Effect of the Trendelenburg position, Deep Breathing Exercise, and Warm Water Application on Shoulder Pain and Post-gynecologic Laparoscopic Recovery

Afaf Hassan Ahmed[1], Naglaa Fathy Fathalla [1], Noha Mohamed Mahmoud[1a,b], Zohour Ibrahim Rashwan[2a,b], Abeer Hassan Shamekh Taman [3]

[1] Assist. prof. of Obstetric and Gynecologic Nursing, Faculty of Nursing, Alexandria University, Egypt.

[1a] Assist. prof. of Obstetric and Gynecologic Nursing, Faculty of Nursing, Alexandria University, Egypt.

[1b] Assist. prof. of Obstetric and Gynecologic Nursing, Faculty of Nursing, The British University in Egypt (BUE), Egypt.

[2a] Assist. Prof. of Pediatric Nursing, Faculty of Nursing, Alexandria University, Egypt.

[2b] Nursing Department, College of Health Sciences, University of Bahrain, Zallaq, Kingdom of Bahrain.

[3] Lecturer of Obstetrics and Gynecologic Nursing, Faculty of Nursing, Alexandria University, Egypt.

Abstract

Background: Shoulder pain is a prevalent complaint after laparoscopic surgery. Non-pharmacological nursing measures reduce pain, and analgesic drug dosage, improve women's emotional control, and increase their functional capability. **Aim**: This study aimed to investigate the effect of the Trendelenburg position, deep breathing exercise, and warm water application on shoulder pain and post-gynecologic laparoscopic recovery. **Design**: A quasi-experimental study was conducted in the post-laparoscopic unit at El-Shatby Obstetrics and Gynecology University Hospital, Alexandria, Egypt. **Methods**: A sample of 90 women were randomly assigned to three groups; women in study groups either placed in Trendelenburg position or instructed to perform deep breathing exercises while the third group received warm water application. Participants rated their shoulder pain and the postoperative quality of recovery at baseline, 12, and 24 hours. **Results**: A significant decline in the pain score was noticed at 24 hours measurement where, the mean score was 2.70±1.47 in the Trendelenburg position group while it was 3.97±1.83 in deep breathing exercise group and 3.90±1.95 in warm water application group ($p<0.001$ for each group). The mean score of postoperative quality of recovery was 166.87±9.63 in the Trendelenburg group, 131.27±10.96 in the deep breathing exercise group and 154.70±7.53 in the warm water application group, ($P<0.001$). **Conclusion**: The three interventions showed a noticeable decline in PLSP. However, Trendelenburg's position showed a superior effect to the other two measures. **Recommendations**: The authors suggested the incorporation of the three studied interventions for caring of women suffering from PLSP in order to benefit from all their effects and maximize pain relieve and enhancing postoperative recovery. Being non-pharmacologic, they can also be administered by trained nursing staff and can even be taught to patients and implemented at home.

Keywords: Trendelenburg Position; Breathing Exercises; Warm Water Application; Shoulder Pain; Gynecologic Surgery; Laparoscopic; Post-operative; Recovery.

Introduction

Laparoscopic gynecologic surgery has gained widespread acceptance as a valuable alternative to traditional laparotomy in the treatment of many gynecologic disorders **(Galaal et al., 2018).** Currently, it is one of the most common minimally invasive procedures that is considered the most significant surgical innovation performed by gynecologists in the last 30 years **(Antonilli et al., 2021).** Laparoscopic surgeries are utilized for managing several disorders such as ovarian cysts, tumors, pelvic adhesions, fibroids, endometriosis, and infertility **(Zeeni et al., 2020).** Compared to the traditional laparotomy, laparoscopic surgeries have several advantages, such as a smaller surgical wound, accelerates abdominal wound healing, less complications such as bleeding and infection, shorter hospital stay, faster recovery, and better cosmetic results **(Sao et al., 2019).** Therefore, performing surgical intervention through laparoscope enables women to resume their daily activities as fast as possible. As a part of laparoscopic surgeries, gas insufflation is commonly used to expand operative space and improve the visualization of the intra-pelvic organs. Carbon Dioxide (CO_2) is the most widely utilized gas for creating pneumoperitoneum because it is affordable, nonflammable, and has higher blood solubility than air **(Galetin & Galetin, 2022).**

Post-Laparoscopic Shoulder Pain (PLSP), is a prevalent complaint following laparoscopic surgery as the incidence of PLSP is as high as 80% among women worldwide **(Kiyak et al., 2019).** The severity of pain can range from mild to severe, and some women may experience it for up to 72 hours postoperatively. Furthermore, PLSP has been observed to be less responsive to treatment than incision and visceral pain. Continuous shoulder pain will not only induce discomfort among women, but it may also lead to an increase in the incidence of numerous postoperative complications, delay in postoperative recovery, and a reduction in women's satisfaction **(Li et al., 2021).** According to **Kiyak et al. (2019),** the most common causes of PLSP are CO_2 buildup, stretching of the diaphragm, and irritation of the phrenic nerve.

In order to relieve the CO_2 accumulation, gynecologists adopt several strategies, such as instillation of local anesthetics intraperitoneally, pulmonary recruitment maneuvers, warm and humidified CO_2 insufflation, and intraperitoneal normal saline instillation. Unfortunately, conflicting results regarding the effectiveness and clinical outcomes of such interventions have been reported in the literature **(Li et al., 2021).** Therefore, non-pharmacological nursing measures may reduce analgesic drug dosage and their associated adverse effects, improve women's emotional control, and increase their functional capability. These interventions include, but are not limited to, massage, deep breathing exercise, warm water application, and positioning **(Metawie et al., 2015).** In this context, Trendelenburg position may decrease shoulder pain by minimizing the mechanical pressure exerted by carbon dioxide on the upper abdominal muscles and the diaphragm **(Zeeni et al., 2020). Besides, Gao D et al., (2022)** reported that Trendelenburg position during and after laparoscopic abdominal surgeries had improved lung function and oxygen index compared to that in the supine position. Moreover, warm water application is one of the alternative therapies used for relieving PLSP. It enhances circulation, improves oxygenation, and boosts nutrient supplies to the affected area, which in turn relieves any discomfort. Besides, the deep breathing exercise is a procedure that entails inhaling through the nose and slowly expelling through pursed lips. It has a prominent role in pain signaling, autonomic activation, emotional modulation, and acid-base balance, as well as improving lung ventilation and blood oxygenation. So, this kind of exercise may be helpful in decreasing the severity of PLSP **(Asman & Maifita, 2019; Erol Ursavas & Catakli, 2020).**

Postoperative recovery is a key indicator of women's health status after surgical procedures. However, pain, nausea, vomiting, and a wide range of anesthesia-induced complications might adversely interfere with the quality of recovery. Nurses can make a difference in the recovery room. They play a

pivotal role in managing these undesirable symptoms, alleviating women's discomfort, and accelerating their recovery **(Gustafsson et al., 2020; Yu et al., 2022).**

The emerging evidence is scarce in the area of relieving PLSP and improving postoperative recovery after gynecologic laparoscopy. Hence, adopting non - pharmacological measures enable nurses to use safe, cost-effective, and applicable methods that promote women's health and alleviate their suffering.

Aim of the study

This study aimed to investigate the effect of the Trendelenburg position, deep breathing exercise, and warm water application on shoulder pain and post-gynecologic laparoscopic recovery.

Research hypotheses

H1: Women with gynecologic disorders who assume the Trendelenburg position after laparoscopic surgeries exhibit lower shoulder pain level than those who perform deep breathing exercise or receive warm water application.

H2: Women with gynecologic disorders who assume the Trendelenburg position after laparoscopic surgery exhibit better quality of postoperative recovery than those who perform deep breathing exercise or receive warm water application.

Materials and Methods

A quasi-experimental study was carried out in the post-laparoscopic unit at El-Shatby Obstetrics and Gynecology University Hospital in Alexandria, Egypt. This hospital was selected because it receives the most gynecologic laparoscopies and is the largest maternity health center in Alexandria.

Participants

A convenience sampling of 90 women who fulfilled the following inclusion criteria was recruited; (a) women who had 18–60 years, (b) scheduled for diagnostic or therapeutic gynecologic laparoscopic surgery for non-malignant pathologies with (c) a shoulder pain score of 4 and above and received single dose of analgesic drugs immediately after the laparoscopic surgery. However, women who had a medical history of gastroesophageal reflux, thrombophilia, or high risk of rupture of an ectopic pregnancy, rupture of an ovarian cyst, deep vein thrombosis, chronic shoulder pain, and shoulder surgery were excluded from the study.

The researchers interviewed 267 women scheduled for gynecologic surgery to detect patients who match the above-mentioned criteria. The detected cases were 105 women. Epi info program version 10 was used to estimate the sample size using the following parameters: population size of 105, Confidence coefficient of 95%, expected frequency of 50%, and acceptable error of 5%. The minimum sample size required was 83 women.

During the study period (beginning of January to the end of August 2022), 90 out of 105 eligible women agreed to participate in the study. They were assigned randomly into three groups: namely (a) Trendelenburg, (b) deep breathing exercise, and (c) the warm water application groups (30 women per each group). During data collection period, the researcher gets a list of all cases scheduled for gynecologic laparoscopy at that day. The researchers used a random number generator program to enroll women into different study groups till reaching the desired sample size.

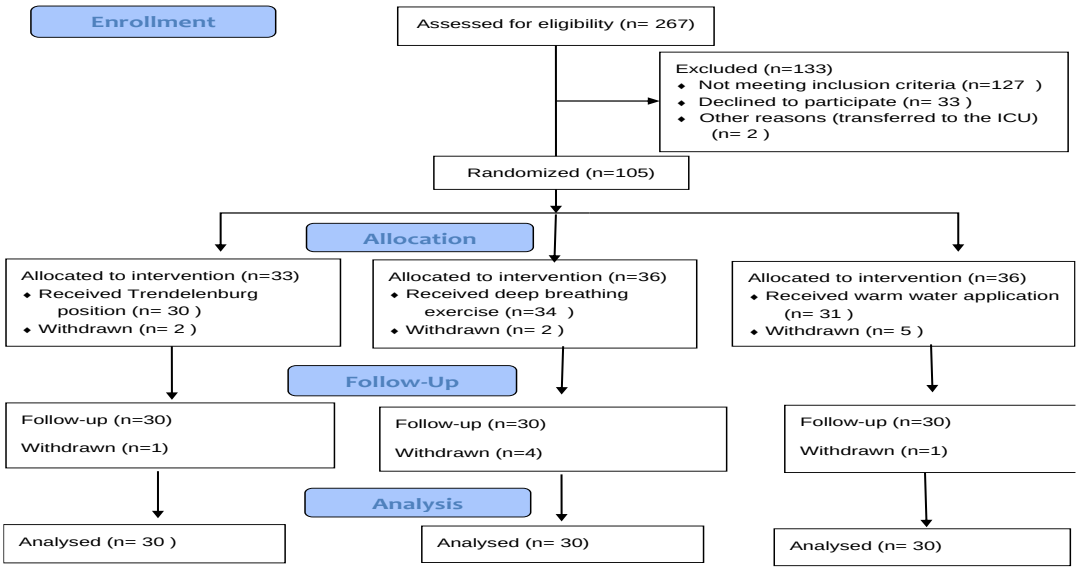

Figure (1): Flow Chart of Participants' Recruitment Process.

Measurement tools

Initially, the researcher assessed the patients' socio-demographic data such as age, education level, occupation, marital status, type of family residence, and family income/month.

Tool I: "Numerical Pain Rating Scale (NRS)".

This tool was adopted from the Clinical Manual for Nursing Practice **(McCaffery & Beebe, 1993).** It is a unidimensional measure of the severity of pain in adults; the 11-point numeric scale was used to assess four levels of pain: "0 = no pain, 1-3 = mild pain, 4-6 = moderate pain, and 7-10 = severe pain".

Tool II: "Postoperative Quality of Recovery Scale (QoR40)".

This tool was initially developed by **Myles et al. (2000).** It is used to measure the quality of postoperative recovery. It is composed of 40 items categorized according to five dimensions of recovery, including emotional state (9 items), physical comfort (12 items), psychological support (7 items), physical independence (5 items), and pain (7 items). Participants rated their responses on a 5-point Likert scale; "1 = none of the time, 2 = some of the time, 3 = usually, 4 = most of the time, and 5 = all of the time". For negative items, the scoring was reversed. The total score on the QoR40 scale could be between 40 and 200. The higher the score, the better the quality of postoperative recovery (Myles et al., 2000).

Data Collection Procedure.

Initially, the researchers contacted the eligible women who met the inclusion criteria and agreed to participate in the study during the preoperative period to collect socio-demographic data. Then, the level of PLSP was measured for women in all groups once they regain consciousness and became cooperative within 2 to 4 hours (baseline measurement) **(Yu et al., 2022).** For those who scored their PLSP greater than 4/10, the researchers started to implement the interventions for each group.

For study group 1: The women were placed in a Trendelenburg position, in which they were placed supine with the bed tilted down 20 degrees, causing the head to be lower than the pelvis **(Antonilli et al., 2021; Zeeni et al., 2020).** The arms of women are in a relaxed position, either at the side or on bilateral arm boards. They

remained in this posture for the first 24 hours postoperatively. This period is quite enough to allow the retained CO_2 gas to be shifted to the pelvic cavity away from the diaphragm. Women were instructed to avoid straight-up positions as much as possible to obtain the desired outcome, relieve PLSP, and they were periodically inspected for maintaining the Trendelenburg position. While women were allowed only five times to assume any other position throughout the intervention period where the duration of each time did not exceed 15-min.

For study group 2, women were instructed to assume a sitting position and place their hands down on border of ribcage and count to four while inhaling through their nose until the greatest chest expansion is achieved. Then to hold that breathe for 2 seconds and count to four while exhaling through the lips. After that, women were asked to repeat this deep breathing technique five times. Then, the deep breathing exercise was performed four times after the laparoscopic surgery (3, 6, 12, and 24 hrs. postoperatively) **(Hosseinzadeh et al., 2020).** The researchers supervised the women performance of the deep breathing exercise according to the designed time plan.

For study group 3, women received warm water application (38◦C -40◦C) on the shoulder. The researchers performed the warm water application for a period of 5-10 minutes every 4 hours during the first 24 hours postoperative to unify the procedure among the participants.

For all groups, the pain level was re-evaluated 2 times; at 12 and 24 hours postoperatively. According to the care protocol of the gynecologic laparoscopic surgeries in current study setting; the women should be transferred to the postoperative recovery room within 4 to 6 hours for the purpose of monitoring vital signs and then to be admitted to the postoperative general ward at least 24-48 hours where the postoperative quality of recovery was measured after 24 hours **(Kaya et al., 2021).**

Ethical considerations

Approval for performing the study was received from the Ethical Research Committee review board of Faculty of Nursing, Alexandria University and ClinicalTrials.gov Identifier: NCT05344677. The researchers obtained permission to conduct the study from the responsible authorities of the study setting as well. Women who fulfilled the inclusion criteria were interviewed by the researchers prior to the application of any intervention and provided with a thorough explanation of the interventions' nature, benefits, and any potential risks. Researchers also reassured women that their participation in the study is completely voluntary and emphasized their right to withdraw from the study at any time. Confidentiality of the obtained data, women's anonymity, and privacy were maintained. After the participants' agreement, they individually signed a written informed consent.

Statistical analysis

Initially, the collected data was validated, checked for any missing, and cleaned accordingly. The "Statistical Package for Social Sciences (SPSS)" version 23.0 was used for data analyses. Descriptive statistics included "number, percentage, the mean, and standard deviation" to describe demographic characteristics, the severity of PLSP, and postoperative recovery. "Kolmogorov-Smirnov test" was used to check whether the study variables are normally distributed or not. In order to compare the differences between the total mean scores of women's postoperative recovery, "Kruskal-Wallis test" was used. Additionally, the "Chi-square" and "Fisher's Exact" tests were employed to assess the significance of pain scores. "Pearson's Correlation Coefficient" was utilized to determine the strength and direction of the relationship between the PLSP intensity (NRS) and the quality of postoperative recovery. All the statistical analyses were considered significant at $P \leq 0.05$.

Results

Table 1 shows that the mean age is 31.73 ± 7.95 in Trendelenburg Position group, 35.20 ± 7.58 in the deep breathing exercise group, and 32.87 ± 7.61 in the warm water group. Regarding the level of education, 33.3% of the Trendelenburg position group, 16.7% of breathing exercise group, and 23.3% of warm water application group are university graduates. In addition, a substantial proportion (73.3% of Trendelenburg position group, 76.7% of deep breathing exercise group, & 93.3% of warm water group) are housewives. There were no statistically significant differences between the studied groups in relation to sociodemographic characteristics.

Table 2 presents that 33.3% of women in both the Trendelenburg position group and deep breathing and 40 % of those in the warm water application groups undergone gynecologic laparoscopic surgeries for diagnostic purpose. It is noticed that the ovarian cystectomy is the most common cause of conducting therapeutic laparoscopic surgery among the Trendelenburg position and deep breathing exercise groups (23.3% and 26.7% respectively), while the most common cause in warm water application was myomectomy (20%). The mean time of the operation was 61.0 ± 24.26 minutes in the Trendelenburg position group, 65.33 ± 13.06 minutes in the deep breathing exercise group, and 64.0 ± 10.37 minutes in the warm water application group.

Table 3 displays that the mean pain score at the baseline measurement was 8.20±1.58 in the Trendelenburg position group, 8.03±1.65 in the deep breathing exercise group, and 7.80±1.94 in the warm water application group**.** After 12 hours, the mean pain score decreased to 6.43±2.08 in the Trendelenburg position group, 6.63±2.27 in the deep breathing exercise group, and 6.89±2.11 in the warm water application group. A significant decline in the pain score was noticed at 24 hours measurement where, the mean score was 2.70±1.47 in the Trendelenburg position group while it was 3.97±1.83 in deep breathing exercise group and 3.90±1.95 in warm water application group ($p<0.001$ for each group).

Figure 2 illustrates the severity of PLSP after recovery from laparoscopy, 93.3% of women in the Trendelenburg position group, 90% of deep breathing exercise groups, and 83.3% of warm water application group reported severe pain. After 12 hours, pain severity decreased to moderate level in 53.3% of Trendelenburg position group, 43.3% of breathing exercise group, and 50% of warm water application group. While repeating the measurement of pain severity at 24 hours after laparoscopy, the pain level declined to mild among 60% of women in the Trendelenburg position group while it was moderate in 66.7% of women in deep breathing exercise group and 63.3% of warm water application group with statistically significant differences were observed between the three groups during repeated measurements 12 hours ($p=0.001$) and 24 hours after laparoscopy ($p= 0.031$).

Table 4 shows a statistically significant differences between the three groups regarding physical comfort, emotional state, psychological support, physical independence, and pain where ($P=<0.001$ for each). The table also shows that the mean score of postoperative quality of recovery was 166.87 ± 9.63 in the Trendelenburg, 131.27 ± 10.96 in the deep breathing exercise and 154.70 ± 7.53 in the warm application groups, ($P=<0.001$ in the favor of the Trendelenburg position).

Table 5 presents a negative correlation between pain scores (NRS) and the overall means of postoperative recovery in Trendelenburg position ($r =-0.541$, $p=0.002$), deep breathing exercise groups ($r =-0.420$, $p=0.021$) and warm water application ($r=-0.488$, $p=0.006$). This denotes that controlling the women's PLSP enhanced their postoperative recovery.

Table 1: Socio-Demographic Characteristics among Women in the Three Groups (n =30 for each group)

Socio-demographic characteristics	Trendelenburg Position Group	Deep Breathing Exercise Group	Warm Water Application Group	Test of Sig.	*p*
	No. (%)	No. (%)	No. (%)		
Age (Years)					
<30	14 (46.7)	8 (26.7)	10 (33.3)		
30-<40	8 (26.7)	10 (33.3)	16 (53.3)	χ^2=8.809	0.066
≥40	8 (26.7)	12 (40.0)	4 (13.3)		
Min. – Max.	22.0 – 50.0	26.0 – 49.0	20.0 – 48.0	*kw*–χ^2=1.57	0.213
Mean ± SD.	31.73 ± 7.95	35.20 ± 7.58	32.87 ± 7.61	5	
Marital status					
Married	24 (80.0)	30 (100.0)	28 (93.3)		
Widow	4 (13.3)	0 (0.0)	2 (6.7)	χ^2=7.113	^{MC}p=0.056
Divorced	2 (6.7)	0 (0.0)	0 (0.0)		
Educational level					
Illiterate or Read/write	6 (20.0)	5 (16.7)	6 (20.0)		
Primary or preparatory education	6 (20.0)	11 (36.7)	8 (26.7)	χ^2=3.442	0.752
Secondary	8 (26.7)	9 (30.0)	9 (30.0)		
University	10 (33.3)	5 (16.7)	7 (23.3)		
Occupation					
Housewife	22 (73.3)	23 (76.7)	28 (93.3)		
Worker	2 (6.7)	3 (10.0)	2 (6.7)	χ^2=7.527	^{MC}p=0.097
Employee	6 (20.0)	4 (13.3)	0(0.0)		
Type of Family					
Nuclear	14 (46.7)	17 (56.7)	18 (60.0)	χ^2=1.165	0.559
Extended	16 (53.3)	13 (43.3)	12 (40.0)		
Residence					
Urban	14 (46.7)	12 (40.0)	16 (53.3)	χ^2=1.071	0.585
Rural	16 (53.3)	18 (60.0)	14 (46.7)		
Family Income/Month					
More than enough	2 (6.7)	6 (20.0)	3 (10.0)		
Just enough	22 (73.3)	13 (43.3)	18 (60.0)	χ^2=5.885	^{MC}p=0.202
Not enough	6 (20.0)	11 (36.7)	9 (30.0)		

χ^2: **Chi square test** MC: **Monte Carlo** ***kw–χ^2: Kruskal-Wallis***

Table 2: Indications of Laparoscopic Surgeries among Women in the Three Groups (n =30 for each group)

Gynecological surgical history		Trendelenburg Position		Deep Breathing exercise		Warm Water Application		Sig.
		No.	%	No.	%	No.	%	
a.	Diagnostic Laparoscopy	10	33.3	10	33.3	12	40.0	
b.	Therapeutic Laparoscopy							
-	Chocolate Cyst Evacuation	3	10.0	0	0.0	2	6.7	
-	Endometriosis	2	6.7	5	16.7	2	6.7	χ^2=1.731
-	Myomectomy	6	20.0	4	13.3	6	20.0	P=0.421
-	Lysis of Pelvic Adhesions	2	6.7	3	10.0	4	13.3	
-	Ovarian Cystectomy	7	23.3	8	26.7	2	6.7	
-	Ovarian Abscess Evacuation	0	0.0	0	0.0	2	6.7	
Time of operation (minutes)								
Min. – Max.		40.0 – 90.0		40.0 – 90.0		60.0 – 90.0		H=4.752
Mean ± SD.		61.0 ± 24.26		65.33 ± 13.06		64.0 ± 10.37		0.093
Median		50.0		60.0		60.0		

χ^2: **Chi square test** H: H for **Kruskal Wallis test**

SD: **Standard deviation** p: p value for the comparison between the three studied groups.

Table 3: Mean Scores of Pain Severity among Women in Trendelenburg Position, Deep Breathing Exercise, and Warm Water Application Groups (n =30 for each group)

Pain Intensity	Trendelenburg Position			Deep Breathing Exercise Group			Warm Water Application Group		
	Baseline	12 hours	24 hours	Baseline	12 hours	24 hours	Baseline	12 hours	24 hours
Mean ±SD	8.20±1.58	6.43±2.08	2.70±1.47	8.03±1.65	6.63±2.27	3.97±1.83	7.80±1.94	6.89±2.11	3.90±1.95
Wilcoxon Signed Ranks Test	p1 = 0.001*, p2<0.001*, p3<0.001*			p1 = 0.003*, p2<0.001*, p3<0.001*			p1 = 0.040*, p2<0.001*, p3<0.001*		

P1: p value for the comparison between baseline and 12 hours.

P2: p value for the comparison between baseline and 24 hours.

P3: p value for the comparison between 12 hours and 24 hours.

*: Statistically significant at p≤ 0.05.

Figure 2: Pain Severity among Women in Trendelenburg Position, Deep Breathing Exercise, and Warm Water Application Groups

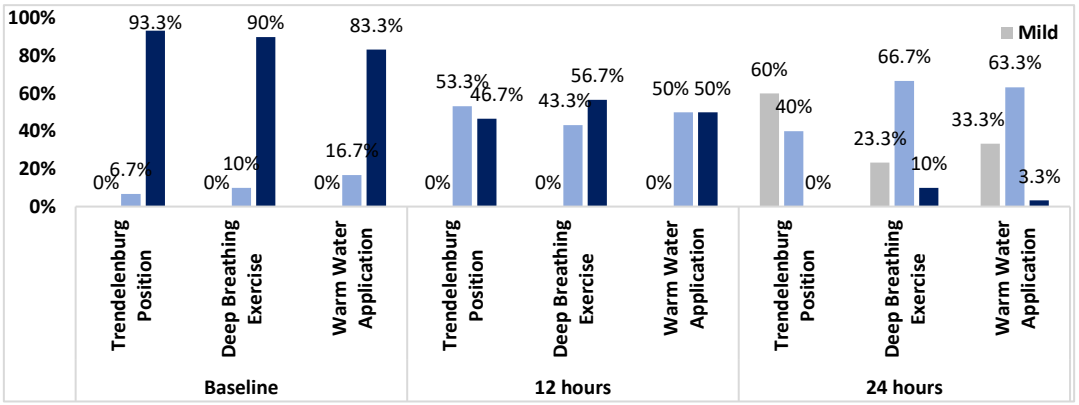

Table 4: Postoperative Quality of Recovery among Women in Trendelenburg Position, Deep Breathing Exercise, and Warm Water Application Groups (n =30 for each group)

Postoperative Quality of Recovery scale (QoR40) After 24 hrs. of operation	Trendelenburg Position Group	Deep Breathing Exercise Group	Warm Water Application Group	Significance	
	Mean ± SD.	Mean ± SD.	Mean ± SD.	*kw–χ^2*	*P*
Physical Comfort	51.87 ± 3.36	43.27 ± 3.05	48.23 ± 2.76	**51.684***	**<0.001***
Emotional State	36.20 ± 2.95	30.87 ± 2.29	34.40 ± 1.33	**45.171***	**<0.001***
Psychological Support	33.07 ± 2.91	18.47 ± 3.01	30.13 ± 3.69	**63.905***	**<0.001***
Physical Independence	15.13 ± 1.70	8.73 ± 2.91	13.80 ± 1.35	**50.464***	**<0.001***
Pain	30.60 ± 1.28	26.23 ± 1.41	28.13 ± 1.11	**37.452***	**<0.001***
Overall Total score	166.87 ± 9.63	131.27 ± 10.96	154.70 ± 7.53	**59.775***	**<0.001***

kw–χ^2: Kruskal-Wallis ***Significant at *P≤0.001**

Table 5: Correlation between Pain intensity (NRS) and Postoperative Quality of Recovery among the Studied Groups.

		Pain Score after 24 hrs.		
		Trendelenburg Position	Deep Breathing Exercise	Warm Water Application
Overall Postoperative	r	-0.541*	-0.420*	-0.488*
Recovery	p	0.002*	0.021*	0.006*

r: Pearson coefficient ***: Statistically significant at p ≤ 0.05**

Discussion

Most women suffer from severe shoulder pain after laparoscopic procedures, which hinders their post-operative recovery. This pain interferes with the woman's ability to take deep breaths, which may result in pulmonary complications such as atelectasis and pneumonia **(Ko-Iam et al., 2016).** Adopting various innovative nursing strategies that alleviate PLSP and improve the quality of postoperative recovery is one of the fundamental responsibilities of nurses. In this context, the findings of the present study revealed significantly lower pain scores at the three measurements among the Trendelenburg position group, followed by warm water application and then the deep breathing exercise group. This could be justified in light of the fact that CO_2 gas has a low density. So, placing the women in the Trendelenburg position makes insufflated CO_2 to shift toward the pelvic area (in the Trendelenburg position, the pelvis is higher than the trunk). Therefore, this position might decrease the PLSP by reducing the mechanical pressure exerted by the CO_2 on the diaphragm and the upper abdominal muscles, thereby decreasing phrenic nerve irritation. In addition, the displacement of the highly soluble CO_2 toward the pelvis, which has a rich vasculature, may speed up its absorption and relieve pneumoperitoneum (accumulation of CO_2 in the peritoneal cavity). Sequentially, Trendelenburg positioning modifies the perception of shoulder pain and promotes comfort among women during post-gynecologic laparoscopic surgery **(Chaichian et al., 2018; Haghgoo et al., 2016).**

The current study findings are congruent with **Zeeni et al. (2020),** who concluded that Trendelenburg's position is a beneficial non-pharmacologic intervention in reducing PLSP, reducing the intake of analgesics, and improving women's overall satisfaction with the gynecologic laparoscopic surgical experience. It also agrees with **Chaichian et al. (2018),** who revealed that the mean score of shoulder pain was decreased at 12, and 24 hours while the scores dramatically declined to zero among all women who assumed the Trendelenburg position 48 hours post-surgery.

On investigating the effect of warm water application on PLSP, the result of the present study showed a significant reduction in pain scores at 12 and 24 hours. This could be attributed to the soothing effect of the superficial heating that reduces sympathetic nerve drive, dilates local blood vessels, and increases circulation and tissue oxygenation **(Mooventhan & Nivethitha, 2014).** In this context, **Ibrahim and Ali (2020)** concluded that the warm bag application and shoulder effleurage massage have eventually led to a reduction of shoulder pain 6 hours after the interventions. The authors reported that warm water application acts through the heat receptors, which in turn blocks the effect of chemical messengers that cause pain, while **Pan et al. (2013)** concluded that both warm compress and oxygen treatment are effective in relieving shoulder pain after gynecologic laparoscopy.

Likewise, the current study findings revealed a reduction in the pain scores at 12 and 24 hours after laparoscopy among women who performed deep breathing exercises every 4 hours postoperatively. Deep breathing exercise reduces PLSP through multidimensional mechanisms including cognitive (e.g., distraction), emotional (e.g., reduced arousal), and autonomic (e.g., increased parasympathetic activity) modulations. Generally, it improves the ventilation capacity and reverses postoperative hypoxemia, which in turn results in the reduction of respiratory complications after surgery. When women were instructed to do slow deep breathing, it increased vagal afferent signals, stimulated the pulmonary stretch receptors, which are primarily found in the vagus nerve, and provided input to the nucleus of the solitary tract in the brain stem. They also synapse with ascending circuits terminating at subcortical and cortical levels and contribute to the processing of respiratory signals **(Gholamrezaei et al., 2022).** Deep breathing exercises also improve pulmonary compliance, alveolar ventilation, and oxygenation **(Gholamrezaei et al., 2022; van Weerdenburg et al., 2017).** When women breathe deeply, nitrous oxide levels increase in the blood, reducing tension in the connective tissues and muscles. More specifically, after gynecologic laparoscopic surgery, it seems that deep breathing has proven to be effective, as it

eliminates the accumulated CO_2 on a regular basis. A comparable result was reported by **Hosseinzadeh et al. (2020)**, who performed a randomized clinical trial to compare the effects of deep breathing technique and drain removal on a female's shoulder pain after gynecologic laparoscopic surgery and revealed a significant reduction in shoulder pain severity between the two groups at 3, 6, 12, and 24 hours after surgery. Further, the present study findings are congruent with **Wei et al. (2010),** who cited that deep breathing exercises were an effective, simple, and inexpensive method for relieving sub-phrenic shoulder pain in women after gynecologic laparoscopic surgery.

Nowadays, the use of minimally invasive laparoscopic surgery is the procedure of choice as it is strongly associated with improved postoperative clinical outcomes and recovery **(Abeles et al., 2017).** It has been shown to reduce post-operative pain, length of stay, and complications. The present study revealed improvements in the total scores of postoperative quality of recovery concerning physical comfort, emotional state, psychological support, physical independence, and pain among women in the Trendelenburg position group, followed by warm water application and deep breathing exercise groups.

Since postoperative pain interferes with a woman's performance after laparoscopy, the effective nursing management of PLSP can enhance postoperative recovery and expedite resuming the activities of daily living. This is confirmed by our results where the correlation analysis showed a significant negative relationship between shoulder pain intensity and postoperative quality of recovery. In this regard, **Zeeni et al. (2020)** spotlighted the impact of pain on the ability to resume usual activities and routines, in addition to emphasizing the need for better pain management beyond the first 24 hours following surgery. The current finding relatively coincides with **Chaichian et al. (2018),** who applied a new approach for alleviating shoulder pain produced by gynecological laparoscopy and showed that draining the residual gas from abdominal cavity after gynecologic laparoscopic procedures through positioning seems to be beneficial in decreasing the duration of hospital stay after surgery. This method could probably be used as a helpful technique for reducing PLSP. Additionally, **Mohamed and Elhady (2016)** revealed that the postoperative quality of recovery score was highly significant in the heat water group.

The authors reported that heat water application enhanced the recovery of women undergoing gynecological laparoscopic surgery after 24 hours, where emotional state, physical comfort, psychological support, physical independence, and pain had a substantial improvement in the study group than in the control group after intervention. Hence, it is reasonable to provide evidence that may help in updating as well as enhancing the body of knowledge in the maternity nursing field and improving nurses' clinical practices, which ultimately contribute to achieving the optimum women's health **(Kaloo et al., 2019).**

Limitation of the study

Although the current study showed a favorable impact of Trendelenburg position on reducing the PLSP and improving postoperative quality of recovery, the study has limitations related to the small sample size. Further studies with larger sample sizes are needed to confirm the findings. The study had limitations related to the randomization process, as researchers struggled to find women who fulfilled inclusion criteria and it was not feasible to obtain sampling frame. Thus, convenience sampling technique was utilized in this study. The researchers also faced the challenge of maintaining blindness during data collection where the raters were able to distinguish women in the study who were advised to lie in the Trendelenburg position, perform deep breathing exercises and who received warm

water application. The authors also struggled with obtaining the response from the women especially the Postoperative Quality of Recovery Scale which consisted of 40 items.

Conclusions

The three interventions showed a noticeable decline in PLSP. However, Trendelenburg's position showed a superior effect to the other two measures. So, women who received the three interventions felt mitigated from such a great source of discomfort and exhibited a high quality of postoperative recovery.

Recommendations:

- The authors suggested the incorporation of the three studied interventions for caring of women suffering from PLSP in order to benefit from all their effects and maximize pain relieve and enhancing postoperative recovery. Being non-pharmacologic, they can also be administered by trained nursing staff and can even be taught to patients and implemented at home.

- Additional studies are required to determine whether Trendelenburg positioning, warm pad application and deep breathing exercise improve postoperative shoulder pain following non-gynecologic procedures and to delineate the optimal duration of these interventions to maximally decrease shoulder pain scores.

Implications for Nursing Practice

Given that there is significant evidence that shoulder pain is one of the devastating symptoms affecting women during the early postoperative period of laparoscopic gynecologic surgeries **(Kiyak et al., 2019)**. In the current study the Trendelenburg position, deep breathing exercise, and warm water application have been proven to be effective and simple alternative nursing interventions that alleviate women's PLSP **(Zeeni et al., 2020; Asman & Maifita, 2019; Erol Ursavas & Catakli, 2020).** These non-pharmacologic interventions are zero cost and can potentially decrease medical expenses. They can be performed by nursing staff in the health care setting or can be implemented at home. Additional studies are required to determine the effect of combining the three interventions to maximize shoulder pain relief after the laparoscopic surgeries.

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Declaration of Competing Interest

No conflict of interest has been declared by the authors.

References

Abeles, A., Kwasnicki, R. M., & Darzi, A. (2017). Enhanced recovery after surgery: Current research insights and future direction. *World journal of gastrointestinal surgery*, *9*(2), 37-45. https://doi.org/10.4240/wjgs.v9.i2.37.

Antonilli, M., Sevas, V., Gasparri, M., Farooqi, A., & Papadia, A. (2021). Minimally Invasive Surgery in Gynecology.

In A. Sanna (Ed.), *Advances in Minimally Invasive Surgery* (p.p. 1-16). IntechOpen

Asman, A., & Maifita, Y. (2019). Effect of Deep Breathing Relaxation Techniques for Reducing Pain after Hernia Surgery in Inpatient of Regional Hospital Pariaman West. *Age (years), 50*(64), 444-447.

Chaichian, S., Moazzami, B., Haghgoo, A., & Sheibani, K. (2018). A New Approach to an Old Concept for Reducing Shoulder Pain Caused by Gynecological Laparoscopy. *Journal of reproduction & infertility*, *19*(1), 56-60.

Erol Ursavas, F., & Catakli, M. (2020). The effect of diaphragmatic breathing exercise on pain, anxiety, and depression in patients undergoing total knee replacement: A randomized controlled trial. *Annals of Medical Research*, *27*(9), 2408-2413. https://doi.org/10.5455/annalsmedres.2020.04.295.

Galaal, K., Donkers, H., Bryant, A., & Lopes, A. D. (2018). Laparoscopy versus laparotomy for the management of early stage endometrial cancer. *The Cochrane Database of Systematic Reviews*, *10*(10), Cd006655. https://doi.org/10.1002/14651858.CD006655.pub3.

Galetin, T., & Galetin, A. (2022). Influence of gas type, pressure, and temperature in laparoscopy—a systematic review. *Annals of Laparoscopic and Endoscopic Surgery*, *7*, 6–6. https://doi.org/10.21037/ales-21-24

Gao, D., Sun, L., Wang, N., Shi, Y., Song, J., Liu, X., Yang, Q., & Su, Z. (2022). Impact of 30° Reserve Trendelenburg Position on Lung Function in Morbidly Obese Patients Undergoing Laparoscopic Sleeve Gastrectomy. *Frontiers in Surgery*, *9*, *792697*. https://doi.org/10.3389/fsurg.2022.792697

Gholamrezaei, A., Van Diest, I., Aziz, Q., Pauwels, A., Tack, J., Vlaeyen, J., & Van Oudenhove, L. (2022). Effect of slow, deep breathing on visceral pain perception and its underlying psychophysiological mechanisms. *Neurogastroenterology and Motility*, *34*(4), e14242. https://doi.org/10.1111/nmo.14242.

Gustafsson, S., Strömqvist, M., Ekelund, J., & Engström, Å. (2020). Factors influencing early postoperative recovery after laparoscopic cholecystectomy. *Journal of PeriAnesthesia Nursing*, *35*(1), 80-84. https://doi.org/10.1016/j.jopan.2019.06.002.

Haghgoo, A., Chaichian, S., Ghahremani, M., Nooriardebili, S., Akbaian, A., & Moazzami, B. (2016). The Use of Peritoneal Suction Drainage to Reduce Shoulder Pain Caused by Gynecological Laparoscopy. *Archives of Iranian Medicine, 19*(3), 173-178. https://doi.org/10.1088/1475-7516/2016/03/004.

Hosseinzadeh, F., Nasiri, E., & Behroozi, T. (2020). Investigating the effects of drainage by hemovac drain on shoulder pain after female laparoscopic surgery and comparison with deep breathing technique: a randomized clinical trial study. *Surgical Endoscopy*, *34*(12), 5439-5446. https://doi.org/10.1007/s00464-019-07339-z.

Ibrahim, H. I., & Ali, W. K. (2020). Effect of effleurage massage versus warm application on shoulder pain among postoperative women with gynecological laparoscopic surgery. *Journal of Nursing Education and Practice, 10*(4), 51-64. https://doi.org/10.5430/jnep.v10n4p51.

Kaloo, P., Armstrong, S., Kaloo, C., & Jordan, V. (2019). Interventions to reduce shoulder pain following gynaecological laparoscopic procedures. *The Cochrane Database of Systematic Reviews, 1*(1), Cd011101. https://doi.org/10.1002/14651858.CD011101.pub2.

Kiyak, H., Yilmaz, G., & Ay, N. (2019). Semi-Fowler positioning in addition to the pulmonary recruitment manoeuvre reduces shoulder pain following gynaecologic laparoscopic surgery. *Videosurgery and Other Miniinvasive Techniques, 14*(4), 567-574. https://doi.org/10.5114/wiitm.2019.84384.

Ko-Iam, W., Paiboonworachat, S., Pongchairerks, P., Junrungsee, S., & Sandhu, T. (2016). Combination of etoricoxib and low-pressure pneumoperitoneum versus standard treatment for the management of pain after laparoscopic cholecystectomy: a randomized controlled trial. *Surgical Endoscopy, 30*(11), 4800-4808. https://doi.org/10.1007/s00464-016-4810-4.

Li, X. Y., Tian, M., Li, A. Z., Han, C. L., & Li, K. Z. (2021). The risk of shoulder pain after laparoscopic surgery for infertility is higher in thin patients. *Scientific Reports, 11*(1), 13421. https://doi.org/10.1038/s41598-021-92762-3.

McCaffery, M., & Beebe, A. (1993). *Numeric Rating Scale. Pain: Clinical manual for nursing practice*. Mosby Company.

Metawie, M. A.-H., Amasha, H., Abdraboo, R. A., & Ali, S. E. (2015). Effectiveness of aromatherapy with lavender oil in relieving post caesarean incision pain. *Journal of Surgery, 3*(2-1), 8-13. https://doi.org/10.11648/j.js.s.2015030201.12.

Mohamed, A. I., & Elhady, R. (2016). Heating pads and early mobilization for reducing postoperative shoulder pain and enhancing recovery of women undergoing gynecological laparoscopic surgery. *IOSR Journal of Nursing and Health Science, 5*(1), 10-16. https://doi.org/10.9790/1959-05121016.

Mooventhan, A., & Nivethitha, L. (2014). Scientific evidence-based effects of hydrotherapy on various systems of the body. *North American Journal of Medical Sciences, 6*(5), 199-209. https://doi.org/10.4103/1947-2714.132935.

Myles, P. S., Weitkamp, B., Jones, K., Melick, J., & Hensen, S. (2000). Validity and reliability of a postoperative quality of recovery score: the QoR-40. *British Journal of Anaesthesia, 84*(1), 11-15. https://doi.org/10.1093/oxfordjournals.bja.a013366.

Pan, X., Niu, L., & Ren, L. (2013). Effect of three therapies on shoulder pains after

gynecological laparoscopies. *Modern Clinical Nursing*, 45-48.

Sao, C. H., Chan-Tiopianco, M., Chung, K. C., Chen, Y. J., Horng, H. C., Lee, W. L., & Wang, P. H. (2019). Pain after laparoscopic surgery: Focus on shoulder-tip pain after gynecological laparoscopic surgery. Journal of the Chinese Medical Association, 82(11), 819-826.

van Weerdenburg, L. J., Brock, C., Drewes, A. M., van Goor, H., de Vries, M., & Wilder-Smith, O. H. (2017). Influence of exercise on visceral pain: an explorative study in healthy volunteers. *Journal of Pain Research*, *10*, 37-46. https://doi.org/10.2147/jpr.s121315.

Wei, L., Yan, W., & Fang, H. (2010). Effect of breathing exercises on relieving subphrenic pain in patients after gynecological laparoscopic surgery. *Chinese Journal of Nursing, 45*(10), 904-906.

Yu, X., Hu, D., & Chen, L. (2022). Evidence-based nursing in the operating room of obstetrics and gynecology departments alleviates patients' adverse moods and improves their quality of life. *American Journal of Translational Research, 14*(7), 4768.

Zeeni, C., Chamsy, D., Khalil, A., Abu Musa, A., Al Hassanieh, M., Shebbo, F., & Nassif, J. (2020). Effect of postoperative Trendelenburg position on shoulder pain after gynecological laparoscopic procedures: a randomized clinical trial. *BMC Anesthesiology*, *20*(1), 27. https://doi.org/10.1186/s12871-020-0946-9.