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Original Research Article

Dexamethasone and magnesium sulphate as adjuvants to bupivacaine in ultrasound guided subcostal transverse abdominis plane block during laparoscopic cholecystectomy: A prospective randomized comparative study

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Abstract

Background and Aims: Dexamethasone and magnesium sulphate ($MgSO_4$) are commonly used adjuvants to prolong the efficacy of regional nerve blocks. However, their specific effectiveness in subcostal transverse abdominis plane (SCTAP) blocks during laparoscopic cholecystectomy (LC) remains unclear. This study aimed to evaluate and compare the efficacy of dexamethasone and $MgSO_4$ as adjuvants to bupivacaine in ultrasound-guided (USG) bilateral SCTAP blocks for postoperative analgesia.

Methods: Sixty-eight patients (94.2% females, 5.8% males) classified as American Society of Anaesthesiologists (ASA) category I or II undergoing LC were enrolled. Patients were randomized to receive bupivacaine 0.25% (45 mg) combined with either dexamethasone (8 mg, Group-D) or $MgSO_4$ (200 mg, Group-M) on each side via USG-guided SCTAP blocks performed using a 10 cm Braun Stimuplex needle and a linear USG probe after surgery and before extubation. Postoperative pain was assessed using the Visual Analog Scale (VAS) at intervals of 10 min, 30 min, 2 hrs, 4 hrs, 8 hrs, 12 hrs, and 16 hrs. Rescue analgesia with intravenous (IV) fentanyl (25 µg) or IV paracetamol (1 g) was administered as needed. Data were analyzed using the Student's t-test and Chi-square test, with normality assessed using the Shapiro-Wilk W test.

Results: Group-M ($MgSO_4$) demonstrated consistently lower VAS pain scores, which were statistically significant at all time points except 4 and 12 hours. A smaller proportion of patients in Group-M required rescue analgesia compared to Group-D (8.82% vs. 29.41%, respectively).

Conclusion: $MgSO_4$ as an adjuvant to bupivacaine in subcostal transverse abdominis plane (SCTAP) blocks for laparoscopic cholecystectomy provides superior analgesic effects, with a longer postoperative pain-free period and reduced need for rescue analgesics compared to dexamethasone.

Keywords: Bupivacaine; dexamethasone; Laparoscopic cholecystectomy; Magnesium sulphate; Subcostal transverse abdominis plane block.

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1. Introduction

The adverse effects (respiratory depression, paralytic ileus, postoperative nausea, and vomiting leading to delayed post-operative recovery) seen with the opioids and non-steroidal anti-inflammatory drugs (NSAIDs) prompted the introduction of alternative strategies for post-operative analgesia.[1] The Transverse abdominis plane (TAP) block remains the mainstay of providing analgesia in majority of anterior abdominal wall procedures and is widely employed for laparoscopic cholecystectomy (LC). Effective postoperative pain management is crucial in post-operative management to reduce the incidence of respiratory and cardiovascular complications, promote early ambulation and rapid recovery.

Pre-emptive analgesia, by reducing postoperative discomfort, also helps prevent chronic pain, with opioids and NSAIDs being the most commonly used intraoperative analgesics.[2] Though dexamethasone and magnesium sulphate ($MgSO_4$) are the most effective adjuvants for extending the duration of action with lesser side effects, their efficacy in

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prolonging the subcostal TAP (SCTAP) block is yet to be well established, particularly among the Indian population.

This study evaluated and compared the efficacy of dexamethasone and $MgSO_4$ as adjuvants to bupivacaine in ultrasound-guided (USG) SCTAP blocks for patients undergoing laparoscopic cholecystectomy. The findings of this study aim to assist anaesthesiologists in optimizing adjuvant selection for USG-guided SCTAP blocks, thereby improving the quality of postoperative care and enhancing overall patient outcomes in LC.

2. Materials and Methods

This prospective, randomized, double-blind, comparative study was conducted by the department of Anaesthesiology at a tertiary care teaching institution after approval by the Institutional Ethics Committee (AHJ-ACD-007/01-21). The study adhered to the ethical standards outlined in the Indian Council of Medical Research's National Ethical Guidelines for Biomedical and Health Research Involving Human Participants (2017) and the Helsinki Declaration of 1975, as revised in 2013. Written informed consent was obtained from all prospective participants before screening.

The study aimed to evaluate and compare the efficacy of dexamethasone and $MgSO_4$ as therapeutic adjuvants to bupivacaine during USG guided SCTAP blocks for postoperative analgesia in patients undergoing bilateral block during LC. The primary objective was to assess the efficacy of these adjuvants by measuring postoperative pain scores using the Visual Analog Scale (VAS). The secondary objective was to evaluate the requirement for rescue analgesia.

The study included patients aged 18–70 years, classified as American Society of Anaesthesiologists (ASA) category I or II, and scheduled for elective LC. All patients underwent a pre-anaesthetic evaluation and later randomized into two groups using a closed-envelope method. A computer-generated sequence determined treatment allocation, which was concealed in sealed envelopes and opened sequentially upon patient enrolment. Group D received 18 mL (45 mg) of 0.25% bupivacaine with 2 mL (8 mg) dexamethasone on each side using a USG-guided SCTAP approach. Group M received 18 mL (45 mg) of 0.25% bupivacaine with 2 mL (200 mg) $MgSO_4$ on each side using the same technique.

All patients received intravenous (IV) midazolam at 0.02 mg/kg body weight as premedication 20 minutes before the induction of anaesthesia. Standard institutional monitoring practices were followed, including non-invasive blood pressure monitoring, continuous electrocardiography, oxygen saturation via pulse oximetry, and capnography. General anaesthesia was induced with IV fentanyl (1.5 µg/kg body weight) and IV propofol (2 mg/kg body weight). Tracheal intubation was facilitated using IV atracurium (0.5 mg/kg body weight) and maintained with IV atracurium (0.1 mg/kg body weight) and isoflurane at 1–2% minimum alveolar concentration (MAC).

Laparoscopic cholecystectomy was performed in the reverse Trendelenburg position. After the surgery and prior to extubation, a USG-guided bilateral SCTAP block was performed using a 10 cm Braun Stimuplex needle and a linear USG probe. With the patient in the supine position, the skin was disinfected, and the transducer was placed below the xiphoid process to visualize the linea alba (**Figure 1**). The probe was directed obliquely along the costal margin to view the rectus abdominis muscle. The transverse abdominis muscle was visualized beneath the rectus abdominis (**Figure 2**). A 10 cm echogenic needle was inserted in-plane medial to lateral until the needle tip reached the fascia between the rectus abdominis (posterior rectus sheath) and the transverse abdominis muscle. A "pop" sensation indicated entry into the TAP plane, confirmed by injecting 1–2 mL of saline (**Figure 3**). A total of 20 mL of local anaesthetic solution was administered bilaterally.

Postoperative pain was evaluated using VAS score on a 10 cm line (0 = no pain; 10 = worst pain) at intervals of 10 minutes, 30 minutes, 2 hours, 4 hours, 8 hours, 12 hours, and 16 hours after shifting the patient to recovery ward. Rescue analgesics, including IV fentanyl (25 µg) and IV paracetamol (1 g), were administered as needed, with all details recorded.

2.1. Statistical analysis

The sample size was determined using a priori analysis based on a pilot study.[3] Calculations were performed in accuracy mode with the VAS as the primary variable. Assuming a type-I error rate of 0.05 and an effect size convention of 0.9, a total of 68 patients were required to achieve adequate statistical power.

Data were collected and recorded on Microsoft Excel (2007) and analyzed using the Statistical Package for Social Sciences (SPSS) version 24. Continuous data were expressed as mean and standard deviation, while ordinal data were represented as median and interquartile ranges. The normality of the data distribution, a prerequisite for applying the Student's t-test, was assessed using the Shapiro-Wilk W test.

The Student's t-test was employed to compare continuous variables, such as age and weight, between the two groups. Pain scores measured by VAS were analyzed using repeated measures ANOVA, followed by LSD multiple comparison analysis. Categorical data, represented as frequencies and percentages, were analyzed using the Chi-square test. A p-value of less than 0.05 was considered statistically significant for all analyses.

3. Results

Sixty-eight (N=68) patients meeting the inclusion criteria were randomized into two groups, with 34 participants in

each group. All patients were within the ASA categories 1 and 2. The study population predominantly consisted of females, with 64 (94.12%) female participants overall (Group D: 33, 97.06%; Group M: 31, 91.18%).

The mean±SD age of the participants was 42.06 ± 12 years, with Group M being marginally older (Group D: 40.94 ± 10.876 years; Group M: 43.17 ± 13.13 years; p=0.442). The mean±SD weight of the study population was 60.33 ± 5.324 kg, with no statistically significant difference between the groups (Group D: 59.46 ± 3.936 kg; Group M: 61.206 ± 6.712 kg; p=0.190). All patients had cholecystitis due to gallstones, and the mean±SD duration of surgery was 84.535 ± 16.85 minutes (Group D: 85.80 ± 18 minutes; Group M: 83.27 ± 15.701 minutes; p=0.634).

Table 1 presents the mean VAS scores for postoperative pain in both groups. Group M consistently demonstrated lower mean VAS scores throughout the postoperative period, with statistically significant differences observed at all time points except at 4 hours (Group M: 1.37 ± 0.808; Group D: 1.69 ± 0.718; p=0.090) and 12 hours (Group M: 2.14 ± 0.974; Group D: 2.49 ± 0.702; p=0.096). Although the VAS scores increased over time in both the groups, the scores in Group M remained consistently lower (**Table 1**). **Figure 4** illustrates the trend of VAS scores at different time points.

Thirteen patients (19.11%) required rescue analgesia, with a significantly lower proportion in Group M compared to Group D (8.82% vs. 29.41%). The total dose of rescue analgesics administered was 2 µg IV fentanyl and 1 g IV paracetamol. Details of the first rescue analgesic administered are provided in **Table 2**.

There were no complications reported among any of the patients in the study population.

Table 1: VAS scores at different time interval among the two study groups

VAS	Group D	Group M	Pooled	p-value
	Mean ± SD	Mean ± SD	Mean ± SE	
10 min	1.54 ±1.039	0.26 ±0.443	0.900[a] ±0.095	0.000
30 min	1.80±0.868	0.97 ±0.822	1.386 [b]±0.101	0.000
2 hours	1.57±0.739	1.14±0.845	1.357 [b] ±0.095	0.027
4 hours	1.69±0.718	1.37 ±0.808	1.529 [b] ±0.091	0.090
6 hours	2.29±0.825	1.31 ±0.900	1.800 [c] ± 0.103	0.000
8 hours	2.69±0.758	2.00 ±0.939	2.343 [d] ±0.102	0.001
12 hours	2.49 ±0.702	2.14 ±0.974	2.314 [e] ±0.101	0.096
16 hours	2.91 ±0.853	2.49 ±0.612	2.700 [f] ±0.089	0.018
24 hours	3.23 ±0.690	2.51 ±0.562	2.871 [g] ±0.075	0.000

Variations in superscripts indicate significance of mean difference across the time points

Table 2: Requirement for first dose of rescue analgesics

Time of administration	Group D	Group M
10 min	01	-
08 hours	05	02
12 hours	-	01
16 hours	07	-

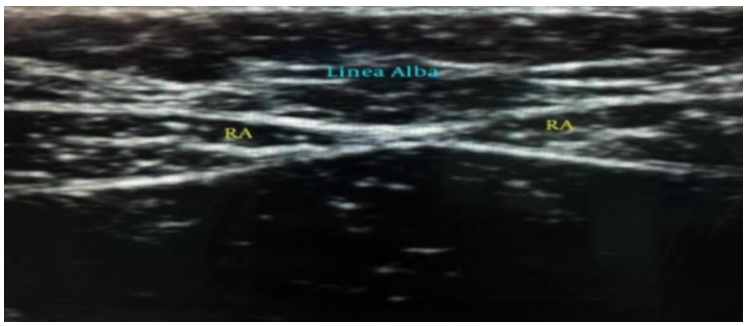

Figure 1: Ultrasonographic Image showing Linea Alba with two Rectus Abdominis (RA) muscles

Figure 2: Needle insertion in plane to the probe from medial side

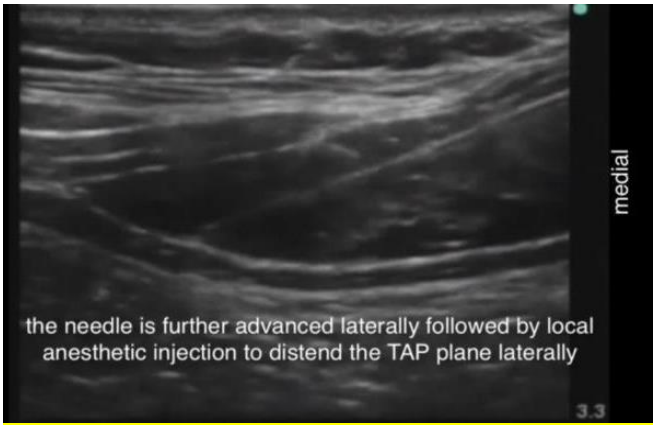

Figure 3: Ultrasnographicc image showing needle in plane and drug dispersal at the desired plane

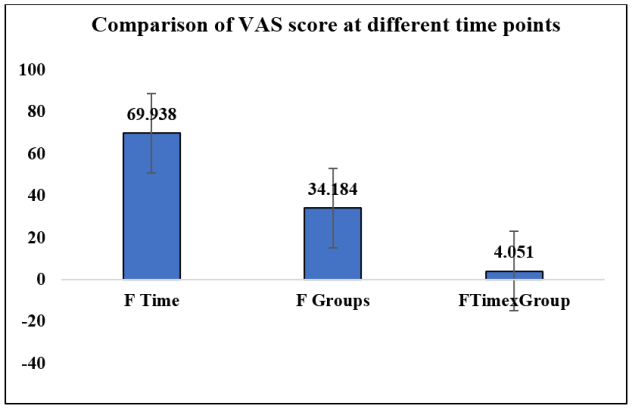

Figure 4: Comparison of VAS score at different timepoints (with error bars)

4. Discussion

Laparoscopic cholecystectomy has advantages such as fewer complications, a shorter hospital stay and better postoperative comfort over open surgery. However, it has the disadvantage of inducing a greater intensity of pain. A SCTAP block is a relatively safe technique, and the use of USG enhances the accuracy of the block, as it ensures proper deposition of local anaesthetic solution at the desired location,[4] and is an effective method of pain management in LC.[5-10]

Bupivacaine, an amide local anaesthetic introduced in 1963, is widely used due to its moderately long duration of action, typically lasting 3 to 6 hours in peripheral truncal nerve blocks. This duration is crucial for covering the highly painful postoperative period, which often extends through the first 12–16 hours. When continuous techniques are not feasible or when extended analgesia is required, adjuvants can be added to prolong the effect of local anaesthetics. Agents such as epinephrine, clonidine, dexmedetomidine, buprenorphine, dexamethasone, and magnesium sulphate ($MgSO_4$) have been studied for this purpose.

Both dexamethasone and $MgSO_4$ exhibit potential analgesic benefits when combined with local anaesthetics such as bupivacaine. Dexamethasone prolongs the duration of nerve blocks through its anti-inflammatory properties and modulation of nociceptive pathways. $MgSO_4$, a known N-methyl-D-aspartate (NMDA) receptor antagonist, exerts analgesic effects by inhibiting central sensitization and reducing pain perception.

Despite their potential, there is limited data on the use of $MgSO^4$ as an adjuvant in SCTAP blocks, particularly in comparison to dexamethasone, in adult Indian patients undergoing LC. This study aimed to address this gap by evaluating and comparing the efficacy of dexamethasone and $MgSO_4$ in SCTAP blocks for LC. The findings provide valuable insights into optimizing postoperative pain management strategies, ensuring better analgesic outcomes, and enhancing patient recovery following laparoscopic cholecystectomy.

Studies have consistently supported the use of $MgSO_4$ as an adjuvant in regional anaesthesia,[11-13] demonstrating an enhanced and prolonged postoperative analgesia in TAP blocks, particularly in LC.[14,15] $MgSO_4$ has been shown to reduce postoperative analgesic requirements and the incidence of nausea and vomiting.[16] A meta-analysis of four studies involving 263 patients confirmed these benefits, including improved pain control and prolonged analgesia.[7] Al-Refaey et al., in their three-arm comparative study, highlighted the efficacy of $MgSO_4$ as an adjuvant in TAP blocks with bupivacaine, noting lower pain scores and longer durations of analgesia. Similar observations were made by Sravanthi et al., who reported enhanced postoperative analgesia in patients undergoing LC with $MgSO_4$ as an adjuvant.[17] Other studies have supported these findings, emphasizing reduced analgesic requirements and improved pain control with $MgSO_4$ in TAP blocks.[8,18-20]

Jee et al. demonstrated that $MgSO_4$ also attenuates arterial blood pressure increases during LC, further highlighting its clinical benefits.[21] Bhat et al. confirmed the efficacy of $MgSO_4$ as an adjuvant in ultrasound-guided bilateral TAP blocks in Indian patients, reinforcing its safety and effectiveness in this demography.[22] In pediatric laparoscopic surgeries, $MgSO_4$ has also been reported as a safe and effective adjuvant to bupivacaine.[23] Dheeraj et al. further validated these results in a study of 82 Indian patients, noting similar positive outcomes.[24] These findings collectively encouraged the selection of $MgSO_4$ as an

anaesthetic adjuvant in our study, comparing it with dexamethasone for postoperative pain management in LC.

The dose of $MgSO_4$ used in this study was selected based on the findings of Gad et al., who evaluated the analgesic efficacy of 200 mg and 100 mg $MgSO_4$ as the sole agent in axillary blocks.[25] Their results showed better pain relief with 200 mg compared to 100 mg, suggesting its superior efficacy for prolonged analgesia. Dexamethasone at a dose of 8 mg was chosen as a comparator based on the study by Ammar et al., which highlighted its effectiveness as an adjuvant for extending the duration of analgesia in regional blocks.[26]

The efficacy of intraperitoneal administration of $MgSO_4$ for postoperative pain relief has been demonstrated in previous studies, showing lower VAS scores and reduced rescue medication requirements.[17,27] Evidence supports the effectiveness of $MgSO_4$ administered via intraperitoneal route and intravenously during LC.[28,29] A comparative study reported that intraperitoneal $MgSO_4$ was safe and effective for postoperative pain management, offering a shorter emergence and extubation time, while intravenous $MgSO_4$ provided better perioperative hemodynamic control.[30] Lu et al. observed that intravenous $MgSO_4$ improved physical comfort, independence, and overall recovery quality from anaesthesia.[31] Studies also indicate that intraperitoneal instillation of bupivacaine with $MgSO_4$ results in significant pain relief and a longer pain-free period during the first 24 hours postoperatively, along with a reduced need for rescue medication.[32] Saadawy et al. corroborated the beneficial effects of $MgSO_4$ in pain management[33], while Kansal et al. highlighted its safety and efficacy when used intraperitoneally compared to the intravenous route as an adjuvant to bupivacaine in LC.[30]

Mentes et al. reported that intraoperative $MgSO_4$ infusion effectively managed postoperative pain in LC.[29] Similarly, Yadava et al. emphasized that intraperitoneal bupivacaine-$MgSO_4$ combinations provide significant initial pain relief during the first 24 hours postoperatively, with a reduced requirement for rescue medications like paracetamol.[32]

Kocman et al., in their randomized comparative study, evaluated the effect of preemptive intravenous low-dose $MgSO_4$ on early postoperative pain after LC and reported that preemptive IV administration of $MgSO_4$ (5.0 mg/kg and 7.5 mg/kg) significantly reduce early postoperative pain after LC, and a better efficacy was noted with 7.5 mg/kg.[34] Various studies have compared $MgSO_4$ with normal saline,[17] tramadol[32] dexmedetomidine[35] and confirmed the better efficacy of $MgSo_4$.

Sravanthi et al. evaluated intraperitoneal $MgSO_4$ against normal saline for pain control in daycare LC, reporting significantly lower VAS scores within the first 6 hours and prolonged analgesia, resulting in delayed rescue medication use.[17] Hosalli et al. and Anand et al., documented prolonged postoperative analgesia, reduced rescue medication requirements, and better overall pain management with $MgSO_4$ as an adjuvant to bupivacaine in Indian patients.[36,37]

Our study showed a female preponderance, with patients in their forties and a diagnosis of cholecystitis. While both groups experienced a gradual increase in pain scores over time, the $MgSO_4$ group consistently exhibited lower VAS scores. The requirement for rescue analgesics was approximately 3.5 times lower in the $MgSO_4$ group compared to the dexamethasone group. These findings align with Gad et al., who concluded that 200 mg $MgSO_4$ is a superior adjuvant compared to dexamethasone 8 mg in LC.[25] However, our results contrast with Ammar et al., who found dexamethasone to prolong the duration of TAP block analgesia effectively.[26] Mahgoup et al. reported no significant difference in analgesic duration when comparing $MgSO_4$ and dexamethasone in supraclavicular brachial plexus blocks, suggesting that the variability in results could be attributable to the type of block used.[38] Shambhavi et al. favored dexamethasone in their randomized clinical trial, citing its ability to provide longer analgesia, fewer rescue analgesic requirements, and better patient satisfaction, although $MgSO_4$ also showed efficacy.[39]

No complications, intraoperative or postoperative, were reported in our study population, affirming the safety of both the drug and the procedure. However, isolated complications such as liver injury have been reported by Farooq et al., while performing TAP Block.[40]

Study limitations included a small sample size from a single center, which may limit the generalizability of our findings. Factors such as serum magnesium levels, hemodynamic changes, and time taken to perform the block were not assessed. Additionally, the follow-up period was limited to the first 24 hours postoperatively, whereas TAP blocks have been suggested to provide benefits for up to 48 hours.[41] Comparing our results with a control group receiving standard care could have provided clearer insights. Furthermore, intraoperative parameters such as surgical details, emergence time, and extubation time were not recorded, as they were beyond the scope of this study. Finally, variability in patient characteristics and the diverse population in our region limit the broader applicability of these findings. Our results specifically apply to the use of $MgSO_4$ as an adjuvant to bupivacaine in TAP blocks for LC patients.

5. Conclusion

A subcostal transverse abdominis plane block is a safe and effective technique for postoperative analgesia in LC, with adjuvants enhancing and prolonging its analgesic effects. $MgSO_4$, as an adjuvant in SCTAP block, provides superior analgesia, demonstrated by lower VAS scores, a prolonged pain-free postoperative period, delayed need for rescue analgesics, and reduced overall analgesic requirements.

$MgSO_4$ also exhibits an excellent safety profile with no recorded complications, making it a reliable option for enhancing postoperative pain management in LC.

6. Source of Funding

None.

7. Conflict of Interest

None.

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