Clinical Article
J Korean Neurosurg Soc 66 (6) : 652-663, 2023
https://doi.org/10.3340/jkns.2023.0010
pISSN 2005-3711 eISSN 1598-7876

Effects of Scalp Nerve Block on the Quality of Recovery after Minicraniotomy for Clipping of Unruptured Intracranial Aneurysms : A Randomized Controlled Trial

Seungeun Choi,[1,*] Young Hoon Choi,[2,*] Hoo Seung Lee,[1] Kyong Won Shin,[1] Yoon Jung Kim,[1] Hee-Pyoung Park,[1] Won-Sang Cho,[2] Hyongmin Oh[1]

Department of Anesthesiology and Pain Medicine,[1] Seoul National University Hospital, Seoul National University College of Medicine, Seoul, Korea
Department of Neurosurgery,[2] Seoul National University Hospital, Seoul National University College of Medicine, Seoul, Korea

Objective : This study compared the quality of recovery (QoR) after minicraniotomy for clipping of unruptured intracranial aneurysms (UIAs) between patients with and without scalp nerve block (SNB).

Methods : Patients were randomly assigned to the SNB (SNB using ropivacaine with epinephrine, n=27) and control (SNB using normal saline, n=25) groups. SNB was performed at the end of surgery. To assess postoperative QoR, the QoR-40, a patient-reported questionnaire, was used. The QoR-40 scores were measured preoperatively, 1–3 days postoperatively, at hospital discharge, and 1 month postoperatively. Pain and intravenous patient-controlled analgesia (IV-PCA) consumption were evaluated 3, 6, 9, and 12 hours and 1–3 days postoperatively.

Results : All QoR-40 scores, including those measured 1 day postoperatively (primary outcome measure; 155.0 [141.0–176.0] vs. 161.0 [140.5–179.5], p=0.464), did not significantly differ between the SNB and control groups. The SNB group had significantly less severe pain 3 (numeric rating scale [NRS]; 3.0 [2.0–4.0] vs. 5.0 [3.5–5.5], p=0.029), 9 (NRS; 3.0 [2.0–4.0] vs. 4.0 [3.0–5.0], p=0.048), and 12 (NRS; 3.0 [2.0–4.0] vs. 4.0 [3.0–5.0], p=0.035) hours postoperatively. The total amount of IV-PCA consumed was significantly less 3 hours postoperatively in the SNB group (2.0 [1.0–4.0] vs. 4.0 [2.0–5.0] mL, p=0.044).

Conclusion : After minicraniotomy for clipping of UIAs, SNB reduced pain and IV-PCA consumption in the early postoperative period but did not improve the QoR-40 scores.

Key Words : Scalp · Nerve block · Enhanced recovery after surgery · Craniotomy · Surgical clipping · Intracranial aneurysm.

• Received : January 11, 2023 • Revised : March 13, 2023 • Accepted : April 10, 2023
• Address for correspondence : **Hyongmin Oh**
Department of Anesthesiology and Pain Medicine, Seoul National University Hospital, Seoul National University College of Medicine, 101 Daehak-ro, Jongno-gu, Seoul 03080, Korea
Tel : +82-2-2072-1478, Fax : +82-2-747-5639, E-mail : gudals0118@snu.ac.kr, ORCID : https://orcid.org/0000-0001-9708-3954

Won-Sang Cho
Department of Neurosurgery, Seoul National University Hospital, Seoul National University College of Medicine, 101 Daehak-ro, Jongno-gu, Seoul 03080, Korea
Tel : +82-2-2072-2824, Fax : +82-2-744-8459, E-mail : nsdrcho@snu.ac.kr, ORCID : https://orcid.org/0000-0002-3345-8718

*These are co-first authors with equal contributions to the manuscript.

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (http://creativecommons.org/licenses/by-nc/4.0) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Copyright © 2023 The Korean Neurosurgical Society

INTRODUCTION

Recent advances in radiological technology and increased demand for brain examinations in health screening have led to an increase in the accidental detection of unruptured intracranial aneurysms (UIAs). Both surgical and endovascular treatments have been actively performed for UIAs. Surgical clipping is generally associated with higher rates of perioperative morbidity and aneurysm obliteration and lower rates of aneurysm recurrence compared to endovascular coiling[35].

The incidence of moderate to severe postcraniotomy headache (PCH) has been reported to be as high as 80%[12]. However, acute PCH is frequently overlooked and undertreated in clinical practice because systemic or neuraxial administration of analgesics, particularly opioids, can cause sedation and hinder neurological examinations[15]. In addition, the use of local anesthetics rather than opioid for pain control is emphasized in enhanced recovery after surgery[3,10,24]. Therefore, scalp nerve block (SNB) has been increasingly used as an effective alternative to systemic administration of opioids in PCH. SNB is known to effectively reduce PCH, opioid consumption, inflammation, and postoperative nausea and vomiting (PONV) in conventional craniotomy patients[1,2,17,41,42,45].

In recent years, enhanced recovery after surgery, including craniotomy, has been in the spotlight in perioperative management, as it has shown to improve postoperative outcomes in terms of complications and hospital stays[11,22,23,34,39]. The quality of recovery (QoR)-40 is a patient-reported questionnaire based on five dimensions of health (emotional state, physical comfort, psychological support, physical independence, pain), and is widely used as a tool for assessing postoperative QoR quantitatively over a period of 24 hours[14,25]. The QoR-40K, the Korean version of the QoR-40, offers a high level of validity, reliability, and clinical utility for evaluating postoperative QoR in Korean populations[20]. However, there have been no clinical studies investigating the effects of SNB on the QoR in minicraniotomy patients, especially using such questionnaire.

Low postoperative QoR-40 scores were associated with PCH and postoperative complications, including PONV, in cranial surgery patients[21]. Based on this, this study hypothesized that SNB would improve the QoR by reducing PCH, opioid consumption, and PONV in the early postoperative period in minicraniotomy patients. This study compared the QoR-40 scores, severity of PCH, use of analgesics, incidence and severity of PONV, and length of hospital stay between patients with and without SNB after minicraniotomy for clipping of UIAs.

MATERIALS AND METHODS

Ethics

This double-blind, parallel-group, randomized, and placebo-controlled trial was approved by Seoul National University College of Medicine/Seoul National University Hospital Institutional Review Board (number : 2005-232-1130, date : August 11, 2020) and registered at the Clinical Research Information Service (number : KCT0005354, date : August 26, 2020). This study was conducted according to Good Clinical Practice guidelines and this paper adhered to the applicable Consolidated Standards of Reporting Trials guidelines.

Subjects

Patients aged 20–79 years who were scheduled for an elective single keyhole minicraniotomy for clipping of UIAs at single academic tertiary hospital were included. Patients with symptomatic aneurysms, allergies to local anesthetics or analgesics, chronic use of opioids, a history of craniotomy or scalp incision, other diseases (scalp disease, cancer, dementia, mood disorder, psychiatric disorder), or American Society of Anesthesiologists physical status $\geq$3 were excluded. Patients unable to communicate with their healthcare provider or complete a written version of the QoR-40K were also excluded.

Randomization and blinding

Randomization software (Random Allocation Software version 1.0.0; Isfahan University of Medical Sciences, Isfahan, Iran) was used for block randomization with a block size of four. By an anesthesiologist not involved in this study, a random allocation sequence was created, concealed in an opaque envelope, and checked just after anesthetic induction. Patients were assigned to the SNB (SNB using ropivacaine with epinephrine) and control (SNB using normal saline) groups at a 1 : 1 ratio based on the random allocation sequence. The drugs for SNB were prepared by the same anesthesiologist so as to be indistinguishable. The anesthesiologists who performed SNB, neurosurgeons, patients, and researchers who investigated

perioperative variables, including the QoR-40 scores, were blinded to group assignment.

SNB

At the end of surgery, landmark-guided SNB was performed using aseptic technique by one of the four attending anesthesiologists who had performed more than 50 SNBs. SNB was induced using 0.75% ropivacaine with 1 : 200000 epinephrine and normal saline in the SNB and control groups, respectively. These solutions were prepared in three 10-mL syringes labeled as "study drug" so that their composition was unknown to the anesthesiologist who performed SNB. To cover the area of surgical incision and skull clamp, seven scalp nerves, including the supratrochlear, supraorbital, zygomaticotemporal, auriculotemporal, great auricular, lesser occipital, and greater occipital nerves, were blocked bilaterally by injecting 2–3 mL of the solution using a 25-gauge needle. The supratrochlear and supraorbital nerves were blocked at the eyebrow, near the superomedial margin of the orbit and above the palpable supraorbital notch, respectively[26]. The zygomaticotemporal nerve was blocked between the superolateral margin of the orbit and the posterior margin of the zygomatic arch[26]. The auriculotemporal nerve and the posterior branch of the great auricular nerve were blocked at the level of the tragus, near the pulsating superficial temporal artery and on the mastoid process, respectively[26]. The greater and lesser occipital nerves were blocked at the medial and lateral thirds of the superior nuchal line, respectively[26]. SNB-related adverse events such as infection, hematoma formation, facial nerve palsy, local anesthetic systemic toxicity, and severe hemodynamic instability (a change more than 20% in mean arterial pressure or heart rate) were noted if present.

Anesthesia

Patients were monitored with non-invasive blood pressure measurement, electrocardiography, and peripheral oxygen saturation in the operating room. Total intravenous anesthesia was induced and maintained using target-controlled infusion of propofol and remifentanil. The upper airway was topically anesthetized using a 10% lidocaine spray during mask ventilation to minimize hemodynamic response to tracheal intubation. The patient's radial artery was catheterized to continuously monitor invasive blood pressure. After anesthetic induction, intravenous dexamethasone (5 mg) were administered for PONV prophylaxis. The effect site concentrations of propofol and remifentanil were adjusted to keep bispectral index and mean blood pressure within 40–60 and 80–120% of its preoperative baseline, respectively. Intravenous acetaminophen (1000 mg), fentanyl (50 μg), and ramosetron (300 μg) were administered 30 minutes before the end of surgery. At the end of surgery, intravenous patient-controlled analgesia (IV-PCA; total volume, 100 mL; fentanyl concentration, 15 μg/mL; ramosetron concentration, 3 μg/mL; continuous infusion rate, 0 mL/h; bolus injection volume, 1 mL; lockout time, 10 minutes) was established. After the end of surgery, all patients were extubated in the operating room and transferred to the postanesthesia care unit.

Surgery

All craniotomies and clipping of UIAs were performed by a skilled neurosurgeon. A skull clamp with three pins (MAYFIELD® Skull Clamps; Integra LifeSciences, Princeton, NJ, USA) was used to immobilize the patient's head. The surgical approach for clipping of UIAs was based on the location and direction of the aneurysms, spatial relationship among the aneurysms, brain parenchyma, and bony structures, and neurosurgeon's preference. Four types of keyhole minicraniotomy were considered : supraciliary supraorbital, frontolateral supraorbital, lateral supraorbital, and minipterional approaches[8,16]. Surgical complications, including intraoperative premature aneurysmal rupture and postoperative stroke with neurological deficit, were recorded if present.

Postoperative management

IV-PCA was maintained until the patient requested its removal. Before resuming sips of water, intravenous acetaminophen (1000 mg) was administered every 6 hours, while intravenous fentanyl (50 μg) was used for rescue analgesia. After resuming sips of water, oral acetaminophen (650 mg) was administered every 6 hours, while oral aceclofenac (100 mg) and tramadol (50 mg), transdermal fentanyl patches (25–100 μg/h), and intravenous fentanyl (25 μg) were used in order for rescue analgesia. For PONV control, intravenous ramosetron (300 μg) and metoclopramide (10 mg) were administered up to twice a day as first-line and second-line antiemetics, respectively.

Outcomes

The primary outcome measure was the QoR-40 scores mea-

 https://doi.org/10.3340/jkns.2023.0010

sured 1 day postoperatively. As secondary outcome measures, the QoR-40 scores were measured 2–3 days postoperatively, at hospital discharge, and 1 month postoperatively and the severity of PCH, total amount of IV-PCA consumed, total number of rescue analgesics administered, and incidence and severity of PONV were evaluated 3, 6, 9, and 12 hours and 1–3 days postoperatively. The time from the end of surgery to the first administration of rescue analgesics and length of hospital stay were also investigated. The severity of PCH was assessed using a numeric rating scale (NRS; 0, no pain; 10, worst pain imaginable). The severity of PONV was divided into three grades (mild, no requirement for antiemetic administration; moderate, relief after antiemetic administration; severe, no relief even after antiemetic administration).

Sample size calculation

In a prospective observational study, the mean and standard deviation of the QoR-40 scores measured 1 day postoperatively in cranial surgery patients were 160 and 19, respectively[21]. Under the assumption that a 10% increase in the mean QoR-40 scores measured 1 day postoperatively in minicraniotomy patients with SNB is clinically significant, a minimum sample size of 46 patients (23 patients per group) was calculated with α of 0.05 and β of 0.2. Considering a drop rate of 20%, at least 56 patients (28 patients per group) were required.

Statistical analysis

All statistical analyses were performed using statistical software (SPSS version 25; IBM Corp., Armonk, NY, USA). The normality of data distribution was determined using Shapiro-Wilk test. Categorical variables were presented as numbers (proportions) and compared using Pearson's chi-squared test with continuity correction or Fisher's exact test depending on the expected frequency of cells. Continuous variables were presented as means (standard deviations) or medians (interquartile ranges) and compared using Student's t-test or Mann-Whitney U test according to the normality of their data distribution. The time effect of the QoR-40 scores within the groups and the time × group effect of the QoR-40 scores was evaluated using repeated measures analysis of variance. To determine whether there would be differences in the effects of SNB according to the type of minicraniotomy, a subgroup analysis was performed by dividing patients into those who underwent minicraniotomy with muscle incision (lateral su-

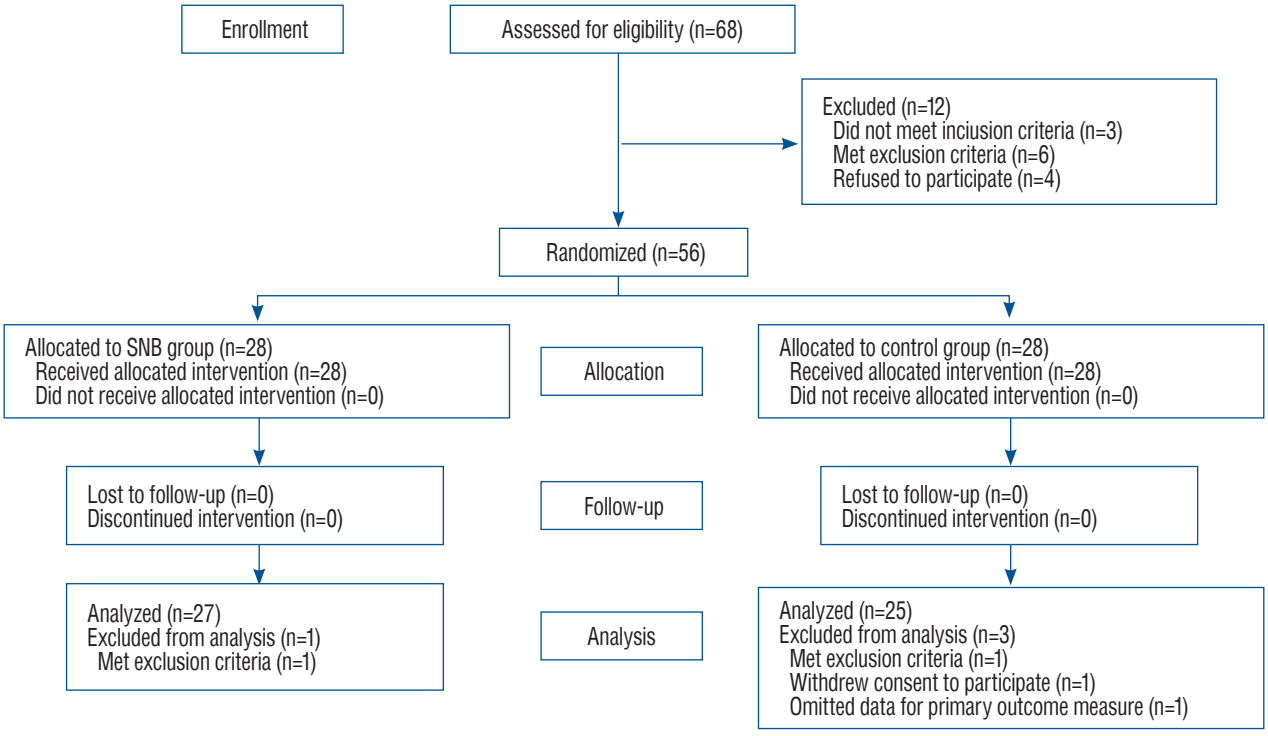

Fig. 1. Consolidated standards of reporting trials diagram. SNB : scalp nerve block.

praorbital and minipterional approaches) and those who underwent minicraniotomy without muscle incision (supraciliary and frontolateral supraorbital approaches). A *p*-value less than 0.05 was considered statistically significant.

RESULTS

A total of 56 patients were enrolled between October 2020 and November 2021 (Fig. 1). Four patients (two exclusion criteria, one withdrawn consent to participate, and one missing data for the primary outcome measure) were excluded from the analysis. There were no significant differences in demographic and intraoperative variables between the SNB and control groups except for a longer surgical duration in the SNB group (2.6±0.6 vs. 2.1±0.5 hours, p=0.002; Table 1).

All QoR-40 scores, including those measured 1 day postoperatively (155.0 [141.0–176.0] vs. 161.0 [140.5–179.5]; median difference, -5.0; 95% confidence interval, -18.0 to 9.0; p=0.464; Table 2), were not significantly different between the SNB and control groups. The QoR-40 scores showed no significant time × group (p=0.469) effect, whereas a significant time (p<0.001) effect within the groups. The QoR-40 scores measured 1 (155.0 [141.0–176.0] vs. 185.0 [167.0–195.0], p<0.001)

Table 1. Comparisons of demographic and intraoperative variables between patients with and without scalp nerve block

Variable	SNB group (n=27)	Control group (n=25)	*p*-value
Demographics			
Age (years)	59.3±9.4	62.6±9.6	0.218
Male sex	5 (18.5)	4 (16.0)	1.000
Body mass index (kg/m^2)	25.1±3.6	25.3±2.9	0.818
American Society of Anesthesiologists physical status			0.410
1	4 (14.8)	7 (28.0)	
2	23 (85.2)	18 (72.0)	
Surgery			
Location of aneurysm			
Internal carotid artery	3 (11.1)	0 (0.0)	0.236
Anterior cerebral artery	1 (3.7)	2 (8.0)	0.603
Middle cerebral artery	23 (85.2)	15 (60.0)	0.083
Anterior communicating artery	4 (14.8)	4 (16.0)	1.000
Posterior communicating artery	1 (3.7)	5 (20.0)	0.094
Anterior choroidal artery	1 (3.7)	3 (12.0)	0.341
Superior cerebellar artery	1 (3.7)	0 (0.0)	1.000
Multiple arteries	6 (22.2)	4 (16.0)	0.729
Approach			
Supraciliary supraorbital craniotomy	0 (0.0)	1 (4.0)	0.481
Frontolateral supraorbital craniotomy	11 (40.7)	15 (60.0)	0.267
Lateral supraorbital craniotomy	10 (37.0)	7 (28.0)	0.690
Minipterional craniotomy	6 (22.2)	2 (8.0)	0.252
Duration (hours)	2.6±0.6	2.1±0.5	0.002
Anesthesia			
Infusion rate			
Propofol (mg/kg/h)	7.4±1.0	7.3±0.9	0.726
Remifentanil (μg/kg/h)	7.4±1.1	7.2±1.1	0.629

Values are presented as mean±standard deviations or numbers (proportions). SNB : scalp nerve block

 https://doi.org/10.3340/jkns.2023.0010

and 2 (161.0 [142.0–179.0] vs. 185.0 [167.0–195.0], $p<0.001$) days postoperatively and those measured 1 (161.0 [140.5–179.5] vs. 187.0 [174.0–191.5], $p<0.001$) day postoperatively were significantly lower than those measured preoperatively in the SNB

Table 2. Comparisons of perioperative quality of recovery-40 scores between patients with and with scalp never block

Variable	SNB group (n=27)	Control group (n=25)	Median difference (95% CI)	*p*-value
Preoperatively	185.0 (167.0 to 195.0)	187.0 (174.0 to 191.5)	-1.0 (-9.0 to 6.0)	0.734
Physical comfort	57.0 (54.0 to 59.0)	57.0 (54.5 to 58.0)	0.0 (-2.0 to 2.0)	0.985
Emotional state	42.0 (38.0 to 44.0)	42.0 (38.5 to 44.0)	0.0 (-2.0 to 1.0)	0.825
Physical independence	22.0 (17.0 to 25.0)	22.0 (20.0 to 24.5)	0.0 (-3.0 to 1.0)	0.603
Psychological support	34.0 (29.0 to 35.0)	33.0 (29.5 to 35.0)	0.0 (-1.0 to 2.0)	0.829
Pain	32.0 (28.0 to 34.0)	34.0 (31.0 to 34.5)	-1.0 (-2.0 to 0.0)	0.218
1 day postoperatively	155.0 (141.0 to 176.0)	161.0 (140.5 to 179.5)	-5.0 (-18.0 to 9.0)	0.464
Physical comfort	46.0 (38.0 to 53.0)	45.0 (41.5 to 52.0)	-1.0 (-5.0 to 4.0)	0.748
Emotional state	32.0 (28.0 to 38.0)	35.0 (27.5 to 39.0)	-1.0 (-5.0 to 2.0)	0.469
Physical independence	16.0 (13.0 to 21.0)	18.0 (13.5 to 22.0)	-1.0 (-4.0 to 2.0)	0.446
Psychological support	29.0 (24.0 to 34.0)	30.0 (27.0 to 34.0)	-1.0 (-4.0 to 2.0)	0.550
Pain	33.0 (29.0 to 35.0)	34.0 (30.0 to 34.5)	0.0 (-1.0 to 1.0)	0.978
2 days postoperatively	161.0 (142.0 to 179.0)	176.0 (157.5 to 181.0)	-10.0 (-22.0 to 1.0)	0.109
Physical comfort	45.0 (41.0 to 52.0)	51.0 (45.5 to 53.0)	-4.0 (-8.0 to 0.0)	0.053
Emotional state	35.0 (30.0 to 39.0)	37.0 (34.0 to 41.0)	-2.0 (-5.0 to 1.0)	0.177
Physical independence	18.0 (13.0 to 21.0)	20.0 (16.0 to 22.5)	-2.0 (-5.0 to 1.0)	0.165
Psychological support	30.0 (28.0 to 34.0)	33.0 (27.5 to 35.0)	-1.0 (-3.0 to 1.0)	0.269
Pain	32.0 (29.0 to 34.0)	34.0 (32.0 to 35.0)	-1.0 (-3.0 to 0.0)	0.063
3 days postoperatively*	175.0 (151.1 to 189.0)	180.5 (169.3 to 187.0)	-5.0 (-18.0 to 5.0)	0.331
Physical comfort	53.0 (43.0 to 56.0)	54.0 (50.3 to 55.8)	-1.0 (-6.0 to 1.0)	0.330
Emotional state	37.0 (34.0 to 42.0)	40.0 (36.3 to 41.0)	-1.0 (-4.0 to 2.0)	0.545
Physical independence	20.0 (16.0 to 23.0)	22.0 (18.0 to 24.0)	-1.0 (-4.0 to 1.0)	0.338
Psychological support	33.0 (26.0 to 35.0)	33.0 (29.0 to 35.0)	0.0 (-3.0 to 1.0)	0.391
Pain	33.0 (30.0 to 35.0)	33.5 (31.3 to 35.0)	0.0 (-2.0 to 1.0)	0.885
At hospital discharge†	169.5 (145.5 to 188.8)	174.4 (158.0 to 191.5)	-7.9 (-21.0 to 7.0)	0.296
Physical comfort	51.0 (43.8 to 56.3)	53.0 (47.5 to 56.3)	-2.0 (-6.0 to 2.0)	0.445
Emotional state	36.5 (32.8 to 42.3)	39.5 (36.3 to 43.0)	-1.0 (-5.0 to 1.5)	0.365
Physical independence	19.5 (14.8 to 24.0)	21.0 (18.0 to 24.3)	-1.0 (-4.0 to 1.0)	0.189
Psychological support	29.0 (23.0 to 34.3)	32.5 (27.8 to 35.0)	-1.5 (-5.3 to 1.0)	0.246
Pain	33.5 (28.0 to 35.0)	34.0 (30.8 to 35.0)	0.0 (-2.0 to 1.0)	0.443
1 month postoperatively‡	182.0 (169.0 to 191.0)	178.1 (164.0 to 194.0)	-0.6 (-10.1 to 10.0)	0.852
Physical comfort	56.0 (53.0 to 58.0)	55.0 (49.0 to 58.0)	0.0 (-2.0 to 4.0)	0.675
Emotional state	41.0 (36.0 to 43.0)	41.0 (37.0 to 44.0)	0.0 (-3.0 to 2.0)	0.667
Physical independence	21.0 (18.0 to 23.0)	21.0 (17.0 to 25.0)	0.0 (-3.0 to 2.0)	0.682
Psychological support	32.0 (29.0 to 33.0)	30.1 (28.0 to 35.0)	0.0 (-2.0 to 2.9)	0.773
Pain	32.0 (30.0 to 34.0)	34.0 (30.0 to 35.0)	-1.0 (-2.0 to 1.0)	0.372

Values are presented as median (interquartile range) unless otherwise indicated. *Twenty-seven patients in SNB group and 24 patients in control group. †Twenty-two patients in SNB group and 22 patients in control group. ‡Twenty-three patients in SNB group and 23 patients in control group. SNB : scalp nerve block, CI : confidence interval

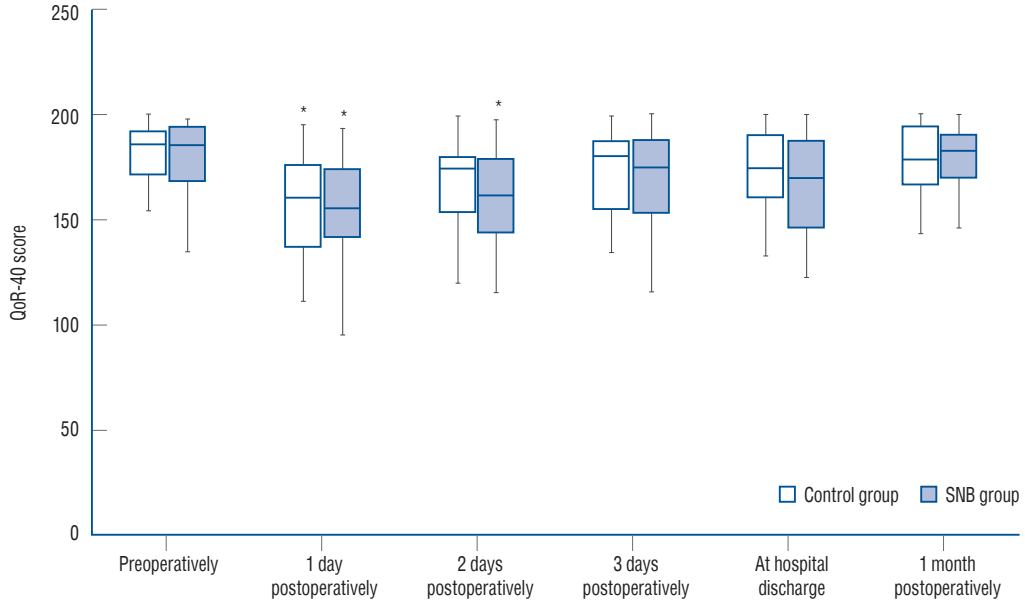

Fig. 2. Box and whiskers plot of perioperative quality of recovery (QoR)-40 scores in patient with and without scalp nerve block (SNB). *p<0.001 vs. preoperative QoR-40 scores within groups.

Table 3. Comparisons of postoperative outcomes between patients with and with scalp never block

Variable	SNB group (n=27)	Control group (n=25)	p-value
Severity of PCH*			
3 hours postoperatively	3.0 (2.0–4.0)	5.0 (3.5–5.5)	0.029
6 hours postoperatively	3.0 (2.0–5.0)	4.0 (3.0–5.0)	0.088
9 hours postoperatively	3.0 (2.0–4.0)	3.0 (2.5–5.5)	0.048
12 hours postoperatively	3.0 (2.0–4.0)	4.0 (3.0–5.0)	0.035
1 day postoperatively	3.0 (2.5–3.8)	3.2 (2.8–4.0)	0.267
2 days postoperatively	3.0 (2.5–3.8)	3.0 (2.5–3.5)	0.963
3 days postoperatively	2.5 (2.3–3.3)	2.8 (2.4–3.0)	0.876
Total amount of IV-PCA consumed (mL)			
3 hours postoperatively	2.0 (1.0–4.0)	4.0 (2.0–5.0)	0.044
6 hours postoperatively	3.0 (1.0–6.0)	5.0 (3.0–6.5)	0.203
9 hours postoperatively	3.0 (1.0–8.0)	6.0 (3.5–8.0)	0.128
12 hours postoperatively	4.0 (2.0–8.0)	7.0 (4.0–8.0)	0.207
1 day postoperatively	7.0 (4.0–15.0)	11.0 (4.5–14.0)	0.804
2 days postoperatively	13.0 (6.0–24.0)	15.0 (5.5–23.0)	0.985
3 days postoperatively	16.0 (7.0–31.0)	17.0 (5.5–26.5)	0.673
Total number of rescue analgesics administered			
3 hours postoperatively	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.447
6 hours postoperatively	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.893
9 hours postoperatively	0.0 (0.0–1.0)	0.0 (0.0–0.0)	0.417
12 hours postoperatively	1.0 (0.0–1.0)	0.0 (0.0–1.0)	0.101
1 day postoperatively	1.0 (0.0–2.0)	0.0 (0.0–1.5)	0.092

 https://doi.org/10.3340/jkns.2023.0010

Table 3. Continued

Variable	SNB group (n=27)	Control group (n=25)	*p*-value
2 days postoperatively	1.0 (0.0–3.0)	1.0 (0.0–2.0)	0.332
3 days postoperatively	1.0 (0.0–3.0)	1.0 (0.0–2.0)	0.330
Time to first administration of rescue analgesics (hours)	10.5 (5.4–14.1)	11.3 (4.2–34.0)	0.431
PONV			
3 hours postoperatively	10 (37.0)	3 (12.0)	0.078
Mild	5 (18.5)	1 (4.0)	0.193
Moderate	5 (18.5)	2 (8.0)	0.422
6 hours postoperatively	9 (33.3)	2 (8.0)	0.058
Mild	7 (25.9)	2 (8.0)	0.143
Moderate	2 (7.4)	0 (0.0)	0.491
9 hours postoperatively	4 (14.8)	4 (16.0)	1.000
Mild	3 (11.1)	2 (8.0)	1.000
Moderate	1 (3.7)	2 (8.0)	0.603
12 hours postoperatively	4 (14.8)	2 (8.0)	0.670
Mild	2 (7.4)	1 (4.0)	1.000
Moderate	2 (7.4)	1 (4.0)	1.000
1 day postoperatively	10 (37.0)	11 (44.0)	0.819
Mild	4 (14.8)	9 (36.0)	0.149
Moderate	6 (22.2)	2 (8.0)	0.252
2 days postoperatively	10 (37.0)	14 (56.0)	0.275
Mild	4 (14.8)	9 (36.0)	0.149
Moderate	6 (22.2)	5 (20.0)	1.000
3 days postoperatively	7 (25.9)	9 (36.0)	0.627
Mild	5 (18.5)	9 (36.0)	0.268
Moderate	2 (7.4)	0 (0.0)	0.491
Length of hospital stay (days)	7.0 (6.0–7.0)	7.0 (6.0–7.0)	0.984

Values are presented as medain (interquartile rage) or number (proportion). *Was assessed using a numeric rating scale (NRS; 0, no pain; 10, worst pain imaginable). SNB : scalp nerve block, PCH : postcraniotomy headache, IV-PCA : intravenous patient-controlled analgesia, PONV : postoperative nausea and vomiting

and control groups, respectively (Fig. 2).

PCH was significantly less severe 3 (NRS; 3.0 [2.0–4.0] vs. 5.0 [3.5–5.5], p=0.029), 9 (NRS; 3.0 [2.0–4.0] vs. 3.0 [2.5–5.5], p=0.048), and 12 (NRS; 3.0 [2.0–4.0] vs. 4.0 [3.0–5.0], p=0.035) hours postoperatively in the SNB group (Table 3). The total amount of IV-PCA consumed was also significantly less 3 hours postoperatively in the SNB group (2.0 [1.0–4.0] vs. 4.0 [2.0–5.0] mL, p=0.044). There were no significant differences in the total number of rescue analgesics administered, time to the first administration of rescue analgesics, incidence and severity of PONV, and length of hospital stay between the SNB and control groups. In both groups, neither SNB-related adverse events nor surgical complications were observed.

In the subgroup analysis, all demographic and intraoperative variables, perioperative QoR-40 scores, and postoperative outcomes were not significantly different between the SNB and control groups in patients who underwent craniotomy with muscle incision (Supplementary Tables 1-3). In patients who underwent minicraniotomy without muscle incision, the SNB group showed significantly less severe PCH until 6 hours postoperatively and significantly less total amount of IV-PCA consumed until 12 hours postoperatively, whereas the SNB group had a significantly longer surgical duration and a significantly higher incidence of PONV 6 hour postoperatively.

Other demographic and intraoperative variables, perioperative QoR-40 scores, and postoperative outcomes did not significantly differ between the two groups in these patients.

DISCUSSION

The importance of postoperative QoR is increasingly emphasized, but methods to improve the QoR after neurosurgery, especially craniotomy, have not yet been fully investigated[34]. To the best of our knowledge, this is the first study evaluating the effects of SNB on the QoR after craniotomy using a self-rated questionnaire. In this randomized controlled trial, SNB did not improve the QoR-40 scores but reduced PCH and IV-PCA consumption during the first few hours postoperatively in patients who underwent a minicraniotomy for clipping of UIAs.

No significant improvement in the QoR-40 scores in the SNB group may be because PCH and PONV account for relatively small proportions in the QoR-40. In the QoR-40, the number of direct questions for PCH and PONV are only 3 out of 7 and 3 out of 12 in the dimensions of pain and physical comfort, respectively[25]. Therefore, it is difficult to show a statistically significant difference in postoperative QoR-40 scores unless there is a dramatic amelioration of PCH and PONV. However, in this study, the maximum median difference in the severity of PCH was only 1 (NRS) on the day of surgery, while the incidence and severity of PONV did not significantly differ between the SNB and control groups. Furthermore, significant differences in surgical duration between the two groups could affect the QoR in the early postoperative period. Compared to conventional craniotomy, minicraniotomy generally has the advantage of reducing intraoperative loss of cerebrospinal fluid and blood as surgical duration is about half as short[8,16,27,28]. However, long surgical duration in the SNB group may have offset these advantages of minicraniotomy, causing greater discomfort and hindering early ambulation after surgery, and may have ultimately counterbalanced the benefits of SNB on postoperative QoR[31,38]. In addition, contrary to our expectation that SNB might prevent persistent PCH, SNB did not significantly affect the QoR-40 scores 1 month postoperatively[5,6,13].

As mentioned earlier, the analgesic effect of SNB, although statistically significant, was not clinically significant during the first 12 hours postoperatively in this study. This may be because the surgery was performed through a minimally invasive approach. PCH mainly originates in superficial structures, including the scalp and pericranial muscles[9]. The keyhole minicraniotomies performed in this study may have caused less trauma to the skin and temporalis muscles, resulting in reduced PCH compared to the conventional pterional craniotomy[29,40]. Thus, the analgesic effect of SNB may not have been noticeable as PCH had already been surgically minimized. Furthermore, multimodal analgesia, including IV-PCA, preemptive administration of intravenous fentanyl and acetaminophen at the end of surgery, periodic administration of acetaminophen after surgery, and active rescue analgesia, was provided equally in both groups except for SNB. Thus, it is possible that PCH was largely controlled even without SNB in the control group. Nevertheless, the control group had significantly severe PCH despite significantly more IV-PCA consumption up to 3 hours postoperatively, suggesting that SNB had significant analgesic effect in the immediate postoperative period.

Contrary to previous findings that SNB could help reduce PONV by reducing opioid consumption, the incidence and severity of PONV in this study were comparable between the SNB and control groups despite significantly more IV-PCA consumption up to 3 hours postoperatively in the control group[17,41]. This could be explained by significantly longer surgical duration in the SNB group with a mean difference of 30 minutes compared to the control group. Longer surgical duration is associated with an increased risk of PONV and a 30-minute increase in surgical duration may increase the risk of PONV by 60%[4,7,38]. Moreover, longer surgical duration in craniotomy patients also results in greater loss of cerebrospinal fluid, which is another risk factor for PONV[31,38]. Since the incidence of PONV was slightly higher in the SNB group, although not statistically significant, the negative effects of longer surgical duration on PONV may overweigh the positive effects of SNB.

In the subgroup analysis, the analgesic effect of SNB was significant during the first 12 hours postoperatively in patients who underwent minicraniotomy without muscle incision, but not in patients who underwent minicraniotomy with muscle incision. The reason for these findings is thought to be that blocking the zygomaticotemporal and auriculotemporal nerves are more essential to reduce the pain from temporalis

 https://doi.org/10.3340/jkns.2023.0010

muscle incision in the latter patients. However, the zygomaticotemporal nerve is known to have a significantly higher failure rate of landmark-guided SNB than other scalp nerves including the supratrochlear, supraorbital, auriculotemporal, lesser occipital, and greater occipital nerves, because it has many anatomical variations, such as wide distribution of emergence point form the temporalis fascia, diverse course, and various number and orientation of accessary branches, and is distributed deep below the skin[18,32,36]. In addition, the auriculotemporal nerve, which communicates with the zygomaticotemporal nerve and also innervates part of the temporalis muscles, was reported to have the second highest failure rate of landmark-guided SNB among the aforementioned six scalp nerves[32,36]. Therefore, there was a possibility that the pain from temporalis muscle incision was not effectively reduced by SNB in some patients who underwent minicraniotomy with muscle incision in this study.

This study has several limitations. First, the sample size was insufficient to compare other postoperative outcomes, particularly in the subgroup analysis, between the SNB and control groups with statistically sufficient power. Additional studies are necessary to verify the effects of SNB on postoperative outcome, especially QoR-40 scores, with statistically sufficient power in each minicraniotomy. Second, the effectiveness of landmark-guided SNB may have been greatly influenced by anatomical variations in the target nerves and surrounding structures. Although there have been no studies comparing landmark-guided and ultrasound-guided SNBs, ultrasound guidance may improve the effectiveness of SNB[37,44]. Third, the pattern of postoperative recovery may be different in patients undergoing a craniotomy for other procedures which can directly damage the brain parenchyma, such as the resection of brain tumors and arteriovenous malformations. Thus, the results of this study may not be reproducible in such patients. Fourth, in this study, SNB was performed at the end of surgery using 0.75% ropivacaine with 1 : 200000 epinephrine to maximize its analgesic effect in the postoperative period. Results may differ if the timing of SNB and the type and dose of local anesthetics and adjunctives used for SNB are different from those of this study. In particular, the use of local anesthetics with a much longer duration of action, such as liposomal bupivacaine, for SNB may further improve the QoR after craniotomy by reducing PCH for a longer time. Fifth, in this study, the sites of skull clamp were not noted and the pain from skull clamp was not investigated separately from the pain from surgical incision. In addition, because SNB was performed uniformly targeting bilateral seven scalp nerves in this study, it was difficult to know how much and long SNB reduced the pain from skull clamp. Further studies are needed to determine which scalp nerves need to be mainly blocked to effectively reduce the pain from skull clamp. Lastly, the QoR-40 was used in this study because it was the only validated tool for evaluating postoperative QoR in Korean populations at the time of this study[20]. However, there are various other tools for assessing postoperative QoR, including the QoR-15, a shortened version of the QoR-40, and Postoperative QoR Scale, and results may vary if these tools are used instead of the QoR-40[19,30,33,43].

CONCLUSION

In conclusion, this study shows that SNB did not significantly improve postoperative QoR-40 scores despite reductions in PCH and opioid consumption in the early postoperative period in patients who underwent a minicraniotomy for clipping of UIAs. Further clinical study is needed to find methods to significantly improve the QoR after minicraniotomy.

AUTHORS' DECLARATION

Conflicts of interest

No potential conflict of interest relevant to this article was reported.

Informed consent

Informed consent was obtained from all individual participants included in this study.

Author contributions

Conceptualization : YHC, YJK, HPP, WSC, HO; Formal analysis : SC, YHC, HSL, KWS; Funding acquisition : WSC; Methodology : YHC, YJK, HPP, WSC, HO; Project administration : HO; Visualization : HSL, KWS; Writing - original draft : SC, YHC; Writing - review & editing : YJK, HPP, YHC, WSC, HO

Data sharing

None

Preprint

None

ORCID

Seungeun Choi	https://orcid.org/0000-0002-9762-2492
Young Hoon Choi	https://orcid.org/0000-0003-1864-9230
Hoo Seung Lee	https://orcid.org/0000-0003-0439-0571
Kyong Won Shin	https://orcid.org/0000-0003-0563-8479
Yoon Jung Kim	https://orcid.org/0000-0003-4320-2502
Hee-Pyoung Park	https://orcid.org/0000-0002-4772-0780
Won-Sang Cho	https://orcid.org/0000-0002-3345-8718
Hyongmin Oh	https://orcid.org/0000-0001-9708-3954

• Acknowledgements

This study was presented as an abstract from KNS 2022 (October 8, 2022, Songdo Convensia Incheon, Korea).

This work was supported by a grant (number : 1120215060) from the SNUH Research Fund.

• Supplementary materials

The online-only data supplement is available with this article at https://doi.org/10.3340/jkns.2023.0010.

References

1. Akcil EF, Dilmen OK, Vehid H, Ibisoglu LS, Tunali Y : Which one is more effective for analgesia in infratentorial craniotomy? The scalp block or local anesthetic infiltration. **Clin Neurol Neurosurg 154 :** 98-103, 2017
2. Akhigbe T, Zolnourian A : Use of regional scalp block for pain management after craniotomy: review of literature and critical appraisal of evidence. **J Clin Neurosci 45 :** 44-47, 2017
3. Altman AD, Helpman L, McGee J, Samouëlian V, Auclair MH, Brar H, et al. : Enhanced recovery after surgery: implementing a new standard of surgical care. **CMAJ 191 :** E469-E475, 2019
4. Apfel CC, Kranke P, Eberhart LH, Roos A, Roewer N : Comparison of predictive models for postoperative nausea and vomiting. **Br J Anaesth 88 :** 234-240, 2002
5. Batoz H, Verdonck O, Pellerin C, Roux G, Maurette P : The analgesic properties of scalp infiltrations with ropivacaine after intracranial tumoral resection. **Anesth Analg 109 :** 240-244, 2009
6. Bowyer AJ, Royse CF : Postoperative recovery and outcomes--what are we measuring and for whom? **Anaesthesia 71 Suppl 1 :** 72-77, 2016
7. Chatterjee S, Rudra A, Sengupta S : Current concepts in the management of postoperative nausea and vomiting. **Anesthesiol Res Pract 2011 :** 748031, 2011
8. Cho WS, Kim JE, Kang HS, Son YJ, Bang JS, Oh CW : Keyhole approach and neuroendoscopy for cerebral aneurysms. **J Korean Neurosurg Soc 60 :** 275-281, 2017
9. de Gray LC, Matta BF : Acute and chronic pain following craniotomy: a review. **Anaesthesia 60 :** 693-704, 2005
10. Echeverria-Villalobos M, Stoicea N, Todeschini AB, Fiorda-Diaz J, Uribe AA, Weaver T, et al. : Enhanced recovery after surgery (ERAS): a perspective review of postoperative pain management under ERAS pathways and its role on opioid crisis in the United States. **Clin J Pain 36 :** 219-226, 2020
11. Elayat A, Jena SS, Nayak S, Sahu RN, Tripathy S : "Enhanced recovery after surgery - ERAS in elective craniotomies-a non-randomized controlled trial". **BMC Neurol 21 :** 127, 2021
12. Flexman AM, Ng JL, Gelb AW : Acute and chronic pain following craniotomy. **Curr Opin Anaesthesiol 23 :** 551-557, 2010
13. Gan TJ : Poorly controlled postoperative pain: prevalence, consequences, and prevention. **J Pain Res 10 :** 2287-2298, 2017
14. Gornall BF, Myles PS, Smith CL, Burke JA, Leslie K, Pereira MJ, et al. : Measurement of quality of recovery using the QoR-40: a quantitative systematic review. **Br J Anaesth 111 :** 161-169, 2013
15. Gottschalk A, Yaster M : The perioperative management of pain from intracranial surgery. **Neurocrit Care 10 :** 387-402, 2009
16. Hong N, Cho WS, Pang CH, Choi YH, Bae JW, Ha EJ, et al. : Treatment outcomes of 1-stage clipping of multiple unruptured intracranial aneurysms via keyhole approaches. **J Neurosurg 136 :** 475-484, 2021
17. Hwang JY, Bang JS, Oh CW, Joo JD, Park SJ, Do SH, et al. : Effect of scalp blocks with levobupivacaine on recovery profiles after craniotomy for aneurysm clipping: a randomized, double-blind, and controlled study. **World Neurosurg 83 :** 108-113, 2015
18. Janis JE, Hatef DA, Thakar H, Reece EM, McCluskey PD, Schaub TA, et al. : The zygomaticotemporal branch of the trigeminal nerve: part II. Anatomical variations. **Plast Reconstr Surg 126 :** 435-442, 2010
19. Lee JH, Ki M, Choi S, Woo CJ, Kim D, Lim H, et al. : Validity and reliability of the Korean version of the quality of recovery-15 questionnaire. **Korean J Anesthesiol 74 :** 142-149, 2021
20. Lee JH, Kim D, Seo D, Son JS, Kim DC : Validity and reliability of the Korean version of the quality of recovery-40 questionnaire. **Korean J Anesthesiol 71 :** 467-475, 2018
21. Leslie K, Troedel S, Irwin K, Pearce F, Ugoni A, Gillies R, et al. : Quality of recovery from anesthesia in neurosurgical patients. **Anesthesiology 99 :** 1158-1165, 2003
22. Liu B, Liu S, Wang Y, Zhao B, Zhao T, Zhao L, et al. : Neurosurgical enhanced recovery after surgery (ERAS) programme for elective cranioto-

mies: are patients satisfied with their experiences? A quantitative and qualitative analysis. **BMJ Open 9 :** e028706, 2019
23. Liu B, Liu S, Zheng T, Lu D, Chen L, Ma T, et al. : Neurosurgical enhanced recovery after surgery ERAS for geriatric patients undergoing elective craniotomy: a review. **Medicine (Baltimore) 101 :** e30043, 2022
24. Mancel L, Van Loon K, Lopez AM : Role of regional anesthesia in enhanced recovery after surgery (ERAS) protocols. **Curr Opin Anaesthesiol 34 :** 616-625, 2021
25. Myles PS, Weitkamp B, Jones K, Melick J, Hensen S : Validity and reliability of a postoperative quality of recovery score: the QoR-40. **Br J Anaesth 84 :** 11-15, 2000
26. Osborn I, Sebeo J : "Scalp block" during craniotomy: a classic technique revisited. **J Neurosurg Anesthesiol 22 :** 187-194, 2010
27. Park J : Superciliary keyhole approach for unruptured anterior circulation aneurysms: surgical technique, indications, and contraindications. **J Korean Neurosurg Soc 56 :** 371-374, 2014
28. Park J : Supraorbital keyhole approach for intracranial aneurysms : transitioning from concerns to confidence. **J Korean Neurosurg Soc 63 :** 4-13, 2020
29. Park JS, Kwon MY, Lee CY : Minipterional craniotomy for surgical clipping of anterior circulation aneurysms: compatibility between the feasibility, safety and efficiency. **J Cerebrovasc Endovasc Neurosurg 22 :** 65-77, 2020
30. Royse CF, Newman S, Chung F, Stygall J, McKay RE, Boldt J, et al. : Development and feasibility of a scale to assess postoperative recovery: the post-operative quality recovery scale. **Anesthesiology 113 :** 892-905, 2010
31. Sato K, Sai S, Adachi T : Is microvascular decompression surgery a high risk for postoperative nausea and vomiting in patients undergoing craniotomy? **J Anesth 27 :** 725-730, 2013
32. Sato T, Nishiwaki K : Accuracy of landmark scalp blocks performed during asleep-awake-asleep awake craniotomy: a retrospective study. **JA Clin Rep 7 :** 8, 2021
33. Stark PA, Myles PS, Burke JA : Development and psychometric evaluation of a postoperative quality of recovery score: the QoR-15. **Anesthesiology 118 :** 1332-1340, 2013
34. Stumpo V, Staartjes VE, Quddusi A, Corniola MV, Tessitore E, Schröder ML, et al. : Enhanced recovery after surgery strategies for elective craniotomy: a systematic review. **J Neurosurg 135 :** 1857-1881, 2021
35. Thompson BG, Brown RD Jr, Amin-Hanjani S, Broderick JP, Cockroft KM, Connolly ES Jr, et al. : Guidelines for the management of patients with unruptured intracranial aneurysms: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. **Stroke 46 :** 2368-2400, 2015
36. Totonchi A, Pashmini N, Guyuron B : The zygomaticotemporal branch of the trigeminal nerve: an anatomical study. **Plast Reconstr Surg 115 :** 273-277, 2005
37. Tsan SEH, Goh CH, Tan PCS : Ultrasound-guided scalp blocks for an awake craniotomy: a case report. **A A Pract 16 :** e01618, 2022
38. Uribe AA, Stoicea N, Echeverria-Villalobos M, Todeschini AB, Esparza Gutierrez A, Folea AR, et al. : Postoperative nausea and vomiting after craniotomy: an evidence-based review of general considerations, risk factors, and management. **J Neurosurg Anesthesiol 33 :** 212-220, 2021
39. Wang L, Cai H, Wang Y, Liu J, Chen T, Liu J, et al. : Enhanced recovery after elective craniotomy: a randomized controlled trial. **J Clin Anesth 76 :** 110575, 2022
40. Wong JH, Tymianski R, Radovanovic I, Tymianski M : Minimally invasive microsurgery for cerebral aneurysms. **Stroke 46 :** 2699-2706, 2015
41. Yang X, Ma J, Li K, Chen L, Dong R, Lu Y, et al. : A comparison of effects of scalp nerve block and local anesthetic infiltration on inflammatory response, hemodynamic response, and postoperative pain in patients undergoing craniotomy for cerebral aneurysms: a randomized controlled trial. **BMC Anesthesiol 19 :** 91, 2019
42. Yang Y, Ou M, Zhou H, Tan L, Hu Y, Li Y, et al. : Effect of scalp nerve block with ropivacaine on postoperative pain in patients undergoing craniotomy: a randomized, double blinded study. **Sci Rep 10 :** 2529, 2020
43. Yoon S, Joo H, Oh YM, Lee J, Bahk JH, Lee HJ : Validation and clinical utility of the Korean version of the quality of recovery-15 with enhanced recovery after surgery: a prospective observational cohort study. **Br J Anaesth 125 :** 614-621, 2020
44. Zetlaoui PJ, Gauthier E, Benhamou D : Ultrasound-guided scalp nerve blocks for neurosurgery: a narrative review. **Anaesth Crit Care Pain Med 39 :** 876-882, 2020
45. Zheng L, Hagan KB, Villarreal J, Keerty V, Chen J, Cata JP : Scalp block for glioblastoma surgery is associated with lower inflammatory scores and improved survival. **Minerva Anestesiol 83 :** 1137-1145, 2017