discomfort experienced in the early postoperative period and is markedly different from shoulder pain

Table 1. Patient demographics and clinical data.

		Active gas aspiration group (n=30) (Group 1)	Pulmonary recruitment maneuver group (n=30) (Group 2)	Intraperitoneal normal saline infusion group (n=30) (Group 3)	p
Age (years)		Mean 37.3	Mean 36.08	Mean 37.08	0.740
Gender		M;F 12:18	M;F 13:17	M;F 14:16	0.820
BMI (kg/m²)		41.8±4.2	42.6±5.2	42.8±6.1	0.670
Comorbidity	Hypertension, n(%)	14 (46.6 %)	13 (43.3%)	14 (46.6%)	
	Diabetes, %	5 (16.6 %)	4 (13.33%)	5 (16.6%)	
					0.801
	Dyslipidemia, %	9 (30 %)	10 (33.3%)	10 (33.3%)	
	Obstructive sleep apnea (with CPAP) %	2 (6.6 %)	3 (10%)	1 (3.33%)	
	Hipotroidizm	1 (3.33%)	1 (3.33%)	0	
	Kardiovasküler	1 (3.33%)	0	1 (3.33%)	

BMI: Body mass index, CPAP: Continuous positive airway pressure, M: Male, F: Female, n: Number, %: Percent

Table 2. Main measurable outcomes

	Active gas aspiration group (n=30) (Group 1)	Pulmonary recruitment maneuver group (n=30) (Group 2)	Intraperitoneal normal saline infusion group (n=30) (Group 3)	p
Operation time (min)	36.5±2.4	37.1±1.7	36.5±5.3	0.688
Total CO_2 volume (L)	65.1±16.3	68.0±22.3	66.8±15.1	0.675
IOP (intraabdominal pressure)	16.0±0.3	16.0±0.0	16±0.2	0.241
Time to the first analgesic request (min)	318.8±31.4	322.5±32.3	321.1±30.9	0.518
Diclofenac consumption (mg)	135.14±9.34	138.25±9.64	99.73±22.32	<0.001[a,b]
Requirement for rescue analgesics	12	11	5	<0.001[a,b]
Number of patients who needed additional mepridine	8	6	3	<0.001[a,b]
Hospitalisation (day)	3.5 ± 0.7	3.4 ± 0.8	3.7 ± 1.2	0.779
Return to normal activity (weeks)	3.8±1.2	3.9±1.4	3.7±1.5	0.317
Follow up (months)	12.0± 0.7	12.0± 0.0	12.0±0.2	0.155

n: Number, %: Percent, a: Post-hoc comparisons test: Group 1 versus Group 3, b: Post-hoc comparisons test: Group 2 versus Group 3, Data are presented as mean ± Standart Deviation.

Table 3. Pain levels in all groups.

Interval	Active gas aspiration group (n=30) (Group 1)	Pulmonary recruitment maneuver group (n=30) (Group 2)	Intraperitoneal normal saline infusion group (n=30) (Group 3)	p
4 h	3.97	3.7	3.95	0.904
24 h	2.49	2.5	1.86	0.001*
48 h	2.37	2.25	1.22	0.001*
Day 3	1.65	1,6	1.14	0.001*

n: Number, h: Hours, One Way ANOVA test; * indicates significance at p≤0.05

(10). Shoulder pain often becomes noticeable on the day after surgery, when the visceral pain component decreases. Pneumoperitoneum, which is formed as a result of CO_2 insufflation, increases intra-abdominal pressure, peritoneal tension, diaphragmatic irritation, causing tension of diaphragmatic muscle fibers and due to these causes, the patient develops shoulder pain (SP). In addition, abdominal trauma caused by trocar penetration into the abdominal wall causes somatic pain, while intra-abdominal interventions cause visceral pain (11,12). Other factors associated with pain are the temperature and type of insufflated gas, intra-

Table 4. Pain level differences in females and males in the active gas aspiration group.

Interval	Females	Males	*p*
4 h	4.25	3.7	0.008*
24 h	2.84	2.14	0.017*
48 h	2.62	2.12	0.016*
Day 3	1.90	1.40	0.007*

n: Number, h: Hours, Independent t test; * indicates significance at p≤0.05

Table 5. Pain level differences in females and males in the pulmonary recruitment maneuver group.

Interval	Females	Males	*p*
4 h	4.10	3.30	0.006*
24 h	2.7	2.3	0.016*
48 h	2.48	2.02	0.017*
Day 3	1.80	1.40	0.007*

n: Number, h: Hours, Independent t test; * indicates significance at p≤0.05

Table 6. Pain level differences in females and males in the intraperitoneal normal saline infusion group

Interval	Females	Males	p
4 h	4.50	3.40	0.006*
24 h	2.15	1.58	0.017*
48 h	1.38	1.07	0.005*
Day 3	1.20	1.08	0.003*

n: Number, h: Hours, Independent t test; * indicates significance at p≤0.05

abdominal pH, presence of intra-abdominal residual gas, abdominal distension, irritation of the peritoneum (11). In addition, the conversion of CO_2 in the abdomen to carbonic acid on the peritoneal surfaces also causes pain (11,13). Therefore, the insufflated CO_2 should be completely removed when the procedure is completed to reduce complications (14).

Various causes of shoulder pain after laparoscopic surgery have been reported in the literature, but the leading hypothesis is based on carbon dioxide (CO_2) in the abdominal cavity. Pneumoperitoneum is thought to cause diaphragmatic irritation by overstretching the diaphragmatic muscle fibers and causing pain sensation mediated by the phrenic nevre (15). According to Jackson et al. investigated the relationship between the size of gas bubbles in the peritoneal cavity and the severity of pain and found a relationship between residual gas volume and laparoscopic pain (15). To support the theory of overstretched diaphragmatic muscle fibers, it has also been shown that a low insufflation rate reduces postoperative SP (16). It causes postoperative pain with rapid bloating, rupture of blood vessels, traumatic traction of nerves, and release of inflammatory mediators (17). Despite all this, certain etiology of inspiration is not fully known (18). The incidence of SP on the first day after surgery is 35 to 61% (17,19,20). Some patients even have SP for more than 72 hours after surgery (21). In our study, the pain levels of the groups also increased significantly in all groups at the 4th hour, and then it reduced on the 3rd day. Any patient not experienced shoulder pain after 72nd hours. In addition, the differences between the pain levels in all groups were statistically significant over three-time intervals (p=0.001 *) (Table 3).

A technique based on the removal of residual CO_2 from the abdominal cavity is intraperitoneal saline instillation. INSI the upper part of the abdominal cavity is filled evenly and bilaterally with isotonic normal saline (25-30 mL/kg body weight) and then left in the abdominal cavity (22,23). Intraperitoneal saline instillation (intraperitoneal saline instillation) is believed to reduce shoulder pain (SP) by two different mechanisms of action. First, it increases intraperitoneal pressure, which removes residual carbon dioxide from the peritoneal cavity. Secondly, it acts as a physiological buffer in which residual carbon dioxide dissolves (22-24). CO_2 in the abdominal cavity dissolves in water and becomes carbonic acid. From here, carbonic acid is converted to bicarbonate through the red blood cell in the intravascular cavity. In the lungs, bicarbonate is converted back into CO_2, which is inhaled by the patient (20). In studies, they have shown that INSI significantly reduces the incidence and intensity of

shoulder pain after laparoscopic cholecystectomy at 12 and 24 hours (22,25,26). In our study, pain levels at 24 hours, 48 hours, and 3 days were consistently found to be lower in the INSI group. Also, in the INSI Group (Group 3), the upper part of the abdominal cavity was evenly and bilaterally filled with isotonic normal saline (1000 mL). When compared with the literature and considering that our patients were obese, our results were consistent, even though less serum was given. We think that the reason for the success of the procedure is due to the physiological buffer effect.

Another technique based on the removal of residual CO_2 from the abdominal cavity is a pulmonary recruitment maneuver (PRM). PRM works by removing CO_2 from the peritoneal cavity by manually applying pulmonary inflation with a pressure between 40 and 60 cmH_20. The positive pressure causes the lungs to expand and the diaphragm to fall, resulting in the discharge of the remaining CO_2 from the peritoneal cavity (20,27,28). The significant effect of PRM on SP severity was found 4-24 hours after surgery and 12 hours after discharge, and 24 hours postoperatively (20,28). In one of these studies, a significant reduction in postoperative analgesic requirements was found (28). The literature suggests that an alveolar recurrence maneuver of 40 cmH_2O is a safe and effective way to improve arterial oxygenation during anesthesia (29-31). In addition, physiological processes such as coughing and sneezing can increase intrapulmonary pressures up to 80-130 cmH_2O (32,33).

One of the studies applying the PRM technique also compared PRM with intraperitoneal saline. The authors hypothesized that this decrease was due to the longer-term effect of intraperitoneal saline compared to PRM. A possible explanation for this longer-lasting effect is that intraperitoneal saline acts as a buffer system (20).

Another important technique to reduce the pain is to allow CO_2 gas to escape from the abdominal cavity through gas evacuation or forced aspiration at the end of surgery (17,34,35). Kafali and colleagues showed that forced aspiration of residual CO_2 gas with an aspiration cannula after minor gynecological laparoscopic surgery significantly reduces the intensity of shoulder pain and the need for analgesics until 24 hours after surgery (36). In a separate study in which residual gas was removed by active aspiration through active aspiration and manual compression to the abdomen (instead of gas drains), although the VAS scores were similar during the 4-hour study period, they determined the postoperative use of morphine for 1 hour less. Pain scores after discharge were not evaluated (35). There are studies in the literature showing that active aspiration after abdominal operations with minimally invasive surgery reduces the volume of residual CO_2 and the frequency of pain and shoulder pain (37, 38). Erdem and colleagues stated that active aspiration of the remaining gas immediately before the removal of the trocars in laparoscopic sleeve gastrectomy is a simple procedure that reduces pain and provides a more comfortable hospital stay (39).

In our study, pain levels were consistently lower in the 3rd group, and the 2nd and 1st groups followed this. The differences were statistically significant in three-time intervals, except for the first 4 hours (p=0.001*). However, pain levels at 24 hours, 48 hours, and 3 days showed no difference between the active aspiration and PRM groups, while they were consistently lower in the INSI group. The amount and frequency of analgesics used are less in the INSI group. This situation is also statistically significant.

Several studies have reported that younger age and female sex increase the risk of postoperative pain; however, other studies have reported otherwise findings (40-49). A study conducted by Chia and colleagues with 2298 patients in the first three days after surgery found that pain at both movement and rest did not vary by gender on the first and third days, while male experienced 21% more pain when moving than female on the second day, male consumed 24-43% more analgesics than female on all three days (50). While 56.6% of the patients in this study were female, statistically, significant differences were observed in pain levels between male and female patients. After the treatments, female experienced higher pain intensity than male in all three groups (Tables 4, 5, and 6).

PRM is easy enough to apply in daily clinical practice and may also have additional benefits, such as reducing atelectasis caused by laparoscopic technique (27,51,52). Therefore the PRM technique for removing residual CO_2 seems to be more advantageous than drainage in terms of ease of application and potential postoperative complications. In this study, both INSI and PRM interventions reduced the incidence and intensity of upper

abdominal pain and shoulder pain after laparoscopic surgery. The effect of INSI was continuous and permanent until the intraperitoneal heated normal saline was absorbed. The INSI maneuver seemed to be much more effective in reducing upper abdominal and shoulder pain caused by laparoscopy, and the effect lasted longer.

Conflict-of-interest and financial disclosure

The authors declare that they have no conflict of interest to disclose. The authors also declare that they did not receive any financial support for the study.

REFERENCES

1. Kitzinger HB, Karle B. The epidemiology of obesity. Eur Surg. 2013;45(2):80–2.
2. Lazzati A, Guy-Lachuer R, Delaunay V, Szwarcensztein K, Azoulay D. Bariatric surgery trends in France: 2005-2011. Surg Obes Relat Dis. 2014;10(2):328-34.
3. Reames BN, Finks JF, Bacal D, Carlin AM, Dimick JB. Changes in bariatric surgery procedure use in Michigan, 2006-2013. JAMA. 2014;312(9):959-61.
4. D'Hondt M, Vanneste S, Pottel H, Devriendt D, Van Rooy F, Vansteenkiste F. Laparoscopic sleeve gastrectomy as a single-stage procedure for the treatment of morbid obesity and the resulting quality of life, resolution of comorbidities, food tolerance, and 6-year weight loss. Surg Endosc. 2011;25(8):2498-504.
5. Alvarez A, Singh PM, Sinha AC. Postoperative analgesia in morbid obesity. Obes Surg. 2014;24(4):652-9.
6. Chung SA, Yuan H, Chung F. A systemic review of obstructive sleep apnea and its implications for anesthesiologists. Anesth Analg. 2008;107(5):1543-63.
7. Frey WC, Pilcher J. Obstructive sleep-related breathing disorders in patients evaluated for bariatric surgery. Obes Surg. 2003;13(5):676-83.
8. Lopez PP, Stefan B, Schulman CI, Byers PM. Prevalence of sleep apnea in morbidly obese patients who presented for weight loss surgery evaluation: more evidence for routine screening for obstructive sleep apnea before weight loss surgery. Am Surg. 2008;74(9):834-8.
9. Tobias JD. Pain management following laparoscopy: Can we do better?. Saudi J Anaesth. 2013;7(1):3-4.
10. Joris J, Thiry E, Paris P, Weerts J, Lamy M. Pain after laparoscopic cholecystectomy: characteristics and effect of intraperitoneal bupivacaine. Anesth Analg. 1995;81(2):379-84.
11. Memedov C, Menteş Ö, Şimşek A, et al. Laparoskopik kolesistektomi sonrası postoperatif ağrının önlenmesinde çoklu bölgeye lokal anestezik infiltrasyonu: ropivakain veprilokainin plasebo kontrollü karşılaştırılması. Gulhane Med J. 2008;50:84-90.
12. Radosa JC, Radosa MP, Mavrova R, et al. Five minutes of extended assisted ventilation with an open umbilical trocar valve significantly reduces postoperative abdominal and shoulder pain in patients undergoing laparoscopic hysterectomy. Eur J Obstet Gynecol Reprod Biol. 2013;171(1):122-27.
13. Yasir M, Mehta K.S, Banday V.H, Aiman A, Masood I, Iqbal B. Evaluation of post operative shoulder tip pain in low pressure versus standard pressure pneumoperitoneum during laparoscopic cholecystectomy. Surgeon, Apr 2012;10(2):71-4.
14. Acar C, Toktaş C. Laparoskopik cerrahinin temel fizyolojik etkileri. Turk Urol Sem 2010;1:119-25.
15. Jackson SA, Laurence AS, Hill JC. Does post-laparoscopy pain relate to residual carbon dioxide? Anaesthesia. 1996;5:485-7.
16. Berberoglu M, Dilek ON, Ercan F, Kati I, Ozmen M. The effect of CO2 insufflation rate on the postlaparoscopic shoulder pain. J Laparoendosc Adv Surg Tech A 1998;5:273–7.
17. Alexander J. Pain after laparoscopy. Br J Anaesth. 1997;79:369–78.
18. Ng JJ, Leong WQ, Tan CS, et al. A multimodal analgesic protocol reduces opioid-related adverse events and improves patient outcomes in laparoscopic sleeve gastrectomy. Obesity Surgery. 2017;27(12):3075–81.
19. Dobbs FF, Kumar V, Alexander JI, Hull MG. Pain after laparoscopy related to posture and ring versus clip sterilization. Br J Obstet Gynaecol 1987;3:262–6.
20. Tsai HW, Chen YJ, Ho CM, et al. Maneuvers to decrease laparoscopy-induced shoulder and upper abdominal pain: a randomized controlled study. Arch Surg 2011; 12:1360–6.
21. Dixon JB, Reuben Y, Halket C, O'Brien PE. Shoulder pain is a common problem following laparoscopic adjustable gastric band surgery. Obes Surg 2005;8:1111–7.
22. Tsimoyiannis EC, Siakas P, Tassis A, Lekkas ET, Tzourou H, Kambili M. Intraperitoneal normal saline infusion for postoperative pain after laparoscopic cholecystectomy. World J Surg. 1998;22(8):824-8.
23. Tsimoyiannis EC, Glantzounis G, Lekkas ET, Siakas P, Jabarin M, Tzourou H. Intraperitoneal normal saline and bupivacaine infusion for reduction of postoperative pain after laparoscopic cholecystectomy. Surg Laparosc Endosc. 1998;8(6):416-20.
24. Mader SS. Human Biology. Burr Ridge, IL: McGraw-Hill; 2004.
25. Barczyński M, Herman RM. Low-pressure pneumoperitoneum combined with intraperitoneal saline washout for reduction of pain after laparoscopic cholecystectomy: a prospective randomized study. Surg Endosc. 2004;18(9):1368-

73.
26. Esmat ME, Elsebae MM, Nasr MM, Elsebaie SB. Combined low pressure pneumoperitoneum and intraperitoneal infusion of normal saline for reducing shoulder tip pain following laparoscopic cholecystectomy. World J Surg. 2006;30(11):1969-73.
27. Phelps P, Cakmakkaya OS, Apfel CC, Radke OC. A simple clinical maneuver to reduce laparoscopy-induced shoulder pain: a randomized controlled trial. Obstet Gynecol. 2008;111(5):1155-60.
28. Sharami SH, Sharami MB, Abdollahzadeh M, Keyvan A. Randomised clinical trial of the influence of pulmonary recruitment manoeuvre on reducing shoulder pain after laparoscopy. J Obstet Gynaecol. 2010;30(5):505-10.
29. Tusman G, Bohm SH, Vazquez de Anda GF, do Campo JL, Lachmann B. Alveolar recruitment strategy' improves arterial oxygenation during general anaesthesia. Br J Anaesth. 1999;82:8–13.
30. Magnusson L, Tenling A, Lemoine R, Högman M, Tydén H, Hedenstierna G. The safety of one, or repeated, vital capacity maneuvers during general anesthesia. Anesth Analg. 2000;91(3):702-7.
31. Ricard JD. Barotrauma during mechanical ventilation: why aren't we seeing any more?. Intensive Care Med. 2004;30(4):533-5.
32. Bennett WD, Foster WM, Chapman WF. Cough-enhanced mucus clearance in the normal lung. J Appl Physiol (1985). 1990;69(5):1670-5.
33. Guyton AC, Hall JE. Textbook of medical physiology. 11th ed. Philadelphia, (PA): Elsevier/Saunders; 2006. p. 480.
34. Abbott J, Hawe J, Srivastava P, Hunter D, Garry R. Intraperitoneal gas drain to reduce pain after laparoscopy: randomized masked trial. Obstet Gynecol. 2001;98(1):97-100.
35. Fredman B, Jedeikin R, Olsfanger D, Flor P, Gruzman A. Residual pneumoperitoneum: a cause of postoperative pain after laparoscopic cholecystectomy. Anesth Analg. 1994;79(1):152-4.
36. Kafali H, Karaoglanoglu M, Oksuzler C, Bozkurt S. Active intraperitoneal gas aspiration to reduce postoperative shoulder pain after laparoscopy. Pain Clin. 2004;16(2):197–200.
37. Atak I, Ozbagriacik M, Akinci OF, et al. Active gas aspiration to reduce pain after laparoscopic cholecystectomy. Surg Laparosc Endosc Percutan Tech. 2011;21(2):98-100.
38. Das K, Karateke F, Menekse E, et al. Minimizing shoulder pain following laparoscopic cholecystectomy: a prospective, randomized, controlled trial. J Laparoendosc Adv Surg Tech A. 2013;23(3):179-82.
39. Erdem H, Gençtürk M, Çetinkünar S, Şişik A, Sözen S. The effect of active gas aspiration to reduce pain after laparoscopic sleeve gastrectomy for morbid obesity: a randomized controlled study. Arch Med Sci Civil Dis. 2021;6(1):109–16.
40. Gerbershagen HJ, Pogatzki-Zahn E, Aduckathil S, et al. Procedure-specific risk factor analysis for the development of severe postoperative pain. Anesthesiology. 2014;120(5):1237-45.
41. Thomazeau J, Rouquette A, Martinez V, et al. Acute pain Factors predictive of post-operative pain and opioid requirement in multimodal analgesia following knee replacement. Eur J Pain. 2016;20(5):822-32.
42. Cepeda MS, Carr DB. Women experience more pain and require more morphine than men to achieve a similar degree of analgesia. Anesth Analg. 2003;97(5):1464-8.
43. Kest B, Sarton E, Dahan A. Gender differences in opioid-mediated analgesia: animal and human studies. Anesthesiology. 2000;93(2):539-47.
44. Zeidan A, Al-Temyatt S, Mowafi H, Ghattas T. Gender-related difference in postoperative pain after laparoscopic Roux-En-Y gastric bypass in morbidly obese patients. Obes Surg. 2013;23(11):1880-4.
45. Cheung CW, Ying CL, Lee LH, Tsang SF, Tsui SL, Irwin MG. An audit of postoperative intravenous patient-controlled analgesia with morphine: evolution over the last decade. Eur J Pain. 2009;13(5):464-71.
46. Chen WC, Bai YY, Zhang LH, et al. Prevalence and Predictors of Chronic Postsurgical Pain After Video-Assisted Thoracoscopic Surgery: A Systematic Review and Meta-analysis. Pain Ther. 2023;12(1):117-39.
47. Zheng H, Schnabel A, Yahiaoui-Doktor M, et al. Age and preoperative pain are major confounders for sex differences in postoperative pain outcome: A prospective database analysis. PLoS One. 2017;12(6):e0178659.
48. Liu QR, Dai YC, Ji MH, Liu PM, Dong YY, Yang JJ. Risk Factors for Acute Postsurgical Pain: A Narrative Review. J Pain Res. 2024;17:1793-804.
49. Yang Y, Zhang C, Chi W, et al. A risk factor prediction model for moderate-to-severe postoperative pain in patients undergoing laparoscopic sleeve gastrectomy. Medicine (Baltimore). 2025;104(6):e41398.
50. Chia YY, Chow LH, Hung CC, Liu K, Ger LP, Wang PN. Gender and pain upon movement are associated with the requirements for postoperative patient-controlled iv analgesia: a prospective survey of 2,298 Chinese patients. Can J Anaesth. 2002;49(3):249-55.
51. Arslan K, Arslan HÇ, Yalçın N, et al. Effect of Pulmonary Recruitment Maneuver on Postlaparoscopic Shoulder Pain, Postoperative Pain and Outcomes in Gynecologic Laparoscopic Surgeries. Bagcilar Med Bull. 2025;10(1):31-9.
52. Güngördük K, Aşıcıoğlu O, Özdemir İA. Effect of the pulmonary recruitment maneuver on pain after laparoscopic gynecological oncologic surgery: a prospective randomized trial. J Gynecol Oncol. 2018;29(6):e92.