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ORIGINAL ARTICLE

Dexmedetomidine as Adjuvant in Scalp Nerve Block for Craniotomy: A Double-Blind Randomized Clinical Trial

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Abstract

Introduction: Scalp nerve block (SNB) is an effective adjunct for attenuating hemodynamic responses and reducing postoperative pain in craniotomy. Dexmedetomidine (DEX), with its analgesic and anti-inflammatory properties, may enhance the quality of SNB. This study evaluated the effects of adding DEX to SNB on hemodynamic stability, postoperative pain, inflammatory response, and analgesic duration in craniotomy patients.

Methods: A double-blind, parallel-group randomized clinical trial was conducted on 36 adult patients undergoing elective craniotomy (July–September 2025) at a tertiary hospital Denpasar. Participants received SNB using 0.375% ropivacaine (20 mL) with or without DEX 1 µg/kg under standardized general anesthesia. Outcomes included mean arterial pressure (MAP), Visual Analog Scale (VAS) scores at 12 and 24 hours, neutrophil-to-lymphocyte ratio (ΔNLR), and time to first rescue analgesic (TTFAR). Statistical analyses used mixed ANOVA and Mann–Whitney U tests. Ethical approval number was 2159/UN14.2.2.VII.14/LT/2025.

Results: MAP was significantly lower in the DEX group at 10 minutes (Δ = 4.89 mmHg; 95% CI 1.62–8.16), 20 minutes (Δ = 4.83; 95% CI 1.57–8.10), 30 minutes (Δ = 3.67; 95% CI 0.40–6.94), and upon PACU arrival (Δ = 3.72; 95% CI 0.45–6.99) (all $p < 0.05$). Median VAS scores were significantly lower with DEX at 12 hours (1.50 vs 3.00; $p < 0.001$) and 24 hours (1.00 vs 2.00; $p < 0.001$). ΔNLR was reduced in the DEX group (−0.56 vs 3.08; $p = 0.004$). TTFAR was markedly prolonged (554 vs 257 minutes; $p < 0.001$). No adverse events were reported.

Conclusion: Dexmedetomidine added to scalp nerve block enhances hemodynamic stability, reduces postoperative pain for up to 24 hours, suppresses early systemic inflammation, and prolongs analgesic duration in craniotomy without observed complications. DEX–SNB represents a beneficial component of multimodal analgesia in neuroanesthesia and may support enhanced recovery pathways.

Keywords: Craniotomy, Dexmedetomidine, Hemodynamic stability, Inflammation, Postoperative pain, Scalp block

Efektivitas Penggunaan Dexmedetomidine pada Kraniotomi: Uji Klinis Acak Tersamar Ganda

Abstrak

Pendahuluan: Scalp nerve block (SNB) efektif dalam menurunkan respons hemodinamik dan nyeri pascaoperasi pada kraniotomi. Dexmedetomidine (DEX), yang memiliki efek analgetik dan antiinflamasi, berpotensi meningkatkan kualitas SNB. Penelitian ini mengevaluasi efek penambahan DEX pada SNB terhadap kestabilan hemodinamik, intensitas nyeri pascaoperasi, respons inflamasi, dan durasi analgesia pada pasien kraniotomi.

Metode: Uji klinis acak tersamar ganda dengan desain paralel dilakukan pada 36 pasien dewasa yang menjalani kraniotomi elektif (Juli–September 2025) di Rumah Sakit Tersier Denpasar. Peserta menerima SNB menggunakan ropivacaine 0,375% (20 mL) dengan atau tanpa DEX 1 µg/kg di bawah anestesi umum standar. Luaran meliputi mean arterial pressure (MAP), skor Visual Analog Scale (VAS) pada 12 dan 24 jam, perubahan neutrophil-to-lymphocyte ratio (ΔNLR), dan time to first rescue analgesic (TTFAR). Analisis menggunakan mixed ANOVA dan Mann–Whitney U. Nomor persetujuan etik: 2159/UN14.2.2.VII.14/LT/2025.

Hasil: MAP secara bermakna lebih rendah pada kelompok DEX pada menit ke-10 (Δ = 4,89 mmHg; 95% CI 1,62–8,16), menit ke-20 (Δ = 4,83; 95% CI 1,57–8,10), menit ke-30 (Δ = 3,67; 95% CI 0,40–6,94), dan pascaoperasi (Δ = 3,72; 95% CI 0,45–6,99) (seluruhnya $p < 0,05$). Skor VAS lebih rendah pada kelompok DEX pada 12 jam (1,50 vs 3,00; $p < 0,001$) dan 24 jam (1,00 vs 2,00; $p < 0,001$). ΔNLR lebih kecil pada kelompok DEX (−0,56 vs 3,08; $p = 0,004$). TTFAR lebih panjang secara bermakna (554 vs 257 menit; $p < 0,001$). Tidak ditemukan efek samping.

Kesimpulan: Penambahan dexmedetomidine pada scalp nerve block meningkatkan kestabilan hemodinamik,

menurunkan intensitas nyeri hingga 24 jam, menekan respons inflamasi awal, serta memperpanjang durasi analgesia pada pasien kraniotomi tanpa efek samping yang teramati. DEX–SNB layak dipertimbangkan sebagai bagian dari analgesia multimodal dan berpotensi mendukung protokol pemulihan cepat di bedah saraf.

Kata kunci: Kraniotomi, Dexmedetomidine, Kestabilan hemodinamik, Inflamasi, Scalp blok, Nyeri pascaoperasi

Introduction

Postoperative pain following craniotomy remains a significant challenge in neuroanesthesiology. Inadequately controlled pain can trigger sympathetic activation, elevate blood pressure and heart rate, increase intracranial pressure (ICP), and impair cerebral perfusion, potentially worsening cerebral edema and delaying neurological recovery. Noxious stimuli such as scalp incision, skull pinning, drilling, and dural manipulation are well-known triggers of acute hemodynamic surges during craniotomy. Epidemiological data demonstrate that approximately 10–20% of craniotomy patients experience severe postoperative pain, while over 30% report moderate pain, illustrating the clinical importance of optimizing perioperative analgesia.[1]

Opioids remain a conventional component of analgesia in neurosurgery; however, their use is limited by adverse effects including over-sedation, respiratory depression, nausea, and vomiting, which may impair postoperative neurological evaluation. Therefore, multimodal and opioid-sparing approaches such as the scalp nerve block (SNB) have gained increasing traction. SNB using local anesthetics like ropivacaine has been shown to blunt hemodynamic responses to noxious stimuli and reduce postoperative pain and intraoperative opioid requirements in craniotomy patients.[1–3] Dexmedetomidine (DEX), a selective α_2-adrenergic agonist, has emerged as a promising adjuvant in regional anesthesia due to its analgesic, sedative, sympatholytic, and anti-inflammatory properties. Evidence demonstrates that DEX prolongs sensory blockade, enhances the quality of peripheral nerve blocks, and reduces anesthetic and opioid requirements when combined with local anesthetics.[4,5] Beyond analgesia, DEX attenuates perioperative inflammation by reducing pro-inflammatory cytokines such as IL-6 and TNF-α and is associated with lower postoperative neutrophil-to-lymphocyte ratio (NLR), a biomarker of systemic inflammation.[6,7]

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Although the individual benefits of SNB and dexmedetomidine are well documented, there remains a gap in the literature evaluating their combined effects in craniotomy, particularly studies incorporating hemodynamic outcomes and inflammatory biomarkers simultaneously. Existing trials primarily focus on pain or intraoperative hemodynamic responses without assessing systemic inflammation.[5,8,9] Moreover, no study has been conducted in Indonesia, where patient characteristics, anesthetic practice, and surgical workflows may influence treatment response. This gap highlights the need for a comprehensive evaluation of the dexmedetomidine-assisted scalp nerve block in the local population.

Therefore, this study aims to assess the effectiveness of dexmedetomidine as an adjuvant to scalp nerve block in improving intraoperative hemodynamic stability, reducing postoperative pain intensity, and modulating inflammatory response, as measured by the

change in neutrophil-to-lymphocyte ratio (ΔNLR), in patients undergoing craniotomy at a tertiary care center in Indonesia.

We hypothesize that adding dexmedetomidine to scalp nerve block improves intraoperative hemodynamic stability, reduces postoperative pain, suppresses systemic inflammatory response, and prolongs analgesic duration compared with scalp nerve block using ropivacaine alone.

Patients and Methods

This study was designed as a prospective, double-blind, parallel-group randomized controlled trial to evaluate the effect of adding dexmedetomidine (DEX) to scalp nerve block (SNB) on intraoperative hemodynamic stability, postoperative pain, inflammatory response, and analgesic duration in patients undergoing elective craniotomy. The study was conducted at a tertiary hospital in Denpasar, between July and September 2025. Ethical approval was obtained from the Institutional Ethics Committee (Approval No: 2159/UN14.2.2.VII.14/LT/2025), and all procedures adhered to the Declaration of Helsinki and Good Clinical Practice guidelines. Written informed consent was obtained from all participants.

The sample size was calculated using a two-mean comparison formula for a superiority design with a significance level of 5% and power of 80%. The calculation was based on a clinically relevant mean difference in mean arterial pressure (MAP) of 17.2 mmHg with a standard deviation of 13.62 mmHg, derived from previously published data on hemodynamic responses to scalp block during craniotomy.[1] This yielded a minimum requirement of 16 subjects per group, and after accounting for an anticipated 10% drop-out rate, a total of 36 subjects were targeted for enrollment.

Participants were recruited consecutively from adult patients scheduled for elective supratentorial craniotomy. Eligible patients were aged 18 to 65 years, classified as ASA physical status I–III, and had a Glasgow Coma Scale (GCS) score of 15. Exclusion criteria included significant cardiac, pulmonary, hepatic, or renal disease; coagulation disorders; moderate-to-severe traumatic brain injury; local infection at the injection site; chronic opioid use; pregnancy; or known allergy to study drugs. Patients were withdrawn from the study if postoperative ventilatory support was required, if intraoperative blood loss exceeded 2 liters, if arrhythmia or hemodynamic shock occurred, if allergic reactions developed, or in the event of perioperative mortality.

Randomization was carried out using a computer-generated sequence produced by an independent statistician via randomizer.org, employing block randomization with a fixed block size of four to ensure balanced allocation in a 1:1 ratio. Allocation codes were placed in sequentially numbered, sealed, opaque envelopes, which were opened only by a research assistant not involved in anesthesia management or postoperative outcome assessment. The study was double-blinded: patients, postoperative evaluators, and the anesthesiologists assessing outcomes remained unaware of group assignments. The anesthesiologist performing the scalp block was not involved in outcome assessment or data analysis. Study solutions were prepared in identical syringes labeled only as “Study Drug A” or “Study Drug B” to ensure allocation concealment.

All patients received standardized general anesthesia consisting of fentanyl 3 µg/kg, propofol 2 mg/kg, and rocuronium 1 mg/kg for induction, followed by maintenance with sevoflurane at 0.8–1.0 MAC in an oxygen–air mixture. After intubation, the scalp nerve block was performed.

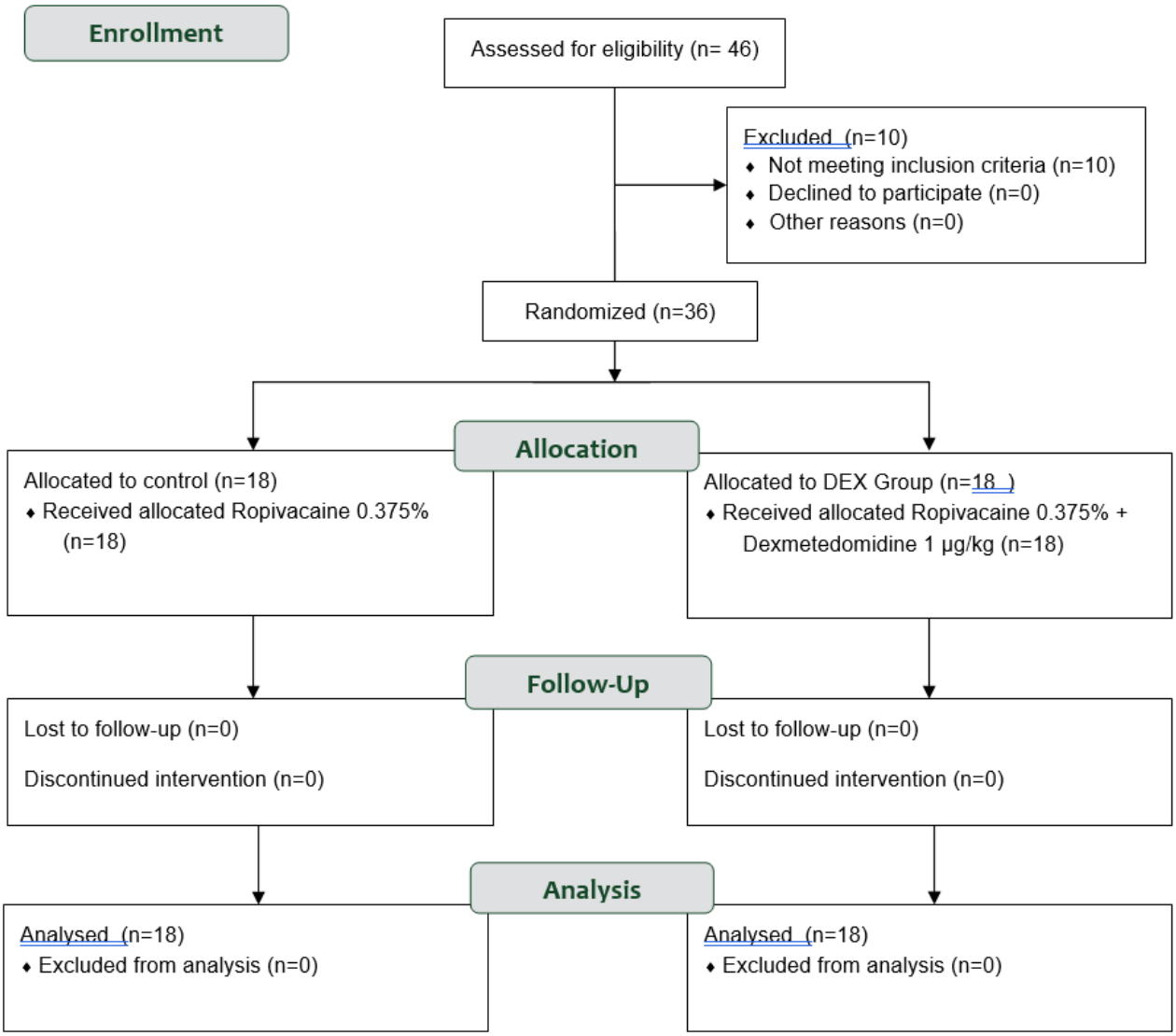

Figure 1. CONSORT diagram

The control group received 20 mL of 0.375% ropivacaine, whereas the DEX group received 0.375% ropivacaine combined with dexmedetomidine at a dose of 1 µg/kg body weight. Dexmedetomidine (100 µg/mL) was diluted in normal saline so that the final injected volume remained 20 mL. The block was administered at the supratrochlear, supraorbital, zygomaticotemporal, auriculotemporal, greater auricular, greater occipital, and lesser occipital nerves, with 3 mL deposited at each anatomical landmark. Mechanical ventilation was performed in volume-controlled mode with end-tidal CO_2 maintained between 35 and 40 mmHg. At the conclusion of surgery, all patients were extubated and transferred to the post-anesthesia care unit (PACU), where they remained under monitoring until achieving an Aldrete score of 10.

The primary outcomes of this study were intraoperative hemodynamic stability, postoperative pain intensity, and systemic inflammatory response. Hemodynamic stability was assessed by MAP measured at baseline (0 minutes), 10, 20, and 30 minutes after incision, and upon PACU arrival. Postoperative pain was evaluated using the Visual Analog Scale (VAS) at 12 and 24 hours after surgery. Inflammatory response was evaluated using the neutrophil-to-lymphocyte ratio (NLR) obtained from venous blood samples collected preoperatively and 12 hours postoperatively. The change in NLR

(ΔNLR) was used as the main inflammatory parameter based on evidence indicating that systemic inflammatory markers peak within 6–24 hours following surgical stress.(6,7) The secondary outcome was the time to first rescue analgesic (TTFAR), defined as the interval between the end of surgery and the first patient-controlled analgesia (PCA) fentanyl demand.

Safety monitoring was conducted intraoperatively and during the first 24 postoperative hours. Adverse events were documented according to predefined clinical criteria: bradycardia was defined as heart rate <50 beats per minute; hypotension as MAP <65 mmHg or ≥20% decrease from baseline; oversedation as a Richmond Agitation–Sedation Scale (RASS) score below –2; and allergic reaction as any occurrence of urticaria, bronchospasm, or hypotension temporally associated with drug administration.

Statistical analysis was performed using IBM SPSS Statistics version 29. Normality of data distribution was assessed with the Shapiro–Wilk test. Normally distributed variables were presented as mean ± standard deviation and compared using the independent t-test, whereas non-normally distributed variables were reported as median and interquartile range and analyzed using the Mann–Whitney U test. Repeated MAP measurements were analyzed using a mixed ANOVA model with Greenhouse–Geisser correction when appropriate. All primary outcomes were presented with 95% confidence intervals. Effect sizes were calculated using Cohen's d for VAS, ΔNLR, and TTFAR, while partial eta squared was used for repeated MAP measures. The primary analysis followed a per-protocol approach, and statistical significance was defined as $p \leq 0.05$.

Results

A total of 46 patients were screened for eligibility during the study period, of whom 36 met the inclusion criteria and were randomized equally into the control group (n = 18) and the dexmedetomidine (DEX) group (n = 18). Ten patients were excluded based on predefined withdrawal criteria. All randomized participants completed the study, and no post-randomization exclusions occurred. Baseline demographic and operative characteristics were comparable between the two groups. The mean age was 39.39 ± 16.28 years in the control group and 44.00 ± 12.86 years in the DEX group ($p = 0.352$). Sex distribution was identical, with 8 males (44.4%) and 10 females (55.6%) in each group. The median duration of surgery was similar between groups (182.5 minutes [IQR 20] vs 190 minutes [IQR 50], $p = 0.748$). All patients were classified as ASA physical status III.

Table 1. Subject Characteristics

Characteristics	Treatment Group		*p*-value
	P1 (n=18)	P2 (n=18)	
Age (years)	39,39 ± 16,28	44 ± 12,86	0,352[T]
Sex			
Male	8 (44,4%)	8 (44,4%)	1,00[C]
Female	10 (55,6%)	10 (55,6%)	
Duration of Surgery (minutes)	182,5 (20)	190 (50)	0,748[M]
ASA Physical Status			
III	100%	100%	-

Mean arterial pressure (MAP) was measured at baseline (0 minutes), 10, 20, and 30 minutes intraoperatively, and upon arrival in the post-anesthesia care unit (PACU). Mixed ANOVA analysis demonstrated a significant overall difference between groups, with consistently lower MAP values in the DEX group. Post-hoc Bonferroni analysis revealed statistically significant reductions in MAP at 10 minutes (Δ = 4.89 mmHg; 95% CI 1.62–8.16; p = 0.004), 20 minutes (Δ = 4.83 mmHg; 95% CI 1.57–8.10; p = 0.004), 30 minutes (Δ = 3.67 mmHg; 95% CI 0.40–6.94; p = 0.028), and in the PACU period (Δ = 3.72 mmHg; 95% CI 0.45–6.99; p = 0.026). Baseline MAP did not differ significantly between groups (p = 0.615). These findings indicate that dexmedetomidine as an adjuvant to scalp nerve block provided superior intraoperative hemodynamic stability.

Table 2. Homogeneity of Variance Test for Parametric Data

Variable	*Levene's Test*		Conclusion
	F Levene	Nilai *p*	
Age	1,619	0,212	Homogeneous
MAP at 0 minutes	9,546	0,004	Heterogeneous
MAP at 10 minutes	1,568	0,219	Homogeneous
MAP at 20 minutes	0,923	0,343	Homogeneous
MAP at 30 minutes	0,573	0,454	Homogeneous
Postoperative MAP	0,166	0,686	Homogeneous
TTFAR	0,164	0,686	Homogeneous

Table 3. Comparative Analysis of Mean Arterial Pressure (MAP) at 0, 10, 20, and 30 Minutes, and Postoperatively in Both Treatment Groups

Characteristics	Treatment Group			*p-value
	P1 (n=18) (EMM ± SE)	P2 (n=18) (EMM ± SE)	Mean Difference 95% CI	
MAP at 0 minutes	78,06 ± 1,17	77,22 ± 1,17	0,83 (−2,44; 4,10)	**0,615**
MAP at 10 minutes	87,83 ± 1,17	82,94 ± 1,17	4,89 (1,62; 8,16)	**0,004**
MAP at 20 minutes	86,06 ± 1,17	81,22 ± 1,17	4,83 (1,57; 8,10)	**0,004**
MAP at 30 minutes	84,44 ± 1,17	80,78 ± 1,17	3,67 (0,40; 6,94)	**0,028**
Postoperative MAP	83,22 ± 1,17	79,50 ± 1,17	3,72 (0,45; 6,99)	**0,026**

Table 4. Comparative Analysis of Visual Analogue Scale at 12 and 24 Hours Postoperatively in Both Treatment Groups

Characteristics	Treatment Group		*p-value
	P1 (n=18)	P2 (n=18)	
VAS at 12 hours postoperatively	3,00 (0)	1,50 (1)	**<0,001[M]**
VAS at 24 hours postoperatively	2,00 (1)	1,00 (1)	**<0,001[M]**

Postoperative pain was assessed using the Visual Analog Scale (VAS) at 12 and 24 hours after surgery. The DEX group demonstrated significantly lower pain scores at both time points. At 12 hours, the median VAS was 1.50 (IQR 1) in the DEX group compared with 3.00 (IQR 0) in the control group ($p < 0.001$). At 24 hours, the DEX group also showed lower scores (1.00 [IQR 1] vs 2.00 [IQR 1], $p < 0.001$). These results confirm a sustained analgesic benefit of dexmedetomidine-assisted scalp nerve block during the first postoperative day.The systemic inflammatory response, measured via the change in neutrophil-to-lymphocyte ratio (ΔNLR) from preoperative to 12-hour postoperative values, was significantly lower in the DEX group. The median ΔNLR was −0.56 (IQR 5.33) in the DEX group compared with 3.08 (IQR 7.60) in the control group ($p = 0.004$), indicating attenuation of the postoperative inflammatory response.

Table 5. Comparative Analysis of Preoperative and Postoperative Neutrophil-to-Lymphocyte Ratio (NLR) in Both Treatment Groups

Characteristics	Treatment Group		*p-value
	P1 (n=18)	P2 (n=18)	
NLR Difference	3,08 (7,60)	-0,56 (5,33)	**0,004[M]**

Analgesic duration, assessed through the time to first rescue analgesic (TTFAR), was markedly prolonged in the DEX group. The median TTFAR was 554 minutes (IQR 45) in the DEX group versus 257 minutes (IQR 53) in the control group ($p < 0.001$). This suggests that dexmedetomidine not only enhanced analgesic quality but also provided a clinically meaningful extension of analgesia duration.

No adverse events—including bradycardia, hypotension, oversedation, or allergic reaction—were observed in either group during the intraoperative period or the first 24 postoperative hours. No participants required withdrawal due to safety concerns.

Table 6. Comparative Analysis of Time to First Analgesia Rescue (TTFAR) Postoperatively in Both Treatment Groups

Characteristics	Treatment Group		*p-value
	P1 (n=18)	P2 (n=18)	
***Time to First Analgesia Rescue* (minutes)**	257 (53)	554 (45)	**<0,001[T]**

Discussion

This randomized controlled trial demonstrated that the addition of dexmedetomidine (DEX) to scalp nerve block (SNB) significantly improved intraoperative hemodynamic stability, reduced postoperative pain intensity, attenuated systemic inflammatory response, and prolonged analgesic duration in patients undergoing elective craniotomy. These findings support the role of DEX as a valuable adjuvant in multimodal neuroanesthesia, complementing existing evidence on the benefits of SNB and α_2-agonist–mediated modulation of nociceptive and inflammatory pathways.

The improved hemodynamic stability observed in the DEX group is consistent with prior studies reporting that DEX attenuates the sympathetic response to noxious cranial stimulation such as scalp incision and skull pinning.[8,9] The magnitude of MAP reduction in this study (3–5 mmHg across key time points) lies within clinically meaningful thresholds for preventing intracranial pressure surges while avoiding hypotension that could compromise cerebral perfusion. From a clinical perspective, even modest stabilization of MAP can facilitate a more controlled surgical field and reduce the risk of bleeding during craniotomy. The hemodynamic benefit observed here likely reflects the synergistic effects of ropivacaine-induced peripheral neural blockade and DEX-induced presynaptic inhibition of norepinephrine release, as described in previous neuroanatomical and pharmacologic studies.[5,10]

Postoperative analgesic outcomes further support the superiority of the DEX–SNB combination. VAS scores were significantly lower at both 12 and 24 hours, accompanied by a substantial prolongation of time to first rescue analgesic. These findings align with meta-analytic data indicating that dexmedetomidine enhances the duration and depth of peripheral nerve block,[4,10] and extend earlier observations by providing a sustained 24-hour analgesic benefit in craniotomy patients—a population in whom early opioid sparing is particularly valuable due to the need for frequent neurological examinations. The large effect sizes observed for pain reduction and TTFAR in this study underscore the clinical significance of these findings.

In addition to hemodynamic and analgesic effects, this study demonstrated a notable reduction in postoperative inflammatory response, as reflected by a significantly lower ΔNLR in the DEX group. This observation is supported by previous reports that DEX suppresses pro-inflammatory cytokines (IL-6, TNF-α) and enhances anti-inflammatory mediators such as IL-10.[6,7] The use of NLR as a biomarker is justified by its sensitivity, simplicity, and established role in detecting systemic inflammation following surgical stress. The selection of the 12-hour time point aligns with evidence that NLR peaks within 6 to 24 hours after major surgery.[6] The suppression of inflammation may contribute to improved recovery profiles and reduced postoperative complications, as indicated by recent trials evaluating DEX in perioperative immunomodulation.[11,12]

The present findings are also relevant within the framework of enhanced recovery after neurosurgery (ERAS-Neuro). By stabilizing hemodynamics, reducing opioid exposure, and modulating inflammation, DEX–SNB can support faster neurological recovery, improve patient comfort, and reduce the risk of secondary brain injury. This aligns with emerging ERAS-Neuro recommendations emphasizing opioid-sparing analgesia, autonomic modulation, and attenuation of inflammatory stress responses during intracranial surgery. While ERAS principles are still evolving in neuroanesthesia, the results of this study provide a compelling rationale for incorporating DEX–SNB into multimodal perioperative pathways.

Comparison with existing literature highlights several unique contributions of this study. Prior investigations have typically evaluated either the hemodynamic impact of DEX-enhanced scalp block,[5,8,9] its analgesic prolongation in peripheral nerve blocks,[4,10] or its systemic anti-inflammatory effects in non-neurosurgical populations.[6,11,12] To our knowledge, no previous study has simultaneously examined all three domains—hemodynamic stability, pain control, and inflammatory modulation—in the context of craniotomy. Furthermore, this is the first study conducted in Indonesia assessing DEX as an SNB adjuvant in neurosurgery, addressing a regional research gap identified in the introduction.

Despite these strengths, several limitations should be acknowledged. The single-center design and relatively small sample size may limit the external validity of the results, particularly for patients with different demographic characteristics or comorbidity profiles. All participants were ASA physical status III, which may restrict generalizability to lower-risk populations. Inflammatory markers were measured only up to 12 postoperative hours, without longer postoperative follow-up or additional biomarkers such as CRP, IL-6, or procalcitonin. No long-term clinical outcomes—including postoperative delirium, neurological recovery, or length of stay—were evaluated. Additionally, although pain and hemodynamic responses were assessed up to 24 hours, the potential benefits of DEX–SNB beyond this period remain unknown. Future multicenter studies with larger sample sizes,

extended follow-up intervals, and comprehensive recovery metrics are warranted to build upon these findings.

In summary, this study reinforces the growing evidence supporting dexmedetomidine as an effective adjuvant to scalp nerve block in craniotomy. The observed improvements in hemodynamic stability, postoperative analgesia, analgesic duration, and attenuation of systemic inflammation highlight its potential to enhance perioperative care within a multimodal neuroanesthesia framework. These findings further support the integration of DEX–SNB into enhanced recovery strategies for neurosurgical procedures, while emphasizing the need for further studies to optimize dosing, timing, and applicability across diverse neurosurgical populations.

Conclusion

This randomized controlled trial demonstrates that the addition of dexmedetomidine to scalp nerve block provides significant perioperative benefits in patients undergoing elective craniotomy. Dexmedetomidine improved intraoperative hemodynamic stability, as reflected by consistently lower mean arterial pressure at multiple surgical time points, without causing hypotension or other adverse effects. Postoperative pain intensity was significantly reduced at 12 and 24 hours, accompanied by a substantial prolongation of time to first rescue analgesic, indicating superior and extended analgesic efficacy. Furthermore, dexmedetomidine attenuated the systemic inflammatory response, evidenced by a markedly lower postoperative ΔNLR compared with scalp block alone.

Dexmedetomidine as an adjuvant to scalp nerve block improves hemodynamic stability, reduces postoperative pain, prolongs analgesia, and attenuates systemic inflammation in craniotomy patients. These benefits support its incorporation into multimodal neuroanesthesia and enhanced recovery pathways. Further multicenter studies are needed to explore long-term outcomes and dosing optimization.

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Conflicts of Interest

The authors report no conflict of interest.

Data Availability Statement

All datasets generated and/or analysed for this study are available from the corresponding author upon reasonable request.

Author's Contributions

All authors contributed significantly to the conception and design of the study, data collection, analysis, and interpretation of the results. All authors participated in writing and critically revising the manuscript for important intellectual content, approved the final version to be published, and are accountable for all aspects of the research.

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