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Analgesic Efficacy Of Dexmedetomidine As An Adjuvant To Ropivacaine In Ultrasound-Guided Transversus Abdominis Plane Block In Inguinal Hernia Surgery: A Randomised Controlled Study

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Abstract

Introduction: *Postoperative pain following abdominal surgery significantly affects patient recovery and satisfaction. The Transversus Abdominis Plane (TAP) block has emerged as a regional anaesthesia technique targeting the nerves of the anterior abdominal wall. While ropivacaine offers prolonged analgesia with minimal motor blockade, its efficacy may be limited for extended relief. Adjuvants like dexmedetomidine have been introduced to enhance analgesic effects.*

Objective: *To assess the efficacy of dexmedetomidine as an adjuvant to ropivacaine in TAP blocks for postoperative analgesia, comparing analgesic duration, quality, patient satisfaction, and safety profiles.*

Methods: *This comprehensive literature-supported report evaluates multiple clinical trials involving TAP blocks administered with ropivacaine alone versus in combination with dexmedetomidine. Both landmark-based and ultrasound-guided TAP block techniques are described. Evaluated parameters include pain scores, time to rescue analgesia, adverse effects, sedation, and overall patient recovery.*

Results: *The two groups were comparable in age, ASA status, and weight (all $p>0.4$). Adverse drug reactions were significantly fewer in Group RD (26.7%) than RN (46.7%, $p<0.001$). Group RD demonstrated a longer duration of analgesia (19.47 ± 4.03 vs 10.73 ± 0.43 h, $p<0.001$), lower rescue analgesic requirement (129.50 ± 9.22 vs 158.90 ± 15.09 mg, $p=0.001$), and consistently lower VAS pain scores ($p=0.000$). Hemodynamic parameters remained stable and comparable. Patient satisfaction was significantly higher in RD (4.60 ± 0.50 vs 3.77 ± 0.77, $p=0.000$).*

Conclusion: *The combination of dexmedetomidine with ropivacaine in TAP blocks provides superior postoperative analgesia compared to ropivacaine alone. It is a safe and effective strategy, particularly for abdominal surgeries, offering a promising enhancement to multimodal analgesia protocols.*

Keywords: *Gallstones, Cholelithiasis, Endoscopy, Digestive System, Ultrasonography, Postcholecystectomy Syndrome, Gastritis, Duodenitis, Esophagitis, Hiatal Hernia, Dyspepsia, Abdominal Pain*

INTRODUCTION:

Effective pain management is a critical part of perioperative care, particularly in abdominal surgeries, where postoperative pain can delay recovery, prolong hospital stay, and increase opioid use.[1] The Transversus Abdominis Plane (TAP) block is a well-established regional anesthesia technique that provides analgesia by targeting the thoracolumbar nerves supplying the anterior abdominal wall.[2]

First described by Rafi in 2001 as a landmark-based abdominal field block, the TAP block was later refined by McDonnell et al. in 2007, who defined its sensory distribution.[2] The introduction of ultrasound guidance has greatly improved the accuracy and safety of TAP block, allowing real-time visualization of muscle layers and precise deposition of local anesthetic, which reduces complications such as intravascular or intraperitoneal injection.[3]

Ropivacaine is commonly used for TAP blocks due to its prolonged action, favorable sensory-to-motor block profile, and lower cardiotoxicity compared to bupivacaine. Despite these advantages, ropivacaine alone may not provide adequate analgesia for extended postoperative periods.[4,5] To prolong the block and enhance analgesic

efficacy, various adjuvants have been studied, including opioids, alpha-2 adrenergic agonists, magnesium sulfate, and steroids. Among these, dexmedetomidine has shown particular promise.[6,7]

Dexmedetomidine is a highly selective alpha-2 adrenergic agonist with potent analgesic and sedative properties, and unlike opioids, it does not cause significant respiratory depression. Its action involves reducing norepinephrine release and enhancing hyperpolarization of nociceptive neurons, thereby prolonging the effects of local anesthetics. When added to ropivacaine in TAP blocks, dexmedetomidine has been shown to extend sensory blockade, reduce opioid consumption, and improve postoperative comfort[8–10],in patients undergoing inguinal hernia surgery.

The use of dexmedetomidine as an adjuvant to ropivacaine in ultrasound-guided TAP blocks represents an effective strategy in multimodal analgesia, offering prolonged pain relief and improved recovery in patients undergoing abdominal surgery.

MATERIALS AND METHODS

This prospective, randomized, double-blind study was conducted among patients undergoing elective inguinal hernia surgery. Approval was obtained from the Institutional Ethics Committee, and written informed consent was taken from all patients prior to enrollment.

All patients were kept nil per oral for at least 8 hours before surgery. Premedication consisted of Tab. Ranitidine 150 mg and Tab. Alprazolam 0.5 mg administered orally on the night before surgery. The operating theatres were maintained at a humidity of approximately 70% and ambient temperature of 21–23°C to ensure standard environmental conditions.

On arrival in the operating room, an intravenous line was secured with an 18G cannula, and patients were preloaded with Ringer's Lactate solution at 10–15 mL/kg. Standard ASA monitors (GE multiparameter monitor) were attached, recording baseline heart rate, electrocardiogram, non-invasive blood pressure, and peripheral oxygen saturation (SpO_2). Patients were blinded to their group allocation, and the anesthesiologists or investigators recording intraoperative and postoperative parameters were also blinded.

Under strict aseptic precautions and with the patient in sitting position, spinal anesthesia was performed using a 25G Quincke spinal needle at the L3–L4 interspace. After confirming free flow of CSF, 3 mL of 0.5% hyperbaric bupivacaine was injected intrathecally at a rate of 0.2 mL/sec without barbotage. Patients were immediately positioned supine, and a sensory block up to T6–T7 was achieved. Oxygen at 4 L/min was administered through a facemask. All intravenous fluids and anesthetic drugs were maintained at room temperature.

Patients were then randomly divided into two groups:

- **Group RN (Ropivacaine + Normal Saline):** 19 mL of 0.5% ropivacaine + 1 mL normal saline.
- **Group RD (Ropivacaine + Dexmedetomidine):** 19 mL of 0.5% ropivacaine + dexmedetomidine 1 μg/kg diluted in 1 mL.

At the end of surgery, an ultrasound-guided Transversus Abdominis Plane (TAP) block was performed bilaterally using a high-frequency linear probe (midaxillary line between iliac crest and subcostal margin). The three muscle layers—external oblique, internal oblique, and transversus abdominis—were identified. A 22G needle was advanced in-plane until the tip reached the fascial plane between the internal oblique and transversus abdominis muscles. After negative aspiration and injection of 1–2 mL saline to confirm correct placement, the study drug solution (20 mL per side) was injected, producing a hypoechoic spread in the TAP.

Patients and anesthesiologists performing the block were blinded to the drug mixture. Postoperatively, patients were shifted to the PACU. Pain was assessed using the Visual Analogue Scale (VAS, 0 = no pain to 10 = worst pain imaginable) every 2 hours for the first 12 hours and every 6 hours thereafter up to 24 hours.

Duration of analgesia was defined as the time from administration of the TAP block to the first report of VAS ≥4. Rescue analgesia was given as IV tramadol 50 mg diluted in 100 mL saline. The time and number of rescue doses were recorded on a structured proforma.

Statistical

Data was collected and compiled in MS Excel. Statistical analysis was performed using SPSS for windows version 26.0. The description of data will be in the form of mean (±) SD for quantitative data and frequency and proportion for qualitative data. Student t test used to compare continuous variables and $\chi 2$ test used to compare categorical variables. P value <0.05 was considered statistically significant.

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SAMPLE SIZE ESTIMATION:

The difference between two means in VAS score at first request for rescue analgesia was 2 and means standard deviation was 1.8. power of study was conducted with confidence limit of 80 % allowing alpha error of 0.001 and beta error of 0.2 per group is 30. Hence a total of 60 subjects will be included in our study and divided into two groups each containing 30 subjects. As all the distributions will merge into normal distribution, sample size i.e. 30 is enough because inference that can be drawn based on 30 observations will more or less remain the same, in spite of any increase in the sample size

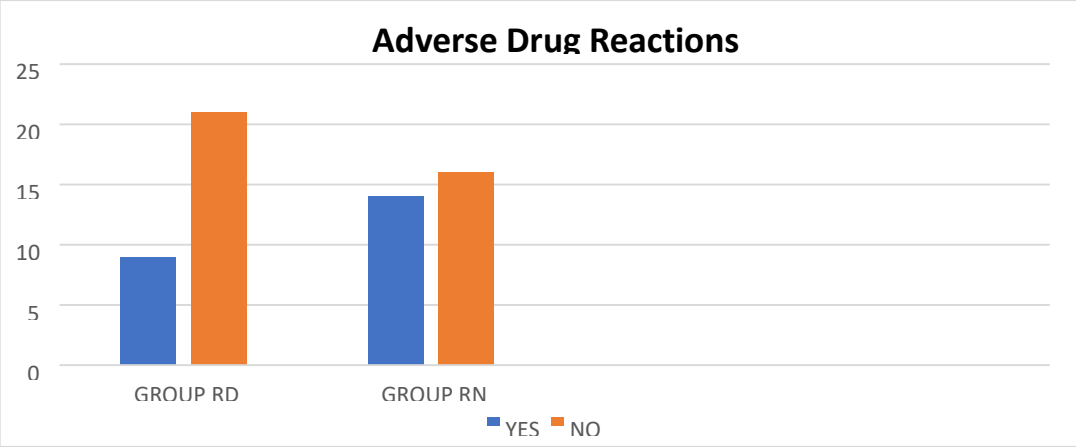
RESULTS

The age distribution between the two groups, RD (Ropivacaine + Dexmedetomidine) and RN (Ropivacaine + Normal Saline), was comparable. In the 45–50 years group, 60% of RD and 73.3% of RN patients were represented. In the 51–55 years group, 26.7% of RD and 13.3% of RN were included, while both groups had 13.3% in the 56–60 years range. The difference was not statistically significant (p=0.498).

ASA physical status was also similar across groups. In Group RD, 90% of patients were ASA I and 10% ASA II, compared to 93.3% ASA I and 6.7% ASA II in Group RN. The difference was not significant (p=1.000).

The mean weight was 56.23 ± 5.14 kg in Group RD and 54.00 ± 5.94 kg in Group RN, with no statistical difference (p=0.872). However, adverse drug reactions were reported less frequently in Group RD (26.7%) than in Group RN (46.7%), a statistically significant finding (p<0.001).

FIGURE 1. Adverse Drug Reactions



The duration of analgesia was significantly prolonged in Group RD (19.47 ± 4.03 hours) compared to Group RN (10.73 ± 0.43 hours, p<0.001). Similarly, mean rescue analgesic consumption was lower in Group RD (129.50 ± 9.22 mg) than Group RN (158.90 ± 15.09 mg), a statistically significant difference (p=0.001).

FIGURE 2. DURATION OF ACTION

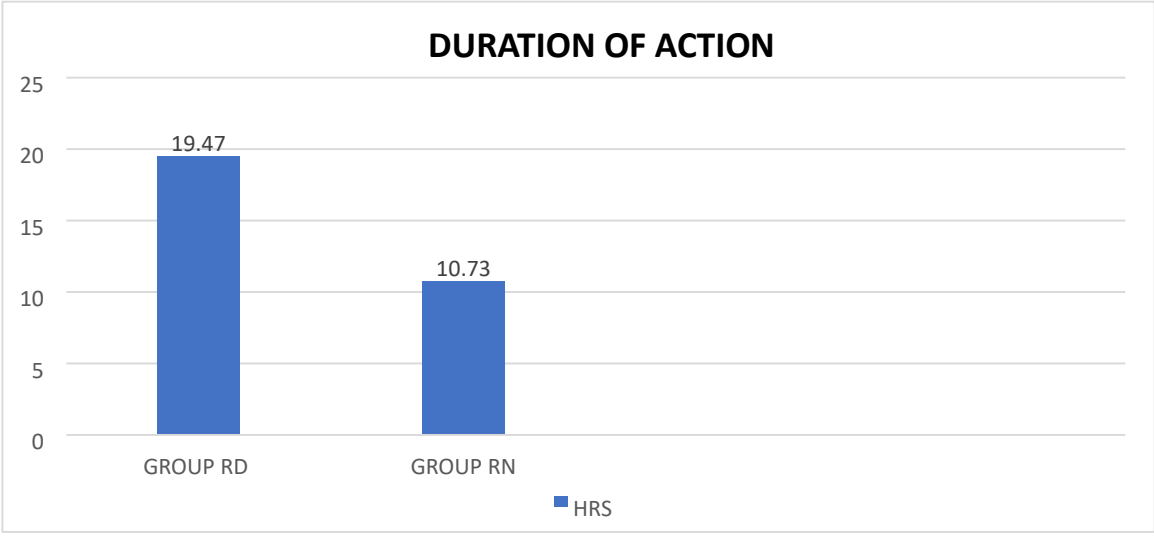


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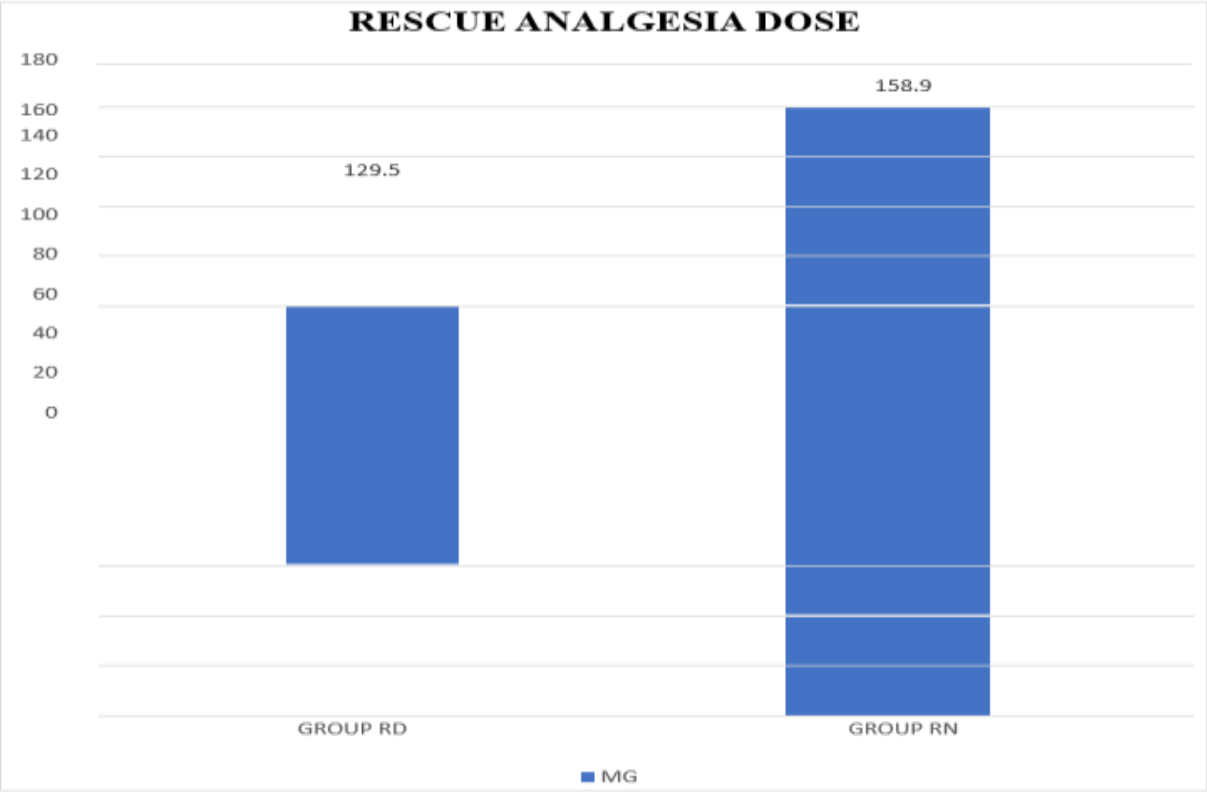
FIGURE 3. RESCUE ANALGESIA DOSE



Hemodynamic parameters remained stable and comparable throughout the 24-hour postoperative period. Systolic blood pressure ranged from 107.5–108.5 mmHg in RD and 109.5–110.5 mmHg in RN (all p>0.2). Diastolic blood pressure remained between 69.5–70.5 mmHg in RD and 70.5–71.5 mmHg in RN (all p>0.3). Pulse rate values were also comparable, ranging from 81.5–82.5 bpm in RD and 82.5–83.5 bpm in RN (all p>0.4).

TABLE 1. VAS Score

VAS Score – Post operative			Group RD	Group RN	p-value
@baseline			1.2 ± 1.1	2.0 ± 1.2	0.000
@15 mins			2.2 ± 1.1	3.0 ± 1.2	0.000
@30 mins			1.2 ± 1.3	2.0 ± 1.5	0.000
@45 mins			1.7 ± 1.1	2.5 ± 1.2	0.000
@1 hour			2.2 ± 1.3	3.0 ± 1.5	0.000
@2 hour			1.2 ± 1.1	2.0 ± 1.2	0.000

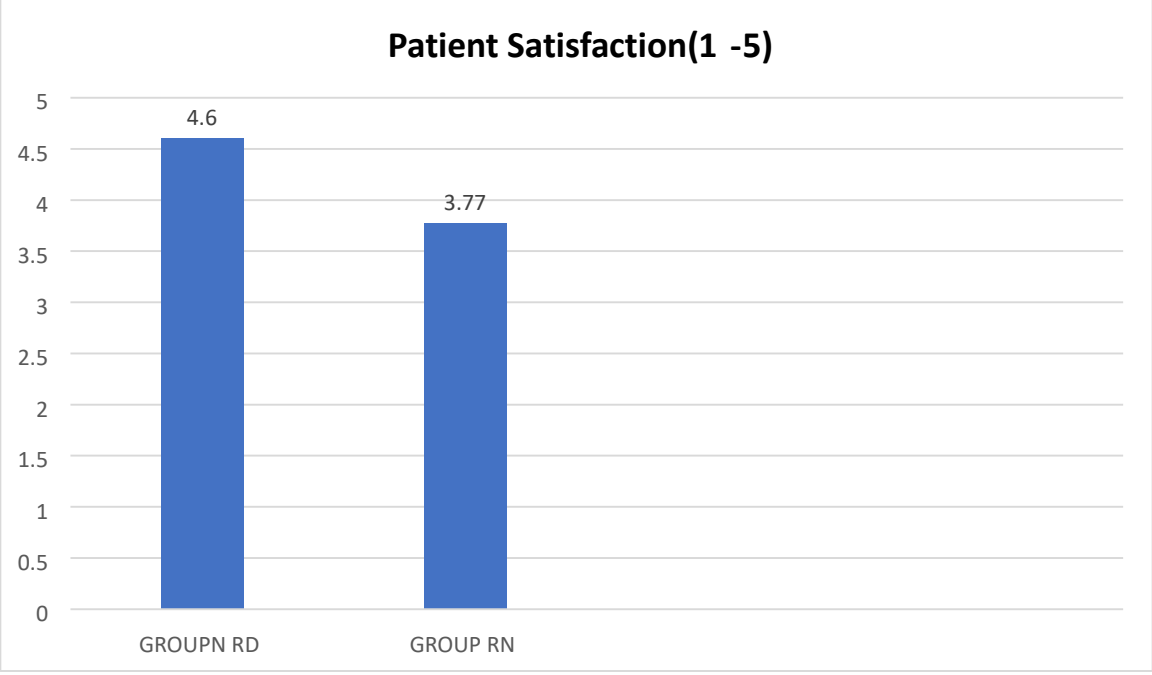
@4 hour			1.7 ± 1.3	2.5 ± 1.5	0.000
@8 hour			2.2 ± 1.1	3.0 ± 1.2	0.000
@10 hour			1.2 ± 1.3	2.0 ± 1.5	0.000
@12 hour			1.7 ± 1.1	2.5 ± 1.2	0.000
@14 hour			2.2 ± 1.3	3.0 ± 1.5	0.000
@16 hour			1.2 ± 1.1	2.0 ± 1.2	0.000
@24 hours			1.7 ± 1.3	2.5 ± 1.5	0.000

Pain scores assessed with the Visual Analogue Scale (VAS) were consistently lower in Group RD at all time points. Baseline VAS was 1.2 in RD versus 2.0 in RN, and this difference persisted through 24 hours (RD: 1.2–2.2 vs RN: 2.0–3.0, all p=0.000).

TABLE 2. Patient Satisfaction

Patient Satisfaction	Group RD	Group RN	p-value
Patient Satisfaction (1–5)	4.60 ± 0.50	3.77 ± 0.77	0.000

FIGURE 4. Patient Satisfaction



Patient satisfaction scores were significantly higher in Group RD (4.60 ± 0.50) compared to Group RN (3.77 ± 0.77), with a highly significant difference (p=0.000).

DISCUSSION

This study evaluated the efficacy of dexmedetomidine as an adjuvant to 0.5% ropivacaine in TAP block compared to ropivacaine alone, assessing duration of analgesia, pain scores, rescue analgesic use, hemodynamics, adverse effects, and patient satisfaction in patients undergoing inguinal hernia surgery. The results demonstrated a significant improvement in postoperative analgesia and satisfaction with dexmedetomidine.

Demographics and Baseline Characteristics

In our study, age distribution was similar between groups (p=0.498). Comparable findings were reported by Pan W11, Gupta13, Zeng Y14, Nazir O17, and Sinha J22, all showing no significant age differences across groups. Similarly, weight distribution was comparable (p=0.872), consistent with Pan W11, Gupta13, Zeng Y14, Nazir O17, and Sinha J18. ASA status was also matched (p=1.000), as confirmed by Pan W11, Gupta13, and Nazir O21[105].

Adverse Effects

Adverse effects were lower in Group RD (26.7% vs 46.7%, p<0.001). Pan W11 reported lower nausea/vomiting with dexmedetomidine, while Zeng Y14 and Sinha J 17 observed no significant intergroup differences.

Duration of Analgesia

Analgesia lasted significantly longer in RD (19.47 ± 4.03 h) versus RN (10.73 ± 0.43 h, p<0.001). Similar prolongation was reported by Bansal P12, Gupta13, Zeng Y14, Qin Z15, and Nazir O17. Meta-analysis by Sun Q[111] 18 showed a pooled 3.33 h increase with dexmedetomidine. Conversely, Ding W16 found no difference between groups.

Rescue Analgesia Requirement

Mean rescue dose was significantly lower in RD (129.50 ± 9.22 mg vs 158.90 ± 15.09 mg, p=0.001). Gupta13, Zeng Y14, Qin Z15, Nazir O16, and Sinha J17 all reported reduced opioid use with dexmedetomidine. Sun Q18 confirmed lower 24 h opioid use in a meta-analysis.

Hemodynamics

In our study, SBP, DBP, and PR were stable and comparable (p>0.2, p>0.3, and p>0.4 respectively). Pan W11 and Gupta13 reported similar findings. However, Qin Z15 and Sinha J 17 observed reductions in MAP and HR at higher dexmedetomidine doses.

VAS Scores

VAS scores were consistently lower in RD at all intervals up to 24 h (p=0.000). Pan W11reported lower scores up to 12 h, Gupta13 found VNRS <3 except transient rises, Zeng Y 14 showed significant reductions only in higher DEX groups, and Nazir O[105] and Sinha J17 also demonstrated significantly lower VAS scores in dexmedetomidine groups. Sun Q18 confirmed significant pooled reductions at multiple time points.

Patient Satisfaction

Satisfaction was significantly higher in Group RD (4.60 ± 0.50 vs 3.77 ± 0.77, p=0.000). Pan W11 and Zeng Y14 reported higher satisfaction with dexmedetomidine, while Gupta13 and Sinha J16 found improvements without statistical significance.

Our findings support dexmedetomidine as a valuable adjuvant to ropivacaine in TAP block, providing prolonged analgesia, reduced opioid use, lower pain scores, and improved patient satisfaction, without major adverse effects or hemodynamic instability. Further trials across varied populations and dosing regimens are warranted to optimize safety and efficacy.

CONCLUSION

The combination of dexmedetomidine with 0.5% ropivacaine in TAP block significantly prolongs postoperative analgesia, reduces the need for rescue analgesia, lowers VAS scores, and improves patient satisfaction without significant adverse effects in patients undergoing inguinal hernia surgery. These findings support the safe and effective use of dexmedetomidine as an adjuvant to ropivacaine in regional anaesthesia for enhanced postoperative pain control.

Limitations

This study was limited by its small sample size and single-center design, which may reduce generalizability. Only ASA I–II patients within a specific age range were included, excluding older and high-risk populations. Long-term outcomes such as chronic pain and recovery were not assessed. Sedation scoring was incomplete across all intervals, and plasma dexmedetomidine levels were not measured to evaluate systemic absorption or pharmacodynamic correlation.

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