Dicle Tıp Dergisi / Dicle Med J (2026) 53 (1) : 129-136

www.diclemedj.org

Original Article / Özgün Araştırma

Effects of dexmedetomidine on postoperative pain, perioperative opioid consumption and hemodynamics in supratentorial craniotomies: Observational study

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Received: 19.12.2025; Revised: 19.02.2026; Accepted: 20.02.2026

Abstract

Objective: The present study aimed to observe the effects of two different doses of dexmedetomidine infusion in supratentorial craniotomies on intraoperative hemodynamics, inhaled anesthetic, and perioperative opioid consumption. The study also examines whether the method reduces adverse events such as postoperative pain and nausea/vomiting.

Methods: Ninety patients aged between 18 and 70 classified as American Society of Anesthesiologists class I–II who underwent supratentorial craniotomy under elective conditions and who received dexmedetomidine infusion (0.2 and 0.4 µg.kg−1h−1) or not were observed. Intraoperative hemodynamic data, remifentanil and sevoflurane consumption, postoperative pain and nausea/vomiting scores, and total opioid consumption were evaluated.

Results: Hemodynamic data of the patients were similar. Sevoflurane consumption intraoperatively and opioid consumption both intraoperatively and postoperatively decreased significantly in the patients receiving dexmedetomidine infusion ($p < 0.001$). The pain and nausea/vomiting scores were similar in the postoperative period.

Conclusion: Dexmedetomidine infusion during general anesthesia for supratentorial craniotomies reduces inhaled anesthetic and perioperative opioid consumption without causing any hemodynamic side effects.

Keywords: Neuroanesthesia, dexmedetomidine, perioperative care, postoperative analgesia, postoperative nausea and vomiting

DOI: 10.5798/dicletip.1906465

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Supratentorial kraniotomilerde deksmedetomidinin postoperatif ağrı, perioperatif opioid tüketimi ve hemodinami üzerine etkileri: Gözlemsel çalışma

Öz

Amaç: Bu çalışma, supratentoryal kraniotomi operasyonlarında uygulanan iki farklı dozda deksmedetomidin infüzyonunun intraoperatif hemodinami, inhalasyon anesteziği ve perioperatif opioid tüketimi üzerindeki etkilerini gözlemlemeyi amaçlamıştır. Ayrıca yöntemin postoperatif ağrı ve bulantı/kusma gibi istenmeyen olayları azaltıp azaltmadığı da değerlendirilmiştir.

Yöntemler: Elektif koşullarda supratentoryal kraniotomi uygulanan, Amerikan Anesteziyologlar Derneği (ASA) sınıf I–II olarak değerlendirilen 18–70 yaş arası toplam 90 hasta incelenmiştir. Hastalar, deksmedetomidin infüzyonu alan (0.2 ve 0.4 $\mu g \cdot kg^{-1} \cdot saat^{-1}$) ve almayan gruplar olarak gözlemlenmiştir. İntraoperatif hemodinamik veriler, remifentanil ve sevofluran tüketimi, postoperatif ağrı ve bulantı/kusma skorları ile toplam opioid tüketimi değerlendirilmiştir.

Bulgular: Hastaların hemodinamik verileri benzer bulunmuştur. Deksmedetomidin infüzyonu uygulanan hastalarda intraoperatif sevofluran tüketimi ile intraoperatif ve postoperatif opioid tüketimi anlamlı olarak azalmıştır ($p < 0.001$). Postoperatif dönemde ağrı ve bulantı/kusma skorları bakımından gruplar arasında anlamlı fark saptanmamıştır.

Sonuç: Supratentoryal kraniotomilerde genel anestezi sırasında uygulanan deksmedetomidin infüzyonu, herhangi bir hemodinamik yan etki oluşturmaksızın inhalasyon anesteziği ve perioperatif opioid tüketimini azaltmaktadır.

Anahtar kelimeler: Nöroanestezi, deksmedetomidin, perioperatif bakım, postoperatif analjezi, postoperatif bulantı ve kusma.

INTRODUCTION

In neurosurgical anesthesia, maintenance of cerebral perfusion, preservation of cerebral autoregulation, and prevention and management of intracranial pressure (ICP) increase are essential during supratentorial craniotomies. Postoperative pain and nausea/vomiting (PONV) management are also important to prevent ICP elevation and cerebral hemorrhage as well as for postoperative recovery and patient wellbeing[1].

The most stressful stages during craniotomies are laryngoscopy, intubation, and the placement of pins for a head holder, which can lead to a sympathetic response such as hypertension or tachycardia[2]. Thus, the depth of anesthesia and analgesia needs to be increased during these stages. A reduction in the consumption of inhaled anesthetics because of their environmental effects is the common approach in general anesthesia practice[3]. An intravenous (IV) adjunct is thus deemed more acceptable. Furthermore, opioids may cause respiratory depression and PONV, which may increase ICP, whereas residual sedative effects of opioids may interfere with neurological examination[4,5].

It is known that dexmedetomidine decreases postoperative pain, PONV and opioid consumption with improved hemodynamic control in patients undergoing neurosurgery[6,7]. However, there appears to be no consensus regarding the best dose regimen for dexmedetomidine in supratentorial craniotomies.

Thus, the primary aim of the present observational study is to evaluate the effects of two different dexmedetomidine infusion doses on intraoperative hemodynamics during supratentorial craniotomies. The secondary aims are to observe the effects on intraoperative consumption of inhalation anesthetics and opioids, postoperative pain scores, PONV, and opioid consumption.

METHODS

The current study is carried out as following the Helsinki Declaration and adhered to STROBE guidelines. The Ethics Committee of Istanbul University-Cerrahpasa, Cerrahpasa Faculty of Medicine (Institutional Review Board for Non-Interventional Clinical Research) approved this study on 03.01.2022 (Ethical Committee No: 337872). This observational study was performed between 21.03.2022 and 12.12.2022 in the neurosurgical operation rooms of Cerrahpasa Faculty of Medicine. Written informed consent obtained from 90 patients classified as American Society of Anesthesiologists (ASA) class I–II and aged 18 and 70 years admitted for elective supratentorial craniotomy were included in the study. Patients were randomized to receive either 0.2 μg.kg.h−1 dexmedetomidine, 0.4 μg.kg.h−1 dexmedetomidine, or no dexmedetomidine. The exclusion criterias were; cerebrovascular disease, second- and third-degree atrioventricular block, and liver failure.

The sedation provided by IV midazolam (0.05 mg.kg−1). Following standard ASA monitoring, the bispectral index and electroencephalographic density spectral array (DSA) were also monitored. Before anesthesia induction, dexmedetomidine infusion was initiated at 0.2 or 0.4 μg.kg.h−1. Anesthesia was induced with sodium thiopental (according to delta waves in the DSA), rocuronium (0.5 mg.kg−1), and remifentanil (0.15 μg.kg.min−1) at 0.7 FiO2 and maintained with a minimum alveolar concentration value for sevoflurane of 0.5–0.8 at 0.4 FiO2, remifentanil (0.1 μg.kg.min−1, titrated according to a >20% decrease or increase in mean arterial pressure [MAP] from baseline), and rocuronium (0.03 mg.kg.min−1) infusions. Following tracheal intubation, scalp block was performed with 2 mg.kg−1 of 0.05 % bupivacaine. Arterial pressures monitorized via radial artery and urinary catheters were placed.

Tramadol (100-mg IV) and ondansetron (4-mg IV) were administered at the dura closure. To reverse the residual muscle relaxation, sugammadex (2 mg.kg−1) administered. The patients transferred to the ward or to the neurosurgical intensive care unit after extubation.

A patient-controlled analgesia (PCA) pump (Abbott Provider®, Chicago, IL, USA) with tramadol used in all patients for 24 h postoperatively. The PCA pump contained tramadol 100 mg in 100 mL of normal saline. The PCA pump provided 10 mg bolus dose on demand and of 10 min lockout period. The pain was evaluated using numeric rating scale (NRS) scores (0 = no pain, 10 = worst pain). Paracetamol (1-g IV) was administered as a rescue analgesic in addition to PCA delivery if the NRS score was >4.

Demographic data, ASA physical status score, corticosteroid use, smoking status, surgery duration, and surgery type recorded.

The heart rates (HRs) and MAPs were recorded before induction of anesthesia (baseline) (t0), after induction (ti), during endotracheal intubation (te), during the pin head holder application (PHHA) (tphh), and 5 min after PHHA (tphh5).

Perioperative cumulative sevoflurane (mL.min−1) and remifentanil (μg.kg.min−1) consumption were recorded.

The NRS and PONV scores were recorded at 15 and 30 min and 1, 2, 6, 12, and 24 h post surgery. Nausea/vomiting was scored as follows: 0 = absent, 1 = nausea, 2 = gagging, 3 = vomiting. The NRS and PONV scores were recorded by an intensive care physician or nursing staff who were blinded to the intraoperative study groups.

Postoperative cumulative tramadol consumption (mg) and rescue analgesic (0 = absent, 1 = administered) were also recorded.

The primary endpoint of the present study is to evaluate the effects of two different dexmedetomidine infusion doses on HR and MAP during endotracheal intubation and PHHA in supratentorial craniotomies. The secondary endpoints are to evaluate the effects on intraoperative consumption of sevoflurane and remifentanil, as well as pain scores, PONV, and tramadol consumption during postoperative 24 h.

Statistical Analysis

Based on previous studies,8-10 we calculated that 84 patients would provide 90% power at alpha = 0.05 to detect a 20% difference in MAP and HR. For the compensation of the dropouts, the study included 90 patients. Power analysis was performed using G*Power version 3.1.5 (program written by Franz Faul, Universität Kiel, Germany; Copyright 1992–2012).

Statistical analysis was performed using SPSS Statistics 21.0 (IBM Corp, Armonk, NY, USA). Determination of the normality and homogeneity of the data distribution was performed using the Shapiro–Wilk test. In the presence of the data not following normal distribution the Kruskal–Wallis test used. The one-way analysis of variance, with post hoc Tukey analysis and Bonferroni correction used for normally distributed data. Pearson's chi-square test was used for comparison of qualitative variables, such as demographic data, which showed binary change. Numerical data following normal distribution were expressed as mean ± standard deviation, and those not following normal distribution were expressed in terms of interquartile range (median). Nominal dichotomous data were recorded as 1 = present, 0 = absent. Significance expressed as $p \leq 0.05$.

RESULTS

This study included ninety patients. Demographic data, corticosteroid use, and smoking status, were similar (Table I) ($p > 0.05$). The duration and type of surgery were also similar (Table II) ($p > 0.05$), as were the MAP and HR values ($p > 0.05$) (Tables III and IV).

Table I: Patient demographic data

	Patients receiving 0.2 μg.kg.h^{-1} Dex	Patients receiving 0.4 μg.kg.h^{-1} Dex	Patients not receiving Dex	p
Age (years) (mean ± SD)	45.50 ± 24.00	51.50 ± 19.00	54.00 ± 25.00	0.111
Female gender n (%)	12 (40.00)	16 (53.30)	16 (53.3)	0.491
BMI (kg/m^2) (mean ± SD)	26.00 ± 5.40	27.05 ± 5.20	25.50± 5.80	0.793
ASA physical status (I/II) (n)	20/10	18/12	22/8	0.252
Corticosteroid administration n (%)	2 (6.70)	3 (10.00)	2 (6.7)	0.861
Smoking status n (%)	8 (26.70)	7 (23.30)	11 (36.70)	0.495

SD: Standard deviation; n: Number; Dex: Dexmedetomidine; BMI: Body mass index; ASA: American Society of Anesthesiologists

Table II: Surgery duration and type

	Patients receiving 0.2 μg.kg.h^{-1} Dex	Patients receiving 0.4 μg.kg.h^{-1} Dex	Patients not receiving Dex	p
Duration of surgery (min) (mean ± SD)	300.00±165.00	360.00±84.00	315.00±244.00	0.513
Type of surgery n (%)				
Tumor	20 (66.70)	19 (63.30)	21 (70.00)	0.944
Aneurysm	4 (13.30)	6 (20.00)	5 (16.60)	
Arteriovenous malformation	2 (6.70)	3 (10.00)	2 (6.70)	
Epilepsy	4 (13.30)	2 (6.70)	2 (6.70)	

SD: Standard deviation; n: Number; Dex: Dexmedetomidine

Table III: Mean arterial pressures at each indicated time interval (mean ± SD)

	Patients receiving 0.2 µg.kg.h^{-1} Dex	Patients receiving 0.4 µg.kg.h^{-1} Dex	Patients not receiving Dex	p
t_0 (mmHg)	92.00 ± 21	100.50 ± 19	94.50 ± 19	0.107
t_i (mmHg)	88.50 ± 20	89.50 ± 24	93.00 ± 31	0.421
t_e (mmHg)	105.63 ± 22.43	112.20 ± 25.37	117.67 ± 24.34	0.159
t_{phh} (mmHg)	94.93 ± 18.63	95.40 ± 15.89	95.90 ± 16.88	0.977
t_{phh5} (mmHg)	75.50 ± 23	75.00 ± 15	74.50 ± 20	0.599

SD: Standard deviation; Dex: Dexmedetomidine; Baseline(t_0), after induction(t_i), during endotracheal intubation(t_e), during the pin head holder application(PHHA)(t_{phh}), 5 min after PHHA (t_{phh5})

Table IV: Heart rate at each indicated time interval (mean ± SD)

	Patients receiving 0.2 µg.kg.h^{-1} Dex	Patients receiving 0.4 µg.kg.h^{-1} Dex	Patients not receiving Dex	p
t_0 (mmHg)	83.50 ± 16	80.00 ± 23	78.50 ± 17	0.644
t_i (mmHg)	84.07 ± 15.06	84.70 ± 12.46	90.43 ± 17.42	0.205
t_e (mmHg)	89.30 ± 24.69	91.97 ± 17.19	99.27 ± 20.09	0.166
t_{phh} (mmHg)	76.87 ± 11.25	79.20 ± 12.32	75.77 ± 14.45	0.569
t_{phh5} (mmHg)	66.50 ± 13	66.50 ± 17	65.00 ± 16	0.835

SD: Standard deviation; Dex: Dexmedetomidine; Baseline(t_0), after induction(t_i), during endotracheal intubation(t_e), during the pin head holder application(PHHA)(t_{phh}), 5 min after PHHA (t_{phh5})

The cumulative sevoflurane and remifentanil consumptions were significantly higher in patients not receiving dexmedetomidine ($p < 0.001$ and $p < 0.001$, respectively) (Table V).

There were no statistically significant differences in NRS scores between the three study groups at any of the measured time intervals ($p > 0.05$). However, a significant intra-group reduction in pain intensity was observed over time; specifically, NRS scores at the 24-hour mark were significantly lower than those at the 15-min, 30-min, 1-hour, and 2-hour points in all patients ($p \leq 0.05$). The 12-h NRS score was significantly lower than the 30-min and 1-h points in the patients receiving 0.2 μg.kg.h−1 of dexmedetomidine (p = 0.003, p = 0.048, respectively) (Figure 1). The 30-min PONV scores were lower in patients receiving 0.2 μg.kg.h−1 of dexmedetomidine than in those receiving 0.4 μg.kg.h−1 of dexmedetomidine or not receiving dexmedetomidine (p = 0.051). The 30-min PONV score was significantly higher than at the 24-h point in patients not receiving dexmedetomidine (p = 0.030). The 30-min PONV score was significantly higher than the 6-, 12-, and 24-h points in patients receiving 0.2 μg.kg.h−1 of dexmedetomidine (p = 0.033, p = 0.021, p = 0.021, respectively) (Figure 2).

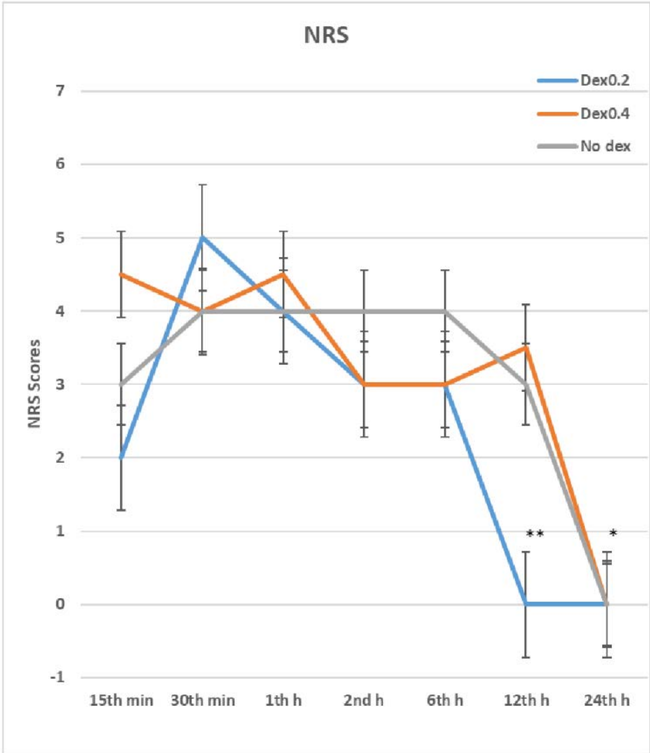

Figure 1. NRS Scores at each indicated time intervals

**The 24th hour NRS scores were significantly lower comparing to 15th, 30th minutes, 1st, 2nd hours in all patients (p ≤ 0.05).*

***The 12th hour NRS score was significantly lower comparing to 30th minutes and 1st hour in the patients receiving 0.2 µg.kg-1h-1 dexmedetomidine (p = 0.003, p = 0.048 respectively)*

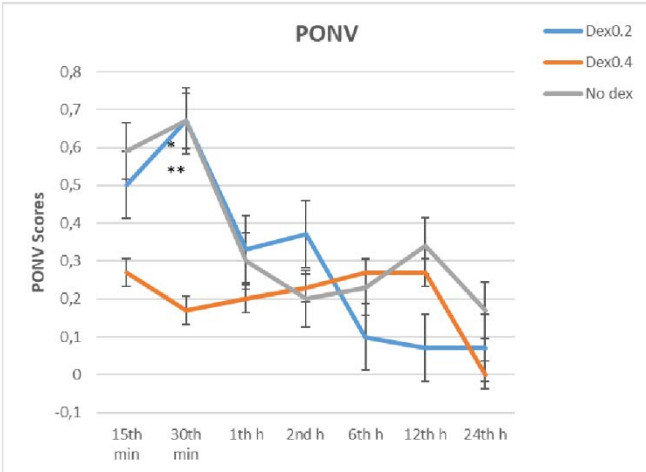

Figure 2. PONV Scores at each indicated time intervals

**The 30th minute nausea and vomiting score was significantly higher comparing to 24th hour in the patients not receiving dexmedetomidine (p = 0.030).*

*** The 30th minute nausea and vomiting score was significantly higher comparing to 6th,12th,24th hours in the patients receiving 0.2 µg.kg-1h-1 dexmedetomidine (p = 0.033, p=0.021, p = 0.021 respectively)*

The total cumulative tramadol consumption at 24 hours postoperatively was significantly lower in the dexmedetomidine groups (88.67 ± 33.91 mg for the 0.2 µg group and 86.67 ± 39.77 mg for the 0.4 µg group) compared to patients who did not receive dexmedetomidine (134.67 ± 53.67 mg) (p < 0.001) (Table V).

Table V: Cumulative sevoflurane and remifentanil consumption (mean ± SD)

	Patients receiving 0.2 $\mu g.kg.h^{-1}$ Dex	Patients receiving 0.4 $\mu g.kg.h^{-1}$ Dex	Patients not receiving Dex	p
Sevoflurane ($mL.h^{-1}$)	11.00 (2.10)	9.05 (3.00)	14.00 (3.90)*	< 0.001
Remifentanil ($\mu g.kg^{-1}.dk^{-1}$)	11.00 (2.10)	9.05 (3.00)	14.00(3.90)**	< 0.001
Tramadol (mg)	88.67±33.91	86.67±39.77	134.67±53.67***	< 0.001

SD: Standard deviation; Dex: Dexmedetomidine

**Cumulative sevoflurane consumption was significantly higher in patients not receiving dexmedetomidine (p < 0.001).*

***Cumulative remifentanil consumption was significantly higher in patients not receiving dexmedetomidine (p < 0.001).*

****Cumulative tramadol consumption postoperatively was significantly higher in patients not receiving dexmedetomidine than in those receiving dexmedetomidine (p < 0.001).*

DISCUSSION

This observational study showed that dexmedetomidine infusion during general anesthesia for supratentorial craniotomies significantly reduces sevoflurane and perioperative opioid consumption without causing any hemodynamic side effects. Moreover, nausea and vomiting occurred most at 30-min postoperatively and clinically occurred less in patients receiving high-dose dexmedetomidine.

Although any hemodynamic side effect such as bradycardia or hypotension was observed alongside the dexmedetomidine infusion; we could not demonstrate its superiority in terms of hemodynamic effect during stressful stages of craniotomies. In previous studies, the authors reported that the addition of dexmedetomidine infusion had a positive effect in terms of hemodynamic stability and reducing sympathetic response[8-11]. This difference might be attributed to the fact that, unlike in previous studies, we did not use a bolus dose of dexmedetomidine, and in the scalp block, we did not observe hypertension episodes during pin head holder replacement.

In general anesthesia practice, the aim is to reduce the related carbon footprint; therefore, inhaled anesthetics are avoided for environmental factors. This study demonstrated that with dexmedetomidine infusion, sevoflurane consumption is reduced, consistent with previous studies[10,12-16].

Given various aspects, there is a trend toward multimodal analgesia to reduce opioid use in anesthesia practice. Moreover, opioids potential side effects; like respiratory depression and related hypercapnia, miosis, sedation, PONV and ICP increase, leading to further avoidance of opioids in neuroanesthesia practice. In this study, a dexmedetomidine adjunction to general anesthesia reduced intraoperative and postoperative opioid consumption, consistent with previous studies[8-10,16-18]. In their pilot study, Sriganesh et al.[19] found no difference regarding opioid consumption between the dexmedetomidine infusion group and the control group. This difference might be attributed to their small sample size.

Compatible with the data of previous studies, there wasn't significant difference between the groups regarding pain and PONV scores[18-23]. However, although not statistically significant, these scores were higher at postoperative 30 min in patients not receiving dexmedetomidine. Peng et al.[23] found that PONV scores were significantly lower in the dexmedetomidine infusion group than in the control group. This might be because these authors used higher doses of dexmedetomidine (0.5 μg.kg.h−1) than the present study. In their meta-analysis, Liang et al.[24] determined that a 0.5-μg.kg−1 IV bolus dose of dexmedetomidine was preventive for nausea and a 1.0-μg.kg−1 bolus dose reduced vomiting. The authors also found that a continuous infusion following the loading dose, could reduce the incidence of PONV. Based on these results, it is necessary to target higher dexmedetomidine plasma concentrations than those used in the present study to prevent PONV.

The present study has some limitations. The lack of recovery and extubation data prevents a quantitative comparison of emergence speed between groups. Further studies with standardized protocols are needed to validate these findings.

In conclusion, dexmedetomidine infusion during general anesthesia reduces inhaled anesthetics and opioid consumption without causing any hemodynamic side effects during supratentorial craniotomies. By significantly reducing the perioperative requirement for opioids and inhaled anesthetics, dexmedetomidine enhances the anesthetic safety profile and potentially facilitates earlier postoperative mobilization, while also contributing to environmental sustainability in clinical practice.

Ethical Approval: The Ethics Committee of Istanbul University-Cerrahpasa, Cerrahpasa Faculty of Medicine (Institutional Review Board for Non-Interventional Clinical Research) approved this study on 03.01.2022 (Ethical Committee No: 337872).

Conflict of Interest: The authors declared no conflicts of interest.

Financial Disclosure: The authors declared that this study has receivet no financial support.

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