SSR Institute of International Journal of Life Sciences
ISSN (O): 2581-8740 | ISSN (P): 2581-8732
Nayak *et al*., 2024
DOI: 10.21276/SSR-IIJLS.2024.10.4.32

Research Article

open access

Comparative Study of Intraperitoneal Ropivacaine vs. Lignocaine Nebulisation for Postoperative Pain and Hemodynamic Stability in Laparoscopic Cholecystectomy

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Received: 06 Mar 2024/ Revised: 05 May 2024/ Accepted: 08 Jun 2024

ABSTRACT

Background: Laparoscopic cholecystectomy, the gold standard treatment for gallbladder stones, offers significant advantages such as reduced postoperative pain, shorter hospital stays, and quicker recovery. However, postoperative pain, particularly diffuse abdominal and shoulder pain, remains a concern, necessitating effective pain management strategies.

Methods: This prospective, randomized, double-blind study included 60 patients aged 20-50 years, ASA grade 1 and 2, undergoing laparoscopic cholecystectomy at MKCG Medical College & Hospital from September 2014 to October 2016. Patients were randomly assigned to receive intraperitoneal nebulization of either 1% ropivacaine (Group 1) or 4% lignocaine (Group 2). Pain levels were assessed using the Visual Analogue Scale (VAS) at various intervals up to 48 hours postoperatively. Hemodynamic parameters, rescue analgesia requirements, incidence of shoulder pain, nausea, vomiting, and urine output were also monitored.

Results: Group I (ropivacaine) demonstrated a significantly longer duration of analgesia (220±62.5 minutes) compared to Group II (lignocaine) (51±13.9 minutes) with a highly significant p-value of 0.00. Mean VAS scores indicated lower pain levels in the lignocaine group immediately post-surgery but higher pain levels after 30 minutes, 1 hour, and 2 hours, necessitating more frequent rescue analgesia. Hemodynamic parameters showed better stability with ropivacaine beyond the first two hours post-surgery. The incidence of shoulder pain, nausea, vomiting, and reduced urine output were comparable between the groups and not statistically significant.

Conclusion: Intraperitoneal nebulisation of ropivacaine is superior to lignocaine in providing longer postoperative analgesia and better hemodynamic stability in laparoscopic cholecystectomy. This technique should be considered a valuable addition to pain management protocols in minimally invasive surgeries to improve patient outcomes and satisfaction.

Key-words: Laparoscopic cholecystectomy, Intraperitoneal nebulization, ropivacaine, lignocaine, postoperative pain, hemodynamic stability

How to cite this article
Nayak J, Jena R, Mishra A, Ludam RK, Sharma DN, et al. Comparative Study of Intraperitoneal Ropivacaine vs. Lignocaine Nebulisation for Postoperative Pain and Hemodynamic Stability in Laparoscopic Cholecystectomy. SSR Inst Int J Life Sci., 2024; 10(4): 6002-6008.

Access this article online
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INTRODUCTION

In the modern era, minimal access surgery has almost replaced conventional laparotomy. Surgeons benefit from better visualization by modern, sophisticated instruments, while patients experience less tissue trauma, early recovery, and shorter hospital stays [1]. Among these surgeries, laparoscopy is the most common. Laparoscopic cholecystectomy is now considered the gold standard of treatment.

DOI: 10.21276/SSR-IIJLS.2024.10.4.32

The introduction of laparoscopic techniques in general surgery has dramatically changed the postoperative course of patients after cholecystectomy. This technique has been proven to significantly reduce postoperative pain, thus allowing for shorter hospital stays and faster recovery periods, which enable patients to return to normal life and work activities sooner [2]. Consequently, laparoscopic cholecystectomy has rapidly developed as a safe and effective treatment option for patients with gallbladder stones. In many centers, patients are discharged home on the first postoperative day. With expanding experience, some series have shown that the operation is safe and feasible even as a day-care procedure in appropriately selected patients. Therefore, pain relief and patient comfort during the early postoperative period are crucial, as the need for analgesics may delay early discharge.[3]

Pain on the day of surgery typically diffuses abdominal pain, especially in the right upper quadrant and right shoulder tip. This pain is thought to be related to abdominal muscle distension during the laparoscopic procedure, the irritative effects of carbonic acid formed by residual carbon dioxide contacting moist surfaces of the peritoneum, and prolonged elevation of the diaphragm by pneumoperitoneum. Post-laparoscopic pain is considered multifactorial.[4] Different modalities have been proposed to relieve pain, but opioids, the mainstay of postoperative analgesia, have significant side effects that can delay hospital discharge. The observation of peritoneal inflammation after CO_2 pneumoperitoneum supports the use of nonsteroidal anti-inflammatory drugs (NSAIDs), though results are mixed regarding their effectiveness for shoulder tip pain. Steroids can reduce inflammation but require further evaluation for their analgesic potential in laparoscopic cholecystectomy. [5]

Several techniques have been tried to address residual CO_2 pneumoperitoneum, including active aspiration of residual CO_2, low-pressure abdominal insufflation, and use of nitrous oxide instead of CO_2, with varying success. [6] Gabapentin has shown promise in dose-response studies for analgesic efficacy in laparoscopic cholecystectomy but is not yet recommended as routine treatment. Local anesthetic agents are widely used, have a good safety profile, and are available in long-acting preparations, providing the benefit of anesthesia without systemic side effects. Studies have shown that the intraperitoneal instillation of local anesthetics like bupivacaine and ropivacaine can reduce postoperative pain and morphine consumption. Nebulization of local anesthetics has been shown to reduce postoperative pain morphine requirements and facilitate earlier mobilization. Comparisons between intraperitoneal lignocaine and bupivacaine have shown both to be effective and safe at reducing postoperative pain [7].

This prospective randomized study aimed to compare the effect of intraperitoneal nebulized ropivacaine with intraperitoneal nebulized lignocaine on peri-operative haemodynamic parameters and postoperative pain management in patients undergoing laparoscopic surgeries.

MATERIALS AND METHODS

This prospective randomized, double-blind study included patients admitted for laparoscopic cholecystectomy under general anesthesia at MKCG Medical College & Hospital, Berhampur, from September 2014 to October 2016. The study population was divided into two groups randomly: Group 1 received ropivacaine (1%), and Group 2 received lignocaine (4%).

Inclusion Criteria

- Both sexes
- Age between 20-50 years
- ASA grade 1 and 2
- Ultrasound proof of gallstones or sludge

Exclusion Criteria

- Patient refusal
- Neurological disorder
- Cardio-respiratory disease
- Inability to understand the Visual Analogue Scale (VAS)
-Requirement of intraoperative intraabdominal pneumoperitoneum pressure >15 mmHg
-Previous upper abdominal surgery & Choledocholithiasis

Methodology- Patients had preoperative tests: blood count, fasting glucose, renal function, blood grouping, urine and stool exams, ECG, chest X-ray, electrolytes, ultrasound, and liver tests. Pre-anesthetic check-ups and fasting were advised. Ranitidine and alprazolam were given. On surgery day, an IV line was secured, monitors attached, and pre-oxygenation and premedication were administered. Anesthesia was induced with propofol and vecuronium and maintained with nitrous oxide, oxygen,

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isoflurane, and vecuronium. The pneumoperitoneum was created with CO_2, and patients were positioned in reverse Trendelenburg with a left-side-down tilt.

Sixty patients received intraperitoneal nebulization of ropivacaine 1% or lignocaine 4% via the Aeroneb Pro® device. Nebulization lasted 5 minutes, allowing a 20-minute drug distribution. Techniques were standardized.

Pain, shoulder pain, analgesic use, nausea, and vomiting were monitored at set intervals of up to 48 hours. Vital signs and urine output were regularly checked.

Pain was assessed using a VAS. Patients with VAS>40 received diclofenac. Ondansetron was given for nausea. Time to first analgesic, total consumption in 24 hours and adverse events were recorded.

Ethical approval- Ethical approval was obtained from the Institutional Ethical Committee. Patients were informed about the procedure, purpose, possible risks, and complications of the study, and written informed consent was obtained.

RESULTS

Table 1 shows the group-wise distribution of age, weight, and mean arterial pressure (MAP). The variables are comparable in both groups (p>0.05). This table shows the group-wise distribution of sex. The variables are comparable in both groups (p>0.05).

Table 1: Distribution of Variables

Variables	Group I (Mean± SD)	Group II (Mean± SD)	p-value	Statistical analysis
Age	44.8 ± 8.6	45.6 ± 11.0	0.756	Not significant
Weight	81.80 ± 16.59	81.80 ± 17.88	1.000	Not significant
MAP	87.40 ± 8.58	87.13 ± 9.81	0.911	Not significant

Table 2: Distribution of Gender

Groups	Gender	Total
	Male	Female
Ropivacaine	18	12
Lignocaine	16	14
Total	34	26

Table 3 shows the mean VAS score in both groups at rest, after deep breath, and after movement. The mean pain score in the Ropivacaine group showed a progressive upward trend over the first four postoperative hours, requiring rescue analgesia after that. In the Lignocaine group, the mean pain score showed a progressive upward trend over the first two postoperative hours, requiring rescue analgesia after that. The mean pain scores in the Lignocaine group (Group II) at rest, after deep breath, and after movement were lower than those in the Ropivacaine group at zero hours postoperatively. The findings were not significant at rest and after deep breath but were significant after movement. The mean pain scores in the Lignocaine group were significantly higher than those in the Ropivacaine group at rest, after deep breath, and after movement at 30min, 1hr, & 2hrs postoperatively, after that requiring rescue analgesia.

Table 3: Postoperative VAS Score

Time	Group	No. of Patients	Mean	Standard Deviation	p-value
Postoperative VAS Score at Rest					
Zero Hr	1	30	9.80	2.72	0.62
	2	30	9.50	1.92	0.00
30 min	1	30	13.10	4.07	0.00
	2	30	18.40	3.71	0.00
1 hr	1	30	22.70	7.12	0.00

DOI: 10.21276/SSR-IIJLS.2024.10.4.32

	2	30	34.00	6.23	0.00
2 hr	1	30	27.83	6.14	0.00
	2	30	43.00	19.25	0.00
4 hr	1	30	46.80	12.15	0.00
	2	30	15.90	4.57	0.00
8 hr	1	30	6.93	5.98	0.00
	2	30	29.60	1.83	0.00
12 hr	1	30	15.90	5.83	0.00
	2	30	35.80	2.26	0.00
24 hr	1	30	29.07	4.77	0.00
	2	30	47.73	6.51	0.00
Postoperative VAS Score on Deep Breath					
15 min	1	30	16.40	3.12	0.61
	2	30	16.00	3.05	
30 min	1	30	21.00	2.33	0.00
	2	30	28.37	2.96	
1 hr	1	30	28.80	6.36	0.005
	2	30	34.73	6.20	
2 hr	1	30	34.60	5.66	0.00
	2	30	44.83	18.57	
4 hr	1	30	47.00	11.08	0.00
	2	30	16.87	4.34	
8 hr	1	30	18.00	5.71	0.00
	2	30	30.63	2.42	
12 hr	1	30	21.13	5.51	0.00
	2	30	36.37	1.84	
24 hr	1	30	25.20	6.11	0.00
	2	30	48.97	6.96	
Postoperative VAS Score on Movement					
15 min	1	30	20.10	1.66	0.61
	2	30	17.03	3.17	
30 min	1	30	22.50	1.92	0.00
	2	30	30.27	3.62	
1 hr	1	30	31.10	5.88	0.001
	2	30	36.40	6.35	
2 hr	1	30	37.37	6.930	0.024
	2	30	45.77	18.54	
4 hr	1	30	49.03	9.38	0.00
	2	30	18.03	4.029	
8 hr	1	30	20.50	6.05	0.00
	2	30	31.53	2.30	
12 hr	1	30	24.83	5.84	0.00
	2	30	36.37	1.84	
24 hr	1	30	28.03	5.96	0.00
	2	30	49.13	7.05	

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The mean duration of analgesia was significantly longer in Group I (220±62.5 minutes) compared to Group II (51±13.9 minutes), with a highly significant p-value of 0.00 (Table 4).

Table 4: Mean Duration of Analgesia

Group	Patients Total No.	Mean Duration of Analgesia (in mins)	Standard Deviation	p- value	Statistical analysis
1	30	220	62.53	0.00	Highly significant
2	30	51	13.98	0.00	Highly significant

DISCUSSION

Minimally invasive surgery, such as laparoscopic cholecystectomy, is known for reduced pain, though it is not initially painless. Patients often experience considerable pain on the day of surgery, frequently requiring analgesics. The primary source of pain post-laparoscopic surgery remains controversial. While Partridge BL et al.[8] identified trocar placement through the abdominal wall as a significant source. Rademaker et al. suggested that intraperitoneal dissection and CO_2 insufflation, leading to abdominal wall distension and diaphragm elevation, were the primary causes.

Early postoperative pain following laparoscopic cholecystectomy involves multiple components, including surgical trauma to the abdominal wall, intra-abdominal trauma from gallbladder removal, abdominal distention, and pneumoperitoneum with CO_2. Consequently, a multimodal approach is essential for effective pain management.[9] Our study evaluated the effect of intraperitoneal nebulized local anesthetic on perioperative hemodynamic parameters and postoperative pain management in patients undergoing laparoscopic cholecystectomy.

Previous studies have shown varied results regarding the efficacy of local anesthetics for postoperative pain relief. Thomas *et al*. found that incisional local anesthetics reduced pain intensity and opioid requirements. In contrast, Narchi *et al*. did not observe significant pain reduction with local infiltration of anesthetics into the abdominal wall.[10,11] Goldstein *et al.* demonstrated significant pain reduction with bupivacaine, and Ingelmo PM et al. observed significant postoperative analgesia up to 6 hours without reducing shoulder tip pain. [12,13] Conversely, Cuffarie et al. reported significant shoulder pain reduction with bupivacaine instillation, while Ingelmo *et al*. found no significant analgesia with intraperitoneal instillation. Ropivacaine nebulization has been noted to reduce postoperative pain, shoulder pain, and opioid requirements.[14,15]

Our study aimed to compare the analgesic and hemodynamic effects of intraperitoneal nebulization of lignocaine and ropivacaine. Lignocaine, 4% solution, was chosen for its known mucosal absorption and relative safety due to biotransformation in the liver. We investigated whether lignocaine nebulization would cause additional cardiovascular suppression compared to ropivacaine.

Both ropivacaine and lignocaine nebulization provided adequate postoperative analgesia. However, the duration of analgesia was significantly longer with ropivacaine (220 minutes) compared to lignocaine (51 minutes), corresponding to their respective durations of action. The hemodynamic effects of both anesthetics were similar within the first 2 hours post-surgery, but ropivacaine showed better hemodynamic stability and analgesic effects beyond 2 hours. This corresponds to the standard duration of action of ropivacaine (3.5-8.5 hours) and lignocaine (1.5-2 hours).

There was no significant cardiovascular depressant action of lignocaine compared to ropivacaine. Rescue analgesia requirements within 24 hours were significantly lower in the ropivacaine group than in the lignocaine group. The incidence of postoperative shoulder pain, nausea, and vomiting was similar between the groups, with urine output remaining normal and identical in both groups.

The mean pain scores increased at around the 4th postoperative hour in the ropivacaine group and around the 2nd postoperative hour in the lignocaine group, correlating with the cessation of the analgesic effects. This increase in pain was associated with an increase in heart rate and mean arterial pressure, which settled after rescue analgesia was administered.

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The intensity of abdominal pain increased with deep breaths and mobilization due to abdominal muscle contraction and movement of intra-abdominal viscera, stimulating the inflamed cholecystectomy wounds. The incidence of nausea and vomiting was lower in the ropivacaine group (10%) compared to the lignocaine group (16.6%), though not statistically significant. This decreased incidence may be attributed to propofol induction, gastric drainage, intraoperative use of ondansetron and dexamethasone, reduced peritoneal irritation, and lower rescue analgesic requirements.

Intraperitoneal local anesthetics around the operative site may reduce referred shoulder pain by obstructing conduction from visceral sites and reducing diaphragmatic irritation. This simple, inexpensive, and effective technique can improve perioperative outcomes and should be routinely practised in elective laparoscopic cholecystectomy, with ropivacaine preferred over lignocaine for longer analgesia and hemodynamic stability.

CONCLUSIONS

The findings demonstrate that while both local anesthetics provide effective postoperative analgesia, ropivacaine offers a significantly longer duration of pain relief compared to lignocaine. Specifically, the mean duration of analgesia with ropivacaine was 220 minutes versus 51 minutes with lignocaine. This prolonged analgesic effect of ropivacaine correlates with its longer duration of action and contributes to improved patient comfort and reduced need for rescue analgesia.

Overall, intraperitoneal nebulization of ropivacaine should be considered a valuable addition to pain management protocols in laparoscopic surgeries. Its implementation can lead to better perioperative outcomes, enhanced patient satisfaction, and potentially shorter hospital stays. Further research with larger sample sizes and varied surgical procedures could provide more comprehensive insights into the benefits and optimization of this analgesic technique.

CONTRIBUTION OF AUTHORS

Research concept- Jagdeep Nayak, Rukmani Jena
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