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Effect of Pulmonary Recruitment Maneuver on Postlaparoscopic Shoulder Pain, Postoperative Pain and Outcomes in Gynecologic Laparoscopic Surgeries

Jinekolojik Laparoskopik Cerrahilerde Pulmoner Recruitment Manevrasının Postlaparoskopik Omuz Ağrısı, Postoperatif Ağrı ve Sonuçlara Etkisi

Kadir Arslan[1], Hale Çetin Arslan[2], Naime Yalçın[1], Ayça Sultan Şahin[1]

[1]University of Health Sciences Turkey, Kanuni Sultan Süleyman Training and Research Hospital, Department of Anesthesiology and Reanimation, İstanbul, Turkey
[2]University of Health Sciences Turkey, Kanuni Sultan Süleyman Training and Research Hospital, Department of Obstetrics and Gynecology, İstanbul, Turkey

Abstract

Objective: Post-laparoscopic shoulder pain (PLSP) is a significant occurrence after laparoscopic surgery. This study investigated the effects of pulmonary recruitment maneuvers (PRM) on PLSP, postoperative pain, and patient outcomes in patients undergoing laparoscopic gynecologic surgery.

Method: Patients who underwent laparoscopic gynecological surgery for benign reasons between April 2023 and October 2023 were retrospectively examined. The patients were divided into the PRM group (group PRM, n=45) and the control group (group C, n=46). In group PRM, five recruitment maneuvers were performed manually at the end of the operation with 40 cm H_2O pressure. The PLSP visual analog scale (VAS) scores were compared with VAS scores at the 6th, 12th, and 24th postoperative hours, postoperative wound VAS scores, ambulation times, postoperative nausea and vomiting (PONV), bowel movement times, and hospital stay.

Results: The study included 91 patients with a mean age of 49.4±9 years. The most commonly performed operations were total laparoscopic hysterectomy and bilateral salpingo-oophorectomy. The PLSP rate in Group PRM was significantly lower than in Group K (31.1% vs. 63%,

Öz

Amaç: Laparoskopik cerrahi sonrasında önemli oranda postlaparoskopik omuz ağrısı (PLSP) görülmektedir. Bu çalışmanın amacı, laparoskopik jinekolojik cerrahi gerçekleştirilen hastalarda pulmoner rekruitment manevrasının (PRM) PLSP, postoperatif ağrı ve hasta sonuçlarına etkisini araştırmaktır.

Yöntem: Nisan 2023 ile Ekim 2023 tarihleri arasında benign sebeplerle laparoskopik jinekolojik operasyon gerçekleştirilen hastalar retrospektif olarak incelendi. Hastalar PRM uygulanan grup (grup PRM, n=45) ve uygulanmayan kontrol grubu (grup K, n=46) olarak iki gruba ayrıldı. Grup PRM'de operasyon bitiminde manuel yöntemle 40 cmH_20 basınçlı 5 rekruitment manevrası gerçekleştirildi. Postoperatif 6, 12 ve 24. saatlerdeki PLSP vizüel analog skala (VAS) skorları, postoperatif yara yeri VAS skorları, ambülasyon süreleri, postoperatif bulantı-kusma (PONV) mevcudiyeti, bağırsak hareketleri zamanı ile hastanede kalış süreleri karşılaştırıldı.

Bulgular: Çalışmaya yaş ortalaması 49,4±9 yıl olan toplam 91 hasta dahil edildi. En çok gerçekleştirilen operasyon, total laparoscopic hysterectomy, bilateral salpingo-oophorectomy idi. Grup PRM'de PLSP oranı Grup K'ye göre anlamlı olarak düşük idi (%31,1 vs. %63, p=0,002). Grup PRM'de postoperatif 6 (3,6 vs. 5,8), 12 (3,3 vs. 4,9) ve 24. saatteki

Address for Correspondence: Kadir Arslan, University of Health Sciences Turkey, Kanuni Sultan Süleyman Training and Research Hospital, Department of Anesthesiology and Reanimation, İstanbul, Turkey
E-mail: kadir.arslan@sbu.edu.tr **ORCID:** orcid.org/0000-0003-4061-0746
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Abstract

p=0.002). In Group PRM, mean PLSP VAS scores at 6 (3.6 vs. 5.8), 12 (3.3 vs. 4.9), and 24 hours (2.8 vs. 3.9) postoperatively were significantly lower (p<0.001 for all). In Group PRM, postoperative 6th-hour wound pain scores were significantly lower (4.8 vs. 5.7, p=0.009). In Group PRM, ambulation time (6.6±0.9 vs. 7.5±1.5 hours, p=0.002) and bowel movement recovery time (14.2±4 vs. 16.4±5 hours, p=0.038) were also significantly lower. In Group PRM, the PONV rate (28.9% vs. 37%) and hospital stay (2.2±0.4 vs. 2.3±0.5 days) were lower, but no statistically significant difference was found.

Conclusion: PRM, which can be easily applied at the end of benign laparoscopic gynecological surgeries, effectively reduces PLSP and early wound pain. It is also helpful in reducing postoperative ambulation time and in the return of bowel functions.

Keywords: Early ambulation, laparoscopy, pneumoperitoneum, postoperative pain, pulmonary recruitment maneuver, shoulder pain

Öz

(2,8 vs. 3,9) ortalama PLSP VAS skorları anlamlı olarak düşük saptandı (hepsi için p<0,001). Grup PRM'de aynı zamanda postoperatif 6. saat yara ağrı skorları da anlamlı olarak düşüktü (4,8 vs. 5,7, p=0,009). Grup PRM'de ambülasyon süresi (6,6±0,9 vs. 7,5±1,5 saat, p=0,002) ile bağırsak hareketlerinin geri gelme süresi de anlamlı olarak düşük idi (14,2±4 vs. 16,4±5 h, p=0,038). Grup PRM'de PONV oranı (%28,9 vs. %37) ve hastanede kalış süresi (2,2±0,4 vs. 2,3±0,5 gün) düşük olmakla birlikte anlamlı farklılık saptanmadı.

Sonuç: Benign laparoskopik jinekolojik cerrahilerde operasyon bitiminde kolayca uygulanabilen PRM, PLSP ve erken dönem yara ağrısının azaltılmasında etkilidir. Bununla birlikte postoperatif ambülasyon süresinin ve bağırsak fonksiyonlarının geri dönmesinde de faydalıdır.

Anahtar kelimeler: Erken ambülasyon, laparoskopi, omuz ağrısı, pnömoperitoneum, postoperatif ağrı, pulmoner rekruitman manevras

Introduction

With the development of minimally invasive surgery (MIS) techniques, these methods have increasingly been used to diagnose and treat various diseases. MIS, including laparoscopic surgery (LS), has been widely accepted instead of traditional laparotomy in the treatment of various benign gynecological diseases (1). LS has advantages over laparotomy, such as shorter hospital stays, smaller incisions, earlier return to daily activities, less postoperative pain, and better cosmetic results (2). However, it is crucial to note that despite the advantages of LS, conditions such as post-laparoscopic shoulder pain (PLSP) are frequently encountered and bother patients. In the literature, the incidence of shoulder or abdominal pain after laparoscopy has been reported to be between 35% and 80% (3,4), highlighting the prevalence of these complications. In addition, postoperative nausea and vomiting (PONV) is seen after LS and negatively affects patient comfort.

During laparoscopy, pneumoperitoneum is created, increasing intra-abdominal pressure. As a result of this pressure increase, the diaphragm is displaced upwards. Functional residual capacity and lung compliance decrease, and patients may develop atelectasis. There needs to be a consensus on the mechanism of PLSP. The generally accepted view is that carbon dioxide (CO_2) causes referred pain in the C4 dermatome due to phrenic nerve irritation (5). Another possible mechanism, is shoulder pain due to CO_2 accumulation between the liver and the right diaphragm. Another perspective is the tissue trauma theory. Stretching or injury of the peritoneum and diaphragm due to pneumoperitoneum causes rupture of blood vessels, traction of nerves (e.g., the phrenic nerve), and release of inflammatory mediators that cause referred pain to the shoulder (6). PLSP may increase postoperative analgesic consumption, lengthen hospital stays and, rarely, may lead to rehospitalizations. Therefore, necessary precautions should be taken to reduce the intensity of PLSP. Although various methods are used to reduce PLSP, the most widely accepted method is to perform a pulmonary recruitment maneuver (PRM) at the end of the surgical procedure to evacuate the remaining CO_2 (7). PRM, with its potential to prevent PLSP and reduce postoperative pain scores, also significantly reduces PONV, providing a comprehensive solution to this issue (8).

This study aimed to investigate the effects of PRM performed at the end of the operation on PLSP, postoperative pain, PONV, ambulation time, and hospital stay in patients who underwent laparoscopic gynecological surgery due to benign gynecological reasons.

Materials and Methods

This retrospective cohort study was initiated after the approval of the University of Health Sciences Turkey, Kanuni Sultan Süleyman Training and Research Hospital Clinical Trials Review Board and Ethics Committee (KAEK/2023.11.166, 29.11.2023). The study was conducted in accordance with the principles of the Declaration of Helsinki. Patients who underwent laparoscopic gynecological surgery for indications other than malignancy (e.g., total laparoscopic hysterectomy, laparoscopic cystectomy, laparoscopic myomectomy) at the University of Health Sciences Turkey, Kanuni Sultan

Süleyman Training and Research Hospital between April 2023 and October 2023 were included in the study. Patient data and patient files were accessed from the hospital information system. Data that were prospectively recorded were analyzed retrospectively.

Inclusion criteria are as follows: (1) American Society of Anesthesiologists (ASA) physical status I-II; (2) 18-65 years old; (3) laparoscopic gynecological surgery performed for non-malignant indications. Exclusion criteria included: (1) chronic shoulder or epigastric pain; (2) previous lung or shoulder surgery; (3) lung diseases such as chronic emphysema; (4) previous pneumothorax; (5) pregnancy; (6) conversion to laparotomy after laparoscopy; (7) missing data.

Patients were retrospectively divided into the pulmonary recruitment maneuver group (PRM) and the control group (K). No randomization method was used to form the groups. The demographic characteristics of the patients, the duration of anesthesia and surgery, preoperative hemoglobin (Hb) and difference (preoperative Hb-postoperative Hb) Hb levels, ASA status, surgical procedure, PLSP, and wound pain VAS scores at 6, 12, 24 hours, postoperatively (0=no pain, 10=the most severe pain ever) were recorded. The postoperative ambulation time, PONV, the time until passage of flatus (time to return of bowel functions), and the duration of hospital stay were analyzed.

Ambulation or mobilization is any activity in which the patient is out of bed, such as standing at the bedside, sitting in a chair, or walking in the hallway. Gastrointestinal motility is the movement of the stomach and intestines (9). In our study, the first gas exit time was assessed and recorded in the evaluation of gastrointestinal motility. Similarly, patients are encouraged to mobilize early and are routinely mobilized at the 6th hour postoperatively.

Anesthesia Management and Pulmonary Recruitment Maneuver

All patients brought to the operating theatre underwent a similar general anesthesia procedure. Following standard anesthetic monitoring (electrocardiography, non-invasive blood pressure, end-tidal carbon dioxide-$EtCO_2$ pressure), premedication was performed with 0.03 mg/kg midazolam. General anesthesia induction was performed with 2-3 mg/kg propofol, 1 mg/kg fentanyl, and 0.6 mg/kg rocuronium. Anesthesia was maintained with 2-3% sevoflurane and 0.5 µg/kg/min remifentanil infusion. Ventilation was performed in volume-controlled mode with a tidal volume of 6-10 mL/kg and an $EtCO_2$ level of 30-40 mmHg. Positive end-expiratory pressure (PEEP) was not applied to the patients. One of the aims of the present study is to assess the effects of pulmonary recruitment maneuvers on oxygenation and hemodynamics, with an expectation of no significant effects. Therefore, the findings, including peripheral oxygen saturation, blood pressure, and heart rate, of the patients included in the study were not evaluated.

All laparoscopic procedures were performed using four ports. A single 10-mm port was placed through the umbilicus, and a 5-mm port was placed through the suprapubic regions and the lateral lower abdominal wall. To ensure laparoscopic vision, 12 mmHg intra-abdominal pressure was achieved by insufflating CO_2 with a flow rate of <3 L/min. The pneumoperitoneum was passively evacuated in the control group. In Group PRM, a recruitment maneuver consisting of five manual inflations to a maximum pressure of 40 cmH_2O was performed in the 30° Trendelenburg position with a fractional oxygen concentration of 100%. The anesthesiologist performed the recruitment maneuver by holding each positive pressure inflation for 5 seconds while the valves in the ports were open.

Diclofenac sodium (Dikloron, Deva Pharma, Turkey) is administered 75 mg intramuscularly, 2x1, intramuscularly as an analgesic in the postoperative period to patients, who undergo gynecological LS in our hospital's obstetrics and gynecology clinic. Tramadol hydrochloride (Tradolex, Menta Pharma, Turkey) is infused intravenously into 100 mL of physiological saline for patients whose pain is not relieved with diclofenac. If patients had moderate pain (VAS ≥4); diclofenac and tramadol were administered.

Sample Size

A previous study was used to calculate the sample size (3). The authors estimated that in the study, PLSP would decrease from 80% to 50% with the effect of PRM. Using the G*Power 3.1 program, they calculated that there should be 45 patients in each group to obtain $p<0.05$ and 80% power (1-β) for chi-square tests. In our study, with significant implications for the statistical analysis, it was determined that there should be at least 45 patients in each group.

Statistical Analysis

Version 26.0 of SPSS (Statistical Package for the Social Sciences, Chicago, IL, USA) was used to analyze the data. The conformity of the data to a normal distribution was tested using the Shapiro-Wilk test and histogram. An independent samples t-test was used to analyze normally distributed data. The Mann-Whitney U test was used to analyze data

that did not show a normal distribution. Pearson chi-square tests and Fisher's exact tests were used to analyze categorical data. Descriptive data were expressed as the number of patients, percentage, mean, standard deviation, and median (interquartile range). The repeated measures ANOVA test with Bonferroni post hoc comparisons was used to analyze VAS scores within and between groups. The significance level for all results was set at $p<0.05$.

Results

The study included 91 patients who underwent laparoscopic gynecological surgery between April 2023 and October 2023 (Figure 1). The mean age of the entire population was 49.4±9 years, and 86.8% (n=79) were in ASA II status. The mean operation time in the entire population was 136±38 minutes. The most commonly performed surgical procedures were total laparoscopic hysterectomy and bilateral salpingo-oophorectomy (TLH+BSO). No significant difference was found between the groups in terms of demographic characteristics, anesthesia and operation time, and perioperative Hb levels (Table 1).

The PLSP rate in Group PRM was significantly lower than that in the control group (31.1% vs. 63%, p=0.002). In Group PRM, mean PLSP VAS scores at 6 (3.6 vs. 5.8), 12 (3.3 vs. 4.9) and 24 hours (2.8 vs. 3.9) postoperatively were significantly lower ($p<0.001$ for all). In addition, the postoperative 6th-hour wound pain scores were significantly lower in Group PRM (4.8±1.5 vs. the 5.6±1.1, p=0.004). However, the 12th and 24th-hour wound pain scores did not differ significantly between the groups (p=0.075 and p=0.089, respectively) (Table 2, Figures 2, 3).

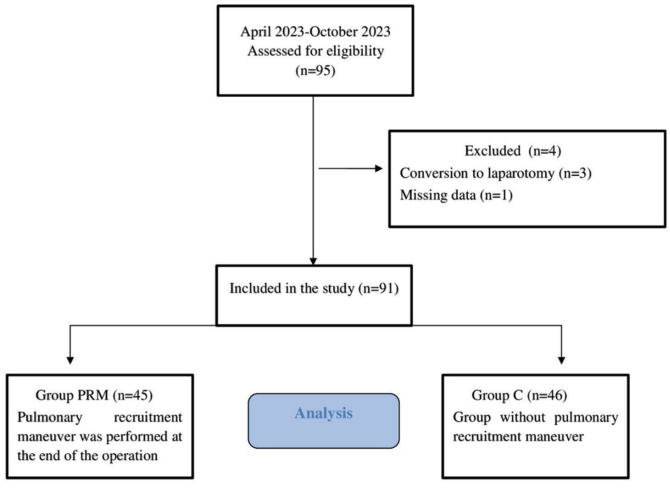

Figure 1. Flow chart of the study
PRM: Pulmonary recruitment maneuver

PONV was detected in 33% of the whole population (n=30). Although the PONV rate was low in Group PRM, there was no significant difference detected (28.9% vs. 37%, p=0.413). Postoperative ambulation time was significantly lower in Group PRM (6.6±0.9 vs. 7.5±1.5 hours, p=0.002). The time to recovery of bowel functions was also significantly lower in Group PRM (14.2±4.7 hours vs. 16.4±5.9 hours, p=0.038). The length of hospital stay was also low in Group PRM, but no significant difference was detected (2.2±0.4 vs. 2.4±0.5 days, p=0.075) (Table 3). No severe cardiovascular instability or pulmonary complications were observed in any patient associated with the recruitment maneuver.

Discussion

In this study, we found that PRM performed manually at 40 cmH_2O pressure, at the end of the operation in benign gynecological laparoscopic surgeries, significantly reduced

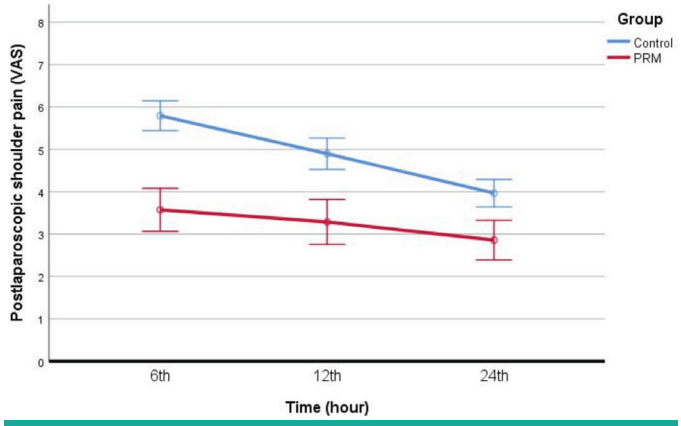

Figure 2. The mean postlaparoscopic shoulder pain VAS scores of the groups in the first 24 hours
VAS: Visual analog scale, PRM: Pulmonary recruitment maneuver

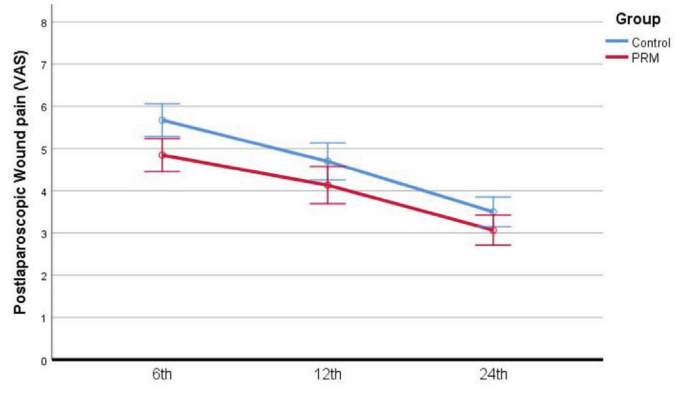

Figure 3. The mean wound pain VAS scores of the groups in the first 24 hours
VAS: Visual analog scale, PRM: Pulmonary recruitment maneuver

Table 1. Clinical characteristics of patients

	Overall (n=91)	Group PRM (n=45)	Group C (n=46)	p-value
Age (years)				0.254
Mean ± SD	49.4±9.0	48.4±8.4	50.5±9.3	
Median (Q1-Q3)	49 (44-54)	49 (44-52)	49 (43-56)	
ASA status				0.967
I	12 (13.2)	6 (13.3)	6 (13)	
II	79 (86.8)	39 (86.7)	40 (87)	
BMI (kg/m²)				0.204
Mean ± SD	29.8±4.7	30.1±3.9	29.6±5.4	
Median (Q1-Q3)	29 (26-33)	30 (27-33)	29 (25-31)	
Parity				0.915
Mean ± SD	2.9±2.0	2.8±1.9	2.9±2.0	
Median (Q1-Q3)	2 (2-3)	2 (2-3)	2 (2-3)	
Operation duration (min)				0.498
Mean ± SD	136±38	131±32	140±42	
Median (Q1-Q3)	135 (110-150)	135 (110-148)	135 (118-156)	
Anesthesia duration (min)				0.845
Mean ± SD	157±37	154±29	160±42	
Median (Q1-Q3)	150 (135-170)	150 (135-170)	153 (136-171)	
Preoperative Hb (g/dL)				0.162
Mean ± SD	12.2±1.5	12.5±1.5	12.1±1.5	
Median (Q1-Q3)	12.4 (11.2-13.4)	13.l (11.2-13.4)	12 (10.9-13.4)	
Δ Hb (g/dL)				
Mean ± SD	1.4±0.7	1.4±0.7	1.5±0.6	0. 173
Median (Q1-Q3)	1.5 (0.8-1.9)	1.3 (0.8-1.6)	1.6 (1.1-2.0)	
Type of surgery				0.309
TLH+BSO	52 (57.1)	24 (53.3)	28 (60.9)	
TLH+BS	24 (26.4)	15 (33.3)	9 (19.6)	
TLH	4 (4.4)	2 (4.4)	2 (4.3)	
LS cystectomy	3 (3.3)	1 (2.2)	2 (4.3)	
LS myomectomy	8 (8.3)	4 (8.9)	4 (8.7)	
PLSP, n (%)	43 (47.3)	14 (31.1)	29 (63.0)	**0.002**

Values are the number of patients, percentage, mean ± standard deviation, median (interquartil range, Q3-Q1), PRM: Pulmonary recruitment maneuver, C: Control, ASA: American Society of Anesthesiologists status, BMI: Body mass index, Hb: Haemoglobin, Δ Hb: Difference between preoperative and postoperative haemoglobin levels, TLH: Total laparoscopic hysterectomy, TLH+BSO: Total laparoscopic hysterectomy+bilateral salpingo-oophorectomy, TLH+BS: Total laparoscopic hysterectomy+bilateral salpingo, LS: Laparoscopic shoulder, PLSP: Post-laparoscopic shoulder pain

the PLSP rate and PLSP VAS scores at 6, 12, and 24 hours. We also found that PRM significantly reduced postoperative 6th-hour wound site VAS scores, ambulation time, and the time to return of bowel functions. Although PONV rates were low in the PRM group, no significant difference was observed compared to the control group.

The main goal of enhanced recovery after surgery (ERAS) protocols is to reduce the length of hospital stay. ERAS protocols mainly focus on reducing perioperative stress, early return of gastrointestinal function, less postoperative pain, and early mobilization. For this purpose, minimally invasive techniques, such as LS, recommended in ERAS protocols, have advantages such as less postoperative pain in gynecological diseases, shorter hospital stays, early ambulation, and early return of gastrointestinal functions (10). However, in addition to the advantages of LS, undesirable conditions, including PLSP, are observed. Although the underlying mechanism of PLSP has not yet been established, neuropraxia of the phrenic nerve is attributed to factors such as distension, an acidic

Table 2. Postoperative pain scores (visual analog scale score)

	Group PRM (n=45)				Group C (n=46)				
	Mean	SD	SE	95% CI	Mean	SD	SE	95% CI	p-value
PLSP (6th h)	3.6	1.1	0.2	3.27-3.87	5.8	1.1	0.2	5.38-6.20	**<0.001**
PLSP (12th h)	3.3	0.5	0.1	3.02-3.56	4.9	1.1	0.2	4.46-5.33	**<0.001**
PLSP (24th h)	2.9	0.4	0.1	2.65-3.07	4.0	1.0	0.2	3.58-4.35	**<0.001**
WP (6th h)	4.8	1.5	0.2	4.38-5.31	5.7	1.1	0.2	5.35-5.99	**0.004**
WP (12th h)	4.1	1.3	0.2	3.73-4.54	4.7	1.6	0.2	4.22-5.18	0.075
WP (24th h)	3.1	1.1	0.2	2.73-3.41	3.5	1.3	0.2	3.13-3.87	0.089

SD: Standard deviation, SE: Standard error, CI: Confidence interval, PLSP: Post-laparoscopic shoulder pain, WP: Wound pain, PRM: Pulmonary recruitment maneuver, C: Control

Table 3. PONV status, ambulation and length of hospital stay

	Overall (n=91)	Group PRM (n=45)	Group C (n=46)	p-value
PONV, n (%)	30 (33)	13 (28.9)	17 (37)	0.413
Ambulation duration (h)				**0.002**
Mean ± SD	7.0±1.3	6.6±0.9	7.5±1.5	
Median (Q1-Q3)	7 (6-8)	7 (6-7)	8 (6-9)	
Recovery time bowel function (h)				**0.038**
Mean ± SD	15.5±5.4	14.2±4.7	16.4±5.9	
Median (Q1-Q3)	16 (10-19)	15 (10-18)	18 (13-20)	
Hospital stay duration (days)				0.075
Mean ± SD	2.3±0.5	2.2±0.4	2.4±0.5	
Median (Q1-Q3)	2 (2-3)	2 (2-2)	2 (2-3)	

Values are the number of patients, percentage, mean ± standard deviation (SD), median (interquartil range, Q3-Q1), PONV: Postoperative nausea and vomiting, PRM: Pulmonary recruitment maneuver, C: Control

intraperitoneal environment, and residual abdominal gas. These conditions are believed to cause C4 pain referred to the shoulder (11,12). Jackson et al. (13) reported that the remaining CO_2 gas bubble size after laparoscopy correlates with the severity of PLSP. The authors stated that the length and height of the subdiaphragmatic gas measured on chest X-ray are related to the severity of PLSP. Different rates of PLSP have been reported in various laparoscopic surgeries. PLSP lasting up to 7 days has been reported in 63% of laparoscopic cholecystectomy (14), in 83% of laparoscopic gynecological surgery (3), and in 66% of laparoscopic gastric band surgery (15). Considering the hospital costs, evaluating the patient's remaining gas volume with a chest X-ray is not cost-effective. Therefore, our study did not pursue this evaluation method. Shoulder pain observed in the patients, was evaluated in the first 24 hours.

Various methods have been used to prevent PLSP, which is believed to occur due to phrenic nerve irritation by CO_2 used in pneumoperitoneum. Methods such as alternative inflation gas in the pneumoperitoneum, heated or humidified insufflation gas, low-pressure pneumoperitoneum, intraperitoneal fluid instillation, intraperitoneal local anesthetic use, intraperitoneal drainage, and active gas absorption at the end of surgery have been used (16,17). It has been reported that patients experience less pain when pneumoperitoneum is created using nitrous oxide instead of CO_2 (18). Tsai et al. (19) investigated the role of the recruitment maneuver applied at the end of the operation and the role of the intra-abdominal injection of saline in removing residual CO_2. The authors reported a significant decrease in shoulder pain. Intraperitoneal local anesthetic application has also been reported to be associated with a decrease in the incidence of shoulder pain and postoperative opioid consumption. PLSP may vary depending on the patient's position. It has been reported that standing causes phrenic nerve irritation and increased pain, which is referred to as shoulder pain, due to the CO_2 bubble moving under the diaphragm. The supine position relieves pain (20). It has been reported

that the semi-Fowler position significantly reduces PLSP after laparoscopy with the recruitment maneuver, which increases intra-abdominal pressure (21). The literature has also investigated the effects of gasless laparoscopy and low-pressure pneumoperitoneum on PLSP and postoperative pain. It has been reported that low-pressure pneumoperitoneum reduces postoperative pain scores, but there is no change in PLSP with gasless laparoscopy (22,23). However, these methods have yet to be widely adopted due to additional costs and potential adverse effects. In our study, CO_2 was used to create pneumoperitoneum. After the operation, PRM was applied in the supine position at safe pressure limits. PLSP and wound pain were evaluated while the patients were in a sitting position.

PRM is used to open collapsed alveoli by applying high airway pressures and increasing oxygenation. It is frequently used in intensive care units and has been reported to be helpful in laparoscopic surgeries for preventing atelectasis, reducing hypercapnia, and improving oxygenation (7). Hemodynamic instability, bullous lung disease and pneumothorax, high intracranial pressure, and congestive heart failure are conditions in which recruitment maneuvers are contraindicated (24). PRM is one of the most effective methods in preventing PLSP, caused by pneumoperitoneum (3-5,8). Phelps et al. (3), investigated the effect of 5 manual recruitment maneuvers with 60 cm H_2O pressure in the Trendelenburg position on PLSP in laparoscopic gynecological surgery. The authors reported that PRM significantly reduced both the incidence of PLSP (63% vs. 31%) and VAS scores at 12, 24, 36, and 48 hours. Güngördük et al. (25) investigated the effect of 2 manual recruitment maneuvers at 40 cmH_2O pressure on PLSP and wound pain in laparoscopic gynecologic oncologic surgery. The authors reported that PRM significantly reduced PLSP and upper abdominal wound pain at 12 and 24 hours postoperatively. However, it should be noted that complications related to PRM, including barotrauma and hemodynamic deterioration, may occur when higher pressures are used (26,27). Yilmaz et al. (28) suggested that a maximum inspiratory pressure of 15 cm H_2O may be preferred to avoid possible complications of PRM by using higher pressures. In our study, 5 manual recruitment maneuvers were applied at 40 cmH_2O pressure in the 30° Trendelenburg position, with the laparoscopy ports in place, at the end of the operation. The PLSP rate decreased, as well as PLSP scores 6, 12, and 24 hours, and the postoperative pain score at 6 hours decreased. However, postoperative 12-hour and 24-hour pain scores were similar between the groups. The recruitment maneuver can reduce shoulder and early postoperative pain by reducing air trapping due to pneumoperitoneum. Since relatively few studies have been conducted on using PRM at low pressures, the optimum pressure level of PRM that minimizes the severity of PLSP and the incidence of adverse events should be investigated. Based on our clinical experience, PRM application with a pressure of 40 cmH_2O is safe. Pressure levels of 15 cmH_2O are low.

It has been reported that PRM reduces postoperative pain scores and the PONV rate in laparoscopic surgeries (3,24). Phelps et al. (3) reported that PRM significantly reduced PONV in the first 24 hours in patients undergoing laparoscopic gynecological surgery. The authors stated that in the control group, greater PLSP and more opioid consumption may have been effective in increasing the PONV rate. However, studies also report that no significant differences were found in the incidence of PONV. Güngördük et al. (25) reported that PRM reduced the PONV rate in patients undergoing laparoscopic gynecological oncological surgery, but no statistically significant difference was found. Another study stated that gas drainage to remove residual CO_2 did not significantly change the frequency and severity of PONV up to 72 hours after laparoscopic cholecystectomy (29). A meta-analysis of 14 randomized controlled trials stated that PRM could significantly reduce PLSP scores at postoperative 12, 24, and 48 hours. However, it did not significantly affect postoperative wound pain, upper abdominal pain, and PONV (30). In our study, PONV was lower, although not significantly, in the PRM group (28.9% vs. 37%). We believe that the residual effect of pneumoperitoneum and opioid analgesics may cause this situation. In our clinic, NSAIDs and tramadol hydrochloride are used for analgesic purposes in postoperative gynecological patients. Although the quantity of analgesics consumed postoperatively was not evaluated in our study, we think, that the higher VAS scores of the patients in the control group increased the quantity of opioids consumed. In addition, the ambulation time in the recruitment group was significantly lower than in the control group (6.6±0.9 vs. 7.5±1.5 h). The return of bowel movements was rapid, and the duration of hospital stay was also short, although not significant. The lower rate of PLSP in the PRM group, along with lower early pain scores, early mobilization, and less opioid consumption, may lead to the observed effects.

Study Limitations

The study has some limitations. First, the study is conducted in a single-center setting and is retrospective. Second, PLSP and wound pain scores were evaluated within the first 24

hours. The shoulder pain of the patients after discharge was not evaluated. Third, diclofenac sodium 2x1.75 mg intramuscularly is administered as an analgesic to patients in the postoperative period. However, tramadol was administered to patients with moderate pain (VAS) pain. Tramadol consumption in the postoperative period was not analyzed in the study. PLSP and wound pain VAS scores may have been affected.

Conclusion

In conclusion, PRM, a technique easily implemented in clinical practice, has been shown to significantly reduce PLSP and early pain scores in laparoscopic gynecological operations. Importantly, PRM aligns with the goals of ERAS protocols, aiming to expedite recovery, promote early ambulation, and restore gastrointestinal function, thereby reducing hospital stays.

Ethics

Ethics Committee Approval: This retrospective cohort study was initiated after the approval of the University of Health Sciences Turkey, Kanuni Sultan Süleyman Training and Research Hospital Clinical Trials Review Board and Ethics Committee (KAEK/2023.11.166, 29.11.2023). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: K.A., H.Ç.A., Concept: K.A., H.Ç.A., N.Y., A.S.Ş., Design: K.A., H.Ç.A., N.Y., A.S.Ş., Data Collection or Processing: K.A., H.Ç.A., N.Y., A.S.Ş., Analysis or Interpretation: K.A., H.Ç.A., Literature Search: K.A., Writing: K.A., H.Ç.A.

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References

1. Wen KC, Sung PL, Chang WH, Horng HC, Chen YJ, Lee WL, et al. A case-control study to compare the outcome of women treated by two minimally invasive procedures-ultraminilaparotomy myomectomy and laparoscopic myomectomy. Taiwan J Obstet Gynecol. 2018;57(2):264-269.
2. Deura I, Shimada M, Azuma Y, Komatsu H, Nagira K, Sawada M, et al. Comparison of laparoscopic surgery and conventional laparotomy for surgical staging of patients with presumed low-risk endometrial cancer: the current state of Japan. Taiwan J Obstet Gynecol. 2019;58(1):99-104.
3. 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):1155-1160.
4. Lee J, Park C, Kim J, Ki Y, Cha SH, Kim JY. The effect of low-pressure pulmonary recruitment maneuver on post-laparoscopic shoulder pain: a randomized controlled trial. J Minim Invasive Gynecol. 2020;27(1):173-177.
5. Radosa JC, Radosa MP, Schweitzer PA, Radosa CG, Stotz L, Hamza A, et al. Impact of different intraoperative CO_2 pressure levels (8 and 15 mmhg) during laparoscopic hysterectomy performed due to benign uterine pathologies on postoperative pain and arterial pCO_2: a prospective randomised controlled clinical trial. BJOG. 2019;126(10):1276-1285.
6. Donatsky AM, Bjerrum F, Gögenur I. Intraperitoneal instillation of saline and local anesthesia for prevention of shoulder pain after laparoscopic cholecystectomy: a systematic review. Surg Endosc. 2013;27(7):2283-2292.
7. Arslan K, Özşahin Y, Yılmaz Ak H, Salihoğlu Z. Effect of pressure-controlled recruitment maneuver on hemodynamics and respiratory mechanics during pneumoperitoneum. Laparosc Endosc Surg Sci. 2021;28(3):141-147.
8. Kihlstedt PE, Andersson E. Pulmonary recruitment maneuver reduces shoulder pain and nausea after laparoscopic cholecystectomy: a randomized controlled trial. World J Surg. 2021;45(12):3575-3583.
9. Arslan K, Arslan HÇ, Yıldız ME, Şahin AS. Effects of ultrasonography-guided transversus abdominis plane block on postoperative analgesia, gastrointestinal motility, and mobilization in patients delivering cesarean delivery under spinal anesthesia: a retrospective study. Duzce Med J. 2023;25(2):167-172.
10. Pache B, Joliat GR, Hubner M, Grass F, Demartines N, Mathevet P, et al. Cost-analysis of enhanced recovery after surgery (ERAS) program in gynecologic surgery. Gynecol Oncol. 2019;154(2):388-393.
11. Ryu KH, Lee SH, Cho EA, Kim JA, Lim GE, Song T. Comparison of impacts of intraperitoneal saline instillation with and without pulmonary recruitment maneuver on postlaparoscopic shoulder pain prevention: a randomized controlled trial. Surg Endosc. 2019;33(3):870-878.
12. Pasquier EK, Andersson E. Pulmonary recruitment maneuver reduces pain after laparoscopic bariatric surgery: a randomized controlled clinical trial. Surg Obes Relat Dis. 2018;14(3):386-392.
13. Jackson SA, Laurence AS, Hill JC. Does post-laparoscopy pain relate to residual carbon dioxide? Anaesthesia. 1996;51(5):485-487.
14. Chang SH, Lee HW, Kim HK, Kim SH, Kim DK. An evaluation of perioperative pregabalin for prevention and attenuation of postoperative shoulder pain after laparoscopic cholecystectomy. Anesth Analg. 2009;109(4):1284-1286.
15. Dixon JB, Reuben Y, Halket C, O'Brien PE. Shoulder pain is a common problem following laparoscopic adjustable gastric band surgery. Obes Surg. 2005;15(8):1111-1117.
16. Berberoğlu 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;8(5):273-277.

17. Kafali H, Karaoglanoglu M, Oksuzler C, Bozkurt S. Active intraperitoneal gas aspiration to reduce postoperative shoulder pain after laparoscopy. Pain Clin. 2004;16:197-200.

18. Aitola P, Airo I, Kaukinen S, Ylitalo P. Comparison of N2O and CO2 pneumoperitoneums during laparoscopic cholecystectomy with special reference to postoperative pain. Surg Laparosc Endosc. 1998;8(2):140-144.

19. Tsai HW, Wang PH, Yen MS, Chao KC, Hsu TF, Chen YJ. Prevention of postlaparoscopic shoulder and upper abdominal pain: a randomized controlled trial. Obstet Gynecol. 2013;121(3):526-531.

20. Kahokehr A, Sammour T, Srinivasa S, Hill AG. Systematic review and meta-analysis of intraperitoneal local anaesthetic for pain reduction after laparoscopic gastric procedures. Br J Surg. 2011;98(1):29-36.

21. Kiyak H, Yilmaz G, Ay N. Semi-Fowler positioning in addition to the pulmonary recruitment manoeuvre reduces shoulder pain following gynaecologic laparoscopic surgery. Wideochir Inne Tech Maloinwazyjne. 2019;14(4):567-574.

22. Özdemir-van Brunschot DM, van Laarhoven KC, Scheffer GJ, Pouwels S, Wever KE, Warlé MC. What is the evidence for the use of low-pressure pneumoperitoneum? A systematic review. Surg Endosc. 2016;30(5):2049-2065.

23. Guido RS, Brooks K, McKenzie R, Gruss J, Krohn MA. A randomized, prospective comparison of pain after gasless laparoscopy and traditional laparoscopy. J Am Assoc Gynecol Laparosc. 1998;5(2):149-153.

24. Liu H, Ma C, Zhang X, Yu C, Yang Y, Song X, et al. Combined incisional ropivacaine infiltration and pulmonary recruitment manoeuvre for postoperative pain relief after diagnostic hysteroscopy and laparoscopy. Chin Med J (Engl). 2014;127(5):825-829.

25. 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.

26. Lovas A, Szakmány T. Haemodynamic effects of lung recruitment manoeuvres. Biomed Res Int. 2015;2015:478970.

27. da Silva PS, de Aguiar VE, Fonseca MC. Iatrogenic pneumothorax in mechanically ventilated children: incidence, risk factors and other outcomes. Heart Lung. 2015;44(3):238-242.

28. Yilmaz G, Kiyak H, Akca A, Salihoglu Z. Low-pressure pulmonary recruitment maneuver: equal to or worse than moderate-pressure pulmonary recruitment maneuver in preventing postlaparoscopic shoulder pain? A randomized controlled trial of 72 patients. Wideochir Inne Tech Maloinwazyjne. 2020;15(3):519-525.

29. Nursal TZ, Yildirim S, Tarim A, Noyan T, Poyraz P, Tuna N, et al. Effect of drainage on postoperative nausea, vomiting, and pain after laparoscopic cholecystectomy. Langenbecks Arch Surg. 2003;388(2):95-100.

30. Deng X, Li H, Wan Y, Lin X. Pulmonary recruitment maneuver reduces the intensity of post-laparoscopic shoulder pain: a systematic review and meta-analysis. BMC Anesthesiol. 2023;23(1):155.