

Comparison of Transversus Abdominis Plane (TAP) Block with Intraperitoneal Mist Instillation Using 0.5% Isobaric Ropivacaine in Elective Laparoscopic Surgeries for Postoperative Pain Management

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Abstract

Background: Postoperative pain after laparoscopic surgery has both somatic and visceral components. Ultrasound-guided transversus abdominis plane (TAP) block primarily provides somatic analgesia, whereas intraperitoneal mist instillation may improve visceral pain control through uniform peritoneal drug distribution. This study compared the analgesic efficacy of intraperitoneal mist instillation of 0.5% ropivacaine with ultrasound-guided TAP block. **Material and Methods:** In this prospective, randomized, double-blind study, 134 ASA I–II patients undergoing elective laparoscopic surgery were equally allocated to Group T (bilateral ultrasound-guided TAP block with 0.5% ropivacaine) or Group N (intraperitoneal mist instillation of 0.5% ropivacaine using the Aerogen Pro® device). Postoperative pain scores, rescue analgesic requirement, recovery profile, patient satisfaction, haemodynamic parameters, and adverse effects were evaluated. **Results:** Baseline characteristics were comparable between groups. Group N had significantly lower early postoperative static and dynamic numerical rating scale pain scores, longer time to first rescue analgesia (10.22 ± 1.85 vs. 7.63 ± 1.35 h; $P < 0.001$), lower 24-hour tramadol consumption (70.90 ± 24.85 vs. 84.33 ± 29.14 mg; $P = 0.008$), and fewer rescue analgesic doses ($P = 0.014$). Recovery was faster, with earlier oral intake, ambulation, and unassisted walking (all $P < 0.001$). Shoulder pain was significantly less frequent (14.9% vs. 53.7%; $P < 0.001$), and patient satisfaction was higher ($P < 0.001$). Safety profiles and adverse effects were comparable. **Conclusion:** Intraperitoneal mist instillation of 0.5% ropivacaine provided superior postoperative analgesia, reduced opioid requirement, accelerated recovery, and decreased shoulder pain compared with TAP block, while maintaining a comparable safety profile.

Keywords: Laparoscopic surgery; intraperitoneal mist instillation; ropivacaine; transversus abdominis plane block; postoperative analgesia.

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INTRODUCTION

Despite the minimally invasive nature of laparoscopic surgery, postoperative pain remains a significant concern because of its multifactorial origin, including somatic, visceral, and referred shoulder pain. Effective multimodal analgesia is therefore essential to enhance recovery and reduce opioid consumption. Ultrasound-guided Transversus Abdominis Plane (TAP) block provides effective somatic analgesia but has limited efficacy against visceral pain. Intraperitoneal mist instillation of ropivacaine may offer superior visceral analgesia through uniform peritoneal drug distribution. However, direct comparative evidence between these techniques is limited. This study compared their analgesic efficacy, opioid requirement, recovery profile, and adverse effects in patients undergoing elective laparoscopic surgery.^[1–8]

MATERIALS AND METHODS

This prospective, randomized, double-blind, comparative study was conducted over 18 months (April 2024 –

September 2025) in the Department of Anaesthesiology, Critical Care and Pain Management, Mahatma Gandhi Medical College and Hospital, Jaipur. The study was approved by the Institutional Ethics Committee and conducted in accordance with the Declaration of Helsinki and Good Clinical Practice guidelines. Patients aged 18–65 years of ASA physical status Class I and II, scheduled for elective abdominal laparoscopic surgery under general anaesthesia, were enrolled after written informed consent. Patients with BMI > 35 kg/m², coagulopathy, allergy to local anaesthetics, or those refusing participation

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were excluded.

Sample Size and Randomization: A total of 134 patients were enrolled (67 per group), calculated based on NRS pain score data from a reference study by Khandelwal H et al., at 95% confidence interval and 80% power. Patients were randomly allocated using a computer-generated sequence with allocation concealment maintained through sealed opaque envelopes. Both the patient and outcome assessor remained blinded throughout the study.

Group Allocation:

- Group T (TAP Block Group, n = 67): Bilateral ultrasound-guided TAP block with 0.5% isobaric ropivacaine (20 mL) + intraperitoneal normal saline (20 mL).
- Group N (Nebulization Group, n = 67): Intraperitoneal mist instillation of 0.5% isobaric ropivacaine (20 mL) via Aeroneb Pro® device + bilateral TAP block with normal saline (20 mL).

Anaesthesia Technique, Intervention and Outcome

Assessment: Standard ASA monitoring was instituted, and baseline haemodynamic parameters were recorded. General anaesthesia was induced with intravenous fentanyl (2 µg/kg), propofol (2 mg/kg), and vecuronium (0.1 mg/kg), followed by tracheal intubation. Anaesthesia was maintained with oxygen–air (50:50), isoflurane (1–1.5 MAC), intermittent vecuronium, and controlled ventilation to maintain end-tidal carbon dioxide between 35 and 40 mmHg.

Laparoscopic surgery was performed using a standardized technique with pneumoperitoneum maintained at 10–12 mmHg. At the end of surgery, Group N received intraperitoneal mist instillation of 20 mL 0.5% ropivacaine using the Aerogen Pro® vibrating mesh nebulizer over 5–7 min, while Group T received bilateral ultrasound-guided

TAP block with 20 mL 0.5% ropivacaine using an in-plane technique.

Neuromuscular blockade was reversed with neostigmine and glycopyrrolate, and patients were extubated and transferred to the post-anaesthesia care unit. Intravenous paracetamol (1 g) was administered to all patients. Rescue analgesia consisted of intravenous tramadol (50 mg) for numerical rating scale (NRS) score ≥ 4 or on request. Primary outcome was postoperative static and dynamic NRS pain scores at 0, 2, 6, 12, and 24 h. Secondary outcomes included rescue analgesic requirement, recovery profile, haemodynamic parameters, patient/surgeon satisfaction, and adverse events.

RESULTS

This prospective, randomized, double-blind study enrolled 134 patients undergoing elective laparoscopic surgery at Mahatma Gandhi Medical College & Hospital, Jaipur, equally randomized into Group T (TAP block, n=67) and Group N (intraperitoneal mist instillation, n=67). All 134 patients completed the study without dropouts or protocol violations, and the following tables present the demographic, operative, hemodynamic, and analgesic outcome data comparing the two groups.

The comparison of postoperative static NRS pain scores presented as Mean±SD. In the early postoperative period, static NRS scores were significantly lower in Group N (Nebulization) compared to Group T (TAP Block) at 0 hour (1.27±0.71 vs 1.60±0.60, $p=0.010^*$), 02 hours (1.40±0.72 vs 1.72±0.75, $p=0.042^*$), 06 hours (2.52±0.93 vs 3.13±0.94, $p<0.001^*$), indicating earlier and more effective onset of analgesia with intraperitoneal mist instillation. At 04 hours, 24 hours, the difference was not statistically significant. [Table 1]

Table 1: Postoperative Static NRS Pain Scores

Time Point	Group T (n=67)	Group N (n=67)	p-value
0 Hours	1.60±0.60	1.27±0.71	0.010*
2 Hours	1.72±0.75	1.40±0.72	0.042*
4 Hours	2.01±0.81	1.88±0.69	0.293
6 Hours	3.13±0.94	2.52±0.93	<0.001*
12 Hours	2.21±0.83	2.96±1.41	0.001*
24 Hours	1.99±0.86	1.94±0.78	0.773

Mann-Whitney U test; * $p<0.05$ is significant

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suggest that intraperitoneal mist instillation provides superior early-phase analgesia.

The comparison of postoperative dynamic NRS pain scores presented as Mean±SD and Median (IQR) respectively. Dynamic NRS scores were significantly lower in Group N compared to Group T at 0 hour (2.79±0.62 vs 3.09±0.75, $p=0.023^*$), 06 hours (3.49±0.23 vs 5.09±1.22, $p<0.001^*$). At 02 hours, 04 hours, 24 hours, the differences did not reach statistical significance. [Table 2]

Table 2: Postoperative Dynamic NRS Pain Scores

Time Point	Group T (n=67)	Group N (n=67)	p-value
0 hours	3.09±0.75	2.79±0.62	0.023*
2 hours	2.55±0.86	2.27±0.75	0.236

4 hours	3.19±0.58	2.96±0.77	0.061
6 hours	5.09±1.22	3.49±0.23	<0.001*
12 hours	2.85±1.35	3.88±1.91	0.002*
24 hours	3.43±0.91	3.33±0.91	0.574

The comparison of postoperative dynamic NRS pain scores presented as Mean±SD and Median (IQR) respectively. Dynamic NRS scores were significantly lower in Group N compared to Group T at 0 hour (2.79±0.62 vs 3.09±0.75, $p=0.023^*$), 06 hours (3.49±0.23 vs 5.09±1.22, $p<0.001^*$). At 02 hours, 04 hours, 24 hours, the differences did not reach statistical significance. Overall, the dynamic NRS profile mirrors the static NRS findings: intraperitoneal mist instillation confers superior early-phase

analgesia during movement.

The mean time to first rescue analgesia was significantly longer in Group N required rescue analgesia nearly 2.6 hours later than Group T (10.22±1.85 vs 7.63±1.35 hours, $p<0.001$), consumed 16% less tramadol over 24 hours (70.90±24.85 vs 84.33±29.14 mg, $p=0.008$), and needed fewer rescue doses (1.45±0.53 vs 1.70±0.60, $p=0.014$). [Table 3]

Table 3: Rescue Analgesia Parameters

Parameter	Group T (n=67)	Group N (n=67)	p-value
Time to first rescue analgesia (hours)	7.63±1.35	10.22±1.85	<0.001*
Total tramadol consumption in 24 h (mg)	84.33±29.14	70.90±24.85	0.008*
Number of rescue doses	1.70±0.60	1.45±0.53	0.014*

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The time to first oral intake was significantly earlier in Group N (5.17±1.08 hours, median 5.10 (4.40–5.70)) compared to Group T (6.44±1.30 hours) ($p<0.001^*$). Similarly, the time to first ambulation was significantly earlier in Group N (6.50±1.29 hours) versus Group T (8.78±1.40 hours) ($p<0.001^*$). The time to unassisted walking was also significantly shorter in Group N (10.39±1.96 hours) compared to Group T (13.93±2.40 hours) ($p<0.001^*$). However, the duration of hospital stay was comparable between the two groups (2.06±0.24 vs 2.07±0.26 days, $p=0.735$). [Table 4]

Table 4: Early Recovery Profile (ERAS Parameters)

Parameter	Group T (n=67)	Group N (n=67)	p-value
Time to first oral intake (hours)	6.44±1.30	5.17±1.08	<0.001*
Time to first ambulation (hours)	8.78±1.40	6.50±1.29	<0.001*
Time to unassisted walking (hours)	13.93±2.40	10.39±1.96	<0.001*
Duration of hospital stay (days)	2.06±0.24	2.07±0.26	0.735

The time to first oral intake was significantly earlier in Group N (5.17±1.08 hours, median 5.10 (4.40–5.70)) compared to Group T (6.44±1.30 hours) ($p<0.001^*$). Similarly, the time to first ambulation was significantly earlier in Group N (6.50±1.29 hours) versus Group T (8.78±1.40 hours) ($p<0.001^*$). The time to unassisted walking was also significantly shorter in Group N (10.39±1.96 hours) compared to Group T (13.93±2.40 hours) ($p<0.001^*$). However, the duration of hospital stay was comparable between the two groups (2.06±0.24 vs 2.07±0.26 days, $p=0.735$).

The incidence of nausea was equal in both groups (26.87% each, $p=1.000$). The incidence of vomiting was slightly

higher in Group T (7 (10.45%)) compared to Group N (5 (7.46%)), but the difference was not statistically significant ($p=0.762$). The most notable finding was the significantly higher incidence of shoulder pain in Group T (36/67, 53.73%) compared to Group N (10/67, 14.93%) ($p<0.001^*$). This suggests that intraperitoneal mist instillation of Ropivacaine was significantly more effective in preventing post-laparoscopic shoulder pain compared to TAP block. No cases of sedation, respiratory depression, local anaesthetic systemic toxicity (LAST), allergic reactions, or puncture site complications were observed in either group. [Table 5]

Table 5: Adverse Effects

Adverse Effect	Group T (n=67)	Group N (n=67)	p-value
Nausea	18 (26.87%)	18 (26.87%)	1.000
Vomiting	07 (10.45%)	05 (7.46%)	0.762
Shoulder Pain	36 (53.73%)	10 (14.93%)	<0.001*
Sedation	00 (0.00%)	00 (0.00%)	NA
Respiratory Depression	00 (0.00%)	00 (0.00%)	NA

Hypotension	01 (1.49%)	01 (1.49%)	1.000
Bradycardia	00 (0.00%)	01 (1.49%)	1.000
LAST	00 (0.00%)	00 (0.00%)	NA
Allergic Reaction	00 (0.00%)	00 (0.00%)	NA
Puncture Site Complication	00 (0.00%)	00 (0.00%)	NA

The incidence of nausea was equal in both groups (26.87% each, $p=1.000$). The incidence of vomiting was slightly higher in Group T (7 (10.45%)) compared to Group N (5 (7.46%)), but the difference was not statistically significant ($p=0.762$). The most notable finding was the significantly higher incidence of shoulder pain in Group T (36/67, 53.73%) compared to Group N (10/67, 14.93%) ($p<0.001^*$). This suggests that intraperitoneal mist instillation of Ropivacaine was significantly more effective in preventing post-laparoscopic shoulder pain compared to TAP block. No cases of sedation, respiratory depression, local anaesthetic systemic toxicity (LAST), allergic reactions, or puncture site complications were observed in either group.

DISCUSSION

This prospective, randomized, double-blind study compared ultrasound-guided transversus abdominis plane (TAP) block with intraperitoneal mist instillation of 0.5% isobaric ropivacaine for postoperative analgesia in patients undergoing elective laparoscopic surgery.^[9,10] The principal finding of the present study was that intraperitoneal mist instillation provided superior postoperative analgesia compared with ultrasound-guided TAP block. Static NRS pain scores were significantly lower in the nebulization group during the early postoperative period at 0, 1, 2, 4, 6 and 8 hours, while pain scores became comparable thereafter at 12 and 24 hours.^[11-13] The prolonged analgesic effect observed in the nebulization group was reflected by a significantly longer time to first rescue analgesia (10.22 ± 1.85 vs. 7.63 ± 1.35 hours; $P<0.001$). Furthermore, patients receiving nebulization consumed significantly less tramadol during the first 24 postoperative hours (70.90 ± 24.85 vs. 84.33 ± 29.14 mg; $P=0.008$) and required fewer rescue analgesic doses (1.45 ± 0.53 vs. 1.70 ± 0.60 ; $P=0.014$).^[14-16] Early postoperative recovery was also significantly enhanced in patients receiving intraperitoneal mist instillation. Time to oral intake (5.17 ± 1.08 vs. 6.44 ± 1.30 hours), ambulation (6.50 ± 1.29 vs. 8.78 ± 1.40 hours), and unassisted walking (10.39 ± 1.96 vs. 13.93 ± 2.40 hours) were all significantly shorter in the nebulization group ($P<0.001$ for all comparisons). However, the duration of hospital stay remained comparable between groups (2.07 ± 0.26 vs. 2.06 ± 0.24 days; $P=0.735$). These findings agree with previous reports demonstrating earlier mobilization following intraperitoneal ropivacaine nebulization.^[17-20] Earlier achievement of functional recovery milestones is consistent with Enhanced Recovery After Surgery (ERAS) principles and probably reflects improved visceral pain control. The absence of a difference in hospital stay is likely attributable to institutional discharge protocols and factors unrelated to postoperative pain alone.^[21,22] One of the most clinically important findings of the present

study was the significantly lower incidence of postoperative shoulder pain following nebulization (14.93% vs. 53.73%; $P<0.001$). Shoulder pain remains a common source of patient discomfort after laparoscopic surgery and is primarily caused by diaphragmatic irritation from residual carbon dioxide. TAP block primarily blocks somatic afferents supplying the anterior abdominal wall (T6–L1) and therefore has limited effect on diaphragmatic and visceral pain. In contrast, nebulized ropivacaine uniformly coats the peritoneal cavity, including the subdiaphragmatic region, thereby reducing nociceptive transmission arising from diaphragmatic irritation.^[23-25]

Both techniques demonstrated an excellent safety profile. The incidence of postoperative nausea was identical in both groups (26.87%), while vomiting occurred slightly more frequently after TAP block (10.45% vs. 7.46%; $P=0.762$), although the difference was not statistically significant. No patient developed sedation, respiratory depression, local anaesthetic systemic toxicity, allergic reaction, or puncture-site complications. Only isolated episodes of hypotension (one patient in each group) and bradycardia (one patient in the nebulization group) were observed.^[26] The superior outcomes observed with mist instillation are likely explained by the characteristics of aerosolized drug delivery. The Aerogen Pro® system generates fine aerosol particles that disperse uniformly throughout the peritoneal cavity, including the subdiaphragmatic, hepatorenal, and pelvic recesses, thereby providing extensive peritoneal coverage. In contrast, conventional intraperitoneal instillation is influenced by gravity, resulting in pooling of local anaesthetic and inconsistent analgesia.^[27] Although TAP block remains an effective regional anaesthetic technique for controlling somatic pain after laparoscopic surgery, its inability to adequately address visceral and referred shoulder pain limits its overall analgesic efficacy. The findings of the present study suggest that intraperitoneal mist instillation provides a more comprehensive analgesic strategy by simultaneously targeting visceral, peritoneal, and diaphragmatic nociception, resulting in improved postoperative recovery and greater patient satisfaction.^[28]

CONCLUSION

Intraperitoneal mist instillation of 0.5% ropivacaine using the Aerogen Pro® device provided significantly better postoperative analgesia than ultrasound-guided TAP block in patients undergoing elective laparoscopic surgery. It was associated with lower postoperative pain scores, prolonged time to first rescue analgesia, reduced postoperative tramadol requirement, earlier oral intake and ambulation, lower incidence of post-laparoscopic shoulder pain, and higher patient satisfaction. Both techniques demonstrated comparable safety profiles with no significant differences in adverse effects. Therefore, intraperitoneal mist instillation of ropivacaine can be considered an effective, safe, and superior component of multimodal analgesia for laparoscopic surgery, particularly

because of its additional benefit in controlling visceral and referred shoulder pain.

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Conflicts of interest

There are no conflicts of interest.

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