Journal of Scientific Innovations in
Anesthesiology

REVO PUBLICATION

Original Research Article

Effects of dexmedetomidine vs. fentanyl on neuro-hemodynamic variables and cerebral perfusion pressure during skull pin head holder application

Shivangi Saxena[1], Parul Jindal[1*], Divya Gupta[1], Ranjeet Kumar[2]

[1]Department of Anesthesia and Pain Management, Himalayan Institute of Medical Sciences (SRHU), Dehradun, Uttarakhand, India
[2]Department of Neurosurgery, Himalayan Institute of Medical Sciences (SRHU), Dehradun, Uttarakhand, India

Abstract

Background and Aims: Application of skull pins can causes changes in the cerebral perfusion and its sequel can have deleterious effect. To compare the effect of dexmedetomidine and fentanyl in mitigating the hemodynamic responses, Bispectral index and Cerebral perfusion pressure changes to pin placement during elective craniotomies.
Materials and Methods: This prospective randomized study was conducted on 60 patients undergoing elective craniotomy with skull pin placement randomly categorized into 2 equal group. Group A received IV dexmedetomidine 1mcg/kg over 10 minutes and Group B received IV fentanyl 1 mcg/kg over 10 minutes prior to pin insertion. Hemodynamic parameter, central venous pressure (CVP), cerebral perfusion pressure, condition of brain and the adverse side effects of the drugs were compared in both the groups at different time intervals. One-way ANOVA test for parameters on categorical scale, independent t-test for parameters on continuous scale within the group on metric parameters.
Results: The demographic data was comparable between both the groups. No significant change in heart rate, cerebral perfusion pressure, BIS among both the groups at all the time intervals. Systolic, Diastolic, mean blood pressure and central venous pressure was significantly increased in the fentanyl as compared to the dexmedetomidine group after the pin insertion ($p<0.05$). Surgeons reported satisfactory brain condition in the dexmedetomidine group.
Conclusions: IV dexmedetomidine a dose of 1mcg/kg infusion over 10 minutes is a better attenuating agent than IV fentanyl 1mg/kg over 10 minutes for blunting the deleterious response to skull pin placement.

Keywords: Cerebral perfusion pressure, Dexmedetomidine, Fentanyl, Hemodynamics.

Received: 20-08-2026

Accepted: 06-10-2026

Published: 02-11-2026

***Corresponding author:** Parul Jindal
Email: parulpjindal@yahoo.co.in

https://doi.org/10.65929/JSIA.2026.1.3.005

How to cite this article: Saxena S, Jindal P, Gupta D, Kumar R. Effects of dexmedetomidine vs. fentanyl on neuro-hemodynamic variables and cerebral perfusion pressure during skull pin head holder application. *J Sci Innov Anesthesiol*. 2026;1(3):83-89.

© 2026 The Author(s). Published by REVO Publication.

This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY 4.0) (https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

1. Introduction

During elective craniotomies insertion of Mayfield or Sugita holder metallic skull pins for stability of head, this along with skin incision and intubation may prove to be a prominent noxious stimulus characterized by an acute sympathetic stimulation, leading to hemodynamic instability[1] which can further lead to myocardial infarction, arrhythmia, pulmonary edema, increased intracranial pressure causing cerebral edema, rupture of aneurysm.[2] In patients having intracranial pathology an abnormal cerebral autoregulation is seen; intracranial pressure rises with increase in systemic blood pressure. Experimental study has revealed that systemic hypertension maybe followed by the development of sudden onset of cerebral oedema and brain herniation within 2 minutes.[3]

Deepening of general anesthesia prior to skull pin placements, local anesthetic infiltration and various scalp blocks and pharmacological agents have been used to attenuate hemodynamic response.[4,5]

A response of the patient under anesthesia to a stimulus which is nociceptive, can be predicted using the BIS index and this has led to a decrease in the incidence of intraoperative awareness.[6]

There is very little research on how skull pin placement affects a patient's brain oxygenation and depth of anesthesia, we designed this study to compare two medications: dexmedetomidine and fentanyl. The Primary Objective was to compare how effectively dexmedetomidine and fentanyl stabilize effect hemodynamic responses when the skull pins are inserted. The Secondary Objectives was to compare the impact of both drugs on the patient's depth of anesthesia using the Bispectral Index (BIS) and cerebral perfusion pressure (CPP) during pin placement.

2. Materials and Methods

This prospective, randomized, single-blinded comparative study was conducted at a tertiary care teaching hospital over a 12-month period following approval from the Institutional Ethics Committee. The study protocol conformed to the 2013 Declaration of Helsinki and Good Clinical Practice guidelines. The study was conducted on sixty subjects aged between 16 - 70 years old of either sex belonging to American Society of Anesthesiologist (ASA) Physical Status grades I, II and III undergoing elective craniotomies under general anesthesia and requiring application of skull pin head holder participated in the study.

Any patient posted for emergency craniotomy, with signs and symptoms of increased intracranial pressure, head injury and Glasgow comma scale < 8, significant cardiac disease, patient on hemodynamic altering medications and patient allergic to any study drug were excluded.

Consecutive eligible patients meeting the inclusion criteria during the study period were enrolled into the study. After recruitment, participants were allocated into either the sevoflurane group or desflurane group using block randomization. An unbiased researcher with no role in intervention or assessment performed the randomization. Patients were randomly allocated to one of the two groups by computer generated table of random numbers: Group A (n = 30) - patients were given dexmedetomidine infusion of 1mcg/kg (dexmedetomidine 2ml ampoule, Manufacturer - Xamdex, Abbott India Ltd, Mumbai), Group B (n = 30) - patients were given fentanyl infusion of 1mcg/kg over 10 minutes. (fentanyl 2ml ampoule, Manufacturer - Troika Pharmaceuticals Ltd, Gujarat, India).

An independent anesthesia technician who was not included further in the study prepared the infusion 2ml of the study drug was diluted into 48 ml of normal saline and the infusion was initiated at the rate of 1µg/kg over 10 minutes. After all invasive monitoring lines were in place the attending anesthesiologist who was blinded to the test drug infusion initiated the infusion.

All the selected patients underwent a thorough pre anesthetic evaluation a day before the surgery and were informed about the effect of various drugs used in the study. Patients were kept nil per oral for 6 hours prior to surgery. Oral alprazolam 0.25mg and ranitidine 150 mg a night before surgery and in the early morning on the day of surgery with only sips of water. After reaching the operating room, multi parameter monitoring, bispectral index (BIS), temperature and urine output monitoring were instituted and all baseline readings were recorded. Two peripheral venous access were established using 18 G and 16G wide bore cannula and 0.9% normal saline infusion was initiated. Radial artery was cannulated with a 20-gauge catheter for continuous invasive blood pressure monitoring. The subclavian vein was cannulated with a 7-Fr polyurethane double-lumen catheter and CVP of 8-10 cm of water was maintained and tip was confirmed by fluoroscopy. Patients were positioned according to requirement of surgical procedure. After a stabilization period of 10 minutes, the protocol began with administration of the i.v. drug infusions to the assigned groups. No intervention was made till study drugs were administered. Three minutes after the i.v. drug infusion, the pin insertion sites were marked by the neurosurgeon, and each pin site was infiltrated with 2ml of 2% lignocaine. Two minutes after local infiltration, the patients head was fixed on a Sugita head frame with three-point pins by applying constant pressure on the scalp until the pins were firmly tightened. Patients requiring repositioning of the pins were excluded from the study. The outcome variables like HR, SBP, DBP, MAP, cerebral perfusion pressure (CPP) which was measured by the formula (CPP = MAP-CVP), BIS, ECG, SpO_2, and $ETCO_2$ were recorded by an independent observer blinded to the type of drug given at the following time interval: B0 (baseline value): Immediately before giving i.v. drugs infusion of dexmedetomidine and fentanyl, I0: At the initiation of IV drug infusion of dexmedetomidine or fentanyl, I2, I4, I6, I8, I10: 2, 4, 6, 8 and 10 minutes during IV drug infusion, T0: At completion of pin insertion, T30, T60, T90, T120, T150, T180, T300, T600,

and T900: 30, 60, 90, 120, 150, 180, 300, 600, and 900 seconds respectively after pin insertion. CVP was recorded at B-0, I-0, I-10, T-0, T-3, T-6, T-9, T-12 and T-15: At baseline, start of infusion, end of infusion, 0, 3, 6, 9, 12, 15 minutes after pin insertion. Group assignment was decoded at the end of study and observation were recorded and analyzed.

Intraoperative bradycardia was defined as decrease in heart rate of >20% fall from baseline, was treated with i.v. atropine (0.6mg bolus). An increase in the HR from baseline by more than 20% was treated with fentanyl 1mcg/kg bolus. If tachycardia persisted i.v. esmolol 5 mg incremental doses every 5 min were given. If the mean arterial pressure decreased by 30% from baseline, it was treated by reducing inspired sevoflurane concentration to 0.5% after ensuring CVP to be between 8 and 10 cm water. If hypotension persisted, it was treated with i.v. mephentermine 6 mg. MAP more than 30% from baseline were treated by incremental increase in inspired concentration of sevoflurane and if it still persisted, fentanyl (1 mcg/kg bolus) was repeated once. If hypertension persisted propofol infusion was started and titrated to the desired response.

After opening of the dura, the condition of the brain was assessed by the operating surgeon and graded as 1. Excellent, 2. Acceptable and 3. Swollen. Anesthesia depth was altered with higher doses of opioids, propofol infusion, or thiopentone depending on the requirements of surgery. We restricted our study recordings to pin insertion period only as use of above-mentioned drugs and changes would alter our observation of hemodynamics.

2.1. Statistical analysis

A sample size of 28 per group was required to detect at least mean difference of 20 mm Hg in MAP taken from both literature available and clinical experience[7] with SD 25 mmHg with a power of 80%and confidence interval 95% at the 5% significance level between two groups. We enrolled 30 subjects in each group to account for possible attrition.

Statistical analysis was carried out using Microsoft office Excel 2010 and statistical package for social sciences (SPSS) IBM version 22, (SPSS South Asia Pvt., Ltd., Bengaluru, India). All quantitative variables were represented using measures of central location (mean, median) and measures of dispersion (standard deviation and standard error). One-way ANOVA test was used to find the significance of study parameters on categorical scale between two groups. For normally distributed measurable data (age and BMI), group means were compared using Student's t-test. The significance was assessed at 5% level of significance and $p<0.05$ was be considered as statistically significant.

3. Results

Demographic characteristics were statically comparable. (**Table 1**) The heart rate was comparable at base line in both groups, after starting the drug infusion the heart rate decreased and thereafter increased after the skull pin head holder application both group within tolerable limits. (**Figure 1**).

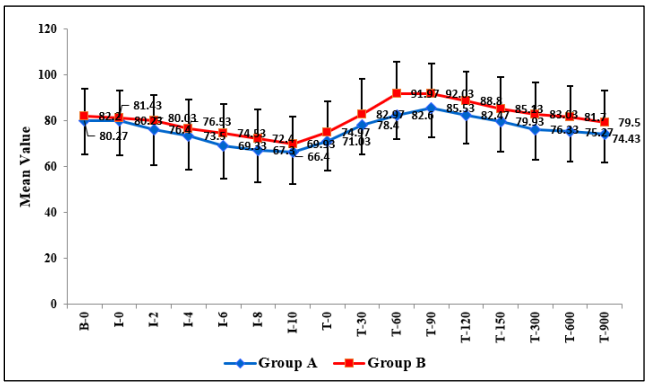


Figure 1: Comparison of Heart Rate (HR) in both Group A and Group B

Table 1: Age based distribution of subjects between Group A and Group B

	Group A	Group B	p value
	Mean ± SD	Mean ± SD	
Age	44.77 ± 14.80	46.30 ± 14.52	0.687
Sex M:F	16:14	13:17	0.438
Weight (Kg)	67.47 ± 11.93	65.80 ± 11.27	0.580
Height (Cm)	163.03 ± 10.25	159.60 ± 8.29	0.159
BMI	25.28 ± 3.02	25.81 ± 3.98	0.565
ASA I:II:III	19:9:2	16:13:1	0.513
Volume of Drug (ml)	16.87 ± 2.98	16.48 ± 2.79	0.609
Quantity of drug (mcg)	67.47 ± 11.93	65.80 ± 11.27	0.609

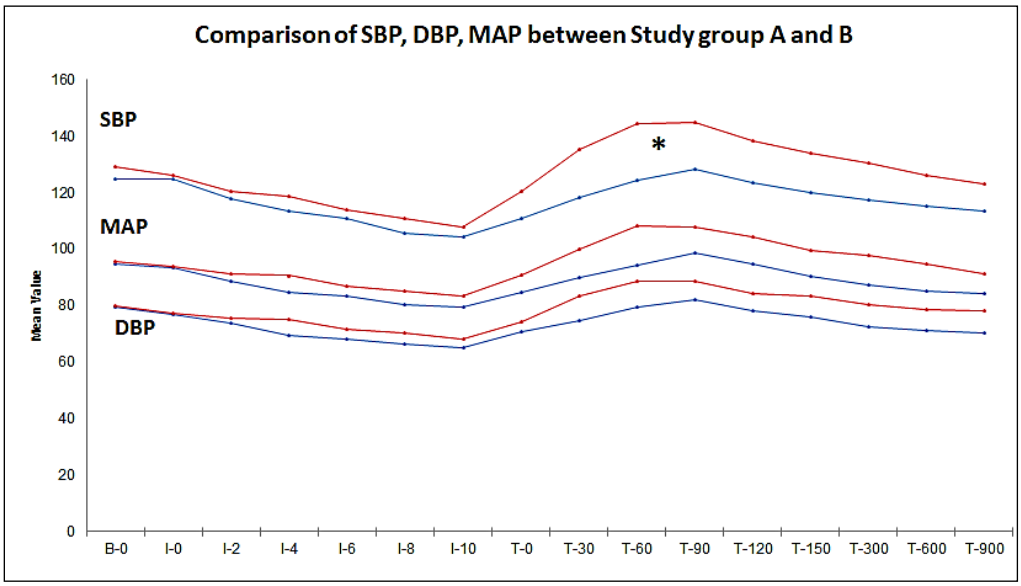


Figure 2: Comparison of SBP, DBP AND MAP in both Group A and Group B

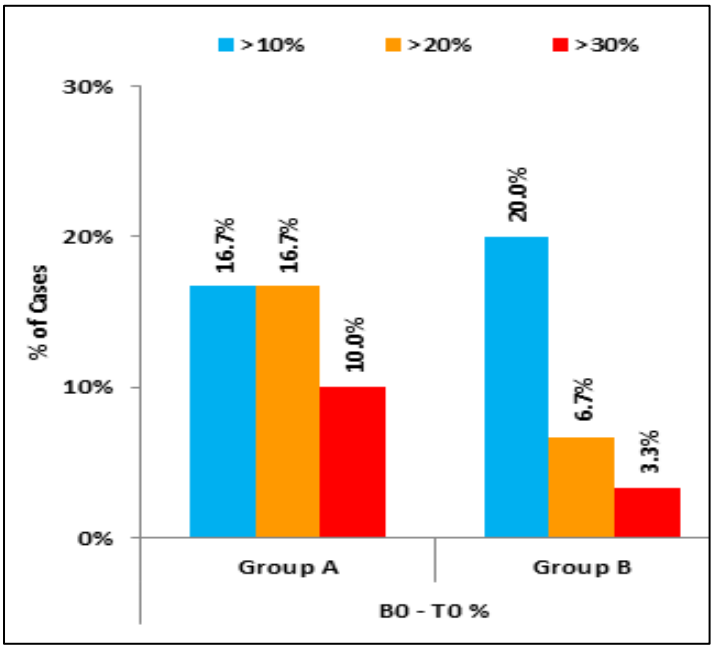


Figure 3: Patients exhibiting a decrease in MAP at 3 levels: >10%, >20% and >30% of the baseline in both the study groups

The SBP, DBP, CVP were comparable at the baseline among both group, there was significant decrease in both the group during infusion, after pin insertion there was significant increase in the blood pressure in fentanyl group (p value < 0.05). (**Figure 2**)

There was more fall in MAP values in dexmedetomidine group during infusion than fentanyl group (p value < 0.05). (**Figure 3**)

The BIS remain between 40-60 in both the group throughout the study, indicating adequate depth of anesthesia in both the groups (p value > 0.05).

There was no significant change in the cerebral perfusion pressure among both the group due to the skull pin head holder application (p value > 0.05). (**Figure 4**) The condition of brain, the surgical field according to the surgeon was better in the dexmedetomidine group (p value < 0.05).

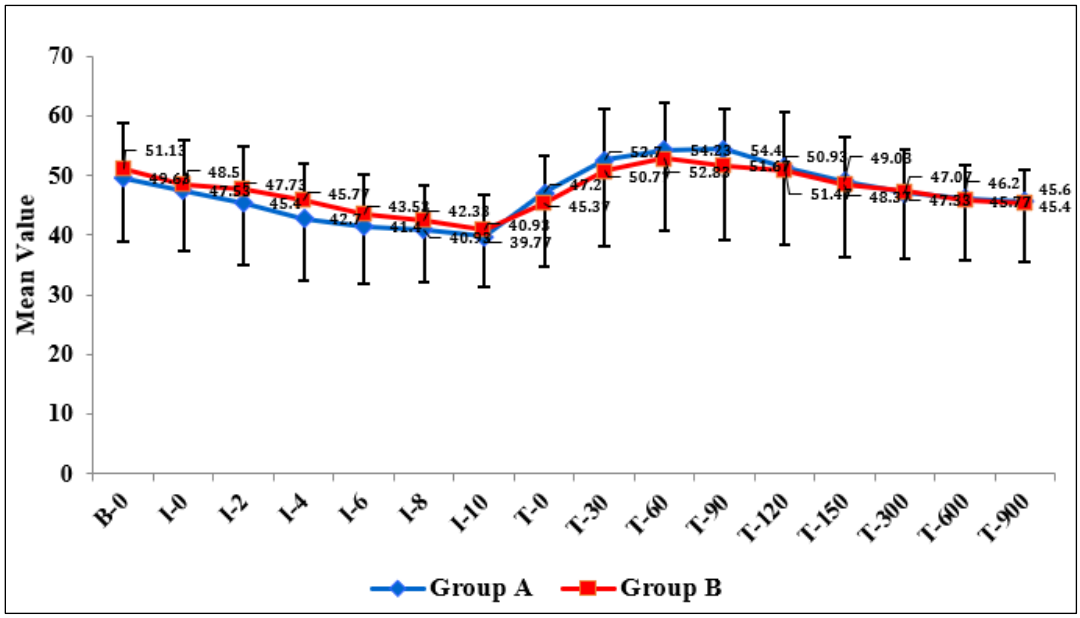


Figure 4: Comparison of Bispectral index (BIS) in both Group A and Group B

In group A 4 cases had significant hypotension and one subject required vasopressor, whereas there was only 1 case in group B fentanyl group.

Two cases of increased BP and 1 case for tachycardia were witnessed in Group B managed by giving bolus fentanyl.

4. Discussion

One of the main goals of neuroanesthesia is to maintain hemodynamic changes and sustain cerebral autoregulation due to skull pin application [8,9] which can be achieved with pharmacological agents that decrease the norepinephrine release in the brain and improve neurological outcome.[10] Infiltration of local anesthetic at the pin application site may not always successful because of changes in pin sites, head movement during fixation, improper infiltration ; cardiovascular changes may occur due to systemic absorption of adrenaline affecting the cerebral perfusion pressure (CPP) and intracranial pressure (ICP),[11] inadequate dosage of local anesthetic and it takes a couple of minutes for a local anesthetic to be effective thus, much time should elapse between infiltration and pinning. Reapplication of pins for head stabilization during neurosurgery is an occasional event and requires re-infiltration, risk of needle stick injury increases with requirement of multiple injections.[12]

We selected plain lignocaine 2% because of its rapid onset of action in both groups as compared to Bupivacaine. It has been observed that epinephrine containing solution can cause hypotension due to activation of beta-2 receptors which can indirectly affect CPP and ICP.[13]

Therefore, we used an adjuvant in either group along with local infiltration. We did not include a placebo group for ethical reasons, as local infiltration alone was inadequate to blunt hemodynamic responses to pin insertion as reported by various studies.[1,12]

Bharne S et al. concluded combination should be considered in conjugation with general anesthesia to attenuate noxious stress response to skull pin application.[14]

Dexmedetomidine acts on α-2 receptors leads to cerebral smooth muscle vasoconstriction and decreasing cerebral blood flow and decreased cerebral metabolic rate owing to compensatory cerebral blood flow changes.[8,15] Pekka-talke et al studied that dexmedetomidine has sympatholytic properties and release of norepinephrine in the brain.[16]

The timing of our study drug infusion and pin application was planned that the peak effect of the study drug coincides with the time of pin application.

In accordance with previous study BIS was maintained between 40-60 eliminating the cause of inadequate depth of anesthesia leading to exaggerated hemodynamic responses to stress such as pin application during the surgery.[6]

In accordance with the previous study we concluded dexmedetomidine is a better agent than fentanyl in preventing

the cardiovascular responses to skull pin insertion during craniotomies.[5]

Adverse effect like bradycardia or hypotension cannot be attributed to dexmedetomidine alone as it can also be due to skull pin application and general anaesthesia.[5,12]

There are a few limitations in our study. Firstly, patients with Glasgow Coma Scale less than 15 and with signs and symptoms of raised ICP were not enrolled in this study and, therefore, we were unable to address the distinct advantage of using either of the drugs in patients with severely increased ICP. Secondly, invasive neurological monitoring which is probably the gold standard, was not included in this study. Thirdly, differentiation between the two groups in containing the sympatho-adrenal response could not be assessed as plasma catecholamine levels were not measured.

5. Conclusion

We stress that even though both the agents have the potential to attenuate this stress response and provide good surgical field, intravenous dexmedetomidine infusion in a dose of 1mcg/kg over 10 minutes just prior to the pin application has better hemodynamic stability than intravenous fentanyl 1mcg/kg over 10 minutes.

Author Contributions

Saxena S: Conceptualization, methodology, data collection, and drafting of the original manuscript.

Jindal P: Supervised the study, designed the methodology, critically revised the manuscript, and final approval of the version to be published.

Gupta D: Data curation, statistical analysis, and writing – review & editing.

Kumar R: Surgical assistance, evaluation of neuro-hemodynamic parameters/brain condition, and critical revision of the manuscript.

Abbreviations

ANOVA: Analysis of Variance; ASA: American Society of Anesthesiologists; BIS: Bispectral Index; BMI: Body Mass Index; CPP: Cerebral Perfusion Pressure; CVP: Central Venous Pressure; DBP: Diastolic Blood Pressure; ECG: Electrocardiogram; $ETCO_2$: End-Tidal Carbon Dioxide; GCP: Good Clinical Practice; HR: Heart Rate; ICP: Intracranial Pressure; IV: Intravenous; MAP: Mean Arterial Pressure; SD: Standard Deviation; SBP: Systolic Blood Pressure; SpO_2: Peripheral Oxygen Saturation; SPSS: Statistical Package for the Social Sciences.

Ethical Approval

Ethical approval was obtained from the Institutional Ethics Committee of Swami Rama Himalayan University, vide approval letter no. SRHU/HIMS/ETHICS/2020/115, dated 3-08-2020.

Financial Support and Sponsorship

None.

Conflict of Interest

None.

Use of Artificial Intelligence (AI)

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, interpretation, or writing of this manuscript.

References

1. Ozköse Z, Yardim S, Yurtlu S, Dogulu F, Kaymaz M, Pasaoglu A. The effects of intravenous fentanyl and lidocane infitration on the haemodynamic response to skull placement. *Neurosurg Rev*. 2000;23(4):218–20. https://doi.org/10.1007/pl00011958
2. Patel LP, Patel JC, Patel KP, Rathva CS, Tandel V. Comparison of effect of labetalol and fentanyl with only fentanyl for attenuating pressure responses to intubation and skull pin inserti0on in neurosurgery. *Indian J Clin Anaesth*. 2018;5(2):199–204. https://doi.org/10.18231/2394-4994.2018.0037
3. Geze S, Yilmaz AA, Tuzuner F. The effect of scalp block and local infiltration on the haemodynamic and stress response to skull-pin placement for craniotomy. *Eur J Anaesthesiol*. 2009;26(4):298–303. https://doi.org/10.1097/EJA.0b013e32831aedb2
4. Nagappa S, Kalappa S, Sridhara RB. Evaluation of the hemodynamic response of intravenous clonidine versus ropivacaine scalp block to insertion of scalp pins in neurosurgical patients. *Anesthesia, Essays and Researches.* 2018;12(1):213. https://doi.org/10.4103%2F0259-1162.194572
5. Thongrong C, Sirikannarat P, Kasemsiri P, Duangthongphon P. Comparison of dexmedetomidine and fentanyl to prevent haemodynamic response to skull pin application in neurosurgery: double blind randomized controlled trial. *Anaesthesiol Intensive Ther*. 2017;49(4):268–73. https://doi.org/10.5603/AIT.a2017.0051
6. Durnev V, Soljakova M, Filipce V, Mijovska MM, Stevanovska MT. Hemodynamic and Bispectral Changes During Pin Insertion in Craniotomy - Effect of Locally Infiltrated Bupivacaine. *Pril (Makedon Akad Nauk Umet Odd Med Nauki)*. 2017;38(2):115–21. https://doi.org/10.1515/prilozi-2017-0029
7. Arshad A, Shamim MS, Waqas M, Enam H, Enam SA. How effective is the local anesthetic infiltration of pin sites prior to application of head clamps: A prospective observational cohort study of hemodynamic response in patients

undergoing elective craniotomy. *Surg Neurol Int*. 2013;4:93. https://doi.org/10.4103/2152-7806.115237

8. Kondavagilu SR, Pujari VS, Chadalawada MV, Bevinguddaiah Y. Low Dose Dexmedetomidine Attenuates Hemodynamic Response to Skull Pin Holder Application. *Anesth Essays Res*. 2017;11(1):57–61. https://doi.org/10.4103/0259-1162.200229
9. Kundra S, Mahendru V, Gupta V, Choudhary AK. Principles of neuroanesthesia in aneurysmal subarachnoid hemorrhage. *J Anaesthesiol Clin Pharmacol*. 2014;30(3):328–37. https://doi.org/10.4103/0970-9185.137261
10. Canakci E, Unal D, Yildirim T, Yilmaz A. Our Scalp Block Results in Craniotomy Cases. *J Anest & Intens Care Med*. 2017;2(4):555592. https://doi.org/10.19080/JAICM.2017.02.555592
11. Balakrishnan K, Ebenezer V, Dakir A, Kumar S, Prakash D. Bupivacaine versus lignocaine as the choice of locall anesthetic agent for impacted third molar surgery a review. *J Pharm Bioallied Sci*. 2015 ;**7**(Suppl 1) :S 230-3. https://https://doi.org/ 10.4103/0975-7406.155921
12. Paul A, Krishna HM. Comparison between intravenous dexmedetomidine and local lignocaine infiltration to attenuate the haemodynamic response to skull pin head holder application during craniotomy. *Indian J Anaesth*. 2015;59(12)**:**785–8. https://doi.org/10.4103/0019-5049.171558
13. Satoh K, Chikuda M, Ohashi A, Kumagai M, Sato M, Joh S. Abnormal Change in Arterial Blood Pressure after Adrenaline-Containing in Lidocaine Infiltrated into Oral Submucosa during General Anesthesia. *Open J Anesthesiol.* 2015;5(5):75–8. https://doi.org/10.4236/ojanes.2015.55015
14. Bharne S, Bidkar PU, Badhe AS, Parida S, Ramesh AS. Comparison of intravenous labetalol and bupivacaine scalp block on the hemodynamic and entropy changes following skull pin application: A randomized, open label clinical trial. *Asian J Neurosurg*. 2016;11(1):60–5. https://doi.org/10.4103/1793-5482.165801
15. Ball D, Hunt K. Pharmacological and pathological modulation of cerebral physiology. *Anaesth Intensive Care Med*. 2025;26(11):689–94. https://doi.org/10.1016/j.mpaic.2025.08.012
16. Kang R, Jeong JS, Ko JS, Lee SY, Lee JH, Choi SJ, et al. Intraoperative dexmedetomidine attenuates norepinephrine levels in patients undergoing transsphenoidal surgery: a randomized, placebo-controlled trial. *BMC Anesthesiol*. 2020;20(1):100. https://doi.org/10.1186/s12871-020-01025-7