Optimizing Posterior Quadratus Lumborum Block: The Roles of Dexamethasone and Magnesium Sulfate in Prolonging Bupivacaine Analgesia

Mohamed Samir Mohamed Khalel, Howida Kamal Abdellatif , Salwa Hassan Waly, Amira Saeed El Sayed

Department of Anesthesia, Intensive Care and Pain Management, Faculty of Medicine, Zagazig University

Corresponding Author: Mohamed Samir Mohamed Khalel

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Abstract

Background: Ultrasound-guided posterior quadratus lumborum block (QLB) is increasingly incorporated into multimodal analgesic pathways for abdominal and pelvic surgery. Although bupivacaine provides effective regional analgesia, the duration of a single-injection block may not cover the entire period of clinically important postoperative pain. Dexamethasone and magnesium sulfate have therefore been investigated as adjuvants capable of extending analgesia and reducing opioid requirements.

Objective: This review evaluates the anatomical basis, mechanisms, analgesic efficacy, and safety of dexamethasone and magnesium sulfate when added to bupivacaine for posterior QLB.

Methods: Relevant anatomical investigations, randomized clinical trials, systematic reviews, meta-analyses, and pharmacological studies were evaluated. Evidence concerning QLB anatomy and injectate distribution, bupivacaine pharmacology, adjuvant mechanisms, analgesic duration, postoperative pain, rescue opioid use, hemodynamic effects, and treatment-related adverse events was synthesized.

Results: Posterior QLB deposits local anesthetic along the posterior surface of the quadratus lumborum muscle, allowing distribution within the thoracolumbar fascial system and blockade of lower thoracic and upper lumbar sensory pathways. Dexamethasone may prolong analgesia through local anti-inflammatory activity, suppression of ectopic neuronal discharge, modulation of potassium channels, and systemic glucocorticoid effects. Magnesium reduces nociceptive transmission principally through N-methyl-D-aspartate receptor antagonism and regulation of calcium influx. Clinical evidence indicates that either adjuvant can reduce postoperative pain and rescue opioid exposure compared with local anesthetic alone. Direct comparative evidence remains limited, but dexamethasone generally appears to produce more consistent and prolonged analgesia. Magnesium sulfate remains potentially valuable when glucocorticoid-related hyperglycemia is undesirable, although hypotension, bradycardia, neuromuscular weakness, and toxicity in renal impairment require consideration.

Conclusion: Dexamethasone and magnesium sulfate can enhance bupivacaine-based QLB, but current evidence more consistently supports dexamethasone for prolonging single-injection analgesia. Adjuvant selection should be individualized, and further adequately powered trials using standardized posterior QLB techniques are required.

Keywords: Quadratus lumborum block, Bupivacaine, Dexamethasone, Magnesium sulfate, Postoperative analgesia

Introduction

Effective postoperative pain control promotes early mobilization, preserves respiratory function, reduces sympathetic stress, and facilitates recovery after abdominal and pelvic surgery. Opioids remain important for treating severe pain, but nausea, vomiting, pruritus, sedation, ileus, urinary retention, and respiratory depression limit reliance on opioid-dominant regimens. Ultrasound-guided fascial plane blocks have therefore become prominent components of multimodal analgesia because they can provide regional pain control while decreasing systemic analgesic exposure [1].

The quadratus lumborum block was developed as an extension of abdominal wall blockade. Unlike the transversus abdominis plane block, which mainly targets somatic nerves within the anterolateral abdominal wall, QLB places local anesthetic adjacent to the quadratus lumborum muscle and thoracolumbar fascia. This deeper location may produce more extensive sensory coverage and, in some approaches, influence visceral nociception through spread toward the thoracic paravertebral region or sympathetic pathways [2].

Several QLB variants have been described according to the relationship between the needle tip, quadratus lumborum muscle, psoas major muscle, erector spinae, and thoracolumbar fascia. These include lateral, posterior, anterior or transmuscular, and intramuscular approaches. Posterior QLB is technically attractive because the injection point is relatively superficial, the target is readily identified using ultrasound, and the needle generally remains distant from the peritoneum and major lumbar plexus structures [3].

Bupivacaine is widely used for QLB because its high protein binding and lipid solubility provide a relatively long duration of sensory blockade. Nevertheless, a single injection may wear off before the period of greatest postoperative pain has resolved. Increasing the concentration or volume may extend coverage but simultaneously raises the total administered dose and the risk of local anesthetic systemic toxicity. Pharmacological adjuvants offer an alternative strategy for prolonging analgesia without substantially increasing the local anesthetic dose [4].

Dexamethasone and magnesium sulfate are among the most extensively studied nonopioid regional-anesthesia adjuvants. They have different biological targets: dexamethasone predominantly modifies inflammatory and neuronal processes, whereas magnesium reduces excitatory nociceptive transmission. Their comparative roles in posterior QLB remain uncertain because clinical studies vary in surgical population, local anesthetic formulation, adjuvant dose, block approach, and outcome definitions [5].

This review examines the anatomical basis of posterior QLB, the pharmacology of bupivacaine, the mechanisms and clinical effects of dexamethasone and magnesium sulfate, and the available evidence guiding selection between these adjuvants.

Anatomical Basis of Posterior Quadratus Lumborum Block

Quadratus lumborum and surrounding structures

The quadratus lumborum is a paired posterior abdominal wall muscle extending from the iliolumbar ligament and posterior iliac crest to the medial border of the twelfth rib and transverse processes of the upper lumbar vertebrae. It contributes to lateral flexion of the trunk, stabilization of the twelfth rib during respiration, and control of lumbar posture. Anteriorly, it is related to the psoas major and transversalis fascia, while the erector spinae muscle group lies posteriorly [1].

The thoracolumbar fascia is a multilayered connective-tissue complex that surrounds the paraspinal musculature and establishes continuity among the abdominal wall, lumbar spine, ribs, and pelvis. Its organization around the quadratus lumborum provides potential pathways through which injectate can distribute beyond the immediate needle-tip location. Fascial architecture, tissue compliance, injection pressure, and anatomical variation contribute to the variability observed in QLB spread [6].

The lower thoracic and upper lumbar ventral rami travel through tissue planes related to the quadratus lumborum and abdominal wall. The subcostal, iliohypogastric, and ilioinguinal nerves are particularly relevant to lower abdominal analgesia. Connections between the thoracolumbar fascia, endothoracic

fascia, and paravertebral tissues have also been proposed as pathways by which QLB may influence thoracic spinal nerves and sympathetic afferents [1].

Injection plane and injectate distribution

During posterior QLB, the needle tip is positioned behind the quadratus lumborum, usually near the lumbar interfascial triangle or the posterior aspect of the middle thoracolumbar fascia. Local anesthetic deposited at this location may extend laterally toward the abdominal wall, medially along the thoracolumbar fascia, and variably in a cranial direction. This pattern helps explain the block's reliable somatic component but also its inconsistent upper thoracic distribution [3].

Cadaveric evaluation has demonstrated that posterior injection can stain the subcostal, iliohypogastric, and ilioinguinal nerves and may involve the T11, T12, and L1 nerve roots. However, spread toward higher thoracic levels and the paravertebral space is less consistent than that observed with some anterior or subcostal approaches. Accordingly, extensive visceral analgesia should not be assumed solely from the performance of posterior QLB [3].

The volume administered is likely to influence longitudinal spread, whereas the precise injection point affects whether the solution remains posterior to the quadratus lumborum or enters adjacent fascial compartments. Because clinical descriptions sometimes apply different terminology to similar needle positions, apparent differences between studies may partly reflect inconsistent classification rather than true differences in block physiology [5].

Ultrasound technique

Posterior QLB may be performed with the patient supine with lateral tilt, in a lateral position, or occasionally prone. A low-frequency curvilinear transducer is placed transversely between the costal margin and iliac crest. The external oblique, internal oblique, and transversus abdominis muscles are followed posteriorly until the quadratus lumborum, psoas major, transverse process, and erector spinae are identified [5].

After skin preparation and infiltration, a block needle is advanced using an in-plane technique until its tip reaches the posterior surface of the quadratus lumborum. Hydrodissection with a small volume of saline or local anesthetic can confirm correct fascial separation. The therapeutic solution is then injected incrementally while observing its spread and repeatedly aspirating to reduce the risk of intravascular administration [4].

The target must be distinguished from intramuscular placement and from an excessively medial needle trajectory. Advancing too deeply may enter the quadratus lumborum or approach the psoas compartment, lumbar plexus, kidney, or peritoneal structures. Clear visualization of the needle tip throughout advancement is therefore more important than achieving a predefined insertion depth [1].

Bupivacaine as the Foundation of QLB Analgesia

Bupivacaine blocks voltage-gated sodium channels from the intracellular side of the neuronal membrane. Prevention of sodium influx inhibits action-potential initiation and propagation, producing reversible sensory and motor blockade. Small myelinated pain fibers are generally affected before larger motor fibers, although the clinical differential block depends on concentration, dose, injection site, and exposure time [7].

Its relatively long duration makes bupivacaine suitable for single-injection truncal blocks. Common QLB concentrations range from 0.20% to 0.375%, but the total dose must be calculated from concentration, injected volume, bilateral administration, patient weight, age, comorbidities, and concurrent local anesthetic exposure. Bilateral blocks deserve particular caution because a large fascial-plane volume can result in substantial systemic absorption [4].

Bupivacaine is strongly protein-bound and primarily metabolized in the liver. Hypoalbuminemia, reduced hepatic blood flow, severe cardiac dysfunction, pregnancy, extremes of age, and drug interactions may increase the pharmacologically active fraction or delay clearance. These factors should be considered before selecting a dose, even when the planned amount is below a conventional maximum threshold [7].

Local anesthetic systemic toxicity can initially present with circumoral numbness, tinnitus, metallic

taste, agitation, dizziness, or seizures. Cardiovascular toxicity may include conduction disturbance, ventricular arrhythmia, myocardial depression, and circulatory collapse. Incremental injection, repeated aspiration, ultrasound visualization, dose calculation, monitoring, and immediate availability of lipid emulsion are essential safety measures [8].

Prolonging QLB by increasing bupivacaine exposure alone may therefore be undesirable. Adjuvants are intended to lengthen analgesia or improve block quality without proportionally increasing local anesthetic dose. Their use should nevertheless be based on a favorable balance among benefit, systemic exposure, tissue compatibility, formulation characteristics, and the patient's clinical condition [7].

Dexamethasone as a Bupivacaine Adjuvant

Pharmacological mechanisms

Dexamethasone is a potent, long-acting synthetic glucocorticoid with minimal mineralocorticoid activity. Its postoperative analgesic effect is partly attributable to suppression of phospholipase A_2 activity and subsequent reduction in prostaglandins, leukotrienes, cytokines, and other inflammatory mediators. These actions can decrease peripheral sensitization and postoperative inflammatory pain [9].

Several local mechanisms have been proposed when dexamethasone is administered near neural or fascial tissues. These include modulation of inhibitory potassium channels, reduction of spontaneous neuronal discharge, attenuation of C-fiber transmission, and local vasoconstriction that may slow vascular uptake of bupivacaine. The relative contribution of these mechanisms remains uncertain because perineural dexamethasone is systemically absorbed and intravenous administration can also prolong analgesia [10].

Meta-analyses of peripheral nerve blocks consistently show that dexamethasone extends the duration of analgesia produced by long-acting local anesthetics and delays the first request for additional analgesia. Reductions in pain scores and opioid use have also been reported, although effect size varies according to local anesthetic, block location, dexamethasone dose, route of administration, and the definition of block duration [11].

Comparisons between perineural and intravenous dexamethasone suggest a modest additional prolongation with perineural administration. The magnitude is usually measured in hours rather than representing a complete additional postoperative day, and heterogeneity among trials remains substantial. Intravenous dexamethasone may therefore be a reasonable alternative when perineural administration is avoided [12].

Dose and administration

Perineural dexamethasone doses used in clinical studies commonly range from 4 to 8 mg. Evidence from broader regional-anesthesia literature suggests that much of the prolonging effect may be achieved at approximately 4 mg, with limited additional benefit from larger doses. However, an optimal posterior QLB-specific dose has not been firmly established [13].

Only preservative-free dexamethasone should be considered when it is mixed with a local anesthetic for regional injection. Compatibility and institutional policy must also be reviewed because perineural dexamethasone remains an off-label route in many jurisdictions. The potential incremental advantage over intravenous administration should be weighed against this regulatory and formulation uncertainty [12].

Dexamethasone has additional perioperative advantages, including prevention of postoperative nausea and vomiting and reduction of inflammatory pain. These systemic benefits can complicate interpretation of regional block studies because improved recovery may not result exclusively from a local action at the injection site [9].

Safety considerations

A single perioperative dexamethasone dose can cause a temporary rise in blood glucose, particularly in patients with diabetes or impaired glucose tolerance. Meta-analytic evidence indicates that antiemetic doses generally produce a limited and transient increase without clearly increasing wound infection, but perioperative glucose surveillance remains advisable in patients at high metabolic risk [14].

Available trials have not demonstrated a consistent clinical signal of permanent neurologic injury from

preservative-free perineural dexamethasone. Nevertheless, many investigations were not large enough to identify rare neurotoxic events, and follow-up was frequently limited. Absence of a detectable complication should not be interpreted as definitive proof of long-term neural safety [11].

Other possible effects include transient leukocytosis, sleep disturbance, mood change, dyspepsia, and suppression of immune-inflammatory responses. These consequences are usually limited after one dose, but dexamethasone should still be selected cautiously in patients with severe uncontrolled hyperglycemia, active infection, recent gastrointestinal bleeding, or a clinical reason to avoid glucocorticoids [14].

Magnesium Sulfate as a Bupivacaine Adjuvant

Pharmacological mechanisms

Magnesium is a physiological antagonist of the N-methyl-D-aspartate receptor channel. By limiting receptor-associated calcium influx, magnesium can reduce central sensitization, wind-up, and amplification of nociceptive signals. It also modulates voltage-gated calcium channels, neuronal excitability, acetylcholine release, and neuromuscular transmission [15].

When added to a regional block solution, magnesium sulfate may enhance or prolong local anesthetic action through effects on peripheral excitatory transmission and local nociceptive processing. Systemic absorption may also contribute to postoperative analgesia, making it difficult to separate a true perineural effect from the broader pharmacological effect of magnesium [16].

A meta-analysis of randomized peripheral nerve-block trials found that magnesium sulfate used with local anesthetics prolonged analgesia and reduced postoperative analgesic consumption. However, substantial variation was present in block type, magnesium dose, local anesthetic, surgical procedure, and outcome reporting, limiting the certainty with which these findings can be transferred specifically to posterior QLB [16].

Evidence in quadratus lumborum block

Peng et al. evaluated 400 mg of magnesium sulfate added to ropivacaine for ultrasound-guided QLB. Magnesium prolonged postoperative analgesia, delayed the first request for additional medication, reduced analgesic requirements, and improved patient satisfaction without a significant increase in reported adverse effects. The study supports biological activity within QLB, although it evaluated ropivacaine rather than bupivacaine [17].

Samir et al. directly compared bupivacaine combined with 500 mg magnesium sulfate, bupivacaine with 8 mg dexamethasone, and bupivacaine with saline in 66 adults undergoing open abdominal surgery. Both adjuvants decreased the proportion of patients requiring pethidine and improved late postoperative pain control. Dexamethasone produced the most favorable pain scores at 30 hours, but differences in cumulative pethidine, overall analgesic duration, and the proportion maintaining analgesia for 36 hours were not statistically significant [18].

Evidence from other truncal blocks is broadly supportive. Trials of transversus abdominis plane block have found that magnesium sulfate can improve analgesia when combined with long-acting local anesthetics. Nevertheless, results vary, and extrapolation to posterior QLB must account for differences in fascial anatomy, systemic absorption, surgery, and the neural structures reached by the injectate [19].

Dose and safety

No universally accepted magnesium sulfate dose has been established for QLB. Published regional-block studies have used markedly different absolute doses and concentrations. Higher doses may not provide proportionally greater analgesia and may increase systemic exposure, particularly when large bilateral volumes are administered [15].

Systemic magnesium can produce vasodilation and suppression of catecholamine release, causing reductions in blood pressure and heart rate. It may also potentiate nondepolarizing neuromuscular blockers and delay recovery from neuromuscular blockade. These effects are usually modest at regional-adjuvant doses but become clinically important in susceptible patients or after inadvertent excessive administration [15].

Magnesium is principally eliminated by the kidneys. Patients with significant renal impairment have an

increased risk of accumulation, hyporeflexia, muscular weakness, respiratory depression, conduction abnormalities, and cardiac arrest. Magnesium-containing regional solutions should therefore be avoided or used with exceptional caution when renal clearance is substantially impaired [20].

The lack of a glucocorticoid-related rise in blood glucose may make magnesium attractive for some patients with poorly controlled diabetes. However, this potential advantage should not be interpreted as proof of superior overall safety because magnesium and dexamethasone have different adverse-effect profiles rather than a simple difference in toxicity [14].

Comparative Evaluation of Dexamethasone and Magnesium Sulfate

Analgesic duration

Both agents can prolong local anesthetic analgesia, but dexamethasone is supported by a larger and more consistent evidence base across peripheral and truncal regional blocks. The typical dexamethasone effect includes delayed first rescue analgesia and extended sensory blockade. Magnesium also prolongs analgesia, although estimates are less precise and appear more dependent on the dose, block, and local anesthetic used [11].

Direct QLB evidence remains limited. The comparative study by Samir et al. favored dexamethasone for late postoperative pain control, but it did not demonstrate statistically significant differences between dexamethasone and magnesium across every analgesic endpoint. Consequently, the study suggests potential superiority rather than providing conclusive proof that dexamethasone is always the better QLB adjuvant [18].

Pain intensity and opioid requirements

Dexamethasone reduces inflammatory sensitization and may prolong neuronal blockade, whereas magnesium primarily attenuates excitatory nociceptive transmission. Either mechanism can reduce breakthrough pain after the initial action of bupivacaine begins to decline. Available evidence indicates that both can lower rescue analgesic exposure compared with local anesthetic alone [18].

Studies comparing dexamethasone and magnesium in transversus abdominis plane block have generally reported longer analgesia and lower pain scores with dexamethasone, although both agents improved outcomes compared with the local-anesthetic control. These findings are supportive but cannot establish equivalence between TAP block and posterior QLB [21].

Hemodynamic effects

Dexamethasone usually has little immediate influence on blood pressure or heart rate after a single regional or systemic dose. Magnesium may lower vascular resistance and attenuate sympathetic responses, leading to greater reductions in mean arterial pressure and heart rate. The distinction may be clinically useful in patients in whom hemodynamic stability is a major concern [15].

Conversely, controlled attenuation of the sympathetic response may be advantageous in selected patients, provided that hypotension and bradycardia are avoided. Hemodynamic interpretation must also consider spinal or general anesthesia, blood loss, fluid management, uterotonic drugs, preoperative cardiovascular status, and other medications rather than attributing every change to the block adjuvant [15].

Recovery and patient-centered outcomes

Prolonged analgesia may facilitate coughing, deep breathing, mobilization, breastfeeding after cesarean delivery, and participation in enhanced recovery pathways. Demonstrating these benefits requires outcomes beyond static pain scores, including dynamic pain, functional recovery, sleep, time to mobilization, opioid-related symptoms, patient satisfaction, and length of stay [22].

Evidence that either adjuvant independently shortens hospital stay remains insufficient. Length of admission is influenced by surgical complexity, institutional discharge practices, postoperative complications, and social factors. Future research should prioritize validated recovery measures rather than treating analgesic duration as the only clinically relevant endpoint [6].

Clinical Applications

Posterior QLB is most frequently considered for lower abdominal, pelvic, cesarean, inguinal, renal, and selected hip-related procedures. Its contribution is likely greatest when incisional somatic pain is

prominent. For operations with a substantial visceral component, the expected block distribution should be considered, and posterior QLB should be integrated with systemic multimodal analgesia rather than used as a complete substitute [1].

Systematic evidence indicates that single-injection QLB can reduce opioid consumption after cesarean delivery and renal surgery, but benefits across other procedures are less consistently established. Variability in technique, comparator regimens, intrathecal morphine use, and timing of assessment contributes to conflicting findings [6].

For cesarean delivery performed under spinal anesthesia with intrathecal morphine, the incremental benefit of QLB may be smaller because intrathecal morphine already provides prolonged analgesia. QLB may be more valuable when neuraxial morphine is omitted, contraindicated, or poorly tolerated, although local protocols and maternal monitoring requirements remain important [23].

Posterior QLB has also been used in pediatric lower abdominal surgery. Pediatric dosing must be weight-based, and bilateral volume should be planned carefully because smaller patients may approach the maximum local anesthetic dose rapidly. Evidence for dexamethasone or magnesium in children remains less mature than adult evidence, and routine extrapolation of adult doses is inappropriate [24].

Practical Selection of an Adjuvant

Dexamethasone may be preferred when the primary objective is the most reliable prolongation of single-injection analgesia, particularly in patients without a major contraindication to glucocorticoids. Intravenous administration deserves consideration when clinicians seek its analgesic and antiemetic effects without using an off-label perineural route [12].

Magnesium sulfate may be considered when glucocorticoid exposure is undesirable or when attenuation of excitatory nociceptive transmission is specifically sought. It is less suitable in clinically important renal impairment, hypotension, conduction disturbance, neuromuscular disease, or situations involving residual neuromuscular blockade [20].

Neither adjuvant should compensate for inaccurate needle placement, inadequate ultrasound visualization, excessive local anesthetic dosing, or incomplete multimodal analgesia. Correct technique and safe bupivacaine administration remain the foundations of successful posterior QLB [5].

Before injection, clinicians should confirm laterality, calculate the cumulative bupivacaine dose, review renal and metabolic status, document the adjuvant and route, and ensure immediate access to resuscitation drugs and lipid emulsion. Postoperative evaluation should include pain at rest and movement, motor weakness, hemodynamics, neurologic symptoms, rescue analgesia, and adverse events [8].

Current Limitations of the Evidence

The QLB literature includes substantial clinical and methodological heterogeneity. Studies differ in whether the injection is described as lateral, posterior, transmuscular, or subcostal; bilateral and unilateral blocks are frequently pooled; local anesthetic concentrations vary; and some publications incompletely describe the needle-tip position. These differences complicate direct comparison and meta-analysis [5].

Many trials enroll relatively small samples and are powered for analgesic duration or pain scores rather than uncommon safety outcomes. The absence of reported neurotoxicity, systemic toxicity, or serious hemodynamic events therefore cannot exclude rare complications [11].

Direct comparisons between dexamethasone and magnesium sulfate in posterior QLB are scarce. Available studies do not fully establish the optimal dose, concentration, route, preservative requirements, or benefit of either adjuvant across different surgical populations. Evidence obtained from brachial plexus, neuraxial, and TAP blocks is informative but indirect [18].

Pain-score differences may reach statistical significance without being clinically meaningful. Future investigations should report the proportion of patients achieving a clinically important improvement, cumulative opioid consumption in standardized morphine equivalents, time to first rescue medication, dynamic pain, quality of recovery, hyperglycemia, hemodynamic events, and persistent neurologic symptoms [22].

Future Research

Future randomized trials should use a clearly defined posterior needle-tip location supported by ultrasound images, standardized bupivacaine concentration and volume, and transparent reporting of whether dexamethasone or magnesium sulfate was administered perineurally or intravenously. Trials should also stratify or adjust for surgery type and background analgesic regimen [5].

A factorial design comparing perineural adjuvant, intravenous adjuvant, and placebo would help separate local from systemic action. Dose-finding studies are also needed to determine the lowest dose that provides clinically meaningful prolongation without increasing adverse effects [12].

Longer follow-up and adequately powered safety surveillance are essential, particularly for perineural dexamethasone and concentrated magnesium solutions. Evaluation of neurologic symptoms, motor function, glucose changes, renal function, infection, and delayed recovery from neuromuscular blockade would provide a more balanced assessment than pain outcomes alone [14].

Conclusion

Posterior quadratus lumborum block is a useful component of multimodal analgesia for selected abdominal and pelvic operations. Its efficacy depends on accurate ultrasound-guided deposition, appropriate bupivacaine dosing, surgical context, and the background analgesic regimen.

Both dexamethasone and magnesium sulfate can improve the duration or quality of bupivacaine-based regional analgesia. Dexamethasone currently has the broader and more consistent supporting evidence and appears more likely to provide sustained postoperative pain relief. Magnesium sulfate remains a reasonable alternative in selected patients but requires particular attention to renal function, hemodynamics, and neuromuscular effects.

Current evidence does not justify a universal adjuvant regimen. Selection should be individualized, preservative-free preparations should be used for regional administration, and patients should be monitored for drug-specific adverse effects. Larger standardized posterior QLB trials are required before firm conclusions can be drawn regarding comparative superiority, optimal dosage, and long-term safety.

References

1. Elsharkawy H, El-Boghdadly K, Barrington M. Quadratus lumborum block: anatomical concepts, mechanisms, and techniques. Anesthesiology. 2019;130(2):322-35.
2. Urits I, Ostling PS, Novitch MB, et al. Truncal regional nerve blocks in clinical anesthesia practice. Best Pract Res Clin Anaesthesiol. 2019;33(4):559-71.
3. Yang HM, Park SJ, Yoon KB, Park K, Kim SH. Cadaveric evaluation of different approaches for quadratus lumborum blocks. Pain Res Manag. 2018;2018:2368930.
4. Gupta A, Sondekoppam R, Kalagara H. Quadratus lumborum block: a technical review. Curr Anesthesiol Rep. 2019;9:257-62.
5. Sondekoppam RV, Ip V, Johnston DF, Uppal V, Johnson M, Ganapathy S, et al. Ultrasound-guided lateral-medial transmuscular quadratus lumborum block for analgesia following anterior iliac crest bone graft harvesting: a clinical and anatomical study. Can J Anaesth. 2018;65(2):178-87.
6. Jin Z, Liu J, Li R, Gan TJ, He Y, Lin J. Single-injection quadratus lumborum block for postoperative analgesia in the adult surgical population: a systematic review and meta-analysis. J Clin Anesth. 2020;62:109715.
7. Heppolette CAA, Brunnen D, Bampoe S, Odor PM. Clinical pharmacokinetics and pharmacodynamics of levobupivacaine. Clin Pharmacokinet. 2020;59(6):715-45.
8. Ok SH, Hong JM, Lee SH, Sohn JT. Lipid emulsion for treating local anesthetic systemic toxicity. Int J Med Sci. 2018;15(7):713-22.
9. Barden A, Phillips M, Shinde S, Corcoran T, Mori TA. The effects of perioperative dexamethasone on eicosanoids and mediators of inflammation resolution: a sub-study of the PADDAG trial. Prostaglandins

Leukot Essent Fatty Acids. 2021;173:102334.

10. De Oliveira GS Jr, Alves LJ, Nader A, Kendall MC, Rahangdale R, McCarthy RJ. Perineural dexamethasone to improve postoperative analgesia with peripheral nerve blocks: a meta-analysis of randomized controlled trials. Pain Res Treat. 2014;2014:179029.
11. Albrecht E, Kern C, Kirkham KR. A systematic review and meta-analysis of perineural dexamethasone for peripheral nerve blocks. Anaesthesia. 2015;70(1):71-83.
12. Baeriswyl M, Kirkham KR, Jacot-Guillarmod A, Albrecht E. Efficacy of perineural versus systemic dexamethasone to prolong analgesia after peripheral nerve block: a systematic review and meta-analysis. Br J Anaesth. 2017;119(2):183-91.
13. Chong MA, Berbenetz NM, Lin C, Singh S. Perineural versus intravenous dexamethasone as an adjuvant for peripheral nerve blocks: a systematic review and meta-analysis. Reg Anesth Pain Med. 2017;42(3):319-26.
14. Pang QY, Wang T, Jiang Y, Liu HL. The safety of perioperative dexamethasone with antiemetic dosage in surgical patients with diabetes mellitus: a systematic review and meta-analysis. Perioper Med. 2023;12(1):4.
15. Gutiérrez-Román CI, Carrillo-Torres O, Pérez-Meléndez ES. Uses of magnesium sulfate in anesthesiology. Rev Med Hosp Gen Mex. 2022;85(1):25-33.
16. 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):629-37.
17. Peng Q, Yang X, Li J, You Y, Zhao XC. The effect of magnesium sulfate in ultrasound-guided quadratus lumborum block on postoperative analgesia: a randomized controlled trial. Pain Ther. 2023;12(1):141-50.
18. Samir GM, Aboulella SK, Moussa ME, Saleh MA. The effect of addition of magnesium sulfate or dexamethasone to bupivacaine on the postoperative analgesic duration of ultrasound-guided quadratus lumborum block in open abdominal surgeries: a comparative study. Ain-Shams J Anesthesiol. 2023;15:24.
19. Umalkar M, Londhe N. Evaluation of magnesium sulfate as an adjuvant to bupivacaine for postoperative analgesia in ultrasound-guided transversus abdominis plane block in patients scheduled for lower-segment cesarean section under subarachnoid block: a prospective, randomized, double-blind study. Indian J Pain. 2020;34(3):189-92.
20. Miri M, Esmailsorkh F, Farhadi E, Rahimi M. Magnesium sulfate toxicity successfully managed with hemodialysis: a case report. J Med Case Rep. 2025;19(1):357.
21. Shambhavi T, Das S, Senapati LK, Padhi PP. Comparative evaluation of bupivacaine with magnesium sulphate and dexamethasone as adjuvants in ultrasound-guided transversus abdominis plane block for open unilateral inguinal hernia surgeries: a randomized controlled trial. Indian J Anaesth. 2023;67(4):370-5.
22. Dai J, Li S, Weng Q, Long J, Wu D. Opioid-free anesthesia with ultrasound-guided quadratus lumborum block in the supine position for lower abdominal or pelvic surgery: a randomized controlled trial. Sci Rep. 2024;14(1):4652.
23. Blanco R, Ansari T, Riad W, Shetty N. Quadratus lumborum block versus transversus abdominis plane block for postoperative pain after cesarean delivery: a randomized controlled trial. Reg Anesth Pain Med. 2016;41(6):757-62.
24. Aksu C, Şen MC, Akay MA, Baydemir C, Gürkan Y. Erector spinae plane block versus quadratus lumborum block for pediatric lower abdominal surgery: a double-blinded, prospective, randomized trial. J Clin Anesth. 2019;57:24-8.