ORIGINAL ARTICLE

Effect of Scalp Block vs Sphenopalatine Ganglion Block with Posterior Occipital Nerve Block on Hemodynamic Response Following Skull Pin Application

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Abstract

Background: Sphenopalatine ganglion (SPG) block combined with occipital nerve block can attenuate the hemodynamic response to the painful stimulus of skull pin application.

Materials and methods: About 60 patients, aged 18–65 years, were randomly assigned to two groups. All patients were classified as American Society of Anesthesiologists (ASA) grades I and II, had a Glasgow Coma Scale (GCS) score of 15/15, and were scheduled for elective craniotomy.

Group S was given a scalp block with 0.25% bupivacaine, while group SPG was given a bilateral transnasal SPG block with 0.5% bupivacaine, along with greater and lesser occipital nerve blocks using 0.25% bupivacaine. The primary objective was to assess the change in mean arterial pressure (MAP) following skull pin application. The dose of propofol used as rescue was also noted.

Results: All 60 patients completed the study. The MAP differed significantly in group SPG from prior to pin insertion to 2 (p-value = 0.034) and 3 minutes (p-value = 0.026) following pin insertion. The maximum percent change from the prior to pin insertion timepoint was observed at 2 minutes ($p < 0.001$). The heart rate (HR) also differed significantly in group SPG from the prior to pin insertion to 2 (p-value = 0.001) and 3 (p-value = 0.006) minutes following pin insertion. The maximum percent change from the prior to pin insertion was observed at 2 minutes following pin insertion ($p < 0.001$). There was no significant difference in the percent change in HR between the two groups from prior to pin insertion to any of the timepoints.

Conclusion: Bilateral SPG block with posterior scalp block can attenuate the hemodynamic response following skull pin insertion in patients undergoing craniotomy under general anesthesia.

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Introduction

Perioperative management of craniotomies is met with unique challenges. Application of Mayfield skull clamps is one important step associated with intense hemodynamic response. The external lamina of the skull is reached by inserting three triangular metallic pins, which form the Mayfield skull clamp, through the scalp and periosteum. Application of this clamp is associated with hypertension and tachycardia despite maintaining a sufficient plane of anesthesia. The intracranial pressure (ICP) may rise as a result of this, along with compromised cerebral perfusion and myocardial ischemic changes.[1,2]

Attempts to attenuate this response have been made using infiltration of local anesthesia at pin sites, that is, scalp block, maintaining a deep plane of anesthesia, and using drugs like opioids, labetalol, or clonidine.[3–7]

Blocking the nerves that supply the scalp and forehead involves scalp block. It efficiently attenuated the hemodynamic response to pin insertion, provided postoperative analgesia, and allowed the freedom to change position of pins since the entire scalp is anesthetized.[4,8] But the procedure requires time and expertise.

Sphenopalatine ganglion (SPG) block inhibits postganglionic sympathetic and parasympathetic nerves and somatosensory afferents belonging to the maxillary nerve that innervate the scalp. It can easily be blocked using the intranasal transmucosal route. This approach is less invasive and has been used successfully for other conditions like trigeminal neuralgia, migraine, postdural puncture headache (PDPH), and cluster headache.[9–11] In patients undergoing craniotomy under general anesthesia, the hemodynamic response following skull pin application can be attenuated effectively by bilateral SPG block, combined with greater and lesser occipital nerve block (posterior scalp block), as an alternative to scalp block.

In patients undergoing craniotomy, this study was conducted to compare the efficacy of bilateral SPG block *via* transnasal transmucosal approach, combined with greater and lesser occipital nerve block (posterior scalp block), with scalp block in attenuating the hemodynamic stress response caused by Mayfield pin insertion.

Materials and Methods

The study was approved by the Institutional Ethics Committee (79/2022/IEC/922) and CTRI (CTRI/2022/11/047030).

Primary Objective

To assess and compare the change in mean arterial pressure (MAP) before and after skull pin application in the scalp block group and SPG block group.

Secondary Objectives

- To assess and compare the change in mean arterial blood pressure before and after skull pin application in the scalp block group and SPG block group.
- To assess and compare the change in heart rate (HR) before and after skin incision and dural incision in the scalp block group and the SPG block group.
- Total dose of propofol used as a rescue drug in attenuating the hemodynamic response in both groups.

Sample Size Calculation

Mean arterial pressure	
Group S: mean ± SD	*Group SPG: mean ± SD*
95.2 ± 5	104 ± 5

The research conducted by Padhy et al.[12] was used as the basis for determining the sample size for our study, in which they provided the

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following mean MAP after skull pin incision for the two groups, wherein the SPG block group is group SPG and the scalp block group is group S. Snedecor and Cochran's method (1989) was used to calculate the minimum sample size needed for each research arm.

Formula

$$\text{Sample size } (N) = \frac{1+2\left(Z_{\alpha}+Z_{1-\beta}\right)^{2}\sigma^{2}}{\delta^{2}}$$

$$\text{Sample size } (N) = \frac{1+2\left(1.96+2.326\right)^{2}5^{2}}{8.8^{2}}$$

σ (pooled SD) = 5

δ (difference of means) = 8.8

Type I error (α) = 5%, Z_{α} (value of standard normal distribution for α = 5%) = 1.96

Type II error (β) = 1%, power (1 – β) = 99%, $Z_{1-\beta}$ = 2.326.

As per the above formula, the minimum sample size is 13 in each group, but to fulfil the central limit theorem, we decided to take a minimum of 30 patients in each group (total = 60).

This prospective, randomized controlled trial was conducted from August 2022 to February 2024. Institute Ethics Committee and CTRI (CTRI/2022/11/047030) approval was obtained. Written informed consent was obtained. Patients aged between 18 and 65 years, classified as American Society of Anesthesiologists (ASA) grades I and II, with a Glasgow Coma Scale (GCS) of 15/15, and posted for elective craniotomies under general anesthesia were included. Patients with nasal infection, polyps, deviated nasal septum, allergy to local anesthetic agents, local infection, coagulopathy, hepatic or renal disease, pregnancy, lactation, or those refusing consent were excluded from the study. Preoperative anesthetic check-up was done, and written informed consent for both surgery and this study was taken. Based on a computer-generated number sequence, patients were then randomized into group S or group SPG.

Group SPG: Patients received bilateral SPG block using 0.5% bupivacaine and greater and lesser occipital nerve block using 0.25% bupivacaine (posterior scalp block).

Group S: Patients received scalp block using 0.25% bupivacaine.

All patients fasted for 6–8 hours prior to surgery. In the operating room, standard ASA monitors, including noninvasive blood pressure (NIBP), electrocardiograph (ECG), and pulse oximeter, were applied, and baseline readings were recorded. A wide-bore IV cannula was also secured. After 3 minutes of preoxygenation with 100% oxygen, anesthesia was induced using 2 µg/kg.

About 2 mg/kg of inj. propofol and 0.5 mg/kg of inj. rocuronium were used for muscle relaxation. Three minutes after the administration of the muscle relaxant, the airway was secured with a cuffed endotracheal tube of the appropriate size. Anesthesia was maintained using a 50:50 mixture of oxygen and air, with sevoflurane adjusted to a MAC value of 1. After induction of anesthesia, additional monitoring like end-tidal CO_2 ($ETCO_2$), urine output, and temperature were done. Central venous access was obtained *via* the subclavian vein, and the radial artery was cannulated. Mechanical ventilation was adjusted to maintain an $ETCO_2$ of 30–35 mm Hg. Patients in group S received scalp block with 40 mL of 0.25% bupivacaine 10 minutes before skull pin application. Using the standard landmark technique, the supraorbital, supratrochlear, zygomaticotemporal, auriculotemporal, greater, and lesser occipital nerves were anesthetized.

Patients in group SPG, bilateral SPG block were given *via* the intranasal transmucosal approach, with the patient positioned supine and the neck extended. Two sterile cotton applicators, each 10 cm long and soaked in 0.5% bupivacaine (5 mL for each nostril), were carefully inserted along the upper edge of the middle turbinate, extending until they reached the back wall of the nasopharynx, where they were left in place for approximately 10 minutes (Fig. 1). These patients were also given greater occipital nerve and lesser occipital nerve blocks using 4 mL of 0.25% bupivacaine each (total = 16 mL for both sides). Also, the total dose of bupivacaine was well within safe limits in both groups.

The primary outcome was the MAP, assessed at baseline, just prior to pin insertion, and at 1, 2, 3, 4, 5, and 10 minutes following pin insertion.

Secondary outcomes were MAP and HR before and after skin incision (at 1, 2, 4, 5, and 10 minutes) and before and after dural incision (1, 2, 3, 4, 5, and 10 minutes). The HR was noted at all the above time points. MAP was also measured at baseline and at the abovementioned time points. An increase in HR and MAP >20% baseline during the stress response was treated with inj. propofol 20 mg IV bolus and repeated if required. Any potential adverse effects of the study medications were also recorded.

Statistical Methods

Descriptive statistics were expressed as follows: categorical variables were expressed as frequency and percentages (%), while continuous variables were shown as mean/standard deviations and medians/IQRs. Graphical representations were used when necessary. For continuous data, an independent sample *t*-test was used when comparing two groups, while a one-way ANOVA was applied for comparisons involving more than two groups. Nonparametric tests, such as the Wilcoxon test or Kruskal–Wallis test, were employed for nonnormally distributed data. Categorical data were analyzed using the Chi-squared test. Linear correlation was explored using Pearson's correlation and Spearman's correlation. Statistical significance was kept at p < 0.05. The data analysis was done using Statistical Package for the Social Sciences version 23.

Results

All 60 patients completed the study. A CONSORT diagram can be seen in Figure 2. The demographic data of both groups were comparable (Table 1). The comparison of MAP between two groups over time is shown in Table 2. The percentage change of MAP after pin insertion, after skin incision, and after dural incision can be seen in Figures 3A to C. In group S, there was no significant difference between any of the timepoints as compared to the prior-to-

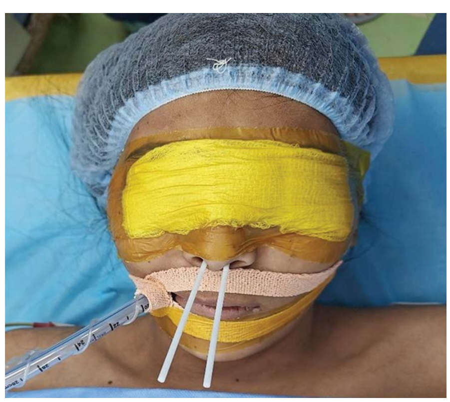


Fig. 1: Bilateral SPG block

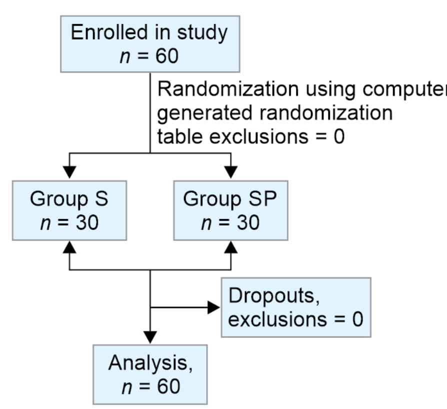


Fig. 2: CONSORT diagram

Table 1: Demographic data

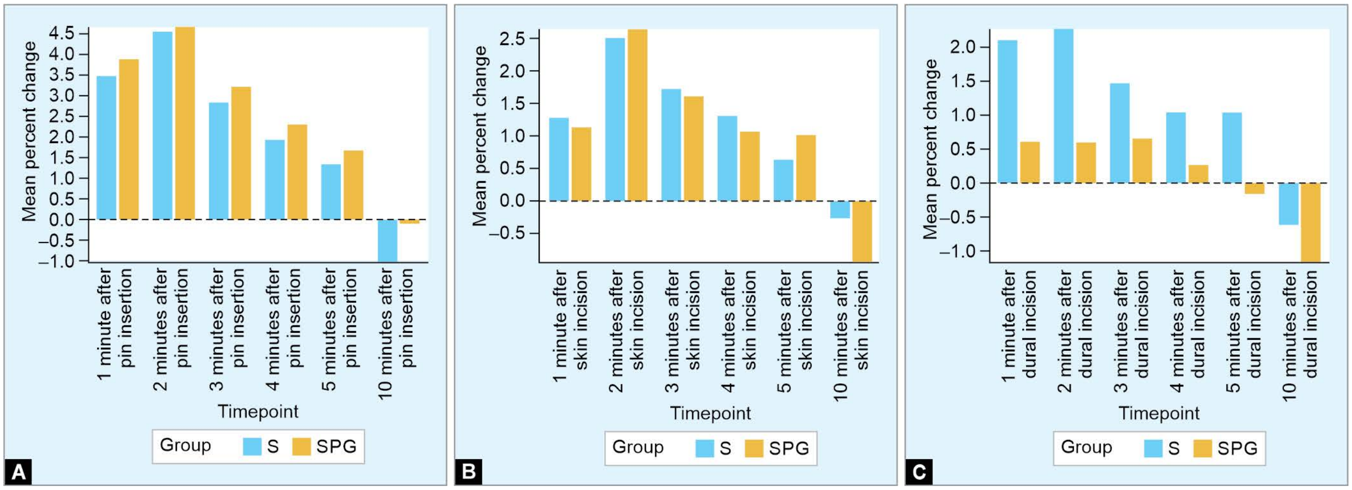
Age (years)	Group			Wilcoxon–Mann–Whitney U test	
	S (n = 30)	SPG (n = 30)		W	p-value
Mean (SD)	38.80 (11.60)	43.53 (12.81)		328.000	0.072
Gender	*Group*			*Chi-squared test*	
	S	*SPG*	*Total*	χ^2	*p-value*
Male	13 (43.3%)	17 (56.7%)	30 (50.0%)	1.067	0.302
Female	17 (56.7%)	13 (43.3%)	30 (50.0%)		
Total	30 (100.0%)	30 (100.0%)	60 (100.0%)		
ASA	*Group*			*Chi-squared test*	
	S	*SPG*	*Total*	*χ2*	*p-value*
I	26 (86.7%)	24 (80.0%)	50 (83.3%)	0.480	0.488
II	4 (13.3%)	6 (20.0%)	10 (16.7%)		
Total	30 (100.0%)	30 (100.0%)	60 (100.0%)		
Weight (kg)	*Group*			*t-test*	
	S	*SPG*		*t*	*p-value*
Mean (SD)	62.13 (7.16)	61.87 (8.16)		0.135	0.893
BMI (kg/m2)	*Group*			*t-test*	
	S	*SPG*		*t*	*p-value*
Mean (SD)	24.85 (2.43)	24.82 (2.32)		0.051	0.959

BMI, body mass index; S, scalp block; SPG, sphenopalatine ganglion

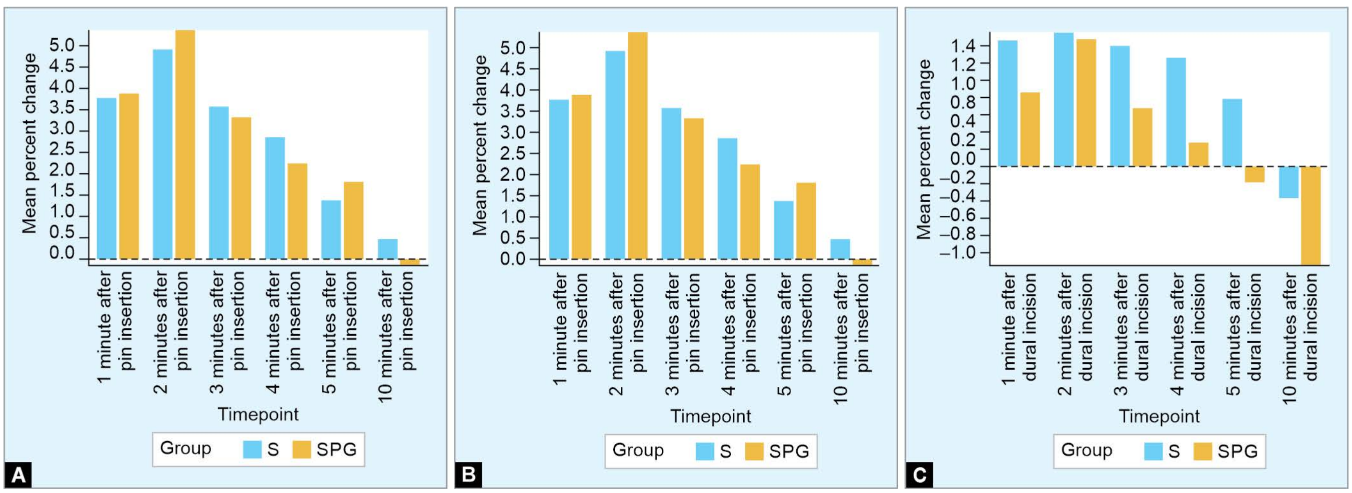
Table 2: Comparison of two groups in terms of change in MAP (mm Hg) over time

MAP (mm Hg)	*Group*		*p-value for comparison of the two groups at each of the time points (Wilcoxon–Mann–Whitney U test)*
	S	*SPG*	
	Mean (SD)	*Mean (SD)*	
Baseline	90.60 (7.93)	90.39 (8.60)	0.994
After block	88.19 (9.12)	86.60 (7.04)	0.387
Prior to pin insertion	84.01 (8.96)	83.53 (7.16)	0.830
1 minute after pin insertion	86.96 (11.40)	86.77 (9.75)	0.982
2 minutes after pin insertion	87.87 (11.58)	87.42 (9.86)	0.982
3 minutes after pin insertion	86.31 (9.90)	86.13 (8.28)	0.959
4 minutes after pin insertion	85.58 (9.65)	85.34 (6.77)	0.745
5 minutes after pin insertion	85.01 (9.03)	84.82 (6.92)	0.859
10 minutes after pin insertion	82.93 (7.47)	83.40 (7.03)	0.615
Prior to skin incision	81.07 (9.37)	81.27 (8.67)	0.894
1 minute after skin incision	82.09 (9.82)	82.20 (9.11)	0.947
2 minutes after skin incision	82.91 (9.12)	83.41 (9.32)	0.971
3 minutes after skin incision	82.23 (8.62)	82.53 (8.94)	0.947
4 minutes after skin incision	81.90 (8.31)	82.08 (8.52)	0.976
5 minutes after skin incision	81.32 (7.92)	82.00 (8.35)	0.762
10 minutes after skin incision	80.69 (8.62)	80.40 (8.07)	0.824
Prior to dural incision	80.50 (7.67)	81.47 (8.02)	0.631
1 minute after dural incision	82.04 (7.37)	81.87 (7.22)	0.871
2 minutes after dural incision	82.22 (7.84)	81.92 (7.89)	0.976
3 minutes after dural incision	81.56 (7.42)	81.87 (7.04)	0.784
4 minutes after dural incision	81.19 (7.08)	81.56 (7.00)	0.756
5 minutes after dural incision	81.16 (7.05)	81.20 (6.99)	0.906
10 minutes after dural incision	79.79 (6.35)	80.38 (7.29)	0.756

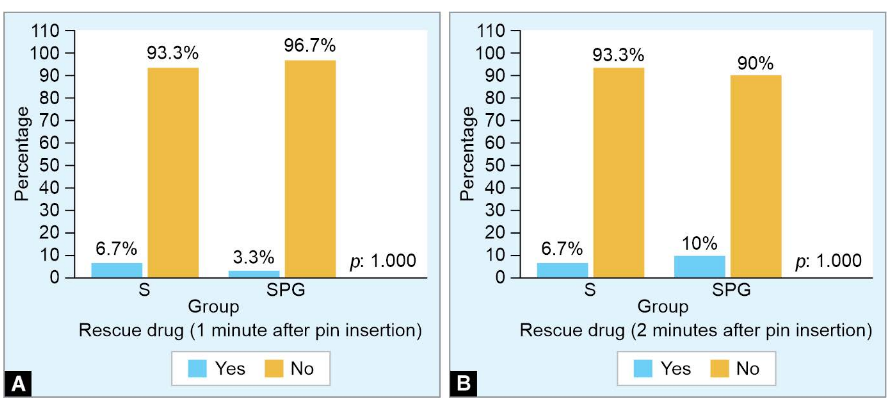
**Post hoc* pairwise tests for Friedman test performed using Nemenyi test were used to explore the statistical significance of the change in MAP (mm Hg) from the prior to pin insertion timepoint to the various follow-up timepoints. Group comparisons for change in MAP (mm Hg) performed using Wilcoxon–Mann–Whitney *U* test. Statistically significant difference at $p < 0.05$



Figs 3A to C: Percentage change of MAP: (A) After pin insertion; (B) After skin incision; and (C) After dural incision



Figs 4A to C: Percentage change of HR: (A) After pin insertion; (B) After skin incision; and (C) After dural incision



Figs 5A and B: Use of rescue drug at (A) 1 minute and (B) 2 minutes of pin insertion

pin-insertion timepoint in terms of MAP. In group SPG, the MAP differed significantly from the prior-to-pin-insertion timepoint at the following timepoints: 2 minutes after pin insertion and 3 minutes after pin insertion (<0.001). The maximum percentage change of MAP from the prior-to-pin-insertion timepoint was observed at the 2 minutes after pin insertion timepoint. There was no significant difference between the two groups in terms of percent change in MAP at any of the follow-up timepoints.

In group S, the HR differed significantly from the prior-to-pin-insertion timepoint at the following timepoints: 2, 3, and 4 minutes after pin insertion. The maximum percent change from the prior-to-pin-insertion timepoint was observed at the 2 minutes after pin insertion timepoint ($p < 0.001$). In group SPG, the HR differed significantly from the prior-to-pin-insertion timepoint at the following timepoints: 2 and 3 minutes after pin insertion. The maximum percent change from the prior-to-pin-insertion timepoint was observed at the 2 minutes after pin insertion timepoint ($p < 0.001$). There was no significant difference between the two groups in terms of percent change in HR from prior to pin insertion to any of the follow-up timepoints. The change of HR after pin insertion, after skin incision, and after incision of dural are shown in Figures 4A to C. The use of rescue analgesics at 1 minute and 2 minutes after pin insertion are shown in Figure 5.

Discussion

This study assessed the change in hemodynamic parameters like MAP and HR after pin insertion, skin, and dural incision in group S and SPG group. There was no significant difference in the percentage change of HR and MAP between the two groups at all the follow-up time points. Group SPG had a statistically significant change in HR and MAP at 2 and 3 minutes for both parameters. The rescue use of propofol was also similar in both groups.

There was no statistical difference between the two groups at any of the time points. The intragroup analysis for the trend of MAP changes (after scalp pin insertion, skin incision, and dural incision) showed maximum mean percent change (4.5 and 4.7%, respectively) in both group S and group SPG at 2 minutes following pin insertion, in which the change in group S was not statistically significant, but the change in group SPG was statistically significant. However, both changes were clinically insignificant.

In a study by Gazoni et al., examining the effect of a scalp block with ropivacaine in patients with supratentorial tumors, the maximum change in HR and MAP occurred 1 minute after pin insertion, whereas in our study, the greatest hemodynamic change was observed 2 minutes following pin insertion. In that study, the HR and MAP decreased to the prepinning values within 5 minutes after pin insertion, which we got at 10 minutes after pin insertion.[13]

Lee et al. examined the effect of bupivacaine scalp block on hemodynamics in patients undergoing frontotemporal craniotomy and recorded the mean changes in MAP and HR from preincision to 10 minutes after incision and dural opening were not statistically significant, which was in concordance with our study.[8] Although scalp block does not anesthetize the dura, dural incision stimuli can be attenuated by low concentrations of volatile anesthetics. This is in accordance with our study that in the scalp block group, dural incision stimuli were obtunded with no statistical significance.

A statistically significant percentage change in HR was indicated by the intragroup analysis at 2 minutes following pin insertion. This corroborates with a similar study done by Padhy et al., where they found that the overall HR was comparable between the groups. On the contrary, no significant statistical difference was found in the intragroup analysis of HR after pin insertion, skin incision, and dural incision.[12]

The efficacy of SPG block in attenuating the hemodynamic response to pin insertion in craniotomies has limited evidence. Padhy et al. studied bilateral SPG block with posterior scalp blockade for obtunding the hemodynamic response and compared it with scalp block.[12] The maximum change of hemodynamics occurred at 2 minutes after pin insertion, which was similar to our study. The overall mean MAP was comparable between the groups. However, in the SPG block, the overall MAP was significantly lower following dural incision. This was explained by the innervation of *dura mater* by projections associated with SPG. However, in our study, no such difference was observed between the groups, as the dural incision did not induce significant hemodynamic instability due to the adequate depth of anesthesia.

Hence, we observed that both scalp block and bilateral SPG block combined with greater and lesser occipital nerve block were effective in suppressing the hemodynamic response to scalp pin insertion, skin incision, and dural incision. Rescue drug received by both groups was similar.

In their study evaluating the effects of levobupivacaine vs bupivacaine on the hemodynamic response to pin insertion, Can and Bilgin found that a greater percentage of patients in the control group required rescue drugs, with 53.3% needing them, compared to 3.3% in the bupivacaine group and 6.6% in the levobupivacaine group.[14] Less requirement of rescue drug is attributed to the fact that both the techniques effectively prevented the hemodynamic response to pin insertion.

Scalp block requires multiple needle pricks and is avoided in patients with depressed skull fractures and scalp infections. SPG block, being less invasive, can be a viable alternative, especially when combined with posterior scalp block.

Possible adverse reactions with bupivacaine, like local anesthetic toxicity, hypotension, or inadvertent intraarterial injection, were not seen. This was avoided by watchful aspiration for blood before injection and precise dose calculation.

The study is not free from limitations. Firstly, it was not blinded. Secondly, scalp block is time-consuming. However, the time taken to perform the block was not noted. Lastly, we did not evaluate the postoperative pain.

In the SPG group, only one patient had mild nasal bleeding, which stopped spontaneously.

Conclusion

We conclude that both scalp block and SPG block plus greater and lesser occipital nerve blocks effectively suppressed the hemodynamic stress response to scalp pin insertion during craniotomies.

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