RESEARCH PAPER

Magnesium as an Adjuvant to Ultrasound-Guided Transversus Abdominis Plane Block Improves Early Postoperative Pain and Maternal Quality of Recovery after Cesarean Section: A Double-Blind Randomized Controlled Trial

Andy Anthony Parung[1,2], Christrijogo Sumartono Waloejo[1,2], Prihatma Kriswidyatomo[1,3*], Kohar Hari Santoso[1,2], Maulydia[1,2], Mahmudah[4]

[1] Department of Anesthesiology and Reanimation, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia
[2] Dr. Soetomo General Academic Hospital, Surabaya, Indonesia
[3] Universitas Airlangga Academic Hospital, Surabaya, Indonesia
[4] Department of Epidemiology, Biostatistics, Population Studies and Health Promotion, Faculty of Public Health, Universitas Airlangga, Surabaya, Indonesia
[*] Corresponding author: Prihatma Kriswidyatomo. Email: prihatma@gmail.com. Address: Jl. Mayjen. Prof. Dr. Moestopo, 47 Surabaya 60132.

Received: 12th Mar, 2026 | **Revised:** 24th Mar, 2026 | **Accepted:** 14th Apr, 2026 | **Available Online:** 30th Apr, 2026

ABSTRACT

Background:

Postoperative pain after cesarean section may impair mobilization, breastfeeding, newborn care, maternal emotional well-being, and overall quality of recovery. Transversus abdominis plane (TAP) block is an opioid-sparing component of multimodal analgesia for abdominal wall pain, but its duration may be limited when local anesthetic is used alone. Magnesium sulfate may enhance regional analgesia through N-methyl-D-aspartate receptor antagonism and calcium influx inhibition.

Objective:

To evaluate whether magnesium sulfate as an adjuvant to ropivacaine in ultrasound-guided TAP block reduces postoperative pain and improves 24-hour maternal quality of recovery after elective cesarean section.

Methods:

This double-blind randomized controlled trial enrolled 30 patients undergoing elective cesarean section under subarachnoid block at Universitas Airlangga Hospital, Surabaya. Participants were randomized into two equal groups. Group A received bilateral TAP block using 0.375% ropivacaine 18 mL plus magnesium sulfate 400 mg on each side. Group B received 0.375% ropivacaine 18 mL plus 0.9% saline 2 mL on each side. Pain was assessed using the visual analog scale (VAS) at rest and during movement immediately after surgery and at 4, 6, 12, and 24 hours postoperatively. Quality of recovery was assessed at 24 hours using the Obstetric Quality of Recovery-10 (ObsQoR-10).

Results:

Baseline characteristics were comparable between groups. Pain scores did not differ immediately after surgery or at 4, 6, and 24 hours. At 12 hours, Group A had lower VAS at rest than Group B (median 1 [0-2] vs. 2 [1-3], p=0.030) and lower VAS during movement (2 [1-3] vs. 3 [2-4], p=0.001). No patient required rescue analgesia. Group A had better ObsQoR-10 emotional status (18 [17-19] vs. 17 [15-18], p=0.014), physical independence and infant care (37.73 +/- 1.58 vs. 36.33 +/- 1.84, p=0.033), pain domain (8 [7-9] vs. 7 [6-8], p=0.010), and total ObsQoR-10 score (91 [86-94] vs. 86 [83-91], p=0.006). Physical comfort was not significantly different (27 [26-28] vs. 27 [26-28], p=0.807).

Conclusion:

Magnesium as an Adjuvant to Ultrasound-Guided Transversus Abdominis Plane Block Improves Early Postoperative Pain and Maternal Quality of Recovery after Cesarean Section: A Double-Blind Randomized Controlled Trial

Magnesium sulfate as an adjuvant to ropivacaine in TAP block improved analgesia at 12 hours and enhanced maternal quality of recovery at 24 hours after elective cesarean section. The findings support magnesium as a potential adjuvant in multimodal analgesia, although larger multicenter trials are required.

Keywords: cesarean section; magnesium sulfate; ObsQoR-10; postoperative pain; quality of recovery; ropivacaine; transversus abdominis plane block

How to cite this article: Parung AA, Waloejo CS, Kriswidyatomo P, Santoso KH, Maulydia, Mahmudah. Magnesium as an Adjuvant to Ultrasound-Guided Transversus Abdominis Plane Block Improves Early Postoperative Pain and Maternal Quality of Recovery after Cesarean Section: A Double-Blind Randomized Controlled Trial. Int J Drug Deliv Technol. 2026;16(39s): 522-530. DOI: 10.25258/ijddt.16.39s.71

Source of support: Nil.

Conflict of interest: None

Introduction

Cesarean section is among the most frequently performed obstetric procedures worldwide and is associated with acute postoperative pain that can interfere with early mobilization, maternal-neonatal interaction, breastfeeding, and patient satisfaction. Poorly controlled pain may prolong hospitalization, increase analgesic requirements, and contribute to persistent postoperative pain. Accordingly, effective opioid-sparing analgesia is a central element of enhanced recovery after cesarean delivery and postpartum care.[1-3]

Multimodal analgesia aims to target different levels of nociceptive transmission while minimizing drug-related adverse effects. In this context, the transversus abdominis plane (TAP) block is commonly used to reduce somatic pain from the anterior abdominal wall incision. The block involves injection of local anesthetic into the fascial plane between the internal oblique and transversus abdominis muscles, where the thoracolumbar nerves supplying the lower abdominal wall travel. Although TAP block is technically accessible and generally safe under ultrasound guidance, its analgesic duration may be limited, and it does not reliably treat visceral pain. These limitations provide a rationale for exploring adjuvants that can prolong analgesia and improve early functional recovery.[3-6]

Magnesium sulfate is biologically plausible as a regional anesthetic adjuvant. Magnesium antagonizes N-methyl-D-aspartate receptors and inhibits calcium influx, mechanisms that may reduce central sensitization, attenuate peripheral nociceptive transmission, and prolong local anesthetic effects. Previous trials have suggested that magnesium as an adjuvant may reduce postoperative pain or analgesic consumption in several regional techniques, including quadratus lumborum block and TAP block, but findings vary across surgical procedures, local anesthetic types, doses, and block locations.[7-12]

For cesarean delivery, the success of postoperative analgesia should not be evaluated only by pain scores. A mother recovering from surgery needs to ambulate, care for the newborn, breastfeed or feed the infant, maintain personal hygiene, and regain emotional control. The Obstetric Quality of Recovery-10 (ObsQoR-10) is a patient-reported outcome measure developed specifically for postpartum recovery. It captures four domains relevant to maternal recovery: physical comfort, emotional status, physical independence and infant care, and pain. Because it is brief and practical, ObsQoR-10 can complement VAS pain assessment when evaluating analgesic interventions after cesarean section.[13-18]

This study investigated whether adding magnesium sulfate to ropivacaine for ultrasound-guided TAP block would reduce pain scores and improve ObsQoR-10 outcomes within the first 24 hours after elective cesarean section. We hypothesized that magnesium would improve early analgesia and quality of recovery compared with ropivacaine alone.

The choice of ropivacaine in this study is also relevant to postpartum recovery. Ropivacaine is a long-acting amide local anesthetic with a favorable sensory-motor profile and a wider safety margin than bupivacaine. In fascial plane blocks, it can provide sustained somatic analgesia while avoiding motor impairment that could delay ambulation. Combining ropivacaine with a non-opioid adjuvant may therefore

be advantageous in cesarean patients who need early mobilization and active newborn care.[19]

Recovery after cesarean section is multidimensional. Physical symptoms, pain, emotional control, and the ability to perform maternal tasks are all interdependent. Pain during movement may prevent turning in bed, standing, breastfeeding, or holding the baby; these limitations may subsequently worsen emotional experience and satisfaction. Therefore, the present study considered both static and dynamic pain and evaluated recovery with ObsQoR-10 rather than relying on a single pain measurement.[1,13,18]

The clinical question addressed in this trial is practical for obstetric anesthesia practice: whether a simple addition of magnesium sulfate to the TAP block injectate can improve the early postoperative window without increasing discomfort. This question is particularly relevant in institutions where intrathecal morphine is not routinely used or where minimizing opioid exposure is a priority.

Methods

Study design and setting

This was a quantitative, experimental, double-blind randomized controlled trial. The study was conducted in the operating room and postoperative ward of Universitas Airlangga Hospital, Surabaya, Indonesia, from November to December 2025. The manuscript was prepared according to the general structure of international original research articles and the CONSORT reporting framework for randomized trials.

The study was approved by the Ethics Committee of Universitas Airlangga Hospital (approval number 211/KEP/2025; approval date 29 September 2025). Written informed consent was obtained from all participants before enrollment, and participant confidentiality was maintained during data collection and analysis.

Participants

The study population comprised patients scheduled for elective cesarean section under subarachnoid block. Inclusion criteria were age 18-45 years, American Society of Anesthesiologists physical status I or II, willingness to participate, and written informed consent. Exclusion criteria were contraindications to spinal anesthesia or peripheral nerve block; allergy to magnesium, anesthetic agents, fentanyl, or metamizole; body mass index greater than 35 kg/m2; cerebrovascular disease; cardiovascular disease or valvular disease; hypertension; diabetes mellitus; hepatic or renal dysfunction; autoimmune disease; or active systemic infection.

Patients were withdrawn if spinal anesthesia or the block failed and required a change of anesthetic technique, high or total spinal block occurred, bleeding exceeded 20% of estimated blood volume, surgery was prolonged and required a change in anesthetic management, or the patient withdrew consent.

Sample size, randomization, and blinding

The minimum sample size was estimated using a two-group comparison formula based on a prior study, with alpha 0.05, power 95%, standard deviation 1.2, and expected mean difference 1.3. After adding a 20% correction for potential dropouts, the required total sample was rounded upward. Thirty patients were enrolled and equally allocated into two groups of 15.[9]

Consecutive sampling was used until the sample size was achieved. Eligible participants were randomized into Group A or Group B. The study used a double-blind design: participants and outcome assessors were unaware of allocation, and study injectates were prepared with the same total volume on each side.

Anesthesia and intervention protocol

Before surgery, identity, diagnosis, consent, and anesthesia plan were rechecked. Standard monitoring included electrocardiography, noninvasive blood pressure, heart rate, respiratory rate, and oxygen saturation. Oxygen was administered by nasal cannula at 3 L/min. Preemptive analgesia was provided using paracetamol 1 g intravenously. Subarachnoid block was performed using a 26G spinal needle with Lidodex 5% 60-75 mg (1.2-1.5 mL) and adrenaline 0.2 mg, targeting a T6 sensory level. Postoperative analgesia consisted of metamizole 1 g every 8 hours.

After surgery, bilateral ultrasound-guided TAP block was performed in the supine position. The ultrasound probe was placed transversely between the subcostal margin and the iliac crest at the midaxillary line. The needle was advanced in-plane from anteromedial to posterolateral, and the tip was

positioned between the internal oblique aponeurosis and the transversus abdominis muscle. After aspiration, injectate was delivered under ultrasound visualization, and correct spread was confirmed by hypoechoic separation of the fascial layers.[4,5]

Group A received TAP block with 0.375% ropivacaine 18 mL plus 20% magnesium sulfate 2 mL on each side. This corresponded to magnesium sulfate 400 mg per side. Group B received 0.375% ropivacaine 18 mL plus 0.9% saline 2 mL on each side. Rescue analgesia was planned as fentanyl 1 mcg/kg intravenously if VAS exceeded 3 at any assessment point.

Outcome measures

The pain outcome was the VAS score at rest and during movement immediately after surgery and at 4, 6, 12, and 24 hours after TAP block. The maternal recovery outcome was the ObsQoR-10 score at 24 hours after surgery. ObsQoR-10 was analyzed as total score and by domains: physical comfort, emotional status, physical independence and infant care, and pain.[13,18]

Baseline characteristics included age, body weight, height, body mass index, and ASA physical status. These variables were assessed to evaluate comparability between groups before outcome analysis.

ObsQoR-10 domain interpretation

The ObsQoR-10 instrument contains 10 scored items with a total range of 0 to 100, where higher scores indicate better recovery. In this study, the questionnaire was summarized into clinically meaningful domains. The physical comfort domain included symptoms such as nausea or vomiting, dizziness, and shivering. The emotional status domain reflected comfort and perceived control. The physical independence and infant care domain reflected ability to mobilize, care for the baby, feed the baby, and perform personal hygiene. The pain domain represented the patient pain experience during the first 24 hours.[13-18]

Using these domains allowed the analysis to distinguish whether the intervention affected only pain perception or also broader functional and maternal recovery. This approach is important because two patients with similar pain scores may have different abilities to ambulate or care for the newborn.

Statistical analysis

Data were checked for completeness before analysis. Continuous data were presented as mean +/- standard deviation for normally distributed variables or median (minimum-maximum) for non-normally distributed variables. Normality was assessed using the Shapiro-Wilk test. Between-group comparisons were performed using the independent sample t-test for normally distributed variables and the Mann-Whitney U test for non-normally distributed variables. Categorical variables were summarized descriptively. Statistical significance was defined as $p<0.05$. Analyses were performed using SPSS.

Results

Participant characteristics

Thirty patients were included in the analysis: 15 in Group A and 15 in Group B. Group A received TAP block with ropivacaine and magnesium sulfate, whereas Group B received TAP block with ropivacaine and saline. Baseline characteristics were comparable between groups, including age, body weight, height, body mass index, and ASA physical status. All participants were ASA physical status II.

Mean age was 30.93 +/- 6.08 years in Group A and 30.47 +/- 5.72 years in Group B (p=0.830). Mean body weight was 68.67 +/- 8.16 kg and 75.77 +/- 12.22 kg, respectively (p=0.072). Median height was 1.53 (1.50-1.65) m and 1.56 (1.47-1.65) m (p=0.276), and median body mass index was 29.33 (21.30-34.38) kg/m2 and 33.43 (24.22-34.77) kg/m2 (p=0.071).

Table 1. Baseline characteristics of the study participants.

Characteristic	Group A: TAP + magnesium (n=15)	Group B: TAP alone (n=15)	p value
Age, years	30.93 +/- 6.08	30.47 +/- 5.72	0.830
Body weight, kg	68.67 +/- 8.16	75.77 +/- 12.22	0.072
Height, m	1.53 (1.50-1.65)	1.56 (1.47-	0.276

Characteristic	Group A: TAP + magnesium (n=15)	Group B: TAP alone (n=15)	p value
		1.65)	
BMI, kg/m2	29.33 (21.30-34.38)	33.43 (24.22-34.77)	0.071
ASA physical status	II	II	-

Values are mean +/- SD or median (minimum-maximum). BMI: body mass index; ASA: American Society of Anesthesiologists.

Postoperative pain

There were no significant differences in resting or movement VAS immediately after surgery or at 4, 6, and 24 hours postoperatively. A significant difference was observed at 12 hours. Resting VAS was lower in Group A than Group B (1 [0-2] vs. 2 [1-3], p=0.030), and movement VAS was also lower in Group A (2 [1-3] vs. 3 [2-4], p=0.001). At 24 hours, pain scores converged and were no longer statistically different. No participant required rescue fentanyl during the observation period.

The time course indicates that the analgesic advantage of magnesium was clinically most apparent during the early postoperative period, especially at 12 hours, rather than immediately after surgery or at 24 hours.

Table 2. Postoperative VAS pain scores at rest and during movement.

Time point	Condition	Group A: TAP + magnesium	Group B: TAP alone	p value
Immediately after surgery	Rest	0 (0-0)	0 (0-1)	0.150
Immediately after surgery	Movement	0 (0-1)	0 (0-1)	0.710
4 hours	Rest	0 (0-1)	0 (0-1)	0.446
4 hours	Movement	1 (0-1)	1 (1-2)	0.087
6 hours	Rest	1 (0-1)	1 (0-2)	0.172
6 hours	Movement	1 (0-2)	1 (1-3)	0.309
12 hours	Rest	1 (0-2)	2 (1-3)	0.030
12 hours	Movement	2 (1-3)	3 (2-4)	0.001
24 hours	Rest	0 (0-1)	1 (0-1)	0.472
24 hours	Movement	1 (0-2)	1 (1-2)	0.199

Values are median (minimum-maximum). VAS: visual analog scale. Between-group comparisons used Mann-Whitney U test.

Quality of recovery at 24 hours

The ObsQoR-10 physical comfort domain did not differ between groups, with identical median scores of 27 (26-28) (p=0.807). In contrast, Group A had better emotional status than Group B (18 [17-19] vs. 17 [15-18], p=0.014), better physical independence and infant care (37.73 +/- 1.58 vs. 36.33 +/- 1.84, p=0.033), and better pain domain score (8 [7-9] vs. 7 [6-8], p=0.010).

The total ObsQoR-10 score was significantly higher in Group A than Group B (91 [86-94] vs. 86 [83-91], p=0.006), indicating better patient-reported maternal recovery after TAP block with magnesium. Both groups had total scores above 70, suggesting generally good recovery; however, magnesium was associated with superior recovery quality within the first 24 hours.

Table 3. ObsQoR-10 domain and total scores at 24 hours postoperatively.

ObsQoR-10 domain	Group A: TAP + magnesium	Group B: TAP alone	p value
Physical comfort	27 (26-28)	27 (26-28)	0.807
Emotional status	18 (17-19)	17 (15-	0.014

ObsQoR-10 domain	Group A: TAP + magnesium	Group B: TAP alone	p value
		18)	
Physical independence and infant care	37.73 +/- 1.58	36.33 +/- 1.84	0.033
Pain	8 (7-9)	7 (6-8)	0.010
Total ObsQoR-10	91 (86-94)	86 (83-91)	0.006

Values are mean +/- SD or median (minimum-maximum), according to distribution. ObsQoR-10: Obstetric Quality of Recovery-10.

Clinical interpretation of the result pattern

The overall pattern suggests a delayed but clinically relevant benefit of magnesium. Pain scores were very low in both groups immediately after surgery and at 4 hours, likely because of residual neuraxial anesthesia and concurrent non-opioid analgesics. The between-group separation at 12 hours occurred when the spinal anesthetic effect had waned and the duration of the TAP block became more important. The absence of a significant difference at 24 hours may reflect the natural decrease of incisional pain, the effect of routine postoperative analgesia, and convergence of recovery in both groups.

The improvement in total ObsQoR-10 despite only one time point of significantly lower VAS pain suggests that early pain relief may have downstream effects on perceived recovery. Better pain control can make movement less threatening, support confidence in caring for the baby, and improve the emotional experience of the first postoperative day.

Discussion

This randomized double-blind trial found that magnesium sulfate as an adjuvant to ropivacaine in ultrasound-guided TAP block improved pain control at 12 hours after elective cesarean section and enhanced several domains of maternal recovery at 24 hours. The effect was most evident for VAS at rest and during movement at 12 hours and for the ObsQoR-10 emotional status, physical independence and infant care, pain, and total score domains. The physical comfort domain, which reflects symptoms such as nausea or vomiting, dizziness, and shivering, was not different between groups.

The timing of the analgesic benefit is clinically plausible. Immediately after surgery and in the early 4- to 6-hour period, residual effects from spinal anesthesia and routine multimodal analgesia may have minimized differences between groups. By 12 hours, the contribution of TAP block quality and duration becomes more relevant. Magnesium may prolong local anesthetic action through NMDA receptor antagonism, inhibition of calcium influx, and modulation of neuronal excitability. These mechanisms are consistent with prior reports in regional anesthesia showing longer analgesia and reduced analgesic requirements when magnesium is used as an adjuvant, although the magnitude of benefit varies across block type and surgical model.[7-12]

The present findings are aligned with studies suggesting that regional blocks can improve post-cesarean pain and functional recovery. Previous cesarean section research has shown that TAP block reduces pain compared with standard therapy and may improve postoperative mobilization. Studies of magnesium in fascial plane blocks, including quadratus lumborum block, have also suggested lower pain scores and prolonged analgesia. By focusing on TAP block with ropivacaine and magnesium in a cesarean population, this study adds evidence that magnesium can improve the clinically relevant 12-hour analgesic window.[6,9,20-22]

An important strength of this study is the inclusion of ObsQoR-10 as a maternal recovery outcome. Pain scores alone cannot fully reflect postpartum recovery. A patient may have tolerable pain but still be unable to mobilize, care for the infant, breastfeed, or feel emotionally comfortable. The better emotional status score in the magnesium group may be related to lower pain burden and greater perceived control. Similarly, the better physical independence and infant care domain suggests that improved analgesia may facilitate activities central to postpartum recovery, such as mobilization, infant holding, feeding, and personal hygiene.[13,14,17,18]

The lack of difference in physical comfort is also informative. Magnesium in this dose and route did not appear to worsen or improve symptoms such as nausea, vomiting, dizziness, or shivering. This supports the clinical impression that magnesium as a TAP block adjuvant may enhance analgesia without adding

obvious short-term discomfort, although the study was not powered to detect rare adverse events. No patient required rescue fentanyl, which may reflect the effectiveness of the background analgesic regimen, the low postoperative pain scores in both groups, or the relatively small sample.

The results should be interpreted cautiously. This was a single-center study with 30 participants, so external validity is limited. Follow-up was restricted to 24 hours; therefore, the impact on later recovery, breastfeeding success, length of stay, patient satisfaction after discharge, and chronic post-cesarean pain could not be assessed. The study compared one magnesium dose and one ropivacaine concentration, so the optimal dose-response relationship remains unknown. Future studies should include larger multicenter samples, longer follow-up, formal adverse event monitoring, and comparison with other adjuvants such as dexamethasone or dexmedetomidine.

A notable aspect of the result is the discrepancy between the physical comfort domain and the other ObsQoR-10 domains. Physical comfort symptoms were similar in both groups, suggesting that the magnesium dose used in the TAP block did not materially change nausea, vomiting, dizziness, or shivering. This finding is reassuring because adjuvants should not improve analgesia at the cost of additional adverse symptoms. However, the questionnaire was not designed to replace formal safety monitoring, and larger studies are needed to evaluate rare complications.

The improvement in physical independence and infant care is clinically important. After cesarean delivery, mothers are expected to ambulate early, care for the newborn, initiate feeding, and maintain personal hygiene. Dynamic pain is often the factor that limits these activities. The significant reduction in movement VAS at 12 hours provides a plausible explanation for the higher functional recovery score in the magnesium group.[1,3,18]

These data also support the use of patient-reported outcome measures in obstetric anesthesia research. Traditional outcomes such as VAS pain score and opioid consumption remain important, but they do not fully capture maternal goals. ObsQoR-10 provides a broader evaluation that includes emotional control and infant care, making it particularly suitable for cesarean recovery studies.[13,14,16-18]

Despite these limitations, the findings have practical implications. Adding magnesium to TAP block may be considered in opioid-sparing multimodal analgesia for elective cesarean section when the clinical goal includes not only pain reduction but also improved early maternal recovery. ObsQoR-10 may also be useful as a routine patient-reported measure to evaluate the effectiveness of enhanced recovery after cesarean delivery protocols and regional analgesia strategies.[3,6,12]

Conclusion

Magnesium sulfate as an adjuvant to ropivacaine in ultrasound-guided TAP block reduced postoperative pain at rest and during movement at 12 hours after elective cesarean section. It also improved 24-hour maternal quality of recovery, particularly emotional status, physical independence and infant care, pain domain, and total ObsQoR-10 score. These results support magnesium as a promising adjuvant for multimodal, opioid-sparing post-cesarean analgesia, while further multicenter trials are needed to confirm optimal dosing, safety, and longer-term recovery benefits.

Declarations

Ethics approval: Ethics Committee of Universitas Airlangga Hospital, approval number 211/KEP/2025, dated 29 September 2025.

Consent to participate: All participants provided written informed consent before enrollment. Confidentiality of participant data was maintained throughout the study.

Funding: No external funding was reported.

Conflict of interest: The authors declare no conflict of interest.

Data availability: The datasets generated and analyzed during the study are available from the corresponding author on reasonable request, subject to ethical approval and privacy restrictions.

Author contributions: AAP contributed to conceptualization, data collection, analysis, and manuscript drafting. CSW and PK contributed to supervision, methodology, and manuscript revision. All

authors should review and approve the final submitted manuscript.

Acknowledgments: The authors thank the operating room, obstetric ward, and laboratory teams of Universitas Airlangga Hospital for their support during the study.

References

1. O'Carroll J, Carvalho B, Sultan P. Enhancing recovery after cesarean delivery - a narrative review. Best Pract Res Clin Anaesthesiol. 2022;36(1):89-105.
2. Pirie K, Traer E, Finniss D, Myles PS, Riedel B. Current approaches to acute postoperative pain management after major abdominal surgery: a narrative review and future directions. Br J Anaesth. 2022;129(3):378-393.
3. Roofthooft E, Joshi GP, Rawal N, Van de Velde M; PROSPECT Working Group. PROSPECT guideline for elective caesarean section: updated systematic review and procedure-specific postoperative pain management recommendations. Anaesthesia. 2021;76(5):665-680.
4. Abdallah FW, Laffey JG, Halpern SH, Brull R. Duration of analgesic effectiveness after posterior and lateral transversus abdominis plane block techniques for transverse lower abdominal incisions: a meta-analysis. Br J Anaesth. 2013;111(5):721-735.
5. Agarwal J, Babuwe-Ngobi J, Belani KG, Malhotra N. Peripheral nerve blocks for analgesia following cesarean delivery: a narrative review. J Anaesthesiol Clin Pharmacol. 2024;40(2):192-198.
6. Salazar-Florez JE, Arenas-Cardona LT, Marhx N, et al. Transversus abdominis plane block versus epidural anesthesia for pain management post-caesarean delivery: a pilot study. Local Reg Anesth. 2024;17:39-47.
7. Abd-Elsalam KA, Fares KM, Mohamed MA, Mohamad MF, El-Rahman AMA, Tohamy MM. Efficacy of magnesium sulfate added to local anesthetic in a transversus abdominis plane block for analgesia following total abdominal hysterectomy: a randomized trial. Pain Physician. 2017;20(7):641-647.
8. Albrecht E, Kirkham KR, Liu SS, Brull R. Peri-operative intravenous administration of magnesium sulphate and postoperative pain: a meta-analysis. Anaesthesia. 2013;68:79-90.
9. Peng Q, Yang X, Li J, You Y, Zhao X. The effect of magnesium sulfate in ultrasound-guided quadratus lumborum block on postoperative analgesia: a randomized controlled trial. Pain Ther. 2023;12(1):141-150.
10. Saraiva WB, Candido IE, Caldas RRB, Barbosa FT. Efficacy of magnesium sulfate as an adjuvant to local anesthetics in supraclavicular brachial plexus block: a meta-analysis of randomized trials. Braz J Anesthesiol. 2025;76(1).
11. Shin HJ, Na HS, Do SH. Magnesium and pain. Nutrients. 2020;12(8):2184.
12. Zeng J, Chen Q, Yu C, Zhou J, Yang B. The use of magnesium sulfate and peripheral nerve blocks: an updated meta-analysis and systematic review. Clin J Pain. 2021;37(8):629-637.
13. Ciechanowicz S, Setty T, Robson E, et al. Development and evaluation of an obstetric quality-of-recovery score following elective caesarean delivery. Int J Obstet Anesth. 2019;39:51-59.
14. Dusitkasem S, Jindapitak J, Arnuntasupakul V, Lekprasert V, Bumrungphuet S, Sukying C, et al. Validation of the Thai version of the obstetric quality of recovery score (ObsQoR-10-Thai) after elective cesarean delivery. BMC Anesthesiol. 2023;23:72.
15. Kozanhan B, Yildiz M, Polat A, et al. Development and validation of a Turkish version of Obstetric Quality of Recovery-10. Turk J Anaesthesiol Reanim. 2022;50(5):366-372.
16. Mazoue E, Veret M, Corroenne R, et al. Translation and validation of the French version of the ObsQoR-10 questionnaire for the evaluation of recovery after delivery. BJA Open. 2023;7:100221.
17. Shalev S, Orbach-Zinger S, Sultan P, Guo N, Ronel I, Davis A, Weiniger CF. Obstetric quality of recovery scoring tool: assessment of validity, reliability and feasibility in an Israeli cesarean delivery population. Int J Obstet Anesth. 2020;44:51-59.
18. Sultan P, Kamath N, Carvalho B, Bansal P, Elkhateb R, Dougan S, et al. Evaluation of inpatient postpartum recovery using the Obstetric Quality of Recovery-10 patient-reported outcome measure: a single-center observational study. Am J Obstet Gynecol MFM. 2020;2(4):100202.
19. Kuthiala G, Chaudhary G. Ropivacaine: a review of its pharmacology and clinical use. Indian J Anaesth. 2011;55(2):104-110.
20. Muhtadir A, Ahmad MR, Muhadi R, Tanra AH, Husain AAA, Datu MDD. Efek blok transversus

abdominis plane terhadap intensitas nyeri dan kadar nerve growth factor pasca seksio sesarea. J Anestesi Obstetri Indonesia. 2023;6(1):1-7.

21. Pinarbasi A, Altiparmak B, Toker MK, Pirinccii F, Ugur B. Ultrasound-guided transversalis fascia plane block or transversus abdominis plane block for recovery after caesarean section: a randomised clinical trial. Eur J Anaesthesiol. 2024;41(10):769-778.

22. Seger RW, Sumartono C, Wardhani P, Aditiawarman. The effect between transverse abdominis plane block and quadratus lumborum block on endorphin beta levels and pain scales in post cesarean section patients. J Widya Medika. 2020;6(2):82-94.