Effectiveness of Lung Recruitment Maneuver in the Oxygenation, Hemodynamics and Post-Operative Pain of Patients Undergoing Laparoscopic Cholecystectomy*

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ABSTRACT

Introduction: Laparoscopic Cholecystectomy uses carbon dioxide (CO_2) which affects the respiratory, cardiovascular and renal system. The residual CO_2 induces phrenic nerve irritation, manifesting as shoulder and abdominal pain. Recruitment maneuvers opens the lungs and helps expelling this residual carbon dioxide. However, there are limited studies on its role to hemodynamics especially in patients undergoing abdominal laparoscopic procedures.

Methods: Sixty patients (51 ± 15.1) scheduled for laparoscopic cholecystectomy under General Endotracheal Anesthesia were randomly allocated to two groups. The control group (Group C) underwent standard laparoscopic cholecystectomy procedures. The experimental group (Group R) was placed in a Trendelenburg and was given 4-5 manual pulmonary inflations at a pressure of 40cmH20. The blood pressure, heart rate, respiratory rate and oxygen saturation, as well as the post operative site pain and shoulder pain were measured using the Numerical Pain Scale (NPS) were monitored at 0, 1 and 2 hours post operatively.

Results: The demographics and preoperative vital signs were comparable. The mean systolic blood pressure [119.5 vs 131.5; *p=0.002*], mean arterial pressure [91.8 vs 95.3; *p=0.049*], heart rate [74.9 vs 87.5; *p=<0.001*] and respiratory rate [15.7 vs 16.2; *p=0.02*] were all differrent only during the immediate post operative period. The mean shoulder pain was lower in Group R immediately [1.9 ± 1.2; *p=0.01*] and 1 hour after surgery [0.7 ± 0.8; *p=0.01*].

Conclusion: Recruitment maneuver significantly reduces the shoulder pain scores after laparoscopic cholecystectomy. It causes a decrease in blood pressure, heart rate and mean arterial pressure in the immediate post operative period.

Keywords: Recruitment Manuever; Laparoscopic Cholecystectomy; Shoulder Pain; Hemodynamics; Carbon Dioxide

Disclosures: The author has formally acknowledged and signed a disclosure affirming the absence of any financial or other relationships (including personal connections), intellectual biases, political or religious affiliations, and institutional ties that could potentially result in a conflict of interest.

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INTRODUCTION

Laparoscopic Cholecystectomy is currently the gold standard in the treatment of cholelithiasis or gallstones[1]. This minimally invasive procedure involves small incisions where the tools can be inserted and carbon dioxide insufflation. Carbon dioxide (CO_2) is a gas that affects the respiratory, cardiovascular and renal system. Increase in intraabdominal pressure leads to compression of inferior vena cava, which can increase venous return and venous resistance. This can increase the cardiac output initially, but as the intraabdominal pressure rises, it eventually decreases the cardiac output, venous return and hepatic blood flow. The residual carbon dioxide during laparoscopic surgery maybe trapped between the liver and diaphragm. This may induce phrenic nerve irritation which manifests as shoulder and abdominal pain[2]. Shoulder pain is said to occur more intensely as compared to post operative site pain in 40% of patients[3].

Lung Recruitment maneuvers, also known as pulmonary recruitment or alveolar recruitment, is a strategy, that improves oxygenation in different ways. This provides a high peak airway pressure for a sustained length of time to open up collapsed alveoli. Many studies show its positive effects on oxygenation especially in preventing complications such as atelectasis, pneumothorax and pulmonary edema[4]. There are also reports of decreased shoulder and abdominal pain because of reduction in residual carbon dioxide1. There are many ways to provide recruitment maneuvers[4,5]. Cinella et al in 2013 used increasing peak inspiratory pressure (PIP) to 40cm H20 with or without peak end expiratory pressure (PEEP) of 20cmH20 for 5-10 respiratory cycles.4 Another method used by Kyoungho R. et al in 2016 wherein a series of three short inflations to reach an inspiratory pressure of 40-55cmH206. The last method known was using a volume-controlled ventilation with a low tidal volume computed at 5ml/kg, PEEP of 30 cmH2O and inspiratory plateau pressure of 15cmH2O above PEEP for two minutes immediately after desufflation[7]. Different studies showed the maximal airway pressure needed in order to open the lungs. However, there are limited studies on its role to hemodynamics especially to patients undergoing abdominal laparoscopic procedures.[3]

This study aims to determine the effectiveness of Recruitment maneuver in terms of oxygenation status, hemodynamic stability and post operative pain of patients undergoing laparoscopic cholecystectomy.

RESEARCH OBJECTIVES

A. General Objective

To determine the effectiveness of Recruitment maneuver in the oxygenation, hemodynamic status and post-operative pain of patients who undergoing laparoscopic cholecystectomy

B. Specific Objectives:

1. To determine the effectiveness of Recruitment Maneuver in the oxygenation status (oxygen saturation) of the patient intraoperatively and post operatively
2. To determine if Recruitment Maneuver will affect the hemodynamics (blood pressure, heart rate and respiratory rate) of the patient intraoperatively and post operatively
3. To determine if the Recruitment Maneuver will reduce the post operative site pain of patients undergoing Laparoscopic Cholecystectomy using Numerical Pain Score (NPS)
4. To determine if the Recruitment Maneuver will reduce the post operative shoulder pain of patients undergoing Laparoscopic Cholecystectomy using Numerical Pain Score (NPS)

RESEARCH METHODOLOGY

Following the approval from the Institutional Review Board, this single blinded randomized control trial was conducted at a government hospital Quezon City from December 2020 to November 2022. There were 61 patients scheduled for laparoscopic cholecystectomy under General Endotracheal Anesthesia (GETA) with the following inclusion and exclusion criteria.

Inclusion criteria:

1. Admitted at the hospital who underwent proper pre-operative protocols.
2. Age 30 years old and above.
3. Body Mass Index (BMI) <35kg/m2
4. ASA physical status I and II.
5. Able to verbalize pain

Exclusion criteria:

1. Poorly controlled cardiac and respiratory pathology
2. Emergency surgery

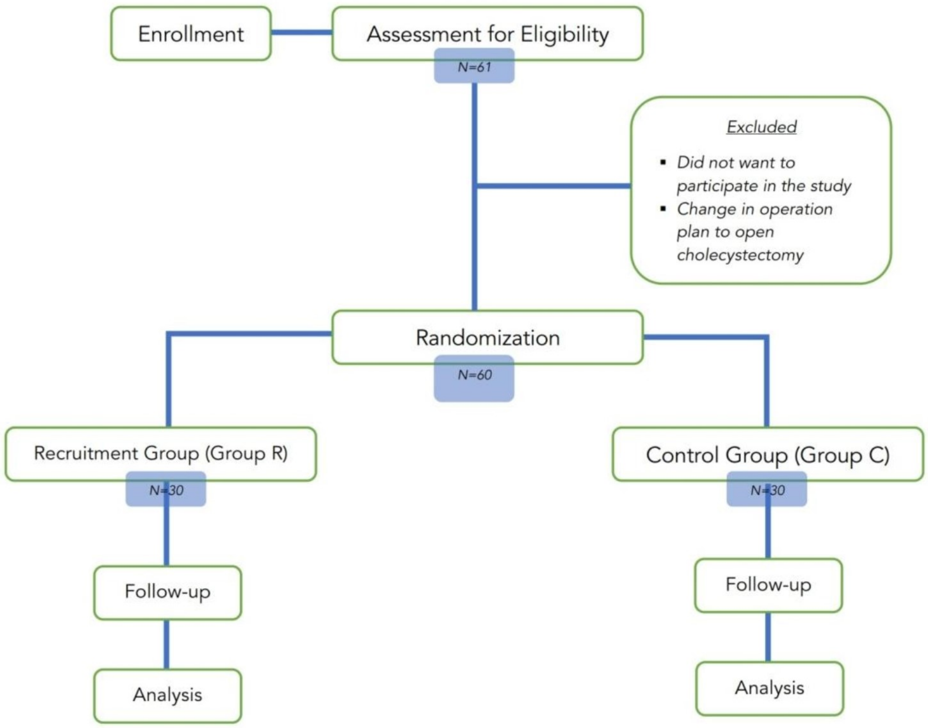
These patients were visited pre-operatively for a standard assessment by the principal investigator. Explanation of the study were done and written consent for the procedure and the study were obtained. All eligible patients were allocated into control and experiment group using a computer-generated random number table. The demographics and the baseline vital signs were also gathered. Following the fasting guidelines, all patients were given Omeprazole 40mg/IV and were started on fluid management at maintenance rate.

Upon arrival at the operating room, standard monitors were applied on all patients to obtain the baseline non-invasive blood pressure (BP), heart rate (HR), respiratory rate (RR) and oxygen saturation (SaO_2). Anesthesia induction were conducted using Fentanyl 1mcg/kg/IV, Propofol 1-2mg/kg/IV and Rocuronium 0.6mg/kg/IV. Anesthesia was maintained using Sevoflurane and adjusted accordingly. During the course of anesthesia, continued monitoring of vital signs were done.

Laparoscopic cholecystectomy for all patients was done by an attending or resident in charge. Insufflation using carbon dioxide (CO_2) and intraabdominal pressure was maintained <15mmHg throughout the surgery. Prior to the removal of the probes, the experimental group (Group R) received the Recruitment maneuver. This was done by asking the surgeon to fully open the sleeve valve to allow carbon dioxide (CO_2) escape. The patient was placed in a Trendelenburg position and was given 4-5 manual pulmonary inflations at a pressure of 40cmH20. After this, the patient was placed into a level position to facilitate removal of the probes and wound closure. Patients were extubated after muscle relaxant reversal using Sugammadex 2mg/kg/IV. For the control group (Group C), standard extubation procedures were also done.

Post operatively, patients were transferred at the Post Anesthesia Care Unit (PACU). They were given oxygen supplementation at 2-3 liters per minute (LPM) via nasal cannula, fluid management at maintenance rate and pain medications. Both groups were given Paracetamol 1g intravenously every 8 hours for 48 hours, Ketorolac 30mg intravenously every 6 hours for 24 hours and Tramadol 50mg intravenously every 8 hours as needed for pain. The blood pressure, heart rate, respiratory rate and oxygen saturation were monitored and recorded upon the arrival at the PACU, 1 hour and 2 hours post operatively. Post operative site pain and shoulder pain were also be recorded and measured using the Numerical Pain Scale (NPS) at 0h (upon arrival) and at 1, 2, 24 and 48 hours after the surgery.

Figure 1. Research flowchart



The data gathered from the participants were recorded, organized and summarized using Medcalc Statistical Software version 20.216 (MedCalc Software Ltd, Ostend, Belguim; https://www.medcalc.org; 2023). Calculation of sample size was adopted from Khanna et al in 2013, wherein the sample size was based on the presumption that postoperative pain scores after recruitment maneuver would be 3 when compared with 4.5 in the control group with a standard deviation of 2 at all time points.[1] Thus, accepting a level of significance of 5% and a power of 80%, a sample size of 60 patients was required to obtain statistically significant differences between the two assessment groups. Patient characteristic data were organized and analyzed as mean and standard deviation, while qualitative variables were tallied as frequency and percentages. Intraoperative and post operative changes in the blood pressure, heart rate, respiratory rate and oxygen saturation as well as the post operative site pain and shoulder pain scores were analyzed using independent t-test at the significant level of 5%. A *P value* of < 0.050 was considered statistically significant.

RESULTS

A total of sixty two (61) patients were initially recruited for the study. However, one from the experimental group (Group R) was excluded from the analysis due to a change in the surgical plan to open cholecystectomy. Thirty (30) patients from the experimental group (Group R) and thirty (30) patients from the control group (Group C) were included in this study.

Table 1. *Demographics of patients undergoing laparoscopic cholecystectomy*

	Group R n=30	Group C n=30	p value
Age (years)	50.1 ± 14.7	51.7 ± 15.6	0.6845
Gender			
Male	17 (56.7)	12 (40.0)	0.2002
Female	13 (43.3)	18 (60.0)	
Weight (kg)	64.17 ± 9.8	65.0 ± 10.17	0.17
Height (cm)	1.60 ± 0.06	1.61 ± 0.07	0.07
BMI	25.1 ± 2.6	25 ± 3	0.9871
ASA			
1	4 (13.3)	5 (16.6)	0.6006
2	26 (86.7)	25 (83.3)	

Table 1 shows no significant difference in the demographic profile of the patients in both groups, specifically average age of patients from experimental group is 50 years old while around 52 for control. There were 57% males and 40% females under ASA 1-2 classification. Other demographic variables such as weight, height, body mass index (BMI) and ASA physical status were comparable between these groups ($p>0.05$)

Table 2. *Pre-operative Vital Signs of Recruitment Maneuver Group (Group R) and Control Group (Group C) undergoing laparoscopic cholecystectomy.*

Pre-operative parameters	Group R n=30	Group C n=30	P value
Systolic blood pressure	117.3 ± 6.4	117 ± 7.5	0.8537
Diastolic blood pressure	76 ± 5.6	76 ± 5.6	1.0000
Mean Arterial Pressure	89.9 ± 4.8	89.7 ± 4.4	0.8529
Heart rate	79.9 ± 7.7	80.1 ± 6.8	0.9295
Respiratory rate	18 ± 0.5	18.2 ± 0.5	0.1904
O2 Saturation	98.3 ± 0.6	98.1 ± 0.5	0.1040

The mean blood pressure (BP), pulse rate (PR), respiratory rate and oxygen saturation (SaO2) were not significantly different between the two groups as shown in Table 2.

Table 3. *Hemodynamic Parameters of Recruitment Maneuver Group (Group R) and Control Group (Group C) undergoing laparoscopic cholecystectomy*

	Group R n=30	Group C n=30	p value
Systolic blood pressure			
Pre-Induction	118.4 ± 8.2	121.5 ± 15.3	0.3369
Induction	118.9 ± 10.6	118.9 ± 12.1	0.9820
Intraoperative	118.4 ± 11.7	115.4 ± 9.6	0.2935
Extubation	119.8 ± 10.5	118.7 ± 12	0.7025
Immediate Post-Op	119.5 ± 14	131.5 ± 14.2	**0.0020****
1 hour Post op	120.4 ± 10.6	118.1 ± 10.1	0.3950
2 hour post op	121.1 ± 11.1	119.7 ± 11.9	0.6500
24 hour post op	118.6 ± 8.7	116.7 ± 7.6	0.3870
48 hour post op	117.2 ± 6.5	117 ± 7.5	0.8900
Diastolic blood pressure			
Pre-Induction	76.8 ± 6.4	78.5 ± 7.2	0.3370
Induction	76.4 ± 7.8	77 ± 10	0.7855
Intraoperative	77.1 ± 6.8	76.2 ± 6.9	0.6110
Extubation	77.1 ± 6.5	75.5 ± 7.2	0.3843
Immediate Post-Op	77.9 ± 7.7	77.2 ± 6.8	0.7275
1 hour Post op	76.1 ± 7.7	79 ± 7.9	0.1642
2 hour post op	77.2 ± 5.6	77.7 ± 6.5	0.7412
24 hour post op	78.2 ± 5	76.5 ± 7.1	0.3016
48 hour post op	76.2 ± 6.2	77.7 ± 6.3	0.3728
Mean Arterial Pressure (MAP)			
Pre-Induction	90.6 ± 4.7	92.8 ± 8.2	0.2186
Induction	90.6 ± 5.6	91 ± 8.2	0.8269
Intraoperative	90.9 ± 5.6	89.3 ± 6.3	0.3076
Extubation	91.3 ± 5.9	89.9 ± 7.3	0.4136
Immediate Post-Op	91.8 ± 6.3	95.3 ± 7.2	0.0488**
1 hour Post op	90.9 ± 6.5	92 ± 5.6	0.4715
2 hour post op	91.8 ± 6.2	91.7 ± 5.6	0.9579
24 hour post op	91.6 ± 4.8	89.9 ± 5.2	0.1911
48 hour post op	86.9 ± 17.4	90.8 ± 4.3	0.2419
Heart Rate (HR)			
Pre-Induction	70.6 ± 7.2	74.1 ± 8.5	0.0963
Induction	72.3 ± 8.8	76.7 ± 8.9	0.0572
Intraoperative	78.6 ± 9.1	77.4 ± 7.6	0.5814
Extubation	72.1 ± 9.4	73.1 ± 8.7	0.6522
Immediate Post-Op	74.9 ± 8.4	87.5 ± 8.3	**<0.0001****
1 hour Post op	73.8 ± 18.9	75.3 ± 8.4	0.6789
2 hour post op	74.8 ± 10.2	74.6 ± 10.1	0.9520
24 hour post op	74 ± 7.5	75.6 ± 8.3	0.4309
48 hour post op	74.4 ± 10	74 ± 8.4	0.8414
Respiratory Rate (RR)			
Pre-Induction	15.7 ± 1	15.9 ± 1.1	0.5406
Induction	15.7 ± 1.1	15.5 ± 0.9	0.5203
Intraoperative	15.7 ± 1.1	15.8 ± 1	0.8133
Extubation	15.6 ± 0.9	16.1 ± 1	0.0674
Immediate Post-Op	15.7 ± 0.8	16.2 ± 1.1	**0.0236***
1 hour Post op	21.7 ± 21.2	15.9 ± 1.1	0.1353
2 hour post op	15.8 ± 1.1	16 ± 0.9	0.4410
24 hour post op	16 ± 1.1	15.6 ± 0.8	0.1121
48 hour post op	15.9 ± 1	15.8 ± 0.9	0.9043
02 Saturation (SaO_2)			
Pre-Induction	98.9 ± 1.3	98.3 ± 1.5	0.1036
Induction	99.8 ± 1.3	99.5 ± 0.8	0.1084
Intraoperative	99.4 ± 1	99.7 ± 0.5	0.0720
Extubation	99.2 ± 1.1	99.5 ± 0.9	0.2200
Immediate Post-Op	99 ± 1.4	98.9 ± 1.4	0.7797
1 hour Post op	99.4 ± 1	99.3 ± 0.8	0.8473
2 hour post op	99.4 ± 0.8	99.2 ± 1	0.4356
24 hour post op	98.1 ± 0.9	98.3 ± 1.2	0.4137
48 hour post op	98.8 ± 1	98.4 ± 1.1	0.2310

Table 3 shows that the parameters mean systolic blood pressure, mean arterial pressure (MAP), heart rate and respiratory rate were all statistically significantly different only during the immediate post operative period. These were all lower in the recruitment maneuver group (119.5 vs 131.5) as compared to the control group. Mean diastolic blood pressure was not significantly difference across all periods. Mean arterial pressure was also significantly different during immediate post op where mean of experimental group was lower (91.8) as compared to 95.3 of control. Similarly, significant difference also existed during immediate op for heart rate where it was lower for experimental group (74.9) as compared to 87.5 of control (Figure 2). Respiratory rate was also significantly lower during immediate post op (15.7) as compared to 16.2 for control (Figure 3). On the other hand, O2 saturation was not significantly different from pre-induction to post-operative period (Figure 4).

Figure 2. *Pulse Rate of the Recruitment Maneuver Group (Group R) and Control Group (Group C) during the post operative course*

Figure 3. *Respiratory Rate of the Recruitment Maneuver Group (Group R) and Control Group (Group C) during the post operative course.*

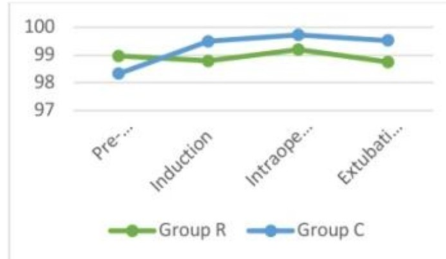


Figure 4. *Respiratory Rate of the Recruitment Maneuver Group (Gropu R) and Control Group (Group C) during the post operative course.*

Table 4. *Post operative Site Pain of the Recruitment Maneuver Group (Group R) and Control Group (Group C) using Numerical Analog Scores*

	Group R n=30	Group C n=30	**p value**
Immediate Post-Op	6.1 ± 2.6	7 ± 2.1	0.1319
1 hour Post op	5.4 ± 2.6	5.4 ± 2.3	0.9741
2 hour post op	2.6 ± 1.5	3.3 ± 1.9	0.1277
12 hour post op	1.9 ± 1.6	1.7 ± 1	0.7200
24 hour post op	0.7 ± 0.9	0.6 ± 0.6	0.4445
48 hour post op	0.3 ± 0.5	0.3 ± 0.5	0.8412

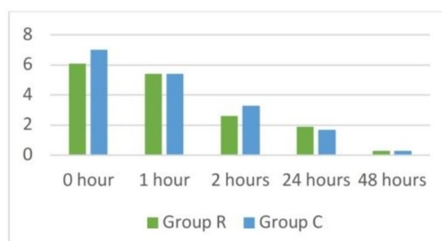


Figure 5. *Post operative Site Pain of the Recruitment Maneuver Group (Group R) and Control Group (Group C) using Numerical Analog Scores*

The overall postoperative site pain scores did not differ significantly between the groups during the 48 hours of monitoring. Both groups showed moderate to severe pain (pain score 5-7/10) during the immediate to 1-hour post-operative period. Whereas, both groups showed mild pain (score 0-3) from 2 hours to 48 hours after the surgery as shown in Table 4 and Figure 5.

Table 5. *Post Operative Shoulder Pain Score of the Recruitment Maneuver Group (Group R) and Control Group (Group C) using Numerical analog scores*

	Group R n=30	*Group C* n=30	***p value***
Immediate Post-Op	1.9 ± 1.2	3.4 ± 1	0.0001*
1 hour Post op	0.7 ± 0.8	2.5 ± 2	0.0001*
2 hour post op	0.3 ± 0.5	0.5 ± 0.5	0.1343
12 hour post op	1.8 ± 2	1.2 ± 1.3	0.1822
24 hour post op	0.1 ± 0.4	0.3 ± 0.5	0.1379
48 hour post op	0.1 ± 0.4	0.2 ± 0.4	0.5334

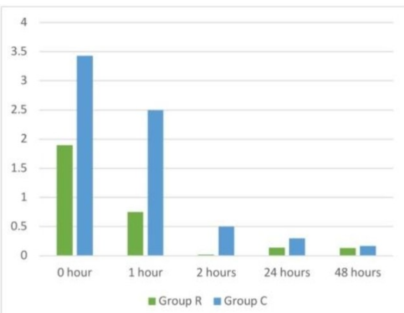


Figure 6. *Post Operative Shoulder Score of the Recruitment Maneuver Group (Group R) and Control Group (Group C) during the postoperative course.*

On the other hand, Table 5 shows a significant difference was found for mean shoulder pain, where it is lower among experimental group immediately after surgery (1.9 ± 1.2) and 1 hour after surgery (0.7 ± 0.8). No significant difference was noted from two hours, twelve hours, twenty four hours and forty eight hours post operatively.

DISCUSSION

The results of the study showed that there was a decrease in the hemodynamic parameters of systolic blood pressure, mean arterial pressure (MAP), heart rate (HR) and respiratory rate (RR) in the experimental group immediately post-operatively as compared to the control group. This may be attributed to the mechanism of the recruitment maneuver of using high inspiratory pressure that causes hemodynamic instability that was also shown in previous studies.[4] The increase in the lung volume from the recruitment maneuver may increase intrathoracic pressures, impeding the venous return and may result to the reduction of cardiac output.

The decrease in heart rate in the recruitment group was also found in different studies, but there was no noted significant hemodynamic instability was noted.[7] The mean arterial pressure was 91.04mmHg from the pre induction to immediate post operative period in the experimental group. This was consistent with the study of Jo et al, who found that there are higher incidence of decrease in heart rate and blood pressure postoperatively may require vasopressor use in the recruitment group (Group R).[1]

Tusman et al. also noted that cardiac output always decreases for a few seconds or a few minutes at the start of the maneuver, and then normalizes within 15-20 minutes of reducing opening pressure. The use of Recruitment maneuver in pressure control mode provides constant driving pressure and step-wise increments in PEEP so the blood pressure changes does not fall below 20%.[8]

From one hour post-operatively to the second day of surgery, the mean hemodynamic scores were the same among both groups. There were also no cases of cardiovascular and pulmonary problems reported for both groups. However, these finding warrants caution especially for patients with cardiovascular disease, pulmonary disease and elderly patients.

For the oxygen saturation, there was no noted significant difference between the two groups. Lee et al also found no significant postoperative pulmonary complications following pulmonary recruitment maneuver among patients who underwent laparoscopic gynecologic surgery.[5] There were many previous studies that used different maximal inspiratory pressures. Recruitment Maneuvers in a level of 40 cmH20 were safe, effective and even improved the arterial oxygenation during anesthesia. This airway pressure reduces the risk of barotrauma and hemodynamic instability.[5]

Khanna et al. showed that early pain after laparoscopic procedures is multifactorial and complex, resulting from a variety of different mechanisms such as abdominal wall penetration by trocar placement for somatic component, rapid insufflation of the peritoneum by carbon dioxide may cause tearing of blood vessels, traction of nerves and release of proinflammatory cytokines accounts for the visceral pain and inflammation and local irritation subsequent to peritoneal and visceral manipulation.[1]

This study showed that the overall scores of post operative site pain has no significant difference between the two groups. Ryu et al. also noted no significant difference on the post operative wound pain scores at 24 to 48 hours after the surgery when the maximal pressures of 40cmH20, 50cm H20 and 60cmH20 for the recruitment maneuver were compared.[5]

However, the mean scores of the post operative shoulder pain were reduced after the recruitment maneuver (Group R) (*p=0.0001*). Recruitment group reduced median Numerical Pain Scale scores of shoulder pain from 2 to 0. Post operative shoulder pain is defined as referred pain to the corresponding dermatome (C3-5) due to carbon dioxide insufflation.[9]

During a laparoscopic surgery, pneumoperitoneum is induced using carbon dioxide because of its safety, higher solubility in the blood and rapid pulmonary clearance. Phelps et al. initially showed that Pulmonary Recruitment Maneuvers (PRM) facilitates the removal of CO2 gas from the peritoneal cavity by opening the alveoli which increases the intrapulmonary pressure allowing the increase in the intraperitoneal pressure. This expulsion of carbon dioxide allows less irritation to the phrenic nerve by 61% to 31%, hence decreasing the incidence of shoulder pain in laparoscopic surgeries.[6]

Post operative shoulder pain scores were considered mild to severe, but was noted to be lower than the post operative site pain. This is in contrast to Kyoungho et al finding that the shoulder pain was more severe than the wound pain at 24 hours post surgery for the control group (70%) and the experimental group (20-21%).[6] This also supports the study done by Gungorduk et. al in 2018, which revealed that the postoperative shoulder pain scores were significantly lower in the maneuver group (2.2±0.5 vs. 4.0±0.5; $p<0.001$).[10] Both studies also showed no significant difference in post operative shoulder pain observed between the groups at 48 hours (1.7±0.5 and 1.9±0.4; $p=0.115$). The degrees of the pain score reduction were similar in this study. To reduce the risk of barotrauma and hemodynamic deterioration, a low airway pressure of 40 cmH2O was used. This was supported by the randomized controlled study by Kyoungho, R. in 2016 who compared low pressure (40 cmH2O) vs high-pressure (60 cmH2O) recruitment manuever for removing CO2 gas from the peritoneal cavity. Low pressure PRM is safe and efficacious for the reduction of post laparoscopic shoulder pain.[5]

In studies investigating shoulder pain after laparoscopic cholecystectomy, the prevalence has been 36–80% (control populations).[6] There seems to be a positive correlation between volume of sub-diaphragmatic gas and intensity in shoulder pain. Also, longer exposure to carbon dioxide will lead to the increase in incidence of pain in laparoscopic surgeries. The duration and level of insufflation and over all duration of the surgery may play a great role in the severity of both post-operative site and post-operative shoulder pain.[11]

This study has several limitations. First, it did not monitor the use of postoperative supplemental analgesics, such as weak opioids. Second, the monitoring of the insufflation flow, intra-abdominal pressure and length of the surgery were not included. Many studies have shown that these factors might affect pain scores. Finally, the use of automated recruitment maneuver may also be explored since most of the anesthesia machines in tertiary hospital are already equipped with different ventilation strategies. Manual hyperinflation using a bag valve mask or bagging was used in these study, but volume controlled ventilation or pressure controlled ventilation along with increasing peak end expiratory pressure (PEEP) may also be used to provide more accurate and timely recruitment maneuver.

CONCLUSION

This study showed that Recruitment maneuver significantly reduces the shoulder pain scores after laparoscopic cholecystectomy. Also, the use of this strategy causes a decrease in blood pressure, heart rate and mean arterial pressure in the immediate post operative period. Overall, this may translate to faster recovery, improved patient satisfaction and faster hospital discharge. Since this is a simple and safe procedure, this may be included by the surgeon and anesthesiologist in the Enhanced Recovery After Surgery (ERAS) protocol.

REFERENCES

1. Khanna, A. et al (2013). *Randomized Clinical Trial of Simple pulmonary recruitment manoeuvre to reduce pain after laparoscopy*. British Journal of Surgery, 100(10), 1290-1294.
2. Atkinson, et al (2017). *Cardiovascular and Ventilatory Consequences of LaparoscopicSurgery*.https://www.ahajournals.org/doi/full/10.1161/circulationaha.116.023262
3. Koivusalo, A.M., and Lindgren, L. (2000). *Effects of carbon dioxide pneumoperitoneum for laparoscopic cholecystectomy.* Acta Anaesthesiol Scandenavica. 44(7), 834-841.
4. Cinnella, G. et al (2013). *Effects of Recruitment Maneuver and Positive End-Expiratory Pressure on Respiratory Mechanics and Transpulmonary Pressure during Laparoscopic Surgery.* Anesthesiology. 118(1), 114-122.
5. Aretha, D. et al, (2017) *Safety and effectiveness of alveolar recruitment maneuvers and positive end-expiratory pressure during general anesthesia for cesarean section: a prospective, randomized trial.* International Journal of Obstetric Anesthesia. 30(1),30-38.
6. Kyoungho, R., Choia, W., Shima, J., and Song, T. (2016). *The impact of a pulmonary recruitment maneuver to reduce post-laparoscopic shoulder pain: A randomized controlled trial.* European Journal of Obstetrics & Gynecology and Reproductive Biology. 208, 55-60.
7. Pasquier, E.K. and Anderson, E. (2021). *Pulmonary Recruitment Maneuver Reduces Shoulder Pain and Nausea After Laparoscopic Cholecystectomy: A Randomized Controlled Trial.* World Journal of Surgery. 45(12), 3575-3583.
8. Lumb, A.B., S. J. Greenhill, M. P. Simpson and J. Stewart (2010). *Lung recruitment and positive airway pressure before extubation does not improve oxygenation in the post-anaesthesia care unit: a randomized clinical trial.* British Journal of Anesthesia.104(5), 643-647
9. Tusman, G., Bohm, S., Vazquez de Anda, G., do Campo, J.L., and Lachmann, B., (1999). *Alveolar recruitment Strategy improves arterial oxygenation during general anesthesia;* British Journal of Anesthesia. 82(1), 8-13

10. García-Fernándeza, J., Romeroa, A., Blancoa, A., Gonzalez, P., Abad-Gurumetad, A., and Bergesega, S.D. (2018). *Recruitment manoeuvres in anaesthesia: How many more excuses are there not to use them?.* Revista Espanola de Anestesiologia y Reanimacion. 65(4), 209-217.
11. Gungorduk, K., et al (2018). *Effect of the pulmonary recruitment maneuver on pain after laparoscopic gynecological oncologic surgery: a prospective randomized trial.* Journal of Gynecologic Surgery. 29(6), 92.
12. Campos, N., et al. (2020) *Re-evaluation of the effects of high PEEP with recruitment manoeuvres versus low PEEP without recruitment manoeuvres during general anaesthesia for surgery -Protocol and statistical analysis plan for an individual patient data meta-analysis of PROVHILO, iPROVE and PROBESE.* Revista Espanola de Anestesiologia y Reanimacion. 62(2), 76-89.
13. Jo, Y. et al, (2020). *Effects of an Alveolar Recruitment Maneuver During Lung Protective Ventilation on Postoperative Pulmonary Complications in Elderly Patient Undergoing Laparoscopy.* Clinical Interventions in Aging. 15(1), 1461-1469
14. Lee, J., et al (2019). *Effect of Low-pressure Pulmonary Recruitment Maneuver on Postlaparoscopic Shoulder Pain: Randomized Controlled Trial.* Journal of Minimally Invasive Gynecology. 27(1), 173-177.
15. Park, S.J., (2016). Effects of intraoperative protective lung ventilation on postoperative pulmonary complications in patients with laparoscopic surgery: prospective, randomized and controlled trial. Surgical Endoscopy. 30(1), 4598-4606
16. Remistico, P. (2011). *Impact of Alveolar Recruitment Manuever in the Postoperative Period of Videolaparoscopic Bariatric Surgery.* Revista Espanola de Anestesiologia y Reanimacion. 61(2), 163-176.