Section: General Surgery

Original Research Article

THE EFFECT OF ACTIVE GAS ASPIRATION TO REDUCE PAIN AFTER LAPAROSCOPIC CHOLECYSTECTOMY

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ABSTRACT

Background: Laparoscopic cholecystectomy (LC) is now regarded as the standard approach for treating gall bladder disease. Yet, even with its minimal invasiveness, postoperative shoulder-tip pain is a common occurrence after laparoscopic cholecystectomy. This study was designed to assess the effectiveness of active gas aspiration compared to passive gas aspiration in alleviating postoperative pain and minimizing analgesic needs. **Materials and Methods:** Over the course of a year, this intervention study was carried out in the general surgery department of Trichy SRM Medical College Hospital and Research Centre. Two groups of 30 patients each were randomly selected from among 60 patients scheduled to have an elective laparoscopic cholecystectomy. After the surgery, the group that used active suction successfully eliminated any remaining CO_2 by controlling the suction to -40 mmHg. Standard passive desufflation techniques were applied to the passive release group. After surgery, pain levels were measured using the Visual Analog Scale (VAS) at 6-, 16-, and discharge intervals. **Result:** The active suction group showed significantly lower mean VAS scores at 6 hours (5.53 ± 0.507 compared to 6.33 ± 0.479; p = 0.001) and at 16 hours (2.57 ± 0.568 versus 3.43 ± 0.679; p = 0.001). The active suction group demonstrated a significantly lower incidence of shoulder pain post-surgery, with rates of 6.7% compared to 26.7% (p = 0.038). The active suction group demonstrated a significantly lower requirement for pain medication post-surgery compared to the other group (3.03 ± 0.32 vs. 4.87 ± 0.973; p = 0.001). **Conclusion:** The research indicated that active gas aspiration may effectively decrease postoperative shoulder pain and the need for analgesics following laparoscopic cholecystectomy.

INTRODUCTION

Laparoscopic cholecystectomy (LC) is the preferred treatment for cholelithiasis. Although there are numerous benefits associated with minimally invasive procedures compared to open surgery, a significant number of patients report experiencing referred pain in the shoulder during their recovery period.[1] Postoperative discomfort following laparoscopic cholecystectomy may be experienced in the abdominal region or the shoulder. The abdominal pain can be categorized into visceral and parietal types. This specific pain is primarily attributed to pneumoperitoneum, resulting in discomfort in both the visceral and shoulder areas.[2] CO2 gas persists in the subdiaphragmatic space for more than 24 hours following laparoscopy. Some have proposed that this gas transforms into carbonic acid on the moist surfaces of the peritoneum, causing irritation to the diaphragm and resulting in referred pain in the shoulder and neck.[3] The intensity is generally mild to moderate, characterized by a dull pain that may last for 2 to 3 days, though it can extend up to 5 weeks after the procedure.[4] Referred pain arises when discomfort originating from deep tissues or internal organs radiates to the skin regions served by the same or neighbouring spinal cord segments, leading to sensations of pain in those skin areas. Given that the phrenic and supraclavicular nerves encompass the C3 - C4 nerve roots, stimulation of the phrenic nerve may lead to referred pain in the shoulder, which underlies the phenomenon known as Post laparoscopy Shoulder pain (PLSP).[4] The incidence

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of PLSP is reported to range between 12% and 80%, usually manifesting within the first 24–48 hours following surgery, and is often underreported.[5]

A variety of interventions were evaluated as methods to eliminate residual gas and consequently mitigate pain following laparoscopic surgery. Applying manual pressure to the abdomen at the last stage of a surgical procedure is the easiest intervention.[6] Installing a subdiaphragmatic gas drain—ideally with active drainage as opposed to passive deflation—is an additional choice. The risk of infection associated with leaving a drain in place for a few days can be avoided by aspirating the leftover gas at the end of the surgical procedure.[6,7] Active suction was carried out by inserting a laparoscopic suction–irrigation device through a 5-mm trocar aimed at the subdiaphragmatic space to avoid organ injury or omental herniation. The remaining intraperitoneal carbon dioxide was subsequently evacuated by using continuous negative pressure suction for 60 seconds.[8] Hence, the study aimed to investigate the decrease in post-operative pain scores of patients undergoing active gas suctioning compared with passive release after laparoscopic cholecystectomy.

MATERIALS AND METHODS

An interventional study aimed to evaluate the relationship between postoperative shoulder pain following laparoscopic cholecystectomy. The study was carried out over 12 months at the Department of General Surgery, Trichy SRM Medical College Hospital and Research Center. The study population consisted of patients who underwent elective laparoscopic cholecystectomy at the facility during the designated study period. After applying the predetermined inclusion and exclusion criteria, a total sample size of 60 patients was determined and recruited. The study encompassed patients diagnosed with adenomyomatosis, gallbladder polyp, porcelain gallbladder, or symptomatic gallstones, aged between 18 and 65 years. Patients with gallstones associated with common bile duct (CBD) stones were included, provided that the CBD stones were removed through endoscopic retrograde cholangiopancreatography (ERCP), performed in the Medical Gastroenterology Department. Individuals diagnosed with acute cholecystitis, empyema of the gallbladder, or obstructive jaundice—conditions associated with gallstone disease—were excluded from participation. Exclusion criteria included patients with coagulopathy, portal hypertension, pregnancy, abnormal liver function tests, or those deemed unsuitable for general anesthesia. Patients requiring drain placement after laparoscopic cholecystectomy, those with a history of upper abdominal surgery, or individuals with significant comorbidities such as diabetes mellitus or systemic hypertension were also excluded. In addition, patients who received cholangiography, underwent common bile duct exploration, were converted to open surgery, or had drain insertion were promptly excluded from the study.

Upon admission, patients who satisfied all eligibility criteria were enrolled after giving written informed consent. The 60 patients were randomly divided into two groups of 30 to ensure a comparable distribution in terms of age and gender. To minimize selection bias, randomization was implemented utilizing an appropriate allocation technique. All patients underwent a standard four-port laparoscopic cholecystectomy under general anesthesia, utilizing carbon dioxide to establish a pneumoperitoneum. Patients in the study group (n = 30) had active evacuation of any residual intraperitoneal CO_2 using a suction tube at the end of the treatment to avoid tissue damage. The suction pressure was maintained at -40 mmHg. Pneumoperitoneum was released passively without the use of active suction for patients in the control group (n = 30). Postoperative pain was assessed utilizing the Visual Analog Scale (VAS), a recognized pain assessment instrument established by Hayes and Patterson in 1921. The scale consists of a 10-cm horizontal line indicating a spectrum of pain intensity, with "no pain" (0 cm) positioned on the left and "worst imaginable pain" (10 cm) on the right. Patients were instructed to make a single mark on the line to denote the intensity of their perceived pain. The distance in centimeters from the left end to the marked point was measured and documented as the VAS score, indicating the severity of postoperative pain.[9]

Pain scores were recorded at six, sixteen hours, and at the time of discharge. Alongside standard postoperative analgesics, patients experiencing moderate to severe pain were administered an additional bolus dose of Inj. Ketorolac 30 mg intravenously as needed, and the requirement for supplementary analgesia was documented.

A structured proforma that included all collected data was utilized for analysis through IBM's Statistical Package for the Social Sciences (SPSS), version 26.0. The normality of continuous variables was examined before analysis. Descriptive statistics, including mean, standard deviation, and range, were calculated for variables that exhibited a normal distribution. The average values of age, body mass index (BMI), and duration of surgery were analyzed between the sexes utilizing an independent t-test. The comparison of age, gender, BMI, length of surgery, and the percentage of patients requiring additional analgesics between the two study groups was conducted using the chi-square test. The independent t-test was employed to analyze the mean VAS scores of the case and control groups, presented as mean ± standard deviation. A two-sided p-value of less than 0.05 was considered statistically significant for all statistical analyses.

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RESULTS

The study included 60 patients, categorized into two groups of 30: the active suction group and the passive release group.

The active suction group (n = 30) exhibited a mean age of 41.03 ± 9.532 years, whereas the passive release group (n = 30) demonstrated a mean age of 42.40 ± 9.846 years. The independent t-test revealed no statistically significant difference in mean age between the two groups (p = 0.587). In the active suction group (n = 30), there were 13 male patients (43.3%) and 17 female patients (56.7%). In the passive release group (n = 30), the composition included 12 men (40%) and 18 women (60%). The gender distribution between the two groups was comparable, with roughly equal numbers of males and women in each.

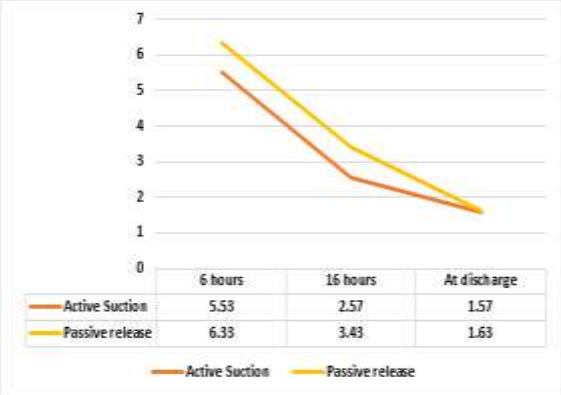

Figure 1: Comparison of Postoperative pain scores based on VAS between groups

At the 6-hour interval, the mean VAS pain score was recorded at 5.53 ± 0.507. At 16 hours, the measurement was 2.57 ± 0.568, and at discharge, it was recorded as 1.57 ± 0.504 among active suction group patients. At 6 hours, the mean VAS pain score was recorded at 6.33 ± 0.479; at 16 hours, it decreased to 3.43 ± 0.679; and at the time of discharge, it further declined to 1.63 ± 0.490 among the passive release group of patients.

[Table 1] illustrates the variations in pain scores following laparoscopic cholecystectomy between the active suction and passive release groups at various time intervals. The Visual Analog Scale (VAS) was employed to assess pain, with results presented as mean ± standard deviation. The active suction group had a mean VAS score of 5.53 ± 0.507 after six hours following surgery, while the passive release group had a mean VAS score of 6.33 ± 0.479. The results were statistically significant (p = 0.001), indicating that patients who underwent active evacuation of residual intraperitoneal CO_2 experienced considerably less pain in the early hours following surgery. At the 16-hour point, the average VAS score decreased once more in both groups. However, the active suction group demonstrated significantly lower pain scores (2.57 ± 0.568) compared to the passive release group (3.43 ± 0.679). A statistically significant difference was observed (p = 0.001). The mean VAS scores recorded were 1.57 ± 0.504 for the active suction group and 1.63 ± 0.490 for the passive release group at the time of patient discharge. The difference was not statistically significant (p = 0.605), indicating that the pain levels in both groups were approximately equivalent upon discharge from the hospital. The active Suction of residual CO_2 from the intraperitoneal space was associated with significantly reduced postoperative pain scores during the initial hours following surgery (at 6 and 16 hours), although no notable difference was observed at the time of discharge.

Table 1: Comparison of postoperative Pain scores between groups

S No	Time points	Active suction (n = 30)	Passive release (n = 30)	p value
1	6 hours	5.53±0.507	6.33±0.479	0.001
2	16 hours	2.57±0.568	3.43±0.679	0.001
3	At discharge	1.57±0.504	1.63±0.490	0.605

The two groups were analyzed to determine the frequency of shoulder pain experienced post-surgery [Figure 2]. Shoulder pain was experienced by 6.7% of patients in the active suction group, compared to 93.3% who did not. The passive release group exhibited a higher incidence of shoulder pain, with 26.7% of patients indicating shoulder discomfort, while 73.3% reported no shoulder pain.

[Table 2] presents a comparison of shoulder pain post-surgery between the groups utilizing active suction and those employing passive release. Ten patients experienced shoulder pain following their surgical procedures. Among the participants, two patients (20%) were assigned to the active suction group, whereas eight patients (80%) were placed in the passive release group. A statistically significant difference was observed between the two groups (p = 0.038), indicating that patients who underwent passive pneumoperitoneum release were more prone to experiencing shoulder pain.

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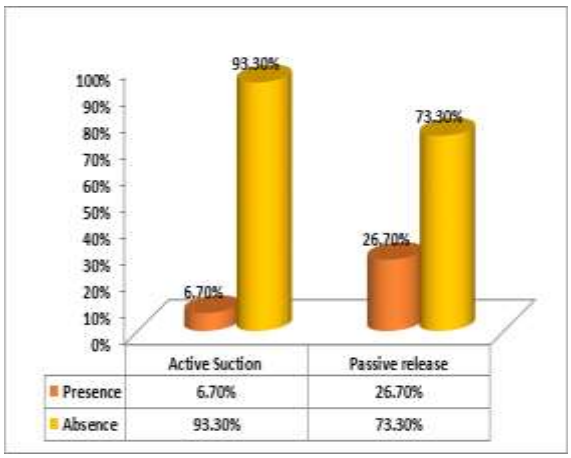

Figure 2: Incidence of Shoulder pain among Groups.

Table 2: Incidence of Shoulder pain among groups

S No	Post operative Shoulder pain	Active suction (n = 30)	Passive release (n = 30)	p value
1	Presence	2 (20%)	8 (80%)	0.038
2	Absence	228 (56%)	22 (44%)	

The mean duration of hospitalization was 4.10 ± 0.305 days, with a median of 4 days (ranging from 4 to 5 days) in the active suction group. The mean number of doses required for pain relief was 3.03 ± 0.320, with a range spanning from 2 to 4 doses. The mean duration of hospitalization was slightly extended, recorded at 4.23 ± 0.430 days (ranging from 4 to 5 days) in the passive release group. The mean total analgesic requirement was significantly increased at 4.87 ± 0.973 doses, with a range spanning from 3 to 6 doses. The observed difference was statistically significant (p = 0.001), indicating that patients who underwent active evacuation of residual intraperitoneal CO_2 required fewer additional doses of analgesics post-surgery.

Table 3: Comparison of postoperative outcome variables between groups

S No	Variables	Active suction (n = 30)	Passive release (n = 30)	p value
1	Total analgesia consumption postoperatively	3.03±0.32	4.87±0.973	0.001
2	Duration of hospital stay	4.1±0.305	4.23±0.430	0.171

DISCUSSION

The current randomized controlled trial demonstrated that active evacuation of residual CO_2 significantly reduced early postoperative pain compared to passive pneumoperitoneum release. The average VAS scores were notably reduced in the active suction group at both 6 hours (5.53 ± 0.507 vs. 6.33 ± 0.479; p = 0.001) and 16 hours (2.57 ± 0.568 vs. 3.43 ± 0.679; p = 0.001). At the time of discharge, pain scores were comparable between the two groups (p = 0.605). The findings suggest that the beneficial effects of active gas evacuation are most pronounced in the early postoperative phase, when residual CO_2-induced diaphragmatic irritation reaches its maximum level. Postoperative pain following laparoscopic cholecystectomy can arise from various factors, with residual intraperitoneal carbon dioxide (CO_2) being a significant contributor, particularly in relation to shoulder tip pain. The pathophysiological origin of shoulder pain following laparoscopy is associated with irritation of the phrenic nerve due to retained CO_2 beneath the diaphragm. Carbon dioxide has the potential to distend the peritoneum, increase acidity in the surrounding area, and cause irritation to the diaphragm. This may result in pain radiating to the shoulder via the C3–C5 nerve roots. Active suctioning likely decreases the volume of gas beneath the diaphragm, thereby minimizing peritoneal irritation and the subsequent release of inflammatory mediators immediately post-surgery. The disparity between the groups diminishes as CO_2 is gradually absorbed over time, which accounts for the comparable pain scores at discharge.[10]

Our study revealed that the active suction group experienced a significantly lower incidence of shoulder pain post-surgery (6.7%) compared to the passive release group (26.7%) (p = 0.038). This outcome aligns with findings from other studies. Haneef et al,[11] conducted a meta-analysis of five randomized trials, revealing that active gas aspiration significantly alleviated shoulder pain within 24 hours. However, there were no notable differences in the duration of hospital stays or the scores for abdominal pain. Atak et al,[12] observed that the simple evacuation group experienced greater shoulder and abdominal pain post-surgery and required a higher consumption of painkillers compared to the active aspiration group.

Erdem et al,[13] observed that the active gas reduction group exhibited significantly lower NPIS scores at the 24-hour interval. However, the variations were

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not substantial at the 1st hour and 3rd day. This reinforces the notion that aspiration plays a significant role during the initial inflammatory phase. Erdem et al,[13] did not observe differences at the first postoperative hour; however, our study demonstrated a significant reduction at six hours. This discrepancy may suggest differences in assessment timing, perioperative analgesic protocols, or the degree of residual CO_2 volume achieved during aspiration. Incisional and visceral nociceptive input may serve as the primary source of pain immediately following surgery, whereas diaphragmatic irritation tends to become more pronounced after several hours. Kumar et al,[14] observed comparable early VAS scores and requirements for pain relief, reinforcing the notion that active gas removal may alleviate discomfort. Arif et al,[15] employed suction pressure restricted to -40 mmHg, consistent with our approach, and observed that the mean VAS scores were significantly lower in the intervention group at 16 hours ($p < 0.001$), closely aligning with our findings. Tuvayanon et al,[16] observed that the active aspiration group experienced significantly reduced shoulder pain post-surgery compared to the control group at both the 4-hour and 24-hour points, which shows consistent results. Das et al,[17] also observed that reduced shoulder pain scores at 1 and 24 hours in the active gas reduction group; however, differences beyond 24 hours were not statistically significant, which follows a similar pattern to our study. Gokder et al,[18] observed that the active aspiration group reported significantly lower pain scores at both the 4-hour and 24-hour marks in a substantial prospective cohort study. A study by Lee et al,[8] also documented the lowest pain scores after six hours of surgery among the active suction group. This reinforces that these findings are reliable across various populations and research methodologies. Abdelsamad et al,[6] documented in a study that active aspiration reduces pain scores that do not attain statistical significance at 12 hours post-surgery and therefore implies that active suctioning has only a minor effect on post laparoscopy pain. The findings indicate that active suctioning could be beneficial; however, they may conflict with our study due to variations in procedures and protocols.

In our study, the active suction group had a shorter hospital stay (4.1 ± 0.305 days) compared to the control group (4.23 ± 0.430 days), although this difference did not reach statistical significance ($p = 0.171$). This observation is consistent with the findings of Haneef et al,[11] and Das et al,[17] both of which reported no significant difference in hospital stay. The absence of variation may be attributed to standardized discharge protocols and the generally brief recovery period following an uncomplicated laparoscopic cholecystectomy, suggesting that early pain relief might not significantly influence outcomes.

The requirement for postoperative analgesics serves as an objective indicator of pain intensity and indicates the clinical significance of interventions designed to minimize postoperative discomfort. The study revealed that the total postoperative analgesic consumption was significantly reduced in the active suction group when compared to the passive release group (3.03 ± 0.32 vs. 4.87 ± 0.973; $p = 0.001$). This finding indicates that the active removal of residual intraperitoneal carbon dioxide (CO_2) not only reduces subjective pain scores but also leads to a measurable decrease in the need for additional analgesics. The findings are consistent with the meta-analysis conducted by Haneef et al., which included five randomized clinical trials involving a total of 367 participants. The meta-analysis demonstrated that active gas aspiration significantly reduced the residual gas in the peritoneum and necessitated less overall pain relief compared to passive evacuation techniques. Active aspiration significantly reduced analgesic consumption; however, it did not have a considerable impact on the duration of hospital stay in our study. This indicates that although reducing analgesics enhances patient comfort, discharge decisions are affected by various factors such as institutional protocols, patient mobility, oral intake tolerance, and the absence of complications. The primary advantage of active suction is its enhancement of recovery, rather than a reduction in hospital stay duration. The active suction of residual CO_2 from the abdomen contributes to alleviating early postoperative pain and shoulder tip pain, all while not significantly extending the duration of hospital stays. The intervention is simple, cost-effective, and easily replicable, making it an effective approach to enhance the comfort of patients following laparoscopic cholecystectomy.

CONCLUSION

Our study determined that, in comparison to passive pneumoperitoneum release, active suction of the remaining carbon dioxide from the abdominal cavity after a laparoscopic cholecystectomy markedly diminishes early postoperative pain, discomfort in the shoulder region, and the overall need for analgesics post-surgery

Limitations: The sample size was limited ($n = 60$), potentially affecting the statistical power and the generalizability of the findings. The Visual Analog Scale (VAS) served as the instrument for quantifying pain levels post-surgery. Despite validation, the assessment remains subjective and can be influenced by individual pain perception, psychological factors, and variations in pain reporting among individuals.

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