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Original Research Article

Comparative Evaluation of Dexmedetomidine and Dexamethasone as Adjuvants to Ropivacaine in Ultrasound-Guided Transversus Abdominis Plane Block for Postoperative Analgesia after Caesarean Section: A Prospective Randomised Double-Blind Study

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Abstract

Background and Aims: Postoperative pain after lower segment caesarean section (LSCS) can delay ambulation, breastfeeding and recovery. Ultrasound-guided transversus abdominis plane (TAP) block reduces opioid requirement, but the analgesic effect of ropivacaine alone is time- limited. We compared dexmedetomidine and dexamethasone as adjuvants to ropivacaine in bilateral TAP block after LSCS, with the primary objective of comparing the time to first demand for rescue analgesia.

Methods: In this prospective, randomised, double-blind study, 60 American Society of Anesthesiologists (ASA) physical status II parturients undergoing elective LSCS under spinal anaesthesia were randomly allocated to receive bilateral ultrasound-guided TAP block with 0.375% ropivacaine plus dexmedetomidine 25 µg (Group A, n = 30) or 0.375% ropivacaine plus dexamethasone 8 mg (Group B, n = 30). Duration of analgesia, Numerical Rating Scale (NRS) pain scores, rescue tramadol consumption, haemodynamic parameters, patient satisfaction and adverse effects were recorded over 24 hours. Continuous variables were compared using the independent t-test or Mann–Whitney U test as appropriate, and categorical variables using the chi-square or Fisher's exact test; p < 0.05 was considered significant.

Results: The duration of analgesia was significantly longer in the dexmedetomidine group than the dexamethasone group (8.20 ± 2.64 h vs 6.01 ± 2.95 h; p = 0.003). Group A required fewer doses of rescue tramadol [median 2 (interquartile range 2–3) vs 3 (3–4); p = 0.0002] and consumed less tramadol overall (250.12 ± 50.04 mg vs 326.00 ± 55.15 mg; p < 0.0001). NRS scores were significantly lower with dexmedetomidine at 6 and 12 hours (p < 0.05). Patient satisfaction was higher with dexmedetomidine (1.83 ± 0.56 vs 1.46 ± 0.74; p = 0.033). Haemodynamic parameters and adverse effects were comparable between the two groups (p > 0.05 for all comparisons).

Conclusion: When added to ropivacaine for ultrasound-guided TAP block after caesarean section, dexmedetomidine provides longer postoperative analgesia, lower rescue analgesic consumption and greater patient satisfaction than dexamethasone, without additional haemodynamic instability or adverse effects.

Keywords: Caesarean Section; Dexamethasone; Dexmedetomidine; Postoperative Analgesia; Ropivacaine; Transversus Abdominis Plane Block.

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Introduction

Caesarean delivery remains one of the commonest surgical procedures performed worldwide, and the proportion of deliveries conducted by this route continues to rise across both high- and low-resource settings.[1] Effective control of postoperative pain after caesarean section is not a matter of comfort alone — unrelieved pain delays ambulation and breastfeeding, interferes with maternal–infant bonding, and predisposes to thromboembolic and pulmonary complications in the early puerperium.[2] A multimodal analgesic strategy that limits systemic opioid exposure is

therefore particularly desirable in this population, since opioids cross into breast milk and can produce sedation in both mother and neonate.[3]

The transversus abdominis plane (TAP) block has emerged as a valuable component of such multimodal regimens. By depositing local anaesthetic in the fascial plane between the internal oblique and transversus abdominis muscles, the block interrupts the thoraco-lumbar nerves (T7–L1) that supply the anterior abdominal wall, providing somatic analgesia for the incisional component of post-caesarean pain.[4,5] Randomised trials have consistently shown that TAP block reduces postoperative opioid consumption after both lower abdominal and gynaecological surgery, whether used as a sole analgesic technique or as an adjunct to neuraxial or general anaesthesia.[6,7,8,9]

A recognised limitation of TAP block with plain local anaesthetic is the relatively short duration of analgesia, typically several hours, after which pain returns and rescue analgesia becomes necessary. Several adjuvants have therefore been co-administered with local anaesthetics in peripheral and fascial plane blocks in an effort to extend the analgesic window. Dexmedetomidine, a highly selective alpha-2 adrenergic agonist, prolongs sensory blockade when added to local anaesthetics, an effect attributed to its action on peripheral alpha-2 receptors and hyperpolarisation-activated cation channels in peripheral nerves.[10] Dexamethasone, a long-acting glucocorticoid, is believed to potentiate local anaesthetic blockade through local vasoconstriction and suppression of the inflammatory mediators that sensitise nociceptors at the site of injury; it has similarly been shown to prolong analgesia when combined with local anaesthetics in peripheral nerve and fascial plane blocks. [11,12]

Individually, both dexmedetomidine and dexamethasone have been reported to extend the duration of analgesia when added to local anaesthetics in TAP block for a variety of abdominal and pelvic procedures, including caesarean section.[13,14,15,16]

However, direct head-to-head comparisons of the two adjuvants specifically in the context of TAP block for LSCS remain sparse, and the relative magnitude of benefit — and the accompanying haemodynamic and side-effect profile — is not well established in this population. We therefore designed this prospective, randomised, double-blind study to compare dexmedetomidine and dexamethasone as adjuvants to ropivacaine in ultrasound-guided bilateral TAP block for postoperative analgesia after LSCS. The primary objective was to compare the time to first demand for rescue tramadol between the two groups; secondary objectives were to compare postoperative NRS pain scores, total tramadol consumption, haemodynamic stability, patient satisfaction and adverse effects.

Material and Methods

This prospective, randomised, double-blind, parallel-group comparative study was conducted in the Department of Anaesthesiology, Government Mahila Chikitsalaya, Jawaharlal Nehru Medical College and Associated Group of Hospitals, Ajmer, Rajasthan, after approval from the Institutional Ethics Committee (Reference number: 040215/Acad-III/2024)

Participants: Pregnant women aged 20–40 years, with a body mass index of 18.5–34.9 kg/m², ASA physical status II, and scheduled for elective or non-urgent LSCS under spinal anaesthesia were considered eligible. Patients were excluded if they declined consent, had a known allergy to local anaesthetics or the study drugs, were already receiving analgesic therapy, or had a contraindication to spinal anaesthesia such as local infection at the site of lumbar puncture, a bleeding diathesis, raised intracranial pressure or hypovolemia.

Sample Size: The sample size was calculated on the basis of a pilot observation in 16 patients (8 per group), in which the mean duration of analgesia was 428.75 ± 40.86 minutes with ropivacaine–dexmedetomidine and 376.25 ± 56.29 minutes with ropivacaine–dexamethasone. Using the standard formula for comparison of two means, with a two-sided α of 0.05 ($Z1-\alpha/2 = 1.96$) and 90% power ($Z\beta = 1.28$), the calculated minimum sample size was 27 patients per group. Allowing for an anticipated 10% attrition, this was rounded up to 30 patients per group, yielding a total sample size of 60.

Randomization and Blinding: Eligible patients were allocated in a 1:1 ratio to the two study groups using a computer-generated table of random numbers. To maintain double blinding, the study drug solutions were prepared and the TAP block administered by an anaesthesiologist who played no further part in patient assessment, while postoperative pain scores, haemodynamic parameters and adverse effects were recorded by an independent observer unaware of the group allocation. Patients themselves were also unaware of the drug they had received.

Study Groups: Group A (n = 30) received bilateral ultrasound-guided TAP block with 0.75% ropivacaine 10 mL diluted to 20 mL with normal saline (final concentration 0.375%) combined with dexmedetomidine 25 µg diluted in 2 mL normal saline on each side (total volume 22 mL per side). Group B (n = 30) received the identical volume and concentration of ropivacaine combined with

dexamethasone 8 mg in 2 mL on each side (total volume 22 mL per side).

Anaesthetic and Block Technique: After confirming patients details, written and informed consent and PAC parturient was given subarachnoid block in the sitting position under strict asepsis with 2.2 mL of 0.5% hyperbaric bupivacaine at the L3–L4 interspace using a 25G Quincke spinal needle, and surgery proceeded once adequate sensory and motor block was confirmed.

At the conclusion of surgery, bilateral TAP block was performed under real-time ultrasound guidance with the patient supine, the probe placed transversely between the costal margin and the iliac crest in the mid-axillary line. The block needle was advanced in-plane through the external and internal oblique aponeuroses, and the assigned study solution was deposited in the fascial plane between the internal oblique and transversus abdominis muscles, with visual confirmation of local spread within the correct plane on each side.

Postoperative Analgesia Protocol and Outcome Measures: All patients received scheduled intravenous paracetamol 15 mg/kg 8-hourly. Intravenous tramadol 2 mg/kg was administered as rescue analgesia whenever the patient requested it or when the NRS pain score reached 4 or more; Duration of analgesia was defined as the interval between completion of the TAP block and the first administration of rescue tramadol. Heart rate, systolic, diastolic and mean arterial pressures, peripheral oxygen saturation and NRS pain scores at rest were recorded at baseline (immediately after the block) and at 1 hour, and thereafter at 4-hourly intervals up to 24 hours. The total dose of rescue tramadol administered and the number of rescue doses required over 24 hours were recorded, as was patient satisfaction with pain management on a 3-point scale (0 = not satisfied, 1 = somewhat satisfied, 2 = fully satisfied). Adverse effects — hypotension, bradycardia, nausea, vomiting, shivering, local anaesthetic systemic toxicity and respiratory depression — were actively looked for and recorded throughout the observation period.

Statistical Analysis: Data were entered in Microsoft Excel and analysed using STATA version 14. Continuous variables were tested for normality using the Kolmogorov–Smirnov and Shapiro–Wilk tests and were summarised as mean ± standard deviation or median (interquartile range) as appropriate; the independent-samples t-test or Mann–Whitney U test was applied accordingly, with the 95% confidence interval reported for the mean difference between groups. Categorical variables were expressed as frequencies and percentages and compared using the chi-square test or Fisher's exact test where cell counts were small. A two-tailed p value < 0.05 was taken as statistically significant.

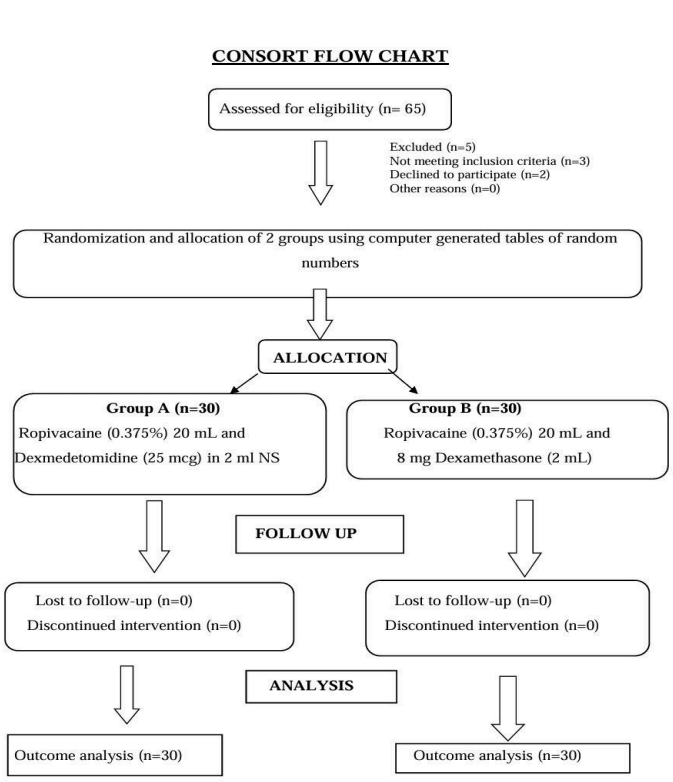

Chart 1: CONSORT flow chart

Results

Table 1: Baseline haemodynamic parameters at the time of TAP block

Parameter	Group A (n = 30)	Group B (n = 30)	p value
Heart rate (bpm)	88.63 ± 9.76	89.48 ± 9.71	0.736
SBP (mmHg)	116.25 ± 10.65	117.18 ± 11.10	0.741
DBP (mmHg)	70.16 ± 6.54	72.51 ± 7.70	0.407
MAP (mmHg)	83.56 ± 10.30	84.56 ± 10.65	0.207
SpO_2 (%)	98.38 ± 1.48	99.10 ± 1.56	0.071

Values are mean ± SD. SBP = systolic blood pressure; DBP = diastolic blood pressure; MAP = mean arterial pressure. All p > 0.05, statistically not significant.

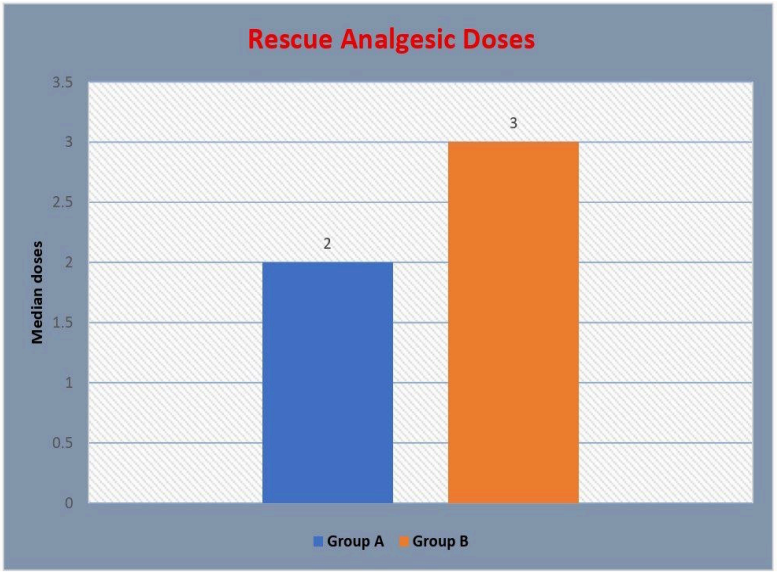

Figure 1: compares rescue analgesic doses in group A and group B

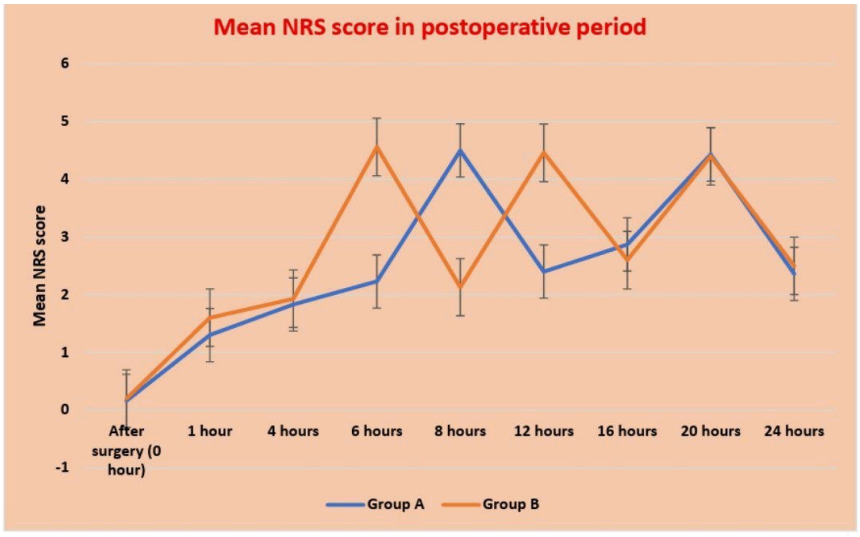

Figure 2: compares mean NRS scores in group A and group B

Table 2: Postoperative analgesic outcomes

Parameter	Group A (n = 30)	Group B (n = 30)	p value
Duration of analgesia (h), mean ± SD	8.20 ± 2.64	6.01 ± 2.95	0.003*
Number of rescue doses, median (IQR)	2 (2–3)	3 (3–4)	0.0002*
Total rescue tramadol (mg), mean ± SD	250.12 ± 50.04	326.00 ± 55.15	< 0.0001*
Patient satisfaction score, mean ± SD	1.83 ± 0.56	1.46 ± 0.74	0.033*

IQR = interquartile range. *p < 0.05, statistically significant.

Figure 3: compares Patient satisfaction score in group A and group B

Discussion

This prospective, randomised, double-blind study found that dexmedetomidine, when added to ropivacaine for ultrasound-guided TAP block after LSCS, produced a longer duration of analgesia, a lower requirement for rescue tramadol and greater patient satisfaction than an equivalent block supplemented with dexamethasone, without any accompanying compromise in haemodynamic stability or increase in adverse effects. The two groups were well matched for age, weight, height, duration of surgery and baseline haemodynamic status, which strengthens the internal validity of the comparison and mirrors the balanced baseline characteristics reported by Deganwa et al.[18] and William et al.[19] in comparable TAP block trials, as well as by Sottie et al.,[20] Wang et al.[21] and Nag et al.[22]

The principal finding — a significantly longer duration of analgesia with dexmedetomidine than dexamethasone (8.20 ± 2.64 h vs 6.01 ± 2.95 h; $p = 0.003$) — is consistent with the broader literature comparing these two adjuvants in TAP block for other surgical populations. Priyanka et al.[23] comparing the same combination in patients undergoing total laparoscopic hysterectomy, likewise reported a substantially longer analgesic duration with dexmedetomidine than dexamethasone (691.64 ± 35.66 min vs 583.44 ± 30.91 min; $p < 0.0001$). Sinha et al.,[24] studying TAP block after total abdominal hysterectomy, found a significantly longer time to first rescue analgesia with dexmedetomidine ($p = 0.002$), and Singla et al.,[25] in a trial closely matched to ours in the caesarean section population, similarly reported a significantly longer time to first self-reported pain with dexmedetomidine. The consistency of this finding across surgical contexts lends weight to the proposed mechanism: dexmedetomidine acting on peripheral alpha-2 receptors and hyperpolarisation-activated cyclic-nucleotide-gated channels appears to produce a more durable local sensory block than the anti-inflammatory, vasoconstrictive mechanism through which dexamethasone is thought to act.[10,11]

Pain scores were comparable in the first four postoperative hours, after which they diverged in a manner that mapped precisely onto the timing of rescue analgesic requirement in each group — rising above the rescue threshold at 6 hours in the dexamethasone group and at 8 hours in the dexmedetomidine group. Sinha et al.[24] similarly observed comparable pain scores in the first postoperative hour that diverged significantly in favour of dexmedetomidine from 6 hours onward, and Gadallah et al.,[26] studying the same comparison in laparoscopic cholecystectomy, reported consistently lower pain scores with dexmedetomidine at rest and on movement from 6 hours through 48 hours.

The lower total tramadol consumption and fewer rescue doses required in the dexmedetomidine group are the clinically meaningful correlates of the prolonged analgesic window, and are again concordant with prior comparative work. Sinha et al.[24] reported significantly lower total tramadol consumption with dexmedetomidine than dexamethasone (161.11 ± 37.93 mg vs 213.33 ± 44.08 mg; $p = 0.027$), and Priyanka et al.[23] found the dexamethasone group required a substantially higher rescue analgesic dose than the dexmedetomidine group.

Reduced systemic analgesic consumption is of particular relevance in the postpartum setting, where minimising opioid exposure supports earlier mobilisation and uninterrupted breastfeeding.

Patient satisfaction, which integrates the overall analgesic experience rather than any single physiological measurement, was significantly higher in the dexmedetomidine group in our study, a finding echoed by Thakur et al.,[27] who reported higher satisfaction and sedation scores with dexmedetomidine than dexamethasone when both were combined with bupivacaine for TAP block after caesarean delivery, and by Priyanka and Swami,[23] who documented a significantly higher satisfaction score in their dexmedetomidine arm.

Despite its systemic sympatholytic properties, dexmedetomidine at the peripheral dose used in this study (25 μg) was not associated with clinically important bradycardia or hypotension relative to dexamethasone; the small numerical excess of bradycardia in Group A did not reach statistical significance. This is broadly in keeping with Singla et al.,[25] who reported no significant between-group difference in postoperative haemodynamic parameters, although they did note a 10% incidence of bradycardia and hypotension in their dexmedetomidine arm, attributable to the drug's action on central alpha-2A adrenergic receptors and the resulting reduction in sympathetic outflow. Adverse effects overall were infrequent and similar between our two groups, consistent with the safety profile reported by Priyanka and Swami,[23] Thakur et al.[27] and Bansal and Sood in their respective comparative trials of these adjuvants. Taken together, our findings support the use of dexmedetomidine in preference to dexamethasone as an adjuvant to ropivacaine in TAP block for post-caesarean analgesia, while acknowledging that dexamethasone remains a reasonable alternative where alpha-2 agonist-related sedation or haemodynamic effects are a specific concern, or where a corticosteroid-based strategy is otherwise preferred, such as in patients with a history suggestive of postoperative nausea and vomiting.

Limitations

It was conducted at a single centre with a relatively modest sample size. Only ASA physical status II parturients were enrolled, so the results cannot be directly extrapolated to women with significant cardiovascular or respiratory comorbidity. Pain was assessed only at rest; dynamic pain scores were not captured. The follow-up period was also limited to the first 24 postoperative hours.

Conclusion

In parturients undergoing lower segment caesarean section under spinal anaesthesia, the addition of dexmedetomidine 25 μg to 0.375% ropivacaine in ultrasound-guided bilateral TAP block provided a longer duration of postoperative analgesia, fewer and smaller doses of rescue tramadol, and greater patient satisfaction than an equivalent block with dexamethasone 8 mg, without any difference in haemodynamic stability or adverse effect profile.

Dexmedetomidine may therefore be considered a more effective adjuvant than dexamethasone for this indication and merits inclusion as a component of multimodal analgesic protocols after caesarean delivery, pending confirmation in larger, multicentric trials.

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