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Original Research Article

Effect of routine abdominal drainage on postoperative pneumoperitoneum induced pain after elective laparoscopic cholecystectomy: a randomised controlled trial

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ABSTRACT

Background: Postoperative pain following laparoscopic cholecystectomy remains a clinical challenge despite the minimally invasive nature of the procedure. Residual pneumoperitoneum causes diaphragmatic irritation and phrenic nerve stimulation, causing referred shoulder pain affecting patient recovery. Various strategies have been proposed to address this problem, including routine abdominal drainage to facilitate carbon dioxide evacuation and sub - diaphragmatic instillation of local anesthetic agents. However, the comparative effectiveness of these two approaches remains inadequately investigated, with conflicting evidence in existing literature regarding their relative benefits.
Methods: This prospective randomized comparative study was conducted over 18 months. 46 patients undergoing elective laparoscopic cholecystectomy were randomly allocated into two equal groups. The study group received sub hepatic abdominal drainage, while the control group received sub-diaphragmatic instillation of local anesthetic agent. Primary outcome was postoperative pain intensity assessed using Visual Analog Scale (VAS) at 3,6,9 and 12 hours post-surgery.
Results: Both groups were comparable in demographic characteristics. VAS scores at 3,6 and 9 hours postoperatively showed no statistically significant differences between groups. However, at 12 hours post-surgery, the study group demonstrated significantly lower pain scores compared to the control group.
Conclusions: Routine abdominal drainage demonstrates statistically significant superiority over sub-diaphragmatic local anesthetic instillation in reducing postoperative pain at 12 hours following elective laparoscopic cholecystectomy, though both interventions show comparable efficacy during the initial 0-9-hour period.

Keywords: Abdominal drainage, Laparoscopic cholecystectomy, Local anaesthesia, Phrenic nerve irritation, Pneumoperitoneum, Postoperative pain

INTRODUCTION

Postoperative pain following laparoscopic cholecystectomy is multifactorial, comprising both somatic and visceral components that may delay mobilisation and discharge. Somatic pain arises from trocar incisions and tissue handling, whereas visceral pain results mainly from peritoneal irritation and residual pneumoperitoneum created by carbon dioxide insufflation. Although pneumoperitoneum is essential for visualisation and operative precision, it causes peritoneal stretching and diaphragmatic irritation that may persist postoperatively. A prominent manifestation is shoulder tip pain due to retained carbon dioxide in the sub-

diaphragmatic space. Studies demonstrate that residual pneumoperitoneum contributes to postoperative pain, with retained gas volume correlating positively with pain incidence and severity.[1,2]

Multiple strategies have been explored to improve postoperative pain control. Surgical modifications include the use of low-pressure pneumoperitoneum, meticulous gas evacuation, gentle tissue handling, and gas-less laparoscopy (e.g. Laparolift device). Pharmacological approaches involve non-steroidal anti-inflammatory drugs, opioids, and local anesthetic techniques. Two interventions have gained particular attention: routine placement of an abdominal drain in the sub-hepatic space to evacuate residual fluid and facilitate removal of retained gas, and intraperitoneal instillation of local anesthetic in the sub-diaphragmatic region and gallbladder fossa to provide targeted visceral analgesia by blocking nociceptive transmission. To our knowledge, limited literature directly compares routine abdominal drainage with sub-diaphragmatic local anesthetic instillation for pneumoperitoneum-induced pain after elective laparoscopic cholecystectomy.

METHODS

We have performed a Randomized controlled trial at Dr. L.H. Hiranandani Hospital, Powai, Mumbai, over a period of 18 months (April 2024 – September 2025) following approval from the institutional ethics committee (approval obtained on 04.04.2024). A total of 46 patients were enrolled in the study. The patients were randomly divided into two groups of 23 patients each using a randomization via computer generated random numbers. Group A consisted of patients in whom a 14 Fr Ryle's tube was inserted through one of the trocar sites and placed intra-abdominally post-surgery, which was subsequently removed after 24 hours. Group B comprised patients who received sub diaphragmatic local anesthesia infiltration intra-operatively, consisting of 20 ml of 0.25% bupivacaine.

Inclusion criteria

All patients undergoing elective laparoscopic cholecystectomy for calculous cholecystitis who consented to participate in the study, had no uncontrolled diabetes, and whose duration of surgery was less than 2 hours were included in the study.

Exclusion criteria

Patients undergoing emergency surgery, those who did not consent to participate in the study, patients with uncontrolled diabetes, cases with a duration of surgery greater than 2 hours, and patients with acute cholecystitis were excluded from the study.

All patients scheduled for elective laparoscopic cholecystectomy were screened for eligibility based on predetermined inclusion and exclusion criteria. Prior to enrolment, written informed consent was obtained from all participants after explaining the nature and purpose of the study. A detailed history was taken with specific reference to the patient's presenting ailment, including the duration and characteristics of symptoms. Any significant past medical or surgical history was also documented. All patients underwent appropriate pre-operative investigations deemed necessary for safe surgical intervention.

All patients underwent elective laparoscopic cholecystectomy as per standard surgical protocol. For patients in Group A, at the completion of the surgical procedure and before closure, a 14 French Ryle's tube was inserted through the right lateral lower trocar site and positioned intra-abdominally to facilitate passive drainage of residual pneumoperitoneum. This drain was maintained in situ for 24 hours postoperatively and then removed. Drain site was sutured under local anesthesia bedside once the drain was removed. For patients in Group B, prior to completion of the surgery, 20 ml of 0.25% bupivacaine was instilled in the sub diaphragmatic region under direct visualization to provide local anaesthesia and reduce postoperative pain.

All patients were followed up in the postoperative period for assessment of pain. Pain intensity was evaluated using the Visual Analogue Scale (VAS) at predetermined time intervals of 3,6,9 and 12 hours postoperatively.

Statistical analysis of the VAS scores obtained from all patients in both groups was performed to determine whether routine abdominal drainage resulted in a statistically significant reduction in postoperative pain experienced by patients due to pneumoperitoneum establishment during laparoscopic surgery, when compared to sub diaphragmatic instillation of local anaesthesia. Appropriate statistical tests (Mann-Whitney U and Chi Square tests) were applied to compare the pain scores between the two groups at different time intervals, and results were considered statistically significant at p value less than 0.05

RESULTS

This study was conducted in a triple-blinded manner. The collected data were entered in the Microsoft Excel 2016 and analyzed with IBM SPSS Statistics for Windows, Version 29.0.(Armonk, NY: IBM Corp).

To describe about the data descriptive statistics frequency analysis, percentage analysis was used for categorical variables and the mean, median, IQR and SD were used for continuous variables. To find the significant difference between the bivariate samples in independent groups the Mann-Whitney U test was used. To find the significance in qualitative categorical data Chi-Square test was used. In both the above statistical tools the probability value of <0.05 is considered as significant

level. The above table shows comparison of Rescue analgesic for shoulder pain between Groups by Pearson's Chi-Square test where χ^2=2.242, p=0.134>0.05, with Study group in None is 16 (70%) and NSAID is 7 (30%), similarly in Control group in None is 11 (48%) and NSAID is 12 (52%), which shows no statistically significant association between Rescue analgesic for shoulder pain and Groups.

Table 1: Comparison of rescue analgesic for shoulder pain between groups by Pearson's chi-square test.

			Groups		Total	χ^2 value	P value
			Study group	Control group			
Rescue analgesic for shoulder pain	None	Count	16	11	27	2.242	0.134#
		%	70	48	59		
	NSAID	Count	7	12	19		
		%	30	52	41		
Total		Count	23	23	46		
		%	100	100	100		

No Statistical Significance at p>0.05 level.

Table 2: Comparison of VAS between groups by using Mann-Whitney U test.

VAS	Groups	N	Mean	SD	Median	IQR	Z value	P value
3 h	Study group	23	7.43	1.41	7.00	1.00	0.389	0.698#
	Control Group	23	7.52	0.95	7.00	1.00		
6 h	Study group	23	6.30	1.61	7.00	2.00	1.052	0.293#
	Control Group	23	6.74	1.10	7.00	2.00		
9 h	Study group	23	5.04	1.80	5.00	2.00	1.596	0.111#
	Control Group	23	5.78	1.38	6.00	2.00		
12 h	Study group	23	3.52	1.97	3.00	3.00	2.407	0.016*
	Control Group	23	4.87	1.69	5.00	3.00		

* Significant at p<0.05 and # no statistical significance at p>0.05.

At 3 hours post-surgery, the VAS scores were comparable between the two groups. The z value was 0.389 and the p value was 0.698, which is greater than 0.05. This indicates that there was no statistically significant difference in pain scores at this time point. At 6 hours postoperatively, the comparison again showed no statistically significant difference between the two groups.

The z value was 1.052 and the p value was 0.293, which is above the level of statistical significance. At 9 hours after surgery, the VAS scores continued to show no significant difference between the Study and Control groups. The z value was 1.596 and the p value was 0.111, which is greater than 0.05. However, at 12 hours postoperatively, a statistically significant difference in VAS scores was observed between the two groups. The z value was 2.407 and the p value was 0.016, which is less than 0.05. This indicates a significant reduction in pain in the study group compared to the control group.

DISCUSSION

Postoperative pain following laparoscopic cholecystectomy is multifactorial and comprises incisional, visceral, and referred (shoulder) components. It results from the inflammatory and neurophysiological mechanisms. Tissue injury during trocar insertion releases mediators such as prostaglandins, bradykinins, histamine, and substance P, sensitizing nociceptors and producing hyperalgesia, it is typically sharp and well localized.[3] Visceral pain arises from peritoneal distension, organ handling, and chemical irritation caused by carbon dioxide.[4] CO_2 dissolves in peritoneal fluid to form carbonic acid, lowering local pH and stimulating nerve endings.[5] Shoulder tip pain, frequently the most distressing component, results from residual CO_2 trapped beneath the diaphragm, causing mechanical stretching and phrenic nerve irritation (C3-C5) and is perceived in the shoulder due to shared dermatomal distribution with supraclavicular nerves.[6,7,8] It often persists longer and is rated more severe than incisional pain.[9] Higher intra-abdominal pressure and prolonged pneumoperitoneum further increase pain severity.[10]

Despite its minimally invasive nature, laparoscopic cholecystectomy can cause discomfort affecting recovery in the initial post-operative period. Inadequate pain control delays mobilization, prolongs hospitalization, and increases healthcare costs.[11] Restricted activity elevates thromboembolic risk and delays return to routine activities. Pain-related limitation of deep breathing can predispose to atelectasis and respiratory complications, especially in elderly or high-risk patients.[12] Persistent postoperative pain may also contribute to anxiety and chronic post-surgical pain.[13] Moderate to severe pain due to above mentioned reasons within is reported in 35-65% of patients within the initial 24-48 hours.[14] Incisional pain

peaks within 6-12 hours and decreases over 48-72 hours.[15] Shoulder pain occurs in 35–80% of patients, often with delayed onset (4-8 hours) and sometimes intensifying on the first postoperative day. Risk factors include female gender, younger age, obesity, prolonged surgery, and higher insufflation pressures.[13]

Table 3: Review of related articles.

Author (year)	Study design/sample	Intervention	Conclusion
Choi et al (2015)[22]	Systematic review; 39 studies; 3045 patients	Intraperitoneal local anesthetic (IPLA)	IPLA beneficial for resting abdominal, visceral, and shoulder pain.
Sharma et al (2016)[19]	Comparative study	Drain vs no drain	Routine drains not advantageous; increase morbidity and hospital stay.
Chauhan et al (2016)[23]	Comparative study	Subhepatic drain vs no drain	Routine drainage unnecessary in uncomplicated LC.
Yi et al (2017)[24]	Prospective study	Ultrasound-guided phrenic nerve block (PNB)	PNB effective in reducing PLSP safely.
Nadeem et al (2019)[25]	Comparative study	Drain vs no drain	Routine drainage should be avoided to reduce pain.
Xu et al (2019)[26]	RCT meta-analysis; 4 RCTs;796 patients	Drain vs no drain (acute cholecystitis)	Drainage offers no benefit in early LC for acute cholecystitis.
Yang et al (2021)[27]	Prospective cohort;448 patients	Drain for residual gas evacuation	Drains may reduce PLSP by expelling residual gas.
Fathi et al (2022)[28]	Prospective RCT;60 patients	Routine abdominal drainage	Drain reduces early postoperative pain; optimal removal timing unclear.
Ali et al (2024)[29]	Comparative study	Drain vs no drain	Drain use should be selective, not routine.

Carbon dioxide pneumoperitoneum, typically maintained at an insufflation pressure of 12-15 mm Hg, is essential for laparoscopic surgery. However, complete evacuation is difficult. Gas tends to accumulate in the sub-diaphragmatic space-especially on the right due to liver anatomy and may persist for 24-72 hours. Residual CO_2 contributes to pain through diaphragmatic stretching and carbonic acid–induced chemical irritation. Absorption occurs primarily through the diaphragmatic peritoneum, and early ambulation facilitates resolution.[16,17] Although routine drainage was standard in open surgery, its role in laparoscopic cholecystectomy remains controversial.[18] Drains placed in the sub-hepatic space may aid removal of residual gas and fluid, potentially reducing diaphragmatic irritation and visceral pain.[19] However, drains can cause discomfort and complications such as infection, clogging, dislodgement, and delayed healing.[20] However infection risk appears minimal with proper care. Intraperitoneal instillation of local anesthetic beneath the diaphragm aims to block phrenic nerve–mediated nociception and reduce shoulder pain. Studies report reduced early postoperative pain scores and the decreased systemic analgesic requirements. When administered in appropriate doses, the technique is generally safe, with rare systemic toxicity and minimal complications.[21] Our study revealed interesting temporal patterns in the postoperative pain intensity. At 3,6 and 9 hours the post-surgery, there were no statistically significant differences in VAS scores between the drainage group and the local anesthetic instillation group (p=0.698, p=0.293, and p=0.111 respectively). However, a significant divergence emerged at the 12-hour mark, where the drainage group demonstrated significantly lower pain scores (3.52±1.97) compared to the local anesthetic group (4.87±1.69), with p=0.016.

The superior performance of abdominal drainage at the 12-hour time point in our study can be explained by the sustained effect of continuous gas evacuation. While subdiaphragmatic local anesthetic instillation provides immediate chemical blockade of pain transmission, its effect is limited by the pharmacokinetic properties of the drug, with most local anesthetics having a duration of action of 4-8 hours.

Our study has certain limitations including a relatively small sample size (n=46) and assessment of pain only up to 12 hours postoperatively. Future studies with larger sample sizes and extended follow-up periods (24-48 hours) would provide more comprehensive insights into the comparative effectiveness of these interventions. Additionally, assessment of other outcomes such as time to ambulation, hospital stay duration, patient satisfaction

scores, and drain-related complications would strengthen the evidence base.

CONCLUSION

As seen in this study, routine abdominal drainage is more effective than sub-diaphragmatic local anesthetic instillation in reducing postoperative pneumoperitoneum-induced pain at 12 hours following elective laparoscopic cholecystectomy. Although both interventions demonstrated comparable pain control during the early postoperative period, continuous evacuation of residual carbon dioxide through abdominal drainage provides sustained analgesic benefit. These findings suggest that selective use of abdominal drainage will improve postoperative comfort in patients undergoing elective laparoscopic cholecystectomy. However, larger studies with longer follow-up are required to further validate these results and assess additional clinical outcomes such as hospital stay, patient satisfaction, and drain-related complications.

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