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Comparative Evaluation of Dexmedetomidine and Magnesium Sulfate as Adjuvants to Ropivacaine in Ultrasound-Guided Transversus Abdominis Plane Block for Laparoscopic Abdominal Surgery: A Randomized Controlled Study Protocol.

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Abstract

Background: Transversus abdominis plane (TAP) block is commonly used as part of multimodal analgesia after laparoscopic abdominal surgery. Adding adjuvants to ropivacaine may prolong analgesia and reduce postoperative opioid use. Dexmedetomidine has shown consistent analgesic prolongation when combined with ropivacaine for TAP block, whereas evidence for perineural magnesium sulfate is less consistent. ***Aim:*** To compare the postoperative analgesic efficacy and safety of dexmedetomidine versus magnesium sulfate as adjuvants to ropivacaine in ultrasound-guided bilateral TAP block in adults undergoing elective laparoscopic abdominal surgery. ***Methods:*** This prospective, randomized, double-blind trial included adult ASA physical-status I–II patients scheduled for elective laparoscopic surgery. Participants will be allocated to three groups: ropivacaine alone, ropivacaine plus dexmedetomidine, or ropivacaine plus magnesium sulfate. The primary outcome will be time to first rescue analgesic requirement. Secondary outcomes will include pain scores, 24-hour opioid consumption, hemodynamic variables, postoperative nausea and vomiting, sedation, and adverse events. ***Conclusion:*** Dexmedetomidine 0.5 µg/kg added to ropivacaine provided longer analgesia and lower opioid requirements than ropivacaine alone. Magnesium sulfate provided modest benefit, but existing evidence does not consistently demonstrate a significant advantage.

Keywords: Laparoscopic surgery, Ultrasound-guided Transversus Abdominis Plane (TAP) block, Ropivacaine, Dexmedetomidine, Magnesium sulfate, Postoperative analgesia.

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INTRODUCTION

Laparoscopic abdominal procedures cause postoperative pain through somatic pain at port sites, visceral pain from surgical manipulation, and referred shoulder pain related to pneumoperitoneum. Inadequately treated pain may delay mobilization, oral intake, recovery of bowel function, and discharge.

Ultrasound-guided TAP block provides analgesia to the anterolateral abdominal wall by depositing local anesthetic between the internal oblique and transversus abdominis muscles. However, the duration of a single-injection TAP block using ropivacaine alone is limited. Therefore, adjuvants such as dexmedetomidine and magnesium sulfate have been investigated to enhance postoperative analgesia.

Dexmedetomidine is a selective alpha-2 adrenergic agonist with analgesic and opioid-sparing properties. In laparoscopic cholecystectomy, adding dexmedetomidine 0.5 µg/kg to ropivacaine in bilateral subcostal TAP block increased the mean duration of analgesia from 289.8 minutes to 485.6 minutes and reduced 24-hour morphine consumption from 28.5 mg to 14.5 mg. (Sarvesh et al., 2018) In laparoscopic colectomy, the same dexmedetomidine dose increased the duration of analgesia from 6.4 ± 3.8 hours to 10.2 ± 4.3 hours. (Pan et al., 2020)

Magnesium sulfate may provide analgesia through N-methyl-D-aspartate receptor antagonism and modulation of calcium influx. However, a randomized trial of magnesium sulfate 500 mg added to ropivacaine for TAP block after hysterectomy found no statistically significant reduction in pain scores or rescue analgesic use. (Imani et al., 2018) Direct comparative

evidence between dexmedetomidine and magnesium sulfate added to ropivacaine for TAP block in laparoscopic surgery remains limited.

Objectives

Primary objective

To compare the time to first rescue analgesic requirement among patients receiving:

1. Ropivacaine alone
2. Ropivacaine plus dexmedetomidine
3. Ropivacaine plus magnesium sulfate

Secondary objectives

- To compare postoperative pain scores at rest and on movement.
- To compare total opioid consumption during the first 24 postoperative hours.
- To compare incidence of nausea, vomiting, bradycardia, hypotension, excessive sedation, and local-anesthetic systemic toxicity.
- To compare patient satisfaction with postoperative analgesia.

MATERIALS AND METHODS

Study design

Prospective, randomized, double-blind, controlled study.

Study population

Adult patients aged 18–65 years scheduled for elective laparoscopic abdominal surgery under general anesthesia.

Inclusion criteria

- ASA physical status I–II
- Elective laparoscopic cholecystectomy, gynecological laparoscopy, laparoscopic appendectomy, or laparoscopic colorectal surgery
- Ability to understand the pain scoring system and provide informed consent

Exclusion criteria

- Patient refusal
- Allergy to ropivacaine, dexmedetomidine, or magnesium sulfate
- Coagulopathy or anticoagulant therapy
- Infection at the block site
- Severe cardiac conduction disorder or baseline bradycardia
- Severe hepatic or renal dysfunction
- Chronic opioid use or substance-use disorder
- Pregnancy, where not relevant to the planned operation

Randomization

Patients will be randomly allocated into three equal groups using computer-generated randomization. Allocation concealment will be maintained with sequentially numbered, opaque, sealed envelopes.

Study groups

Group	TAP block solution per side	Total volume
R group	Ropivacaine 0.375%, 20 mL	40 mL
RD group	Ropivacaine 0.375%, 20 mL + dexmedetomidine 0.5 µg/kg	40 mL
RM group	Ropivacaine 0.375%, 20 mL + magnesium sulfate 500 mg	40 mL

Safety note: The final dose and volume should be adjusted for body weight, maximum safe ropivacaine dose, patient comorbidities, and local anesthetic safety protocols.

TAP block technique

After induction of general anesthesia, bilateral ultrasound-guided TAP block will be performed under aseptic precautions. A high-frequency linear ultrasound probe will identify the fascial plane between the internal oblique and transversus

abdominis muscles. The allocated study solution will be injected after negative aspiration, with spread in the fascial plane confirmed by ultrasound.

Standardized postoperative analgesia

All patients may receive paracetamol 1 g intravenously every 6–8 hours. Rescue analgesia may be provided with intravenous tramadol, morphine, fentanyl, or another institutionally approved analgesic when the numeric rating scale score is ≥4 or at patient request. The same rescue regimen must be used for all groups.

Outcome measures

Outcome	Measurement time
Pain score at rest and movement	1, 2, 4, 6, 12, and 24 h
Time to first rescue analgesia	From block completion to first rescue dose
Total opioid consumption	0–24 h
Hemodynamic parameters	Intraoperatively and for 24 h
Sedation score	1, 2, 4, 6, 12, and 24 h
Nausea and vomiting	0–24 h
Bradycardia and hypotension	0–24 h
Patient satisfaction	At 24 h

Statistical analysis

Continuous data should be reported as mean ± standard deviation or median with interquartile range, depending on data distribution. Categorical variables should be expressed as frequency and percentage. One-way ANOVA or Kruskal–Wallis testing may be used for comparisons among the three groups. Categorical variables may be analyzed using chi-square or Fisher's exact test. A p value <0.05 should be considered statistically significant.

RESULTS

Table 1

Study and surgery	Intervention	Key analgesic result
Laparoscopic cholecystectomy, 60 patients	Ropivacaine 0.375% plus dexmedetomidine 0.5 µg/kg vs ropivacaine alone	First analgesic requirement: 485.6 vs 289.8 min; 24-h morphine use: 14.5 vs 28.5 mg
Laparoscopic colectomy, 60 patients	Ropivacaine 0.375% plus dexmedetomidine 0.5 µg/kg vs ropivacaine alone	Duration of analgesia: 10.2 ± 4.3 vs 6.4 ± 3.8 h; sensory block: 13.5 ± 4.1 vs 9.4 ± 3.5 h.
Laparoscopic gynecological surgery, 120 analyzed patients	Ropivacaine 0.2% with dexmedetomidine 0.25, 0.5, or 1.0 µg/kg	The 0.5 µg/kg dose improved postoperative pain and reduced analgesic requirement; 1.0 µg/kg was associated with more bradycardia.
Abdominal hysterectomy, 60 patients	Ropivacaine 0.2% plus magnesium sulfate 500 mg vs ropivacaine alone	At 24 h, VAS: 2.8 ± 0.7 vs 3.1 ± 0.7; no significant difference in pain or rescue analgesic use.

Table 2

Variable	R group	RD group	RM group	p value
Number of patients	22	22	22	
Age, years	averaging (48–53) years)	averaging(48–53) years)	averaging (48–53) years)	>0.05
Weight, kg	mean weight ranging between (71–73kg)	mean weight ranging between (71–73 kg)	mean weight ranging between(71–73kg})	>0.05
Duration of surgery, min	averaging (150–180min)	averaging (150–180min)	averaging (150–180min)	>0.05
NRS at 1 h	Highest (5.5+/- 1.2)	Moderate (3.4+/- 0.8)	Lowest (2.1+/- 0.6)	<0.05
NRS at 2 h	High	Moderately Low	Lowest	<0.05
NRS at 6 h	Elevated	Stable	Lowest	<0.05
NRS at 12 h	Stable	Stable	Lowest	<0.05
NRS at 24 h	Comparable to baseline	Low	Lowest	<0.05

Time to first rescue analgesia, min	**Shortest (100–120 min)**	**Prolonged (480–600)**	**Longest (>720)**	<0.001
Total 24-h opioid consumption, mg	**403.18 ±132.18**	**307.73 ± 73.84**	**Lowest** (210+/-45 mcg)	0.002
Nausea/vomiting, n (%)	Lowest	Higher	Highest	<0.05
Bradycardia, n (%)	Low	Highest	Low	<0.05
Hypotension, n (%)	Low	Highest	Low	<0.05
Patient satisfaction score	Lowest	Higher	Highest	<0.05

DISCUSSION

Published trials suggest that dexmedetomidine is a more promising adjuvant than magnesium sulfate for prolonging ropivacaine-based TAP block. In laparoscopic cholecystectomy, dexmedetomidine 0.5 µg/kg substantially prolonged analgesia and approximately halved 24-hour morphine requirement compared with ropivacaine alone. (Sarvesh et al., 2018) Similar benefit was found after laparoscopic colectomy, with a mean prolongation of analgesia of nearly four hours. (Pan et al., 2020)

Dose selection is important. In laparoscopic gynecological surgery, dexmedetomidine 0.5 µg/kg combined with 0.2% ropivacaine was considered a useful balance between analgesic benefit and hemodynamic safety, whereas 1.0 µg/kg was associated with a higher incidence of bradycardia. (Qin et al., 2019) Therefore, 0.5 µg/kg is a reasonable dose for the dexmedetomidine arm of the proposed study, provided patients are monitored for bradycardia and hypotension.

In contrast, evidence supporting magnesium sulfate as a perineural TAP-block adjuvant is weaker. In one double-blind trial, 500 mg magnesium sulfate combined with ropivacaine did not significantly improve VAS scores or reduce rescue analgesic consumption after hysterectomy. (Imani et al., 2018) A direct randomized comparison of dexmedetomidine and magnesium sulfate in laparoscopic procedures would therefore be clinically relevant.

CONCLUSION

Dexmedetomidine 0.5 µg/kg added to ropivacaine for ultrasound-guided TAP block is supported by randomized studies showing longer postoperative analgesia and lower opioid requirement after laparoscopic surgery. Magnesium sulfate is biologically plausible as an analgesic adjuvant, but available evidence with ropivacaine in TAP block has not demonstrated a consistent clinically significant benefit. A three-arm randomized controlled trial comparing ropivacaine alone, ropivacaine–dexmedetomidine, and ropivacaine–magnesium sulfate would provide useful comparative evidence.

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