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A Comparative Study between Soda- Bicarbonate and Lignocaine Via Intra- Peritoneal Irrigation in Reducing Post-Operative Shoulder Tip Pain in Patients Undergoing Laparoscopic Cholecystectomy

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KEYWORDS

Laparoscopic cholecystectomy, Shoulder tip pain, Sodium bicarbonate, Lignocaine, Intraperitoneal irrigation, Postoperative pain management.

ABSTRACT:

Background: Post-operative shoulder tip pain is a common complaint after laparoscopic cholecystectomy and is mainly attributed to diaphragmatic irritation caused by residual carbon dioxide pneumoperitoneum. Various intraperitoneal agents have been used to minimise this discomfort. This study aimed to compare the effectiveness of sodium bicarbonate and lignocaine administered via intraperitoneal irrigation in reducing postoperative shoulder tip pain.

Methods: This prospective, randomised comparative study was conducted in the Department of General Surgery at Integral Institute of Medical Sciences and Research (IIMS&R), Lucknow, over 18 months. A total of 100 patients undergoing elective laparoscopic cholecystectomy were randomly divided into two groups (n=50 each). Group A received 50 ml of 7.5% sodium bicarbonate diluted in 1000 ml normal saline, while Group B received 10 ml of 2% lignocaine diluted to 50 ml with normal saline for intraperitoneal irrigation. Postoperative pain was assessed using the Visual Analog Scale (VAS) at 6, 18, and 24 hours and at 1 week postoperatively. Incidence of shoulder tip pain, port-site pain, rescue analgesic requirement, and adverse effects were also recorded. Statistical analysis was performed using SPSS version 26.0, with $p<0.05$ considered significant.

Results: Baseline demographic and operative parameters were comparable between both groups. The incidence of shoulder tip pain was lower in the sodium bicarbonate group (60%) compared to the lignocaine group (72%). Mean shoulder pain VAS scores were significantly lower in Group A at 6 hours (3.2±1.1 vs 3.8±1.3; p=0.014), 18 hours (2.5±0.9 vs 3.1±1.0; p=0.002), and 24 hours (1.8±0.7 vs 2.4±0.9; $p<0.001$). Port-site pain was also lower in the sodium bicarbonate group at 18 and 24 hours. Rescue analgesic requirement was significantly reduced in Group A during the first 24 hours. Adverse effects were minimal and comparable in both groups.

Conclusion: Intraperitoneal irrigation effectively reduces postoperative pain after laparoscopic cholecystectomy. Sodium bicarbonate was more effective than lignocaine in reducing postoperative shoulder tip pain and early analgesic requirement, while both agents were safe and well tolerated. Incorporating sodium bicarbonate irrigation may improve postoperative recovery and patient comfort following laparoscopic cholecystectomy.

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INTRODUCTION

Laparoscopic cholecystectomy is the gold-standard surgical procedure for the management of symptomatic cholelithiasis because of its advantages over open surgery, including reduced postoperative pain, shorter hospital stay, earlier ambulation, and faster recovery (1). Despite these benefits, postoperative shoulder tip pain remains a frequent and distressing complaint after laparoscopic procedures. The reported incidence ranges from 35% to 80% of patients and is often more bothersome than incisional pain during the early postoperative period (2).

The etiology of shoulder tip pain after laparoscopy is multifactorial. It is primarily attributed to diaphragmatic irritation caused by residual carbon dioxide (CO_2) used to create pneumoperitoneum. Carbon dioxide dissolves in peritoneal fluid forming carbonic acid, which irritates the phrenic nerve endings on the diaphragmatic peritoneum. This irritation produces referred pain perceived in the shoulder via the C3–C5 dermatomes (3,4). In addition, peritoneal stretching, tissue manipulation, and inflammatory mediators released during surgery further contribute to postoperative discomfort (5).

Various strategies have been investigated to reduce post-laparoscopic shoulder pain, including low-pressure pneumoperitoneum, active gas evacuation, warm and humidified CO_2, intraperitoneal saline irrigation, and local anesthetic instillation (6). Among these, intraperitoneal irrigation is simple, safe, inexpensive, and easily reproducible. It reduces pain by removing residual CO_2 and inflammatory substances and by minimizing peritoneal irritation (7).

Sodium bicarbonate has been studied as an intraperitoneal irrigation agent because of its buffering action. By neutralizing carbonic acid formed from dissolved CO_2, it decreases peritoneal acidity and reduces diaphragmatic irritation, thereby alleviating referred shoulder pain (8). On the other hand, lignocaine (lidocaine), a widely used local anesthetic, blocks voltage-gated sodium channels and inhibits nerve impulse transmission. Intraperitoneal lignocaine provides visceral analgesia by anesthetizing peritoneal nociceptors and reducing inflammatory response (9).

Several clinical trials have shown that intraperitoneal instillation of local anesthetics can significantly reduce postoperative pain and analgesic requirement following laparoscopic surgeries (10). However, limited studies have directly compared the analgesic effectiveness of sodium bicarbonate and lignocaine irrigation in laparoscopic cholecystectomy. Determining the more effective agent could help improve postoperative comfort and facilitate early recovery and discharge.

Therefore, the present study was undertaken to compare the effectiveness of intra-peritoneal sodium bicarbonate and lignocaine irrigation in reducing postoperative shoulder tip pain in patients undergoing laparoscopic cholecystectomy.

MATERIALS AND METHODS

Study Design and Setting

This prospective, randomized, comparative study was conducted in the Department of General Surgery, Integral Institute of Medical Sciences and Research (IIMS&R), Lucknow, India, over a period of 18 months after obtaining approval from the Institutional Ethics Committee. The study was designed to evaluate the effectiveness of intra-peritoneal irrigation with sodium bicarbonate and lignocaine in reducing postoperative shoulder tip pain following laparoscopic cholecystectomy.

Study Population and Sample Size

A total of 100 patients diagnosed with cholelithiasis and scheduled for elective laparoscopic cholecystectomy were enrolled. Participants were randomly divided into two groups of 50 patients each using permutation block randomization.

Sample Size Estimation

The sample size was calculated using the formula for comparison of two means for continuous variables (Visual Analog Scale pain scores):

$$n = 2(Z_{\alpha/2} + Z_{\beta})^2\sigma^2/\Delta^2$$

Where:

- **n** = sample size per group
- **$Z_{\alpha/2}$** = 1.96 (95% confidence level)
- **Z_{β}** = 0.84 (80% power)
- **σ** = estimated standard deviation of VAS score (assumed 1.5)
- **Δ** = minimum clinically significant difference (assumed 1.0)

The calculated minimum sample size was 36 patients per group. To compensate for possible dropouts, the

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sample size was increased to 50 patients in each group (total n = 100).

Inclusion Criteria

- Patients aged >12 years and ≤70 years.
- Patients diagnosed with cholelithiasis planned for elective laparoscopic cholecystectomy.
- Patients willing to participate and provide written informed consent.

Exclusion Criteria

- Age <12 years or >70 years.
- Known allergy to lignocaine or sodium bicarbonate.
- Chronic use of opioids, steroids, NSAIDs, or alcohol.
- Carcinoma gallbladder.
- Acute cholecystitis with cholelithiasis.
- Conversion to open cholecystectomy.
- Gangrenous or empyematous gallbladder.
- Gallbladder rupture, bile leakage, or significant intraoperative bleeding causing peritoneal irritation.

Randomisation and Study Groups

Participants were randomly allocated into two groups:

Group A (Sodium Bicarbonate Group):
Received 50 ml of 7.5% sodium bicarbonate diluted in 1000 ml of normal saline as intra-peritoneal irrigation.

Group B (Lignocaine Group):
Received 10 ml of 2% lignocaine diluted with normal saline to a total volume of 50 ml as intraperitoneal irrigation.

Surgical Procedure

All patients underwent laparoscopic cholecystectomy using a standardised four-port technique under general anaesthesia.

1. Pneumoperitoneum was created using carbon dioxide with intra-abdominal pressure maintained at 12–14 mmHg.
2. The gallbladder was dissected and removed via the umbilical port.
3. After removal, the allocated irrigation solution was instilled into the peritoneal cavity and evenly distributed by placing the patient in Trendelenburg and reverse Trendelenburg positions.
4. The solution was subsequently suctioned completely, and the procedure was completed.

Postoperative Analgesia

All patients received a standardized postoperative analgesic regimen:

- Intravenous paracetamol 1 g every 8 hours for the first 24 hours.
- Rescue analgesics were administered when required and recorded.

Pain Assessment

Pain intensity was assessed using the **Visual Analog Scale (VAS)** at the following time intervals:

- 6 hours postoperatively
- 18 hours postoperatively
- 24 hours postoperatively
- One week postoperatively (follow-up visit)

Pain was evaluated at multiple anatomical sites:

- Three port-site incisions (umbilical, epigastric, and subcostal)
- Left and right shoulder tips
- Inter-scapular region
- Subscapular areas (left and right)

Data Collection

Demographic variables, operative details (duration of surgery, pneumoperitoneum pressure and time), VAS pain scores, requirement of rescue analgesics, and adverse effects were recorded using a structured proforma.

Outcome Measures

Primary Outcome:

- Reduction in postoperative shoulder tip pain intensity measured by VAS.

Secondary Outcomes:

- Incidence of postoperative shoulder tip pain.

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- Requirement of rescue analgesics.
- Adverse effects related to irrigation solutions.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. One-way ANOVA was used for comparison of continuous variables such as age and pain scores. Fisher's exact test was applied for categorical variables. Pain scores were compared across different anatomical sites and time points between the two groups. A p-value <0.05 was considered statistically significant.

Ethical Considerations

Ethical clearance was obtained from the Institutional Ethics Committee before commencement of the study. Written informed consent was obtained from all participants. Confidentiality of patient information was maintained throughout the study.

RESULTS AND OBSERVATIONS;

The distribution of patients in the study showed that Group A (Soda-Bicarbonate) and Group B (Lignocaine) each comprised 50 patients, representing 50.0% of the total 100 participants.

Table 1: Distribution of studied patients among both groups

Groups	No of patients	Percentage
Group A (Soda-Bicarbonate)	50	50.0%
Group B (Lignocaine)	50	50.0%

Table 2: Distribution of the studied patients based on age group

Age (In Years)	Group A (n=50) (%)	Group B (n=50) (%)	p-value
12–25	3 (6.0%)	2 (4.0%)	0.862
26–50	33 (66.0%)	35 (70.0%)	
51–70	14 (28.0%)	13 (26.0%)	
Age (years) (Mean ± SD)	45.2 ± 12.3	46.1 ± 11.8	0.709
BMI (kg/m²) (Mean ± SD)	26.4 ± 4.1	25.9 ± 3.9	0.533

Table 3: Distribution of the studied patients based on Gender

Gender	Group A (n=50) (%)	Group B (n=50) (%)	p-value
Male	20 (40.0%)	22 (44.0%)	0.685
Female	30 (60.0%)	28 (56.0%)	

Table 4: Comparison of patients based on Operative Parameters in both groups

Operative Parameters	Group A (n=50) (Mean±SD)	Group B (n=50) (Mean±SD)	p-value
Duration of Surgery (min)	52.3 ± 10.5	50.8 ± 9.8	0.462
Pneumoperitoneum Time (min)	49.5 ± 11.2	48.2 ± 10.7	0.554

Table 5: Distribution of studied patients based on the Incidence of Shoulder Tip Pain among both groups

Incidence of Shoulder Tip Pain	Group A (n=50) (%)	Group B (n=50) (%)	p-value
Yes	30 (60.0%)	36 (72.0%)	0.073
No	20 (40.0%)	14 (38.0%)	

Table 6: Comparison of patients based on VAS Score (Shoulder Tip) in both groups

Time Point	Group A (n=50) (Mean±SD)	Group B (n=50) (Mean±SD)	p-value
6 hours	3.2 ± 1.1	3.8 ± 1.3	**0.014**
18 hours	2.5 ± 0.9	3.1 ± 1.0	**0.002**

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24 hours	1.8 ± 0.7	2.4 ± 0.9	**<0.001**
1 week	0.4 ± 0.3	0.6 ± 0.7	0.066

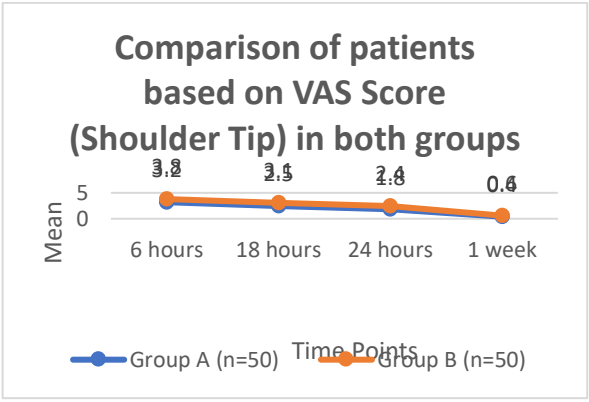

Figure 1: Comparison of patients based on VAS Score (Shoulder Tip) in both groups

Table 7: Comparison of patients based on VAS Score (Port Sites) in both groups

Time Point	Group A (n=50) (Mean±SD)	Group B (n=50) (Mean±SD)	p-value
6 hours	4.1 ± 1.2	4.5 ± 1.40	0.128
18 hours	3.3 ± 1.0	3.7 ± 0.97	**0.045**
24 hours	2.6 ± 0.8	3.0 ± 0.90	**0.020**
1 week	0.8 ± 0.4	1.0 ± 0.66	0.069

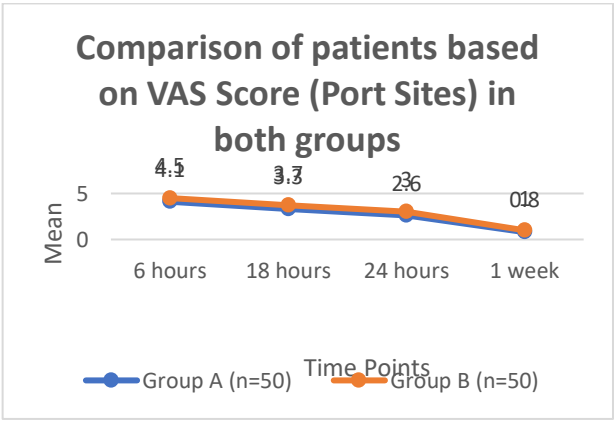

Figure 2: Comparison of patients based on VAS Score (Port Sites) in both groups

Table 8: Distribution of studied patients based on Rescue Analgesic Use among both groups at different time points

Time Point	Group A (n=50) (%)	Group B (n=50) (%)	p-value
1st hour	15 (30%)	22 (44%)	0.108
1–8 hours	30 (60%)	39 (78%)	**0.035**
8–16 hours	20 (40%)	29 (58%)	0.059
16–24 hours	10 (20%)	19 (38%)	**0.042**

Table 9: Distribution of studied patients based on Adverse Effects among both groups

Adverse Effects	Group A (n=50) (%)	Group B (n=50) (%)	p-value
Nausea	4 (8.0%)	5 (10.0%)	0.726
Vomiting	2 (4.0%)	0 (0.0%)	0.153
Dizziness	0 (0.0%)	3 (6.0%)	0.078

DISCUSSION

Although laparoscopic cholecystectomy is considered minimally invasive, postoperative pain continues to be a significant clinical problem, particularly during the first 24 hours. The pain is characteristically divided into parietal (port-site), visceral (intra-abdominal), and referred shoulder tip pain. Among these, shoulder tip pain is unique to laparoscopic surgery and is mainly attributed to irritation of the diaphragmatic peritoneum by residual carbon dioxide (CO_2) pneumoperitoneum (11). Carbon dioxide rapidly diffuses across the peritoneum and forms carbonic acid, lowering the intraperitoneal pH and stimulating phrenic nerve afferents (C3–C5), producing referred pain in the shoulder (12).

The present study evaluated intraperitoneal irrigation as a simple intraoperative intervention to reduce postoperative shoulder pain. Peritoneal lavage has been shown to remove retained CO_2 bubbles and inflammatory mediators such as prostaglandins and bradykinin, thereby decreasing diaphragmatic irritation (13). Active evacuation of pneumoperitoneum and washing of the subdiaphragmatic space have been consistently associated with lower pain scores and

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reduced analgesic consumption in the early postoperative period.

Sodium bicarbonate irrigation acts by correcting intraperitoneal acidosis produced by dissolved CO_2. Neutralization of carbonic acid increases peritoneal pH and reduces chemical stimulation of the phrenic nerve endings (14). Experimental and clinical studies have demonstrated a direct relationship between peritoneal acidosis and severity of postoperative shoulder pain (15). In the present study, patients receiving sodium bicarbonate irrigation demonstrated lower shoulder pain scores, especially during the first postoperative hours, supporting the hypothesis that chemical irritation of the diaphragm is a major contributor to referred pain after laparoscopy.

Lignocaine produces analgesia through a different mechanism. It blocks voltage-gated sodium channels in peripheral nociceptive fibers, inhibiting initiation and propagation of action potentials (16). Intraperitoneal administration allows diffusion across the peritoneum, producing visceral analgesia and attenuation of local inflammatory response. Previous clinical trials and systematic reviews have shown that intraperitoneal local anesthetics significantly reduce early postoperative pain and opioid requirement following laparoscopic procedures (17,18). In our study, lignocaine irrigation provided better relief of generalized abdominal discomfort and reduced requirement of rescue analgesics, indicating effective visceral pain control.

The comparative findings suggest that the two agents target different pathophysiological components of post-laparoscopic pain. Sodium bicarbonate primarily reduces diaphragmatic irritation caused by carbonic acid and, therefore, is more effective for shoulder tip pain, whereas lignocaine acts on neural transmission of nociceptive impulses and provides broader visceral analgesia. Similar observations have been reported in prior laparoscopic studies where buffering solutions improved referred pain while local anaesthetics improved overall pain perception (19).

Adequate postoperative analgesia is important not only for patient comfort but also for early mobilisation, prevention of pulmonary complications, and early oral intake. Effective pain control decreases opioid requirement, thereby minimising opioid-related adverse effects such as nausea, vomiting, and delayed recovery (20). Intraperitoneal irrigation is particularly advantageous because it is inexpensive, technically simple, does not prolong operative time, and can be incorporated easily into routine surgical practice.

Therefore, the findings of the present study indicate that both sodium bicarbonate and lignocaine irrigation are effective modalities for reducing post-laparoscopic pain, but their effectiveness varies according to the pain component involved. Sodium bicarbonate is more beneficial for reducing shoulder tip pain related to pneumoperitoneum, while lignocaine provides better visceral analgesia and decreases overall analgesic requirement.

CONCLUSION

The present study demonstrates that intra-peritoneal irrigation is an effective, simple, and safe method for reducing postoperative pain following laparoscopic cholecystectomy. Both sodium bicarbonate and lignocaine provided significant postoperative analgesia; however, their effects differed according to the type of pain. Sodium bicarbonate irrigation was more effective in reducing postoperative shoulder tip pain during the early postoperative period, likely due to neutralization of carbonic acid formed by residual CO_2 pneumoperitoneum. In contrast, lignocaine provided better overall visceral and port-site pain control and reduced the requirement for rescue analgesics.

Neither intervention was associated with significant adverse effects, indicating good tolerability and safety. Therefore, intraperitoneal irrigation—particularly with sodium bicarbonate for referred shoulder pain and lignocaine for generalized postoperative discomfort—can be incorporated as a routine adjunct to laparoscopic cholecystectomy to improve patient comfort, facilitate early ambulation, and enhance postoperative recovery.

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