



International Journal of Medicine

<https://www.theinternationalmedicine.com>



Original Research

Comparison of Pulmonary Recruitment Maneuver with variable inspiratory pressures in Reducing Shoulder Pain after Laparoscopic Surgeries

Dr. Prakash S.¹, Dr. Pratheeba Durairaj², Dr. Anu Asheetha R.³, Dr. Vijaya G.⁴

¹Post Graduate, Institute of Anaesthesiology, Madurai Medical College, Madurai, Tamil Nadu, India.

²Professor, Institute of Anaesthesiology, Madurai Medical College, Madurai, Tamil Nadu, India.

³Assistant Professor, Institute of Anaesthesiology, Madurai Medical College, Madurai, Tamil Nadu, India.

⁴Professor, Institute of Anaesthesiology, Madurai Medical College, Madurai, Tamil Nadu, India.

Corresponding Author: Dr. Prakash S.

Received: 27 Oct 2025 / Accepted: 20 Dec 2025

Abstract

Background: Post-laparoscopic shoulder pain (PLSP) is a frequent source of morbidity after laparoscopic procedures. Pulmonary recruitment maneuver (PRM) is employed to enhance clearance of residual carbon dioxide and reduce shoulder pain. **Objective:** To compare the effect of PRM performed with inspiratory pressures of 30 cm H₂O and 40 cm H₂O on PLSP and related postoperative outcomes. **Methods:** In this prospective randomized controlled trial, 60 adult patients (ASA I-II) scheduled for elective laparoscopic surgeries at Government Rajaji Hospital, Madurai, were randomized into two groups. Group A received PRM at 40 cm H₂O, while Group B received PRM at 30 cm H₂O, each delivered as six breaths in pressure control mode over one minute. Patients were assessed at 6, 12, 24, and 48 hours for PLSP using a visual analogue scale (VAS). Secondary outcomes included wound pain, postoperative nausea and vomiting (PONV), haemodynamic stability, and extubation-related complications. Statistical analysis was conducted with IBM SPSS v21.0. **Results:** Mean PLSP VAS scores did not differ significantly between 30 cm H₂O and 40 cm H₂O groups at all time intervals ($p > 0.05$). No significant differences were observed for wound pain, PONV, or haemodynamic parameters. Both groups showed absence of extubation difficulties, laryngospasm, or bronchospasm. **Conclusion:** PRM with 30 cm H₂O is as effective as 40 cm H₂O for reducing PLSP, without compromising safety. Adoption of 30 cm H₂O may therefore be sufficient in clinical practice.

Keywords: Pulmonary recruitment maneuver, shoulder pain, laparoscopy, randomized trial, anaesthesia.

Introduction

Post-laparoscopic shoulder pain (PLSP) is a common clinical problem that significantly affects patient comfort and recovery after laparoscopic surgery. Reported prevalence ranges between 35% and 80% depending on the procedure and perioperative practices[1]. The underlying mechanism is thought to involve phrenic nerve irritation caused by residual carbon dioxide (CO₂) under the diaphragm, which results in referred pain to the shoulder. A range of intraoperative strategies have been studied to mitigate this pain. Trials have also suggested potential additive benefits when PRM is combined with intraperitoneal agents such as bupivacaine[2] in minimally invasive gynaecologic surgery[3]. Other perioperative interventions include the use of warmed and humidified CO₂ for pneumoperitoneum and intraperitoneal local anaesthetic instillation, both of which have shown reductions in PLSP severity[4,5]. Among them, the Pulmonary Recruitment Manoeuvre (PRM) has emerged as a simple and effective technique that helps evacuate residual CO₂ before extubation[6]. A meta-analysis of randomized controlled trials has also shown that various strategies, including PRM, are safe and effective in preventing shoulder pain after laparoscopy[7]. Despite this growing evidence, there is no consensus on the optimal inspiratory pressure to be used for PRM. Most published studies have adopted 40 cm H₂O as the standard, but recent data suggest that lower pressures such as 30 cm H₂O may achieve similar results without increasing risks[8,9].

The present study therefore aimed to compare PRM at 40 cm H₂O and 30 cm H₂O in patients undergoing elective laparoscopic surgery, with the primary outcome being postoperative shoulder pain intensity and secondary outcomes including wound pain, haemodynamic changes, and complications.

MATERIALS AND METHODS

This investigation was designed as a randomized controlled trial with two parallel groups. It was carried out prospectively at the Institute of Anaesthesiology, Government Rajaji Hospital, Madurai Medical College, Tamil Nadu, a large tertiary care centre. Ethical approval was obtained prior to the study, and all patients provided written informed consent. Our Objective is to compare the effect of PRM performed with inspiratory pressures of 30 cm H₂O and 40 cm H₂O on PLSP and related postoperative outcomes.

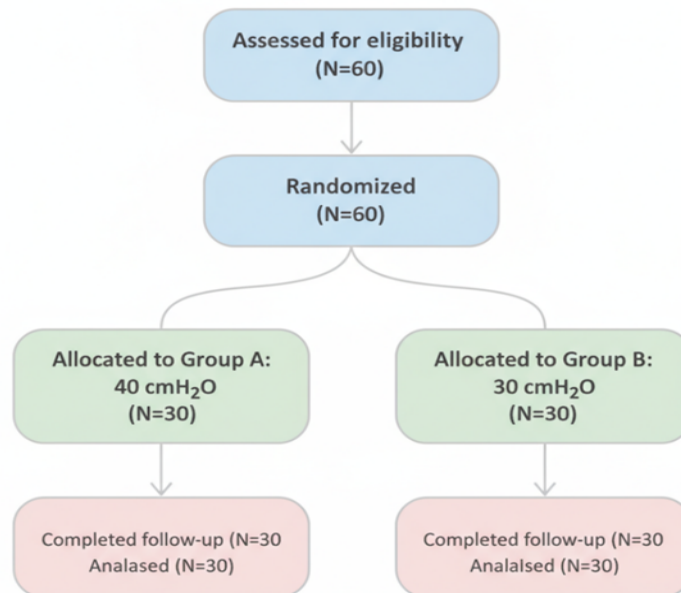
Address for Correspondence Dr. Prakash, Postgraduate, Institute of Anaesthesiology, Madurai Medical College, Madurai, Tamil Nadu, India.

DOI: 10.61336/im/25-12-35

This is an Open Access article under the terms of the Creative Commons Attribution-Noncommercial 4.0 International License (<https://creativecommons.org/licenses/by-nc/4.0/>)

A total of 60 adults aged 18 to 60 years undergoing elective laparoscopic surgery under general anaesthesia were recruited. Eligible participants were those classified as American Society of Anesthesiologists (ASA) physical status I or II. Exclusion criteria included conversion to open surgery, significant cardiovascular or respiratory illness, gastrointestinal or renal disease, pregnancy, or ASA class III or IV. Patients were randomised into two equal groups using a computer-generated sequence. Allocation was concealed using sealed opaque envelopes that were opened only after anaesthetic induction.

- Group A: Pulmonary recruitment manoeuvre (PRM) with inspiratory pressure of 40 cm H₂O, applied as six breaths over one minute in pressure control mode.
- Group B: PRM with inspiratory pressure of 30 cm H₂O applied using the same protocol.
-



All patients were induced with intravenous propofol and fentanyl and intubated facilitated by Succinylcholine and maintenance was achieved with oxygen-nitrous oxide mixture and sevoflurane and titrated doses of Atracurium and Fentanyl. Pneumoperitoneum was established with Carbon dioxide, with intra-abdominal pressure limited to 12 mmHg. At the end of surgery, inhalational agents were discontinued, ventilation with 100% oxygen was commenced, and the allocated PRM was performed. Residual carbon dioxide was actively exsufflated through laparoscopic ports before closure.

Patients were evaluated at 6, 12, 24, and 48 hours postoperatively for shoulder pain, wound pain, any complications like Extubation difficulties, laryngospasm, and bronchospasm and nausea and vomiting. Paracetamol 1 g IV was used as rescue medication. Mean arterial pressure (MAP) and respiratory rate (RR) were documented.

All Data were analysed with IBM SPSS version 21.0. Continuous variables were expressed as mean $\pm$ standard deviation and compared using independent t-tests or Mann-Whitney U tests depending on normality. Categorical variables were analysed using chi-square or Fisher's exact test. A p-value below 0.05 was considered significant.

Results

Demographic and clinical characteristics were comparable across the two groups, with no statistically significant differences in age, sex distribution, body mass index, ASA physical status, or type of laparoscopic procedure (Table 1).

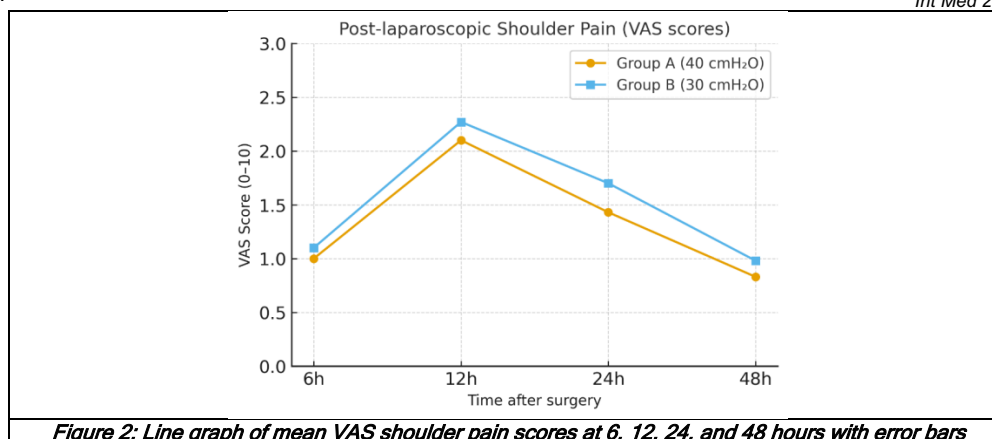
Variable	Group A (40 cm H ₂ O, n=30)	Group B (30 cm H ₂ O, n=30)	p-value
Age (years), mean $\pm$ SD	39.6 $\pm$ 10.2	38.9 $\pm$ 9.8	0.78
Sex (M/F)	14 / 16	13 / 17	0.79
BMI (kg/m ²), mean $\pm$ SD	24.8 $\pm$ 3.1	25.1 $\pm$ 3.4	0.71
ASA I / II	18 / 12	17 / 13	0.79
Laparoscopic cholecystectomy	20	19	0.82
Laparoscopic appendectomy	6	5	
Other laparoscopic procedures	4	6	

Table 1: Baseline demographic and clinical characteristics of participants

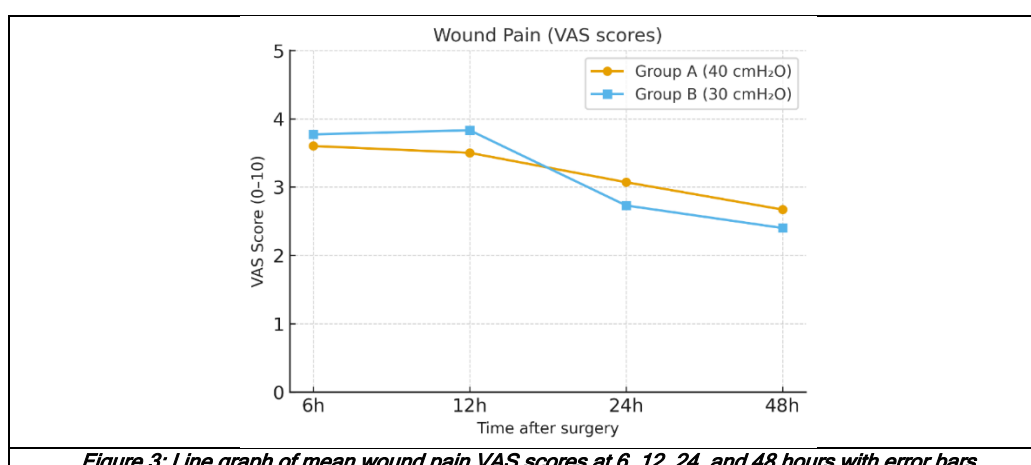
Both groups experienced **Post-Laparoscopic Shoulder Pain (PLSP)** low scores that declined steadily over 48 hours. Pain was numerically lower in the 40 cm H₂O group at each time point, but the differences were not statistically significant (Table 2).

Time point	Group A (40 cm H ₂ O)	Group B (30 cm H ₂ O)	p-value
6 h	1.00	1.10	0.646
12 h	2.10	2.27	0.483
24 h	1.43	1.70	0.305
48 h	0.83	0.98	0.163

Table 2: Post-laparoscopic shoulder pain (VAS scores)



Mean wound pain scores decreased over 48 hours in both groups and showed no significant differences at any time point (Table 3).



Time point	Group A (40 cm H ₂ O)	Group B (30 cm H ₂ O)	p-value
6 h	3.60	3.77	0.454
12 h	3.50	3.83	0.076
24 h	3.07	2.73	0.151
48 h	2.67	2.40	0.182

Table 3: Wound pain (VAS scores)

MAP differences were minimal [5.3 vs 5.1 mmHg immediately post-PRM ($p = 0.413$); 0.7 vs 0.6 mmHg at 15 minutes ($p = 0.348$)] between groups both immediately after PRM and at 15 minutes, with no statistical significance. Respiratory rate differences were also small [1.06 vs 1.10 at 15 minutes ($p = 0.268$); 1.6 vs 1.77 at 6 hours ($p = 0.454$); 2.4 vs 2.62 at 12 hours ($p = 0.076$); 1.2 vs 1.32 at 24 hours ($p = 0.151$); 1.3 vs 1.12 at 48 hours ($p = 0.182$) and did not differ significantly between groups.[fig: 4 & 5]

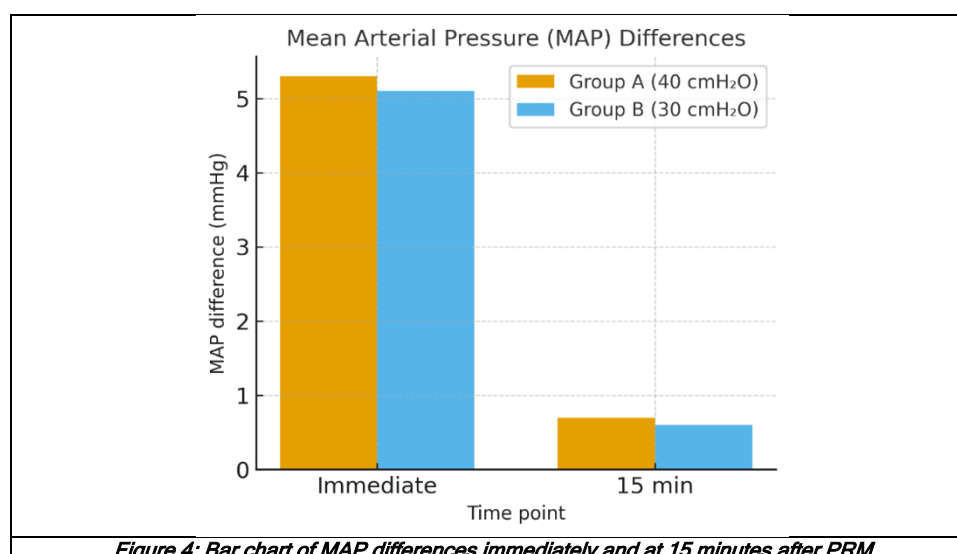


Figure 4: Bar chart of MAP differences immediately and at 15 minutes after PRM

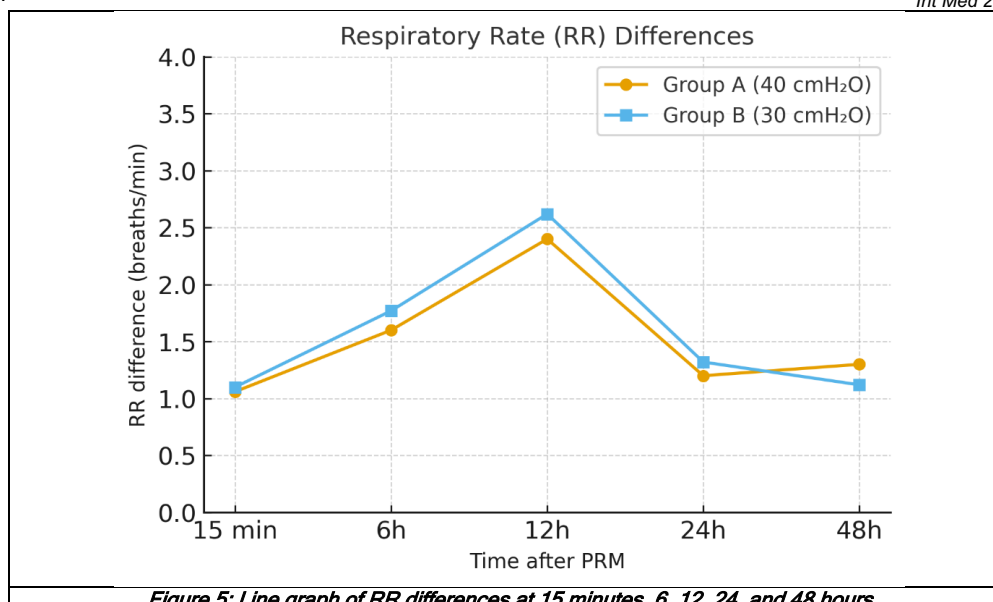


Figure 5: Line graph of RR differences at 15 minutes, 6, 12, 24, and 48 hours

No complications like nausea/vomiting, extubation difficulty, laryngospasm, bronchospasm, or barotrauma were observed in either group. No adverse events were attributable to PRM.

Discussion

Shoulder pain after laparoscopy remains common, with incidence reported as high as 80% [6]. The pain arises mainly from diaphragmatic irritation and phrenic nerve stimulation caused by residual gas. This randomized trial evaluated pulmonary recruitment manoeuvre (PRM) performed at 40 cm H₂O and 30 cm H₂O in patients undergoing laparoscopic surgery. Both strategies led to low levels of post-laparoscopic shoulder pain (PLSP), and the differences between groups did not reach statistical significance. Secondary outcomes, including wound pain, changes in mean arterial pressure and respiratory rate, as well as airway-related events, were also similar. Importantly, no complications were attributable to PRM in either group. Our study suggests that inspiratory pressure of 30 cm H₂O is adequate to achieve the analgesic benefits traditionally attributed to 40 cm H₂O. This observation supports the concept that the essential mechanism of PRM is clearance of residual carbon dioxide, and that this can be achieved without maximal pressure levels. Previous meta-analyses have shown that 40 cm H₂O PRM significantly decreases shoulder pain[6], but our data indicate that lowering the pressure does not reduce efficacy in otherwise healthy surgical patients. Similar findings were reported in a study where PRM, when combined with intraperitoneal bupivacaine, effectively reduced pain intensity.[2]

The present trial reinforces these observations and indicates that lower inspiratory pressure can achieve comparable pain relief. This has practical importance because it reassures clinicians that adequate analgesia can be obtained without subjecting patients to unnecessarily high intrathoracic pressures. In India, laparoscopic cholecystectomy and appendectomy represent a major proportion of routine elective surgeries. Quick recovery and timely discharge are particularly valued in busy public hospitals where turnover is high. Demonstrating that 30 cm H₂O PRM is as effective as 40 cm H₂O provides a safe, inexpensive, and easily implemented strategy for anaesthesiologists. Such an approach has the potential to improve patient comfort while reducing reliance on additional pharmacological interventions.

Strengths and Limitations

Strengths of the present work include its prospective randomized design, standardized anaesthetic protocol, and complete follow-up without attrition. Pain assessments were made using validated visual analogue scales, and haemodynamic variables were recorded systematically. There are, however, limitations. The study involved only 60 participants, which restricts its power to detect smaller differences. It was limited to ASA I-II adults, so applicability to higher-risk groups is uncertain. Being a single-centre study, external validity is also limited. Finally, while baseline characteristics were balanced, individual variability in age, sex, and BMI may still influence subjective pain scores. Larger multicentre trials would help to confirm these findings.

Future Research

Future studies should explore PRM at 30 cmH₂O in more diverse populations, including ASA III-IV patients and those undergoing longer or more complex laparoscopic procedures. Combining PRM with other intraoperative techniques, such as intraperitoneal local anaesthetic instillation or low-pressure pneumoperitoneum, may further enhance outcomes. Patient-reported recovery metrics, such as satisfaction and quality of recovery, should also be incorporated into future research.

Conclusion

Both 30 cm H₂O and 40 cm H₂O PRM significantly reduces shoulder pain after laparoscopic surgery, with no significant differences between groups. The findings suggest that a lower inspiratory pressure is sufficient for effective pain relief while avoiding unnecessary risks. Adoption of 30 cm H₂O PRM in routine anaesthetic practice may enhance patient comfort without additional interventions.

Source of funding: None.

Conflict of interest: None

References

- Alexander JI. Pain after laparoscopy. Br J Anaesth. 1997;79(3):369-78.
- Nakhro S, Verma R, Agarwal A, Maheshwari A, Sharma S. Effect of pulmonary recruitment maneuver and intraperitoneal bupivacaine on postoperative shoulder pain after laparoscopic cholecystectomy: a randomized comparative study. Asian J Med Sci. 2025;16(3):31-7.
- Güngördük K, Ascioglu O, Besimoglu B, Ark C. Effect of pulmonary recruitment maneuver on pain after minimally invasive gynecologic surgery: randomized controlled trial. Eur J Gynaecol Oncol. 2018;39(3):310-6.
- Yazdimoghaddam H, Karimi FZ, Navipour E, Gholami R, Zarenezhad A. Evaluation of interventions to reduce shoulder pain following laparoscopic surgery: a systematic review and meta-analysis. J Adv Med Biomed Res. 2023;31(147):294-315.
- Kang SH, Shin JH, Oh CS, Chung YJ, Lee DH. Effects of warmed, humidified carbon dioxide insufflation on postoperative pain after laparoscopic cholecystectomy: a meta-analysis. SurgEndosc. 2018;32(3):1120-30.

6. Deng X, Xie Y, Liu Y, Zhang D. Pulmonary recruitment maneuver reduces the intensity of shoulder pain after laparoscopic procedures: a meta-analysis of randomized controlled trials. *AnesthAnalg*. 2023;136(4):739-50.
7. Gurusamy KS, Junnarkar S, Farouk M, Davidson BR. Meta-analysis of randomized controlled trials on the safety and effectiveness of different strategies for preventing shoulder pain after laparoscopy. *SurgEndosc*. 2011;25(9):2896-906.
8. Arslan K, Ozdemir A, Ekin S, Cetinkaya MB. The effect of pulmonary recruitment maneuver on postoperative shoulder pain following laparoscopic cholecystectomy. *Bagcilar Med Bull*. 2025;10(1):32-9.
9. Imran S, Khan FA. Effect of different pulmonary recruitment maneuver pressures on postlaparoscopic shoulder pain: a randomized controlled trial. *Pak J Med Sci*. 2019;35(2):408-13.