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# Which one is more effectivartwork corrections requirede for analgesia in infratentorial craniotomy? The scalp block or local anesthetic infiltration☆

Eren Fatma Akcil[a,*], Ozlem Korkmaz Dilmen[a], Hayriye Ërtemšhould delete Vehid[b], Lutfiye Serap Ibısoglu[a], Yusuf Tunali[a]

[a] University of Istanbul, Cerrahpasa School of Medicine, Department of Anesthesiology and Intensive Care, Turkey
[b] University of Istanbul, Cerrahpasa School of Medicine, Department of Biostatistics, Turkey

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ABSTRACT

*Objectives:* The most painful stages of craniotomy are the placement of the pin head holder and the skin incision. The primary aim of the present study is to compare the effects of the scalp block and the local anesthetic infiltration with bupivacaine 0.5% on the hemodynamic response during the pin head holder application and the skin incision in infratentorial craniotomies. The secondary aims are the effects on pain scores and morphine consumption during the postoperative 24 h.

*Methods:* This prospective, randomized and placebo controlled study included forty seven patients (ASA I, II and III). The scalp block was performed in the Group S, the local anesthetic infiltration was performed in the Group I and the control group (Group C) only received remifentanil as an analgesic during the intraoperative period. The hemodynamic response to the pin head holder application and the skin incision, as well as postoperative pain intensity, cumulative morphine consumption and opioid related side effects were compared.

*Results:* The scalp block reduced the hemodynamic response to the pin head holder application and the skin incision in infratentorial craniotomies. The local anesthetic infiltration reduced the hemodynamic response to the skin incision. As well as both scalp block and local anesthetic infiltration reduced the cumulative morphine consumption in postoperative 24 h. Moreover, the pain intensity was lower after scalp block in the early postoperative period.

*Conclusion:* The scalp block may provide better analgesia in infratentorial craniotomies than local anesthetic infiltration.



## 1. Introduction

Optimal pain treatment reduces intra and postoperative surgical stress response, therefore provides hemodynamic stability in craniotomies [1]. Pain following craniotomies has been largely investigated and reported that it could be moderate or severe during postoperative period [2–4].

Postoperative pain treatment might help to prevent rise in intracranial pressure as well as reduce the risk of intracerebral hemorrhage [5,6]. For this purpose, pain control has become a priority in neurosurgery [2].

The aim of multimodal pain treatment is to provide analgesia by different neurophysiological pathways [7]. The combination of systemic analgesics and local anesthetics might reduce the amount of systemic opioids, thereby lower the incidence of opioids adverse effects, such as sedation, miosis, respiratory depression, nausea and vomiting [8,9]. For this purpose; scalp block and local anesthetic infiltration have been used with systemic opoid administration [2,3,10].

The most painful stages of craniotomy are the placement of the pin head holder and the skin incision. Therefore, it is necessary to increase the depth of anesthesia by additional analgesic to prevent hemodynamic response such as tachycardia and hypertension during these stages [11].

It has been known that postoperative pain may be more severe following infratentorial craniotomies than supratentorials [12–14].

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* Corresponding author at: University of Istanbul, Cerrahpasa School of Medicine, Department of Anesthesiology and Intensive Care, 34098 Istanbul, Turkey.
*E-mail addresses:* erenfat@yahoo.com (E.F. Akcil), korkmazdilmen@gmail.com (O.K. Dilmen), ertem@istanbul.edu.tr (H..s.d. Vehid), serap_ibisoglu@hotmail.com (L.S. Ibısoglu), ytunali@yahoo.com (Y. Tunali).

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As far as we know, the efficacy of the scalp block has not been investigated yet in the infratentorial craniotomies.

Thus the primary aim of this prospective, randomized and placebo controlled study is to compare the effects of the scalp block and local anesthetic infiltration with bupivacaine 0.5% on the hemodynamic response during the pin head holder application and the skin incision in infratentorial craniotomies. The secondary aims are the effects on pain scores and morphine consumption during the postoperative 24 h.

## 2. Materials and methods

The study registered to Clinical Trials.gov (NCT 02852382). This prospective, randomized and placebo controlled study was performed between May 2014 to December 2016. After approval from the Ethics Committee of Cerrahpasa School of Medicine (Ethical Committee No: 83045809/604/02-6015; 4 March 2014) and patient written informed consent, 47 American Society of Anesthesiologists (ASA) physical status class I–III patients aged between 18 and 70 years scheduled for elective infratentorial craniotomy were included in the study. Patients presenting with allergy to bupivacaine or opioids, chronic hypertension, coronary artery disease, arrhythmia, coagulopathy, cerebrovascular disease, raised intracranial pressure, trigeminal neuralgia and previous craniotomy were excluded from the study.

Patients were sedated with intravenous (IV) midazolam ($0.05\,mg\,kg^{-1}$) before the surgery. In the operating room, after routine monitoring, anesthesia was induced with propofol ($1.5–2\,mg\,kg^{-1}$), rocuronium ($0.5\,mg\,kg^{-1}$), remifentanil ($0.15\,\mu g\,kg^{-1}\,min^{-1}$), 0.7 $FiO_2$ oxygen-air and maintained with sevoflurane 0.5–0.8 MAC in oxygen/air ($FiO_2 = 0.40$), remifentanil ($0.05–0.1\,\mu g\,kg^{-1}\,min^{-1}$) and rocuronium ($0.03\,mg\,kg^{-1}\,min^{-1}$) infusions. After orotracheal intubation; nasogastric tube, right radial artery and urinary catheters were inserted.

Patients were randomized to one of three groups using a closed envelope technique. The scalp nerve block was performed in the Group S, the local anesthetic infiltration was performed in the Group I and the control group (Group C) only received remifentanil as an analgesic during the intraoperative period.

The scalp block was performed 10 min before the pin head holder application (PHHA) by the anesthesiologist with using the Pinosky's et al. [11] method. The supraorbital and supratrochlear nerves were blocked bilaterally with 6 mL bupivacaine 0.5% injected above the midline of the eyebrow, perpendicular to the skin. The auriculotemporal nerves were blocked bilaterally with 4 mL bupivacaine 0.5% injected to 1.5 cm anterior of the ear at the level of tragus, the needle was introduced perpendicular to the skin and injection was performed deeply to fascia and superficially as the needle was withdrawn. The postauricular branches of the greater auricular nerves were blocked bilaterally with 2 mL bupivacaine 0.5% injected to 1 cm posterior to the ear at the level of tragus, between bone and skin. The greater, lesser and third occipital nerves were blocked bilaterally with 8 mL bupivacaine 0.5% injected along the superior nuchal line, approximately halfway between the occipital protuberance and mastoid process.

In the Group I, the PHHA points and the surgical incision sites were infiltrated with 20 mL of bupivacaine 0.5% 10 min before the PHHA.

In the Group C, IV bolus 50 μg remifentanil was administered 10 s before the PHHA and the skin incision.

Additional remifentanil 50 μg IV was administered if the mean arterial pressure (MAP) and hearth rate increased above the 20% of the baseline in all groups.

Intraoperative analgesia was maintained with remifentanil alone. Sugammadex ($2\,mg\,kg^{-1}$) was used to reverse residual muscle relaxation at the end of surgery. Ondansetron (8 mg IV) administered as an antiemetic prophylaxis. All patients were extubated at the end of the surgery and admitted in the neurosurgical-intensive care unit for postoperative 24 h.

All patients received IV morphine using a patient controlled analgesia (PCA) pumps (Abbott Provider®, Chicago, USA) for postoperative 24 h. The PCA solution contained 100 mg morphine in 100 mL normal saline. The PCA was set to administer a bolus dose of 1 mg on demand with a lockout period of 10 min and maximum 25 mg for 4 h. Pain was evaluated with visual analogue scale (VAS) scores from 0 to 10 (0 = no pain 10 = worst pain). Two mg IV morphine was administered every 20 min in addition to PCA delivery, until the pain score decrease below 4.

The incision types are midline, paramedian and hockey stick incision. The midline and the paramedian incisions are linear. The midline incision extends from 6 cm above the inion to the C2 spinous process; paramedian incision (also referred to as a retrosigmoid approach) begins 5 mm medial to the mastoid notch and extends 4–6 cm above and below the notch. The "hockey-stick" incisions are curved and begin in the midline at the C2 spinous process, extend superiorly to just above the inion, and then laterally to mastoid tip with a terminal caudal curve.

The corticosteroid administration, the type of the surgery, the type and the size of the surgical incision, duration of the surgery, cumulative remifentanil administration in first 15 min, cumulative intraoperative remifentanil administration were recorded.

The heart rates and MAPs were recorded before induction of anesthesia (Baseline), before the PHHA, during the PHHA, 5 min after the PHHA, 10 min after the PHHA and during the skin incision as well as postoperative 10th min, 1th h, 2nd h, 6th h, 12th and 24th h.

The pain scores and postoperative cumulative morphine consumption as well as morphine related side effects such as nausea, vomiting, pruritus and rash were recorded at postoperative 10th min, 1th h, 2nd h, 6th h, 12th and 24th h and defined by a scale with 0 = absent and 1 = present.

The patient and the anesthesiologist who recorded postoperative pain scores were blinded in every case. But the anesthesiologist who applied the scalp block and followed the hemodynamic response to pin fixation and skin incision were sometimes same person.

The primary endpoint of the present study is to compare the effects of the scalp block and the local anesthetic infiltration with bupivacaine on the hemodynamic response to pin head holder application and to skin incision in infratentorial craniotomies. The secondary endpoints are the effects on pain scores and morphine consumption during the postoperative 24 h.

### 2.1. Statistical analysis

On the basis of previous study [5] and the assumption that a difference of 20% on MAP is clinically relevant, setting $\alpha$ equal to 0.005 and $\beta$ equal to 0.9, we calculated a sample size of 15 patients per group. To compensate for dropouts the study included 47 patients. Statistical analysis was performed using SPSS (Statistical Package for Social Sciences) for Windows 15.0. The determination of the normality and homogenity of the data distribution was performed with Shapiro–Wilkinson test. The data determined one out of the normal distribution were analyzed with Kruskal–Wallis test. Differences among the groups were analyzed by using one-way analysis of variance (ANOVA) with the post hoc Tukey analysis for patient characteristics, surgical incision size, duration of surgery, cumulative remifentanil administration in first 15 min, cumulative intraoperative remifentanil administration, heart rates, MAPs and the VAS scores. Postoperative cumulative morphine consumption was analyzed with repeated measures of ANOVA. The differences in gender, ASA physical status, corticosteroid administration, the type of surgery, the type of surgical incision and morphine related side effects were analyzed with Pearson chi-Square test among the groups. Values of $p \leq 0.05$ were considered statistically significant.

## 3. Results

Forty seven patients were included in the study. Intraoperative massive bleeding developed in one patient thus the patient could not extubated at the end of the surgery in the Group S. One patient was unconscious at the end of the surgery in the Group C. Therefore, two patients were excluded from the study.

The study groups were similar with respect to age, gender, ASA physical status scores, height, body weight, body mass index and corticosteroid administration ($p > 0.05$) (Table 1).

The types of the surgery were similar among the groups. The types of surgical incision were significantly different among the groups; the number of the patients who applied hockey-stick incision were higher in the Group S compared to the other groups ($p = 0.025$), therefore the size of surgical incision was longer in the Group S compared to other groups ($p = 0.014$). The duration of surgery was significantly longer in the Group C compared to the Group I ($p = 0.007$).

The cumulative remifentanil administration in intraoperative first 15 min and cumulative intraoperative remifentanil administrations were not different among the groups (Table 2).

The heart rates were significantly higher in the Group C compared to the Group S in 5 and 10 min after the PHHA ($p = 0.019$ and $p = 0.016$ respectively). The heart rates were significantly higher in the Group C compared to the Group S and the Group I during the skin incision ($p = 0.028$ and $p = 0.045$ respectively) (Fig. 1).

The MAPs were significantly higher during the PHHA in the Group I and the Group C compared to the Group S ($p = 0.018$ and $p = 0.004$ respectively). The MAPs were significantly higher 10 min after the PHHA in the Group C compared to the Group S ($p = 0.001$) (Fig. 2).

The VAS scores were significantly higher in the Group C compared to the Group S in the 10th min, 1th and 2ndPlease delete 1th and write 1st h of the postoperative period ($p = 0.001$, $p = 0.007$ and $p = 0.017$ respectively) (Fig. 3).

Postoperative cumulative morphine consumption was higher in the Group C compared to the Group S and the Group I in the 1th, 2nd, 6th, 12th (*p* Please delete 1th and write 1st= 0.001 for all) and 24th h ($p = 0.004$) (Fig. 4).

There was no significant difference with respect to morphine related side effects among the groups.

## 4. Discussion

This prospective, randomized and placebo controlled study showed that the scalp block with 0.5% bupivacaine provides a better hemodynamic response to PHHA than local anesthetic infiltration and only remifentanil administration as well as both the scalp block and local anesthetic infiltration sustained a better hemodynamic response to the skin incision. Moreover, postoperative pain intensity was lower than 4 during the postoperative 24 h in the group of scalp block as well as pain intensity was lower during the postoperative first two hours in the group of scalp block compared to the control. The scalp block and local anesthetic infiltration both decreased the morphine consumption in postoperative 24 h compared to the control.

There are several factors that may have influence on the severity of postoperative pain in neurosurgery. The pain after craniotomy arise from pericranial muscle and soft tissue. Suboccipital and subtemporal interventions are associated with high incidence of pain. It is though that this might be due to surgical stress secondary to the incision in the scalp and the muscle underlying the scalp [15]. It has been shown that, pain scores might be higher following infratentorial craniotomies than supratentorials because of excessive muscle dissection [4,12,14,16]. Therefore, this study included only infratentorial craniotomies. Moreover type and size of the surgical incision may have effect on the postoperative pain. Although the size of the surgical incision was longer in the scalp block group, hemodynamic variables and postoperative pain scores were better.

Age, gender, corticosteroid administration are the factors that may affect the pain intensity. As the age increase, the pain intensity inversely decrease [17]. It has suggested that women have a lower pain threshold than men [18,19]. Corticosteroids may have analgesic effects [20]. In this study, there were no statistical differences between the groups with respect to age, gender and corticosteroid administration.

Lee et al. [21] demonstrated that the scalp block decreases intraoperative anesthesic and analgesic requirements in patients undergoing frontotemporal craniotomy. Although our results showed that, the postoperative cumulative morphine consumption was lower in the group of scalp block, there was no difference with respect to the amount of intraoperative remifentanil administration among the groups. The differences between the Lee et al. [21]′s and our study may arise from the site of the surgical incision and design of the study protocol.

The perioperative hypertension may increase the risk of intracranial hematoma and cerebral oedema, on the other hand perioperative hypotension may cause cerebral ischemia, therefore prevention of the hemodynamic changes is essential for neuroanesthesia [5,21].

The scalp block and its efficacy have been firstly described by Pinosky et al. [11] in patients undergoing craniotomy. They concluded that the heart rate and MAP were significantly lower during PHHA with scalp block compared to the control group. After this description, many studies showed similar results in patients undergoing supratentorial craniotomy [5,21]. Likewise the other studies, the efficacy of the scalp block on the hemodynamic response to the PHHA has been shown in patients undergoing infratentorial craniotomy in the present study.

The scalp block is not only effective to prevent intraoperative pain, but it may also provide postoperative analgesia [4,22–24]. Several studies reported that the prevalence of moderate to severe postoperative pain changed from 60 to 80% in 24–48 h following craniotomies [4,25,26]. Likewise to our study, Gazoni et al. [24] performed the scalp block with 0.5% ropivacaine after induction of analgesia in patients undergoing supratentorial craniotomy but contrary to our study they could not demonstrate the efficacy of the scalp block on postoperative pain. These differences might arise from the differences of the craniotomy type and administered local anesthetic. Unlike our study, Bala et al. [22] and Nyungen et al. [23] performed the scalp block at the end of the surgery in patients undergoing supratentorial craniotomy and likewise to our study results they concluded that the scalp block was effective in postoperative pain. Compared to our study, the scalp block might provide better and longer postoperative analgesia when performed at the end of surgery [22,23]. On the other hand, this method is not effective to prevent hemodynamic response to the PHHA and the skin incision. In the present study, we performed the scalp block 10 min before the PHHA, the postoperative pain scores were lower in first 2 h compared to the control group, as well as the pain scores were below 4 during postoperative 24 h in the group of scalp block.

Although potential side effects of opioids such as; sedation, respiratory depression, hypercapnia, hypoxemia, raise in intracranial pressure, nausea and vomiting produce general reluctance for use in neurosurgery, the efficacy and safety of opioids have been shown following craniotomy [2,3,27–29]. In contrary to our results,

**Table 1**
Patient characteristics and corticosteroid administration.

| | Group S<br>*n* = 15 | Group I<br>*n* = 15 | Group C<br>*n* = 15 | *p* |
|---|---|---|---|---|
| Age (years) (mean ± SD) | 40.60 ± 15.89 | 38.46 ± 10.8 | 38.8 ± 18.17 | 0.91 |
| Female gender *n* (%) | 8 (53.3%) | 11 (73.3%) | 11 (73.3%) | 0.4 |
| ASA physical status (I/II/III) (*n*) | 10/5/0 | 9/6/0 | 10/5/0 | 0.098 |
| Height (cm) (mean ± SD) | 164.40 ± 9.06 | 162.46 ± 6.13 | 168.33 ± 7.01 | 0.1 |
| Body weight (kg) (mean ± SD) | 66.86 ± 15.31 | 71.26 ± 13.58 | 70 ± 9.03 | 0.63 |
| BMI (kg/m$^2$) (mean ± SD) | 24.76 ± 4.67 | 26.94 ± 4.84 | 24.81 ± 3.75 | 0.32 |
| Corticosteroid administration *n* (%) | 2(13.33) | 0 | 2 (13.33) | 0.33 |

*n*: number of patients, ASA: American Society of Anesthesiologists, BMI: Body mass index.
The study groups were similar with respect to age, gender, ASA physical status scores, height, body weight, BMI and corticosteroid administration ($p > 0.05$).

**Table 2**
Surgical characteristics and the amount of remifentanil administration.

| | Group S<br>*n* = 15 | Group I<br>*n* = 15 | Group C<br>*n* = 15 | *p* |
|---|---|---|---|---|
| Type of surgery<br>Tumor *n* (%)<br>Arnold–Chiari malformation *n* (%) | should be placed in below line<br>7 (46.6%)should be placed in below line<br>8 (53.4%) | should be placed in below line<br>6 (40%)should be placed in below line<br>9 (60%) | should be placed in below line<br>10 10 (66.6%) in the same line(66.6%)<br>5 (33.4%) | 0.42 |
| Type of surgical incision (*n*)<br>0: midline<br>1: paramedian<br>2: hockey-stick | 2/8/5 | 3/11/1 | 7/8/0 | 0.025* |
| Size of surgical incision (cm) (mean ± SD) | 15.46 ± 4.68 | 12 ± 3.87 | 11.8 ± 1.78 | 0.014# |
| Duration of surgery (min) (mean ± SD) | 282 ± 81.74 | 234.53 ± 71.31 | 347 ± 118 | 0.007λ |
| Cumulative remifentanil administration in first 15 min ($\mu g\,kg^{-1}$) (mean ± SD) | 5.28 ± 2.09 | 5.87 ± 2.12 | 5.87 ± 3.82 | 0.8 |
| Cumulative intraoperative remifentanil administration ($\mu g\,kg^{-1}\,min^{-1}$) (mean ± SD) | 0.13 ± 0.05 | 0.15 ± 0.04 | 0.13 ± 0.04 | 0.3 |

* The number of the patients who applied hockey-stick incision was higher in the Group S compared to the other groups ($p = 0.025$).
# The size of the surgical incision was significantly longer in the Group S compared to other groups ($p = 0.014$).
λ The duration of surgery was significantly longer in the Group C compared to the Group I ($p = 0.007$).

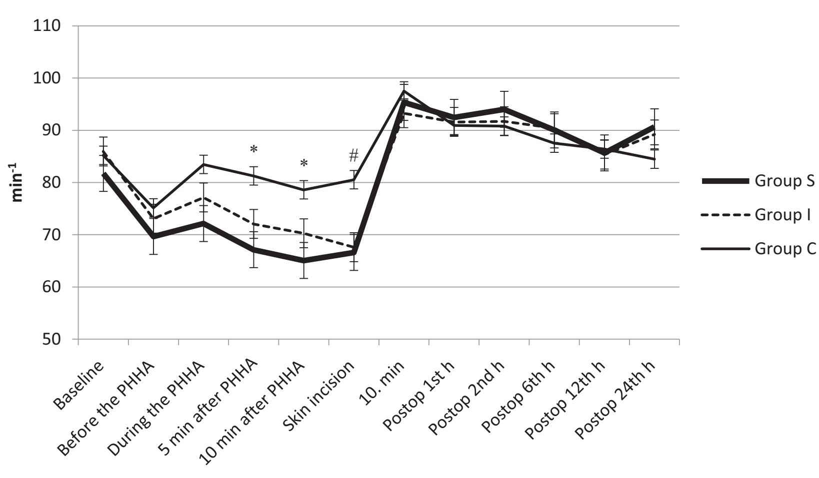


**Fig. 1.** Heart rates at each indicated time intervals (mean ± SD). PHHA: Pin head holder application. * The heart rates were significantly higher in the Group C compared to the Group S in 5 and 10 min after PHHA ($p = 0.019$ and $p = 0.016$ respectively). # The heart rate in the skin incision was significantly higher in the Group C compared to the Group S and the Group I ($p = 0.028$ and $p = 0.045$ respectively).

Gazoni et al. [24] and Nyugen et al. [23] did not observed any difference in morphine consumption during postoperative 24 h among the scalp block and the control groups. Although there was a trend to decrease in morphine consumption with scalp block in these studies, it could not be proven statistically.

Law-Koune et al. [30] found that scalp infiltration with bupivacaine 0.375% and ropivacaine 0.75% at the skin closure decreased morphine consumption compared to the control group in postoperative 2 h following supratentorial craniotomies. In our study, the postoperative 24 h morphine consumption was lower in the scalp block and the local anesthetic infiltration groups compared to the control.

This study has some limitations. The duration of the surgery is one of the factor that influence postoperative analgesic

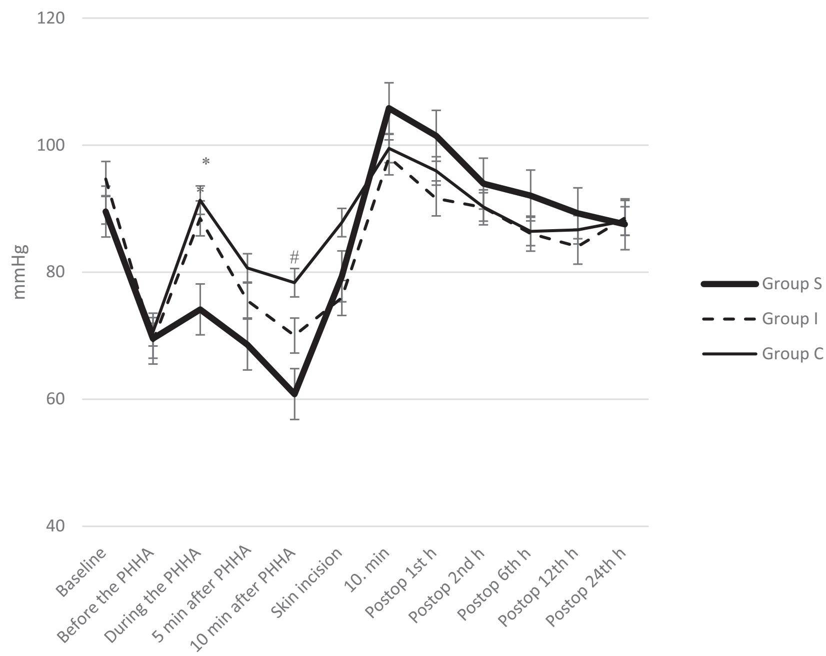


**Fig. 2.** Mean arterial pressures at each indicated time intervals (mean ± SD). PHHA: Pin head holder application. * The mean arterial pressures were significantly higher during the PHHA in the Group I and The Group C compared to the Group S ($P = 0.018$ and $P = 0.004$ respectively). # The mean arterial pressures were significantly higher 10 min after the PHHA in the Group C compared to the Group S ($p = 0.001$).

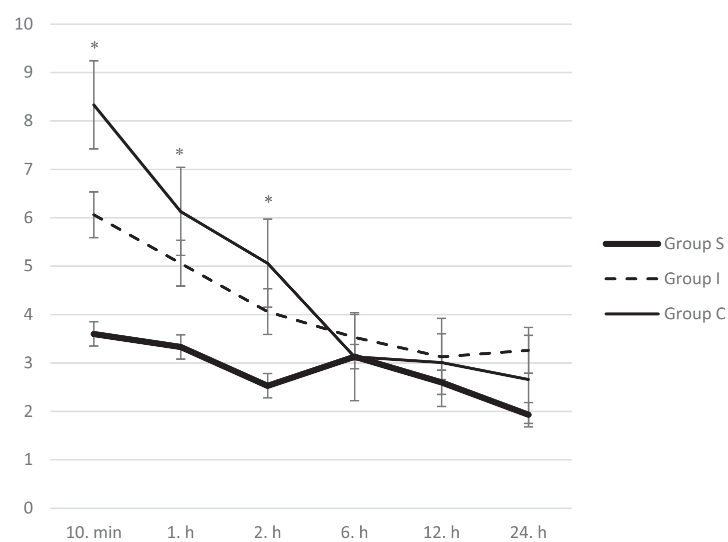


**Fig. 3.** VAS scores at each indicated time intervals (mean ± SD). The visual analog scale scores were significantly higher in the Group C compared to the Group S in the 10th min, 1th and 2ndPlease delete 1th and write 1st h ($p = 0.001$, $p = 0.007$ and $p = 0.017$ respectively).

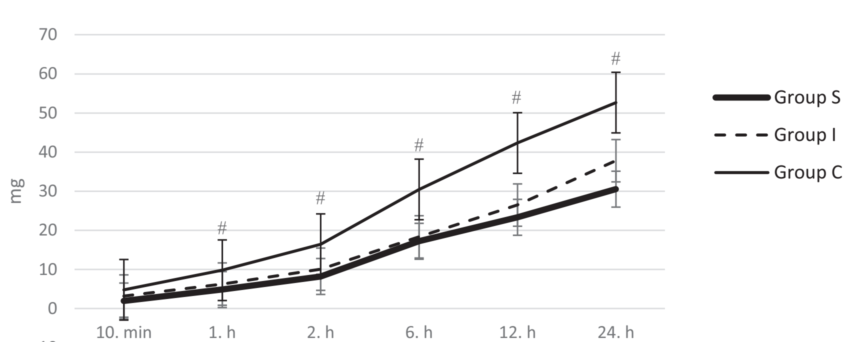


**Fig. 4.** Postoperative 24 h cumulative morphine consumption at each indicated time intervals (mean ± SD). Cumulative morphine consumption was higher in the Group C compared to the Group S and the Group I in the 1th, 2nd, 6th,12th (*pPlease delete 1th and write 1st* = 0.001 for all) and 24th h ($p = 0.004$).

requirement. Dahmani et al. [31] found that the duration of surgery exceeding 100 min associates with increased postoperative morphine consumption. In our study the duration of surgery was significantly longer in the Group C compared to the Group I and postoperative morphine consumption was significantly higher in the control group. Although this, postoperative pain intensity was not significantly different in these two groups as expected.

In conclusion, the scalp block with 0.5% bupivacaine reduced the hemodynamic response to the pin head holder application and the skin incision in infratentorial craniotomies. The local analgesic infiltration reduced the hemodynamic response to the skin incision. As well as both scalp block and local anesthetic infiltration reduced the cumulative morphine consumption for postoperative 24 h. Moreover, the pain intensity was lower after scalp block in the early postoperative period.

## Conflict of interest

None declared.


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