Research Article

Effect of Dexmedetomidine as an Adjuvant to Ropivacaine in Ultrasound-Guided Transversus Abdominis Plane Block for Post-Caesarean Analgesia: A Prospective Randomized Double-Blind Study

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Abstract

Background: Effective analgesia after caesarean delivery facilitates early maternal mobilization and may support breastfeeding and maternal–infant interaction. Ultrasound-guided transversus abdominis plane (TAP) block provides predominantly somatic analgesia for the abdominal wall, but the duration of a single-shot block may be limited. Dexmedetomidine, an alpha-2 adrenergic agonist with analgesic and opioid-sparing properties, has been investigated as an adjuvant to local anaesthetics. This study evaluated whether adding dexmedetomidine to ropivacaine prolongs analgesia after caesarean section.

Methods: In this single-centre, prospective, randomized, double-blind comparative study, 54 women aged 18–40 years with American Society of Anesthesiologists (ASA) physical status II undergoing elective caesarean section under subarachnoid block were randomized equally to bilateral ultrasound-guided TAP block with either 0.2% ropivacaine plus normal saline (Group RS, n=27) or 0.2% ropivacaine plus dexmedetomidine 1 µg/kg (Group RD, n=27). Pain was assessed using a visual analogue scale (VAS) at predefined postoperative intervals. The primary outcome was pain-free duration, defined in the thesis as time until VAS >4/first rescue analgesia. Secondary outcomes included time to rescue analgesia, total 24-hour rescue analgesic requirement, haemodynamic variables, oxygen saturation, sedation score and adverse effects. Tramadol 50 mg intramuscularly was used as rescue analgesia.

Results: Baseline demographic variables were comparable between groups. Mean pain-free duration was significantly longer with dexmedetomidine: 8.67±3.19 hours versus 4.59±0.93 hours with ropivacaine alone (P<0.001). Mean total rescue analgesic requirement over 24 hours was 48.15±9.62 mg in Group RD compared with 100 mg in Group RS (P<0.001). VAS scores differed significantly between groups at 2, 4, 6, 8 and 12 hours; however, the direction of difference varied over time, with a higher mean VAS in Group RD at 8 hours. At 24 hours, VAS scores were similar (P=0.918). Haemodynamic variables showed statistically significant differences at selected time points, but baseline and 24-hour values were comparable. Sedation scores differed significantly at 4, 8 and 12 hours. No major block-related complications were reported in the study.

Conclusion: Within the limitations of this small, single-centre study, adding dexmedetomidine 1 µg/kg to 0.2% ropivacaine for bilateral ultrasound-guided TAP block was associated with a longer pain-free interval and lower 24-hour rescue tramadol requirement after caesarean delivery. Larger, adequately powered trials with standardized multimodal analgesia, rigorous repeated-measures analysis and systematic assessment of maternal and neonatal outcomes are warranted.

Keywords: Caesarean section; transversus abdominis plane block; ropivacaine; dexmedetomidine;

postoperative analgesia; ultrasound-guided regional anaesthesia; tramadol.

1. Introduction

Caesarean delivery is one of the most common major abdominal surgical procedures. Acute postoperative pain following caesarean section has clinical consequences beyond discomfort: it can restrict mobilization, interfere with breastfeeding and infant care, and adversely affect early maternal recovery. The abdominal wall incision contributes a substantial somatic component to postoperative pain, making regional techniques attractive as part of multimodal analgesia. 1,2

The transversus abdominis plane (TAP) block is a fascial plane block designed to deposit local anaesthetic between the internal oblique and transversus abdominis muscles. The plane contains branches of the thoracolumbar nerves supplying the anterolateral abdominal wall. The technique was initially described using anatomical landmarks and subsequently evolved with ultrasound guidance, improving visualization of the abdominal wall layers and needle placement. The thesis review cites evidence supporting TAP block for abdominal and gynaecological surgery, including caesarean delivery. 3,4,5,6

Ropivacaine is widely used for peripheral nerve blockade because of its favourable cardiovascular safety profile relative to bupivacaine and its lower propensity for motor blockade. Nevertheless, the duration of a single-injection TAP block may be insufficient to cover the period of greatest postoperative pain. Various adjuvants have therefore been evaluated to prolong local anaesthetic action. 11

Dexmedetomidine is a highly selective alpha-2 adrenergic receptor agonist with sedative, sympatholytic and analgesic properties. Its analgesic effect may involve both central and peripheral mechanisms. Experimental and clinical studies cited in the dissertation have reported prolongation of peripheral nerve block when dexmedetomidine is combined with local anaesthetics, although the optimal dose and the relative contribution of local versus systemic effects remain incompletely defined. 12,13,14

The present study was undertaken to compare bilateral ultrasound-guided TAP block using 0.2% ropivacaine alone with 0.2% ropivacaine combined with dexmedetomidine 1 µg/kg in women undergoing caesarean section under subarachnoid anaesthesia. The principal clinical question was whether dexmedetomidine could extend the pain-free period and reduce postoperative rescue analgesic requirements without clinically important adverse effects. 6,7,8

2. Materials and Methods

Study design and participants

This was a hospital-based, prospective, randomized, comparative, double-blind interventional study conducted in the Department of Anaesthesiology, South Eastern Railway Central Hospital, Kolkata, during 2020–2022. Institutional Ethics Committee and Scientific Research Committee permissions were obtained, and written informed consent was obtained from all participants.

Women aged 18–40 years, ASA physical status II, scheduled for elective caesarean section under subarachnoid block were eligible. Exclusion criteria included refusal of consent, BMI >35 kg/m², ASA physical status III–V, allergy to study medications, and contraindications to spinal anaesthesia such as local infection, raised intracranial pressure, sepsis, severe spinal deformity or bleeding diathesis.

Randomization and interventions

Fifty-four participants were randomized equally into two groups using a computer-generated

randomization schedule. Group RS received bilateral TAP block with a total of 40 mL of 0.2% ropivacaine supplemented with normal saline. Group RD received the same total volume and concentration of ropivacaine with dexmedetomidine 1 µg/kg, diluted appropriately. Each side received 20 mL of the study solution. Study solutions were prepared and coded by anaesthesiologists not involved in outcome assessment. The anaesthesiologist performing the block and the investigator assessing outcomes were blinded to allocation.

Anaesthetic technique

Subarachnoid anaesthesia was performed at the L3–L4 interspace using a 25-gauge Quincke needle after local infiltration with 2% lignocaine. Hyperbaric bupivacaine 0.5%, 2 mL, was administered intrathecally. Patients were positioned supine with a 15-degree left lateral tilt, and surgery was commenced after achieving a sensory level of T6 or higher.

Following completion of caesarean section, bilateral TAP blocks were performed under aseptic ultrasound guidance. A high-frequency linear probe was placed transversely on the anterolateral abdominal wall between the costal margin and iliac crest. The external oblique, internal oblique and transversus abdominis muscles were identified. A 21-gauge, 10-cm insulated needle was advanced in-plane into the fascial plane between the internal oblique and transversus abdominis muscles. Following negative aspiration, the allocated study solution was injected on each side.

Outcome measures

The primary outcome was pain-free duration. In the dissertation protocol, rescue analgesia was administered when VAS exceeded 4 or when the patient requested analgesia. VAS was recorded at 0, 2, 4, 6, 8, 12 and 24 hours after TAP block. Secondary outcomes included time to first rescue analgesia, total rescue analgesic requirement during 24 hours, heart rate, systolic and diastolic blood pressure, SpO2, sedation score and adverse effects. Tramadol 50 mg intramuscularly was used as rescue analgesia.

Statistical analysis

Data were entered into Microsoft Excel and analysed using SPSS version 24. Categorical variables were expressed as numbers and percentages and compared using Pearson's chi-square test or Fisher's exact test, as appropriate. Continuous variables were expressed as mean±standard deviation and compared using an unpaired t test when normally distributed and the Mann–Whitney U test when distributional assumptions were not met. A two-sided P value <0.05 was considered statistically significant. The sample-size calculation in the dissertation yielded a minimum of 27 participants per group.

3. Results

Fifty-four participants completed the study, with 27 patients in each group. The groups were well balanced with respect to baseline demographic characteristics. Mean age was 28.44±0.51 years in Group RS and 28.52±0.51 years in Group RD (P=0.594). Mean body weight was 64.04±0.90 kg and 63.96±0.81 kg, respectively (P=0.751), while mean BMI was 24.94±0.46 kg/m² and 24.89±0.58 kg/m² (P=0.736). Mean surgical duration was 66.30±4.92 minutes in Group RS and 63.70±4.72 minutes in Group RD (P=0.054). Thus, the principal baseline and procedural variables were comparable.

Oxygen saturation remained high in both groups throughout follow-up. The thesis reported no clinically important oxygenation difference, although a statistical difference was observed at 12 hours (99.85±0.36% in Group RD versus 100.00±0.00% in Group RS; P=0.038). The absolute difference was

small and did not represent a clinically meaningful deterioration.

Pain intensity and pain-free duration

The most important finding was prolongation of the pain-free interval with dexmedetomidine. Mean pain-free duration was 4.59±0.93 hours in Group RS compared with 8.67±3.19 hours in Group RD, an absolute difference of approximately 4.1 hours (P<0.001). This corresponds to nearly a doubling of the mean pain-free period with the addition of dexmedetomidine.

VAS scores were significantly different between groups at 2, 4, 6, 8 and 12 hours. At 2 hours, mean VAS was 2.00±0.00 in Group RS and 0.22±0.42 in Group RD; at 4 hours, 5.56±2.12 versus 1.22±0.85; at 6 hours, 3.81±2.30 versus 2.07±0.38; at 8 hours, 3.89±1.58 versus 6.19±1.39; and at 12 hours, 6.37±2.02 versus 2.52±1.81. At 24 hours, VAS was 2.07±0.96 versus 2.04±1.60 (P=0.918). Importantly, the 8-hour finding was directionally different from the other significant time points and should not be obscured in publication; it indicates that pain trajectories were not uniformly lower in the dexmedetomidine group at every measured interval.

Rescue analgesic requirement

The total 24-hour rescue analgesic requirement was significantly lower in Group RD. Mean tramadol requirement was 100.00 mg in Group RS compared with 48.15±9.62 mg in Group RD (P<0.001). The study also demonstrated a different temporal pattern of rescue analgesic administration between groups, with greater rescue requirement in Group RS during the earlier and later periods and a notable rescue requirement in Group RD at 8 hours. Because rescue administration was linked to VAS >4 or patient request, these time-point findings should be interpreted together with the pain-free-duration outcome rather than in isolation.

Haemodynamic variables and sedation

Heart rate and blood pressure differed significantly between groups at selected postoperative time points, whereas values at baseline and 24 hours were broadly comparable. The study did not identify a persistent clinically important haemodynamic disturbance attributable to the intervention. Sedation scores differed significantly at 4, 8 and 12 hours. The thesis interpreted lower scores at selected time points in the ropivacaine-only group as reflecting pain-related agitation, while the dexmedetomidine group demonstrated higher scores at other time points, consistent with its sedative properties.

No major adverse events or clinically important block-related complications were reported in the study. The dissertation specifically monitored hypotension, bradycardia, nausea and vomiting, in addition to routine physiological variables.

4. Discussion

This study evaluated a clinically relevant strategy for extending analgesia after caesarean delivery. The principal result was a statistically and clinically notable increase in pain-free duration when dexmedetomidine was added to ropivacaine for bilateral ultrasound-guided TAP block. The mean pain-free period increased from 4.59 to 8.67 hours, while 24-hour rescue tramadol requirement was reduced from 100 mg to 48.15±9.62 mg.

The findings are biologically plausible. TAP block targets somatic afferent transmission from the abdominal wall and is particularly relevant to the incisional component of post-caesarean pain. Ropivacaine provides local sodium-channel blockade, whereas dexmedetomidine may augment analgesia through alpha-2 adrenergic mechanisms. The dissertation review cites evidence that

perineural dexmedetomidine can prolong local anaesthetic effects and that the phenomenon has been demonstrated across several peripheral nerve block models. 3,4,5,6,12,14

The present results are broadly consistent with the literature reviewed in the dissertation. Brummett and colleagues demonstrated prolongation of peripheral nerve block duration with perineural dexmedetomidine in an experimental model. Clinical studies cited in the thesis involving brachial plexus and ulnar nerve blocks also reported prolonged sensory block with dexmedetomidine. Within abdominal surgery, studies by Almarakbi et al., Sarvesh et al., Luan et al. and Xu et al. reported improved postoperative analgesia when dexmedetomidine was combined with local anaesthetic in TAP-based techniques. 15,16,17,18,19,20

Evidence specifically relevant to gynaecological surgery is also supportive. In the study by Chen et al. cited in the thesis, patients undergoing elective gynaecological surgery received TAP block with ropivacaine alone or ropivacaine plus dexmedetomidine or fentanyl. The dexmedetomidine-containing TAP regimen was associated with prolonged time to rescue analgesia and fewer patient-controlled analgesia boluses. The present study similarly demonstrated a prolonged analgesic interval and reduced rescue analgesic requirement. 17

The dose of dexmedetomidine used in the present study—1 μg/kg—was selected on the basis of previously reported clinical data. The thesis review notes that dose-response relationships have been described, but higher doses may increase sedation and haemodynamic effects without providing proportionate additional benefit. Thus, the present findings support the feasibility of a 1 μg/kg dose in the studied population, but they do not establish it as an optimal dose. 18,21

An important point for interpretation is that TAP block primarily addresses somatic abdominal wall pain and does not comprehensively treat visceral pain. Accordingly, TAP block should be viewed as a component of multimodal post-caesarean analgesia rather than a replacement for neuraxial or systemic analgesic strategies. The reduction in rescue tramadol in this study suggests an opioid-sparing effect within the specific study protocol, but broader conclusions about opioid-free postoperative care require trials incorporating standardized multimodal regimens. 3,6,7

The VAS findings deserve particular attention. Although significant differences favoured the dexmedetomidine group at several time points, the 8-hour mean VAS was higher in Group RD than Group RS. This temporal inconsistency is important and should be transparently reported rather than selectively emphasizing the time points favouring the intervention. It may reflect the relatively small sample, the timing of rescue analgesia, individual variation in block duration, or other unmeasured factors. The overall primary outcome nevertheless showed a significant difference in pain-free duration.

The haemodynamic findings also merit cautious interpretation. Dexmedetomidine is known to influence sympathetic tone and may produce bradycardia or hypotension, particularly with systemic administration. In this study, selected heart-rate and blood-pressure differences were observed, but baseline and 24-hour measurements were comparable and no major adverse event was reported. Because the sample was small, the study cannot reliably exclude uncommon adverse effects. 12,13,14,21

5. Strengths and Limitations

The study has several strengths: prospective randomized allocation; double-blind assessment; standardized ultrasound-guided bilateral TAP block; a clearly defined local anaesthetic regimen;

predefined pain assessments; and measurement of both patient-centred analgesic outcomes and physiological variables. The two groups were also well matched for age, weight, BMI and surgical duration.

Several limitations should be acknowledged. First, the sample size was small and the study was conducted at a single centre, limiting statistical precision and external validity. Second, dexmedetomidine plasma concentrations were not measured, so the study cannot distinguish confidently between local perineural and systemic contributions to analgesia. Third, the onset of the TAP block could not be assessed because patients had not fully recovered from subarachnoid anaesthesia. Fourth, multiple postoperative time points were analysed independently; a repeated-measures analytical approach would be preferable for longitudinal pain data and would better account for within-patient correlation and multiplicity. Fifth, the thesis does not establish neonatal outcomes or breastfeeding-related endpoints, so conclusions about maternal–infant benefits should not be inferred from the present data. Finally, the study was not designed to establish the optimal dexmedetomidine dose.

6. Conclusion

In women undergoing elective caesarean section under subarachnoid anaesthesia, bilateral ultrasound-guided TAP block with 0.2% ropivacaine combined with dexmedetomidine 1 μg/kg was associated with a significantly longer pain-free duration and lower 24-hour rescue tramadol requirement than ropivacaine alone in this single-centre randomized study. The intervention was not associated with a persistent clinically important difference in physiological variables or major reported complications. These findings support further investigation of dexmedetomidine as an adjuvant to ropivacaine for post-caesarean TAP block, preferably in larger multicentre randomized trials using standardized multimodal analgesia, rigorous longitudinal statistical methods, dose-ranging arms, and maternal and neonatal recovery outcomes.

References

1. Bhatia M, Banerjee K, Dixit P, Dwivedi LK. Assessment of variation in cesarean delivery rates between public and private health facilities in India from 2005 to 2016. JAMA Netw Open. 2020;3:e2015022.
2. Karlstrom A, Engstrom-Olofsson R, Norbergh KG, Sjoling M, Hildingsson I. Postoperative pain after cesarean birth affects breastfeeding and infant care. J Obstet Gynecol Neonatal Nurs. 2007;36:430-440.
3. Joshi G, Gandhi K, Shah N, Gadsden J, Corman SL. Peripheral nerve blocks in the management of postoperative pain: challenges and opportunities. J Clin Anesth. 2016;35:524-529.
4. Brogi E, Kazan R, Cyr S, Giunta F, Hemmerling TM. Transversus abdominal plane block for postoperative analgesia: a systematic review and meta-analysis of randomized-controlled trials. Can J Anaesth. 2016;63:1184-1196.
5. Abdallah FW, Laffey JG, Halpern SH, Brull R. Duration of analgesic effectiveness after the posterior and lateral transversus abdominis plane block techniques for transverse lower abdominal incisions: a meta-analysis. Br J Anaesth. 2013;111:721-735.
6. Mishriky BM, George RB, Habib AS. Transversus abdominis plane block for analgesia after

Cesarean delivery: a systematic review and meta-analysis. Can J Anaesth. 2012;59:766-778.
7. Srivastava U, Verma S, Singh TK, Gupta A, Saxsena A, Jagar KD, et al. Efficacy of trans abdominis block for post caesarean delivery analgesia: a double-blind, randomised trial. Saudi J Anaesth. 2015;9:298-302.
8. Kupiec A, Zwierzchowski J, Kowal-Janicka J, Gozdzik W, Fuchs T, Pomorski M, et al. The analgesic efficacy of transversus abdominis plane block after caesarean delivery. Ginekol Pol. 2018;89:421-424.
9. Rafi AN. Abdominal field block: a new approach via the lumbar triangle. Anaesthesia. 2001;56:1024-1026.
10. Rozen WM, Tran TM, Ashton MW, Barrington MJ, Ivanusic JJ, Taylor GI. Refining the course of the thoracolumbar nerves: a new understanding of the innervation of the anterior abdominal wall. Clin Anat. 2008;21:325-333.
11. Graf BM, Abraham I, Eberbach N, Kunst G, Stowe DF, Martin E. Differences in cardiotoxicity of bupivacaine and ropivacaine are the result of physicochemical and stereoselective properties. Anesthesiology. 2002;96:1427-1434.
12. Grewal A. Dexmedetomidine: new avenues. J Anaesthesiol Clin Pharmacol. 2011;27:297-302.
13. Ebert TJ, Hall JE, Barney JA, Uhrich TD, Colinco MD. The effects of increasing plasma concentrations of dexmedetomidine in humans. Anesthesiology. 2000;93:382-394.
14. Tang C, Xia Z. Dexmedetomidine in perioperative acute pain management: a nonopioid adjuvant analgesic. J Pain Res. 2017;10:1899-1904.
15. Sarvesh B, Shivaramu BT, Sharma K, Agarwal A. Addition of dexmedetomidine to ropivacaine in subcostal transversus abdominis plane block potentiates postoperative analgesia among laparoscopic cholecystectomy patients: a prospective randomized controlled trial. Anesth Essays Res. 2018;12:809-813.
16. Sun Q, Liu S, Wu H, Ma H, Liu W, Fang M. Dexmedetomidine as an adjuvant to local anesthetics in transversus abdominis plane block: a systematic review and meta-analysis. Clin J Pain. 2019;35:375-384.
17. Chen Q, Liu X, Zhong X, Yang B. Addition of dexmedetomidine or fentanyl to ropivacaine for transversus abdominis plane block: evaluation of effect on postoperative pain and quality of recovery in gynecological surgery. J Pain Res. 2018;11:2897-2903.
18. Zeng Y, Wen Y, Yang J, Sun H. Comparing postoperative analgesic effects of varying doses of dexmedetomidine as an adjuvant to ropivacaine for ultrasound-guided dual transversus abdominis plane block following laparotomy for gynecologic malignancies. Exp Ther Med. 2020;20:860-867.
19. Xu L, Hu Z, Shen J, McQuillan PM. Efficacy of US-guided transversus abdominis plane block and rectus sheath block with ropivacaine and dexmedetomidine in elderly high-risk patients. Minerva Anestesiol. 2018;84:18-24.
20. Luan H, Zhang X, Feng J, Zhu P, Li J, Zhao Z. Effect of dexmedetomidine added to ropivacaine on ultrasound-guided transversus abdominis plane block for postoperative analgesia after abdominal hysterectomy surgery: a prospective randomized controlled trial. Minerva Anestesiol. 2016;82:981-988.
21. Jung HS, Seo KH, Kang JH, Jeong JY, Kim YS, Han NR. Optimal dose of perineural

dexmedetomidine for interscalene brachial plexus block to control postoperative pain in patients undergoing arthroscopic shoulder surgery: a prospective, double-blind, randomized controlled study. Medicine (Baltimore). 2018;97:e0440.

22. Ding W, Li W, Zeng X, Li J, Jiang J, Guo C, et al. Effect of adding dexmedetomidine to ropivacaine on ultrasound-guided dual transversus abdominis plane block after gastrectomy. J Gastrointest Surg. 2017;21:936-946.
23. Bansal P, Sood D. Effect of dexmedetomidine as an adjuvant to ropivacaine in ultrasound-guided transversus abdominis plane block for post-operative pain relief in cesarean section. J Obstet Anaesth Crit Care. 2018;8:79-82.