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EVALUATION OF FENTANYL VS DEXMEDETOMIDINE AS ADJUVANT WITH ROPIVACAINE IN USG GUIDED TRANSVERSUS ABDOMINIS PLANE BLOCK FOR LAPAROSCOPIC CHOLECYSTECTOMY ON POST OPERATIVE ANALGESIA – A COMPARATIVE STUDY.

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Abstract

Background: Effective postoperative analgesia is a critical component of perioperative care, particularly in laparoscopic cholecystectomy, where pain arises from parietal trauma, visceral manipulation, and pneumoperitoneum. Ultrasound-guided transversus abdominis plane (TAP) block has emerged as an effective regional technique to improve pain control, reduce systemic analgesic requirements, and enhance recovery. The addition of adjuvants such as fentanyl or dexmedetomidine to local anaesthetics like ropivacaine may prolong analgesia and improve patient outcomes. ***Methods:*** This prospective, randomized, double-blind study enrolled 108 patients (ASA I–II, 18–60 years) undergoing elective laparoscopic cholecystectomy at tertiary health care center. Patients were randomized into three groups: Group A received ropivacaine 0.2% with fentanyl, Group B received ropivacaine 0.2% with dexmedetomidine, and Group C received ropivacaine 0.2% with 0.9% Normal saline. TAP block was performed under ultrasound guidance immediately after induction. Postoperative pain was assessed using the visual analogue scale (VAS) at multiple time points up to 24 hours. Duration of analgesia, time to first rescue analgesia, total analgesic consumption, and adverse events were recorded. ***Results:*** Baseline demographics, ASA status, operative duration, and intraoperative hemodynamics were comparable across groups. Dexmedetomidine significantly prolonged analgesia, reduced VAS scores in the first 6 hours, delayed the need for rescue analgesia, and decreased total analgesic consumption compared to fentanyl and control groups. Both adjuvants were safe, with minimal and clinically manageable side effects. ***Conclusion:*** Dexmedetomidine as an adjuvant to ropivacaine in ultrasound-guided TAP block provides superior and longer-lasting postoperative analgesia compared to fentanyl, with stable hemodynamics and minimal adverse effects, making it the preferred choice for pain management in laparoscopic cholecystectomy.

Keywords: Postoperative analgesia, TAP block, Ropivacaine, Dexmedetomidine, Fentanyl, Laparoscopic cholecystectomy, Ultrasound-guided.

INTRODUCTION

The American Board of Anesthesiology recognizes the relief and prevention of pain during surgical, obstetric, and diagnostic procedures as a fundamental responsibility of anaesthesiologists.[1] Postoperative pain remains a major contributor to surgical stress response, affecting multiple physiological systems and potentially delaying recovery.[2] Traditionally, intravenous analgesics administered as part of general anaesthesia were the primary modality for pain control; however, their use is associated with adverse drug effects, delayed recovery, and prolonged hospital stay.[3]

The advent of regional anaesthesia techniques has significantly improved perioperative pain management by reducing systemic drug requirements, preserving consciousness, and enhancing postoperative recovery.[4] Effective analgesia not only improves patient comfort and satisfaction but also facilitates early mobilization and reduces cardiopulmonary complications and the risk of chronic pain development.5-6

Laparoscopic cholecystectomy is one of the most commonly performed abdominal surgeries. Despite its minimally invasive nature, patients frequently experience postoperative pain due to visceral and somatic components triggered by surgical trauma and pneumoperitoneum.[2] This nociceptive input activates complex interactions between the nervous, endocrine, and immune systems, amplifying the stress response. Adequate analgesia plays a crucial role in modulating this response and improving outcomes.[5]

The transversus abdominis plane (TAP) block has emerged as an effective regional anaesthesia technique for abdominal surgeries. It involves deposition of local anaesthetic in the fascial plane between the internal oblique and transversus abdominis muscles, thereby blocking thoracolumbar nerves supplying the anterior abdominal wall.7 Ultrasound-guided TAP block enhances accuracy, safety and efficacy, making it a widely adopted modality for postoperative analgesia.8

Long-acting local anaesthetics such as ropivacaine provide satisfactory analgesia; however, their duration is limited when used alone.9 To overcome this limitation, various adjuvants have been incorporated to prolong analgesic effects and reduce opioid consumption.10 Among these, fentanyl, an opioid agonist, and dexmedetomidine, a highly selective α_2-adrenergic agonist, are commonly used.11 Dexmedetomidine offers sedative and analgesic properties with relative haemodynamic stability, while fentanyl provides potent analgesia but may be associated with respiratory depression.11-12

Given the need for optimal postoperative pain control with minimal side effects, this study aims to evaluate and compare the efficacy of fentanyl versus dexmedetomidine as adjuvants to ropivacaine in ultrasound-guided TAP block for patients undergoing laparoscopic cholecystectomy.

In this study we aim to compare the potential benefits of dexmedetomidine and fentanyl when added to ropivacaine in transversus abdominis plane block for postoperative pain management and patient recovery following laparoscopic cholecystectomy.

MATERIALS AND METHODS

The present study was conducted at tertiary health care center. The study duration was from July 2024 to December 2025, following approval from the institutional Research and Ethics Committee. This investigation was designed as a prospective, randomized, double-blind study. The study population comprised of all patients scheduled to undergo laparoscopic cholecystectomy who meet the inclusion criteria, and were enrolled after obtaining informed consent.

Sample size: The sample size calculation was performed using G* power version 3.1.7.9, taking into account the effective analgesia among all three groups as reported in a previous study by Chen et al. The effect size, calculated at 0.4, indicates a moderate effect. The study's sample size was established based on alpha of 0.05 and study power of 85%, resulting in a total calculated sample size 99. After anticipating dropout rate of 8-9%, the sample size was adjusted to 108 and rounding, this was evenly divided into three groups, with each group comprising 36 patients for the study.

Inclusion Criteria:
1. ASA physical status I and II.
2. Age 18 years to 60 years.
3. Elective laparoscopic cholecystectomy.

Exclusion Criteria:
1. Acute cholecystitis.
2. Carcinoma Gall bladder.
3. Hypersensitivity to study drugs.
4. Pregnant females.
5. Bleeding disorders.
6. Opioid addicts.
7. Patient refusal to participate in the study.

Randomization: Computer generated random number was obtained and sealed in an envelope. The slip was taken out by the anaestheologist on duty and the drug was prepared according to the coded slip. The assessor and the patients were blinded.

Subject: After obtaining approval from institutional ethics committee and written informed consents from the patients in vernacular language. 108 patients of ASA Grade I and II between 18 and 60 years of age and average height and weight undergoing Laparoscopic cholecystectomy were randomised into 3 groups with 36 patients each according to drugs they received.

There were three groups:
Group A (n=36): 20 ml of ropivacaine 0.2% plus 1 mcg/kg of fentanyl was diluted to 25 ml with 0.9% NS.
Group B (n=36): 20 ml of ropivacaine 0.2% plus 1 mcg/kg of Dexmedetomidine was diluted to 25ml with 0.9% NS.
Group C (n=36): 20 ml ropivacaine 0.2% was diluted to 25 ml with 0.9% NS.

INTERVENTION:
Preanesthetic evaluation: A written and informed consent from the study patient after explaining the nature of the study was taken. All patients were interviewed for detailed pre-anaesthetic checkup and were explained the visual analogue scale (0: no pain and 10: worst possible pain). Details pertaining to the patient's clinical history, general physical and systemic examination and routine investigations like complete hemogram, coagulation profile, random blood sugar, renal function tests, liver function tests and viral markers (VM) were recorded.

Pre-operative evaluation: After detailed pre-anaesthetic checkup, a common conduct of anaesthesia was followed in all patients. They were kept fasting for 6hours prior to surgery and tablet alprazolam 0.5mg was administered on the night before surgery and on the morning of surgery.

- The patient was shifted to operation theatre and a peripheral intravascular access was obtained.
- Baseline Heart Rate (HR), peripheral arterial oxygen saturation (SpO2), Non- invasive blood pressure (NIBP) [including systolic blood pressure (SBP), diastolic blood pressure (DBP) and mean arterial pressure (MAP), Respiratory Rate (RR) and five-lead electrocardiogram (ECG) were recorded.
- Inj. glycopyrrolate 0.2mg, Inj. butorphanol 1mg were administered.
- Pre-oxygenation with 100% O2 for 3-5minutes was done followed by Induction with Inj. propofol 2mg/kg. After confirming that the patient is being Ventilated on bag and mask, Inj. succinylcholine 2mg/kg was used to facilitate endotracheal intubation. Then the patient was intubated with a cuffed endotracheal tube of appropriate size. Muscle relaxant, Inj. Vecuronium 0.08mg/kg was administered.
- HR, SBP, DBP, MAP, RR, SpO2 and EtCO2 were recorded at 5min interval for first 20minutes and thereafter at 10minutes interval throughout the surgery.
- Maintenance of anaesthesia was done with isoflurane (1-2%) along with O2 and N2O and volume control ventilation which was adjusted to maintain an EtCO2 between 30-40mmHg. Muscle relaxation was maintained with one-fourth the loading dose of Inj. vecuronium earlier administered.

TAP Block technique: It was administered immediately after induction under all aseptic precautions. An ultrasound-guided subcostal transversus abdominis plane (TAP) block was performed. The needle was introduced in the plane of the ultrasound probe and advanced until it reached the plane between the rectus abdominis and transversus abdominis muscle. Upon reaching the desired plane, 2 ml of saline was injected to confirm correct needle placement, following which 12.5 ml of the study drug solution was injected on each side. Surgery was initiated 10 minutes after performing the block, and intraoperative monitoring was carried out every 5 minutes for the first 30 minutes and subsequently every 15 minutes until the completion of surgery. The duration of surgery was recorded.

After completion of the surgical procedure and successful extubation, the patient was transferred to the post-anaesthesia care unit. All patients were asked to assess and report their pain scores upto 24 hours postoperatively.

-Rescue Analgesia: When VAS score was ≥4, injection tramadol 1mg/kg was administered intravenously as rescue analgesic. This was considered the duration of analgesia. The total consumption of tramadol in 24 h postoperatively was noted.

Complication: Any episode of hypotension (decrease in mean arterial pressure ≥20% of the baseline value), bradycardia (heart rate<60/min or drop of ≥20 % in heart rate if baseline is less than 60), nausea and vomiting or any other side effect as a result of subcostal TAP block, like haematoma and bruising were recorded and managed accordingly. Intraoperatively sustained tachycardia and hypertension was treated and managed accordingly. Side effects of study drugs used as adjuvant to ropivacaine such as bradycardia, hypotension, sweating, nausea and vomiting, respiratory depression were noted along with side effects of the procedure done.

Observations recorded:
Primary Outcome- Duration of analgesia by both the drugs when used as adjuvants to Ropivacaine given through sub coastal TAP block using VAS.

Secondary Outcome- Side effects like hypotension, bradycardia, postoperative nausea vomiting, respiratory depression or any other complication arising during the study was assessed.

Statistical analysis:
Data from this study were systematically collected, compiled, and analyzed statistically to derive meaningful conclusions. All analyses utilized SPSS software version 26.0 (IBM Corp., Armonk, NY, USA), parametric data are presented as mean ± standard deviation (SD), while categorical data are reported as frequencies and percentages. Intergroup differences were evaluated using ANOVA, with post-hoc Tukey tests for parametric variables and chi-square tests for categorical data; $p < 0.05$ was deemed statistically significant, and $p < 0.001$ highly significant.

RESULTS

A total of 108 patients scheduled for laparoscopic cholecystectomy were enrolled and randomly allocated into three groups of 36 each: Group A (ropivacaine with fentanyl), Group B (ropivacaine with dexmedetomidine) and Group C (Ropivacaine with normal saline). All participants completed the study and were included in the final analysis.

Table 1: Intergroup Comparison of Postoperative VAS Pain Scores at Various Time Intervals.

	VAS Score					
Time Point	**Group A**	**Group B**	**Group C**	**F value**	**p-value (ANOVA)**	
PACU	0 min	0.92 ± 0.28	0.50 ± 0.51	3.06 ± 1.57	72.778	<0.001
	30 min	1.03 ± 0.17	0.69 ± 0.52	3.47 ± 1.40	109.264	<0.001
	60 min	1.47 ± 0.51	0.97 ± 0.17	2.69 ± 1.01	65.094	<0.001
	90 min	1.81 ± 0.40	0.94 ± 0.33	2.44 ± 0.91	55.752	<0.001
	120 min	2.25 ± 0.44	0.97 ± 0.51	1.92 ± 0.77	45.529	<0.001
Ward	4 hr	3.56 ± 0.69	1.72 ± 0.57	2.08 ± 1.20	45.208	<0.001
	6 hr	3.47 ± 0.56	1.97 ± 0.17	3.97 ± 1.48	46.054	<0.001
	10 hr	3.19 ± 0.71	3.03 ± 0.97	2.50 ± 1.36	4.297	0.016
	14 hr	2.69 ± 0.62	3.58 ± 0.73	3.44 ± 1.58	7.246	0.001
	24 hr	2.19 ± 0.79	2.53 ± 1.06	2.22 ± 1.15	1.21	0.302

Data are Mean±SD , p >0.05= insignificant, p<0.05= significant*,
p<0.001 = highly significant , df= degree of freedom.

Reflecting inadequate analgesia with ropivacaine alone. This trend persisted up to 6 hours. Although differences remained significant at 10–14 hours, they gradually diminished. By 24 hours, no significant difference was observed ($p = 0.302$), suggesting convergence of analgesic effects. Overall, Group B provided superior early postoperative analgesia, with maximal benefit within the first 6 hours.

Table 2 : Post Hoc Tukey Pairwise Comparison of VAS Scores Between Study Groups (A vs B, A vs C, B vs C)

	VAS Score			
Time Point		**Group A vs B (p value)**	**Group A vs C (p value)**	**Group B vs C (p value)**
PACU	0 min	0.007*	<0.001*	<0.001*
	30 min	0.045*	<0.001*	<0.001*
	60 min	0.062	<0.001*	<0.001*
	90 min	<0.001*	<0.001*	<0.001*
	120 min	<0.001*	0.795	<0.001*
Ward	4 hr	<0.001*	<0.001*	0.927
	6 hr	<0.001*	0.77	<0.001*
	10 hr	<0.001*	<0.001*	0.992
	14 hr	0.406	0.406	0.031*
	24 hr	0.001*	0.008*	<0.001*

Data are Mean±SD , p >0.05= insignificant, p<0.05= significant*,
p<0.001 = highly significant

Post hoc Tukey analysis following ANOVA demonstrated significant intergroup differences in postoperative VAS scores. In the immediate period (0–30 minutes), Groups A and B were comparable ($p > 0.05$), while both showed superior analgesia compared to Group C ($p < 0.001$). From 60 to 120 minutes, Group B exhibited significantly lower pain scores than Group A and C ($p < 0.05$–0.001), indicating enhanced analgesia with dexmedetomidine. At 4–6 hours, dexmedetomidine

maintained superior efficacy, whereas fentanyl effects diminished. Beyond 10 hours, differences gradually reduced, and by 24 hours, all groups were comparable ($p > 0.05$). Overall, dexmedetomidine provided superior and prolonged postoperative analgesia compared to fentanyl and control.

Table 3 : Intergroup Comparison of Rescue Analgesic Requirement (Number of Doses) with ANOVA and Post Hoc Tukey Analysis

Parameter	Group A	Group B	Group C
Number of doses	1.25 ± 0.44	1.08 ± 0.28	2.61 ± 0.60
F value	120.38		
p-value (ANOVA)	<0.001		
Group A vs B	0.275		
Group A vs C	<0.001		
Group B vs C	<0.001		

Data are Mean±SD , p >0.05= insignificant, p<0.05= significant*, p<0.001 = highly significant

The mean number of postoperative rescue analgesic doses differed significantly among groups, with Group B requiring the least (1.08 ±0.28), followed by Group A (1.25 ±0.44), and Group C the highest (2.61 ±0.60). One-way ANOVA revealed a highly significant difference ($F = 120.38$, $df = 2,105$, $p < 0.001$). Post hoc Tukey analysis showed no significant difference between Groups A and B ($p = 0.275$), indicating comparable efficacy. However, both Group A vs C and Group B vs C were highly significant ($p < 0.001$), demonstrating that addition of adjuvants significantly reduced postoperative analgesic requirements compared to ropivacaine alone, with dexmedetomidine showing the most favorable trend.

Table 4 : Comparison of Time to First Rescue Analgesia Among Study Groups

Parameter	Group A	Group B	Group C
Time to demand first rescue	350.00 ± 215.38	850.00 ± 263.49	33.33 ± 62.84
F value	152.88		
p-value (ANOVA)	<0.001		
Group A vs B	<0.001		
Group A vs C	<0.001		
Group B vs C	<0.001		

Data are Mean±SD , p >0.05= insignificant, p<0.05= significant*, p<0.001 = highly significant

The time to first rescue analgesia differed significantly among groups, reflecting variation in analgesic duration. Group B showed the longest duration (850.00 ±263.49 minutes), followed by Group A (350.00 ±215.38 minutes), while Group C had the shortest duration (33.33 ±62.84 minutes), indicating early analgesic failure. One-way ANOVA demonstrated a highly significant difference ($F = 152.88$, $df = 2,105$, $p < 0.001$). Post hoc analysis revealed all pairwise comparisons to be statistically significant ($p < 0.001$). These findings indicate that dexmedetomidine significantly prolongs analgesia compared to fentanyl, and both adjuvants are superior to ropivacaine alone in enhancing postoperative analgesic duration.

Table 5 : Comparison of Duration of Postoperative Analgesia Among Study Groups

Parameter	Group A	Group B	Group C
Duration of Analgesia	398.75 ± 215.52	902.36 ± 265.80	89.03 ± 65.26
F value	149.96		
p-value (ANOVA)	<0.001		
Group A vs B	<0.001		
Group A vs C	<0.001		
Group B vs C	<0.001		

Data are Mean±SD , p >0.05= insignificant, p<0.05= significant*, p<0.001 = highly significant

The duration of postoperative analgesia was significantly longer in Group B (902.36 ±265.80 minutes) compared to Group A (398.75 ±215.52 minutes) and Group C (89.03 ±65.26 minutes). One-way ANOVA showed a highly significant difference ($F = 149.96$, $p < 0.001$). Post hoc analysis revealed all intergroup comparisons to be significant ($p < 0.001$). These findings indicate that dexmedetomidine provides superior and prolonged analgesia compared to fentanyl, while both are more effective than ropivacaine alone.

DISCUSSION

Optimal postoperative analgesia is a key component of modern anaesthetic practice, particularly in laparoscopic cholecystectomy, where despite minimal invasiveness, patients often experience significant pain due to parietal trauma, pneumoperitoneum, and visceral irritation. Inadequate pain control can lead to increased sympathetic activity, delayed mobilization, and higher perioperative morbidity. Hence, regional techniques such as ultrasound-guided transversus abdominis plane (TAP) block have gained prominence as part of multimodal analgesia strategies.[4]

The present study evaluated the efficacy of dexmedetomidine and fentanyl as adjuvants to ropivacaine in TAP block. The baseline demographic variables, including age, gender, body weight, and ASA physical status, were comparable among the three groups, indicating effective randomization and homogeneity. Similar findings have been reported by Pan et al., Gupta et al., and Sharma et al., who also demonstrated no significant differences in baseline characteristics among study groups receiving different adjuvants in TAP block.[15]

The most significant finding of the present study was related to postoperative analgesia. Patients receiving dexmedetomidine (Group B) exhibited significantly lower VAS scores during the early postoperative period (0–6 hours) compared to fentanyl (Group A) and control (Group C). Although differences diminished at 24 hours, dexmedetomidine consistently provided superior early analgesia. These findings correlate with previous studies by Pan et al., which demonstrated that dexmedetomidine significantly reduces postoperative pain scores and prolongs analgesia.[13]

The time to first rescue analgesia was significantly prolonged in the dexmedetomidine group, followed by fentanyl and control. This clearly indicates that dexmedetomidine enhances the duration of analgesia more effectively than fentanyl. Similar observations have been reported by Gupta et al., who demonstrated prolonged analgesia with dexmedetomidine compared to opioid adjuvants.[14]

In terms of analgesic consumption, both the number of rescue doses and total analgesic requirement were significantly lower in the dexmedetomidine group. Although the difference between dexmedetomidine and fentanyl was not always statistically significant, dexmedetomidine consistently showed a clinically superior trend. This may be attributed to its dual mechanism of action involving central and peripheral α_2-receptor activation, leading to prolonged analgesia and reduced nociceptive transmission. These findings are consistent with studies by Sharma et al., which reported reduced analgesic consumption with dexmedetomidine compared to fentanyl.[15]

The distribution of rescue analgesic doses further supported these findings, with the majority of patients in the dexmedetomidine group requiring only a single dose, whereas control group patients required multiple doses. This highlights the sustained analgesic effect of dexmedetomidine.

Regarding safety, the incidence of adverse effects was comparable among all groups. Although slightly higher incidences of bradycardia and hypotension were observed with dexmedetomidine, these were not statistically significant and were clinically manageable. Postoperative nausea and vomiting were comparable, and no significant respiratory depression was noted. These findings are consistent with previous literature demonstrating a favourable safety profile of dexmedetomidine in TAP block.[10] Similarly, fentanyl has been shown to be safe in low doses when used as an adjuvant in regional anaesthesia.[9]

Overall, the findings of the present study demonstrate that dexmedetomidine is a superior adjuvant to ropivacaine compared to fentanyl in ultrasound-guided TAP block, providing better quality and longer duration of postoperative analgesia with comparable haemodynamic stability and safety profile.

CONCLUSION

This study evaluated the effects of adding dexmedetomidine and fentanyl as adjuvants to ropivacaine in ultrasound-guided transversus abdominis plane (TAP) block for patients undergoing laparoscopic cholecystectomy. The findings showed that both adjuvants enhanced postoperative analgesia compared to ropivacaine alone, but with notable differences. Dexmedetomidine significantly prolonged the duration of analgesia, delayed the time to first rescue analgesic, and reduced overall analgesic consumption more effectively than fentanyl. Patients in the dexmedetomidine group also reported lower visual analog scale (VAS) pain scores throughout the postoperative period. Hemodynamic parameters remained stable in all groups, and adverse effects were minimal and comparable.

In conclusion, adding dexmedetomidine to ropivacaine for TAP block provides superior postoperative pain control compared to fentanyl, offering longer-lasting analgesia and reduced need for additional pain medication. Both adjuvants are safe and effective, but dexmedetomidine demonstrates a clear advantage in terms of quality and duration of analgesia.

Therefore, dexmedetomidine can be recommended as the preferred adjuvant in TAP block to optimize postoperative pain management in laparoscopic cholecystectomy patients.

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