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RESEARCH

Hemodynamic outcomes of adult patients on scalp block using ropivacaine and lidocaine: retrospective cohort study

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ABSTRACT

Background. Hemodynamic instability can occur with the pain from scalp incision to brain retraction during cranial neurosurgery.

Objective. To determine the hemodynamic outcomes of patients who received ropivacaine plus lidocaine scalp block.

Design. Retrospective cohort study.

Setting. Southern Philippines Medical Center, Davao City.

Participants. 44 patients given scalp block for cranial neurosurgery.

Main outcome measures. Heart rate (HR), mean arterial pressure (MAP), and frequencies of tachycardia, hypertension, bradycardia, and hypotension from the time of scalp block administration to 15 minutes after scalp incision (observation period).

Main results. There were 31 (70.45%) male and 13 (20.55%) female patients in this study. The patients' mean age was 42.97 ± 17.33 years. Mean values of MAP from 5 minutes before incision to 15 minutes after incision all significantly differed from mean baseline MAP. There were no significant changes in mean HR within the observation period (p=0.2446). Among the patients, 3/44 (6.82%) had at least one episode of hypertension, 7/44 (15.91%) had at least one episode of tachycardia, 8/44 (18.18%) had at least one episode of bradycardia, and 27/44 (61.36%) had at least one episode of hypotension during the observation period.

Conclusion. The mean MAP of patients in this study significantly decreased from baseline starting from 5 minutes prior to scalp incision to 15 minutes after scalp incision. Many patients had at least one episode of hypotension, while fewer patients experienced at least one episode of hypertension, tachycardia or bradycardia.

Keywords. cranial neurosurgery, heart rate, mean arterial pressure, scalp incision

INTRODUCTION

Pain associated with scalp incision, head pinning, periosteal detachment, dural opening, and brain retraction during neurosurgery can significantly increase a patient's heart rate and blood pressure from baseline values, and can potentially lead to venous hemorrhage, increase in intracranial pressure, brain edema, or even herniation.[1 2] Performing scalp block prior to incision for a cranial neurosurgical procedure prevents pain transmission in the first-order neurons and stabilizes a patient's hemodynamics.[2 3] Blunting the hemodynamic effects of pain by scalp block decreases drug requirements for intraoperative hypertension and tachycardia, and improves postoperative recovery and pain control.[4-10]

In our setting, we use a combination of ropivacaine and lidocaine for scalp block during cranial neurosurgery. Lidocaine is an intermediate-acting local anesthetic that acts as early as 2 minutes after injection.[11] The effects of lidocaine last up to 2 hours without epinephrine,[11] and up to 5 hours with epinephrine.[12] Ropivacaine, on the other hand, is a long-acting local anesthetic, which has a slower onset of action—about 3-15 minutes after injection—but its effects, which last for at least 3 hours, usually cover the entire surgical time for most of our neurosurgical procedures.[13] Compared to bupivacaine, ropivacaine is less likely to penetrate large myelinated motor fibers and is less lipophilic. These properties of ropivacaine are associated with reduced motor blockade, as well as lesser central nervous system toxicity and cardiotoxicity.[14]

IN ESSENCE

Pain at the start of cranial neurosurgery can cause significant increases in heart rate (HR) and mean arterial pressure (MAP).

In this study among patients given ropivacaine plus lidocaine scalp block for cranial neurosurgery, the patients' mean HR did not significantly change from scalp block administration (baseline) to 15 minutes after scalp incision. Compared to the patients' mean MAP at baseline, mean MAP values from 5 minutes before incision to 15 minutes after incision were significantly lower.

The use of scalp block can help maintain hemodynamic stability during cranial neurosurgery.

We did this study to determine the hemodynamic outcomes of patients undergoing scalp block, using ropivacaine plus lidocaine combination, for cranial neurosurgical procedures.

METHODS

Study design and setting

We conducted a retrospective cohort study based on review of medical records of patients who underwent cranial neurosurgery at Southern Philippines Medical Center (SPMC) from January 2015 to July 2016. An average of five neurosurgical procedures are performed daily in the main operating room of SPMC. In our institution, scalp block is performed after general anesthesia induction by infiltrating 5% ropivacaine plus 2% lidocaine into the typical anatomical sites where the supraorbital, supratrochlear, zygomaticotemporal, auriculotemporal, greater occipital, and lesser occipital nerves emerge from the skull. Per anatomical site, 1-4 mL of the anesthetic combination is injected underneath the periosteum. Sterile preparation of the surgical site follows right after scalp block, and scalp incision is done within 10 to 15 minutes from scalp block.

Participants

Patients aged 18 years old and above who underwent either craniectomy or craniotomy under general anesthesia with ropivacaine plus lidocaine scalp block were eligible for inclusion in the study. To determine the minimum sample size for this study, we assumed that the average mean arterial pressure (MAP) of patients who underwent neurosurgery is 97.87 mmHg, with a standard deviation of 16.37 mmHg.[15] Calculation was done in order for the study to detect a 10-mmHg-difference in mean MAP between two data groups as statistically significant. In a statistical test for comparison of two means carried out at a <5% level of significance, a minimum sample size of 44 will have 80% power of rejecting the null hypothesis if the alternative holds. We included a total of 44 eligible patients into this study.

Data collection

We collected the patient's age, sex, indication for neurosurgery, comorbidities, preoperative Glasgow Coma Scale (GCS) score, and American Society of Anesthesiologists physical status classification (ASA classification).

To determine the hemodynamic effects of scalp block, we looked at the patients' serial heart rate (HR) and MAP within the following observation period: time of scalp block administration (baseline), 5 minutes before scalp incision (5BI), upon incision (UI), 5 minutes after incision (5AI), 10 minutes after incision (10AI), and 15 minutes after incision (15AI). We computed the MAP as the value of the diastolic blood pressure (DBP) multiplied by 2 and added to the value of the systolic blood pressure (SBP), then divided by 3. We also determined occurrences of tachycardia, bradycardia, hypotension, and hypertension, as well as the need for rescue analgesia postoperatively, among the patients. Tachycardia was considered when there was at least one episode of a >20% increase in HR from baseline value at any point during the observation period. Bradycardia was considered when there was at least one recorded HR of <60 beats per minute at any point during the observation period. Hypertension was considered when there was at least one episode of a >20% MAP increase from baseline value at any point during the observation period. Hypotension was considered when there was at least one episode of a >20% MAP decrease from baseline value at any point during the observation period. We also monitored the patients postoperatively to look for possible scalp block complications such as hematoma, swelling of the upper eyelid, and undesired facial nerve block.

Statistical analysis

We used Epi Info™ 7.2.1.10 and R version 3.4.1 to analyze the data. We summarized continuous data as means and standard deviations, and categorical variables as frequencies and percentages. To compare mean MAPs and mean HRs across time, we used repeated measures analysis of variance (ANOVA). We conducted simple pairwise comparisons after results of significant difference in repeated measures ANOVA. Two-sided level of significance was set at $p<0.05$. We constructed the graphs shown in this article in Google Sheets.

RESULTS

The demographic and clinical profile of the 44 patients who underwent scalp block are shown in Table 1. There were 31/44 (70.45%) males and 13/44 (29.55%) females. The mean age of the patients was 42.97 ± 17.33 years. The most common indication for neurosurgery

Characteristics	PNB (n=44)
Mean age ± SD, *years*	42.97 ± 17.33
Sex, *frequency(%)*	
Male	31 (70.45)
Female	13 (29.55)
Indication for neurosurgery, *frequency (%) n=43*	
Blunt head trauma	24 (55.81)
Brain tumor	9 (20.93)
Cerebrovascular accident	7 (16.28)
Gunshot wound	2 (4.65)
Hacking	1 (2.33)
Comorbidities, *frequency(%)*	
Hypertension	7 (15.91)
Pneumonia	1 (2.27)
ASA classification, *frequency(%)*	
ASA II	25 (56.82)
ASA III	13 (29.55)
ASA IV	5 (11.36)
ASA V	1 (2.27)
Mean GCS score ± SD	12 ± 3

Table 1 Demographic and clinical profile of patients

ASA—American Society of Anesthesiologists; GCS—Glasgow Coma Scale.

was blunt head trauma (24/44, 55.81%). Some patients had coexisting hypertension (7/44, 15.91%) or pneumonia (1/44, 2.27%). Most of the patients (25/44, 56.82%) belong to ASA II classification. The mean GCS score of the patients was 12 ± 3.

Table 2 and Figure 1 show the mean blood pressure, MAP, and HR readings during the observation period. The mean SBP, mean DBP and mean MAP values significantly differed across time (all p-values for repeated measures ANOVA <0.001). Pairwise comparisons revealed that the mean values of SBP, DBP and MAP from 5BI to 15AI all significantly differed from their respective baseline values. The mean HR readings had a decreasing trend, but the values across time were not significantly different from each other (p=0.2446).

Table 3 shows the proportions of patients who had at least one episode of significant hemodynamic change during the study period. Hypertension occurred in 3/44 (6.82%) patients, tachycardia occurred in 7/44 (15.91%) patients, and bradycardia occurred in 8/44 (18.18%) of patients. Hypotension, which happened in 27/44 (61.36%) patients, was the most frequent hemodynamic change.

Postoperatively, 3/44 (6.82%) patients required rescue analgesia. None of the patients in this study experienced hematoma at the infiltration site, swelling of upper eyelids, or undesired facial nerve block.

DISCUSSION

Key results

In this group of patients undergoing cranial neurosurgery, the mean MAP values from 5 minutes prior to scalp incision to 15 minutes after scalp incision were significantly lower compared to the mean baseline MAP at the time of scalp block administration using ropivacaine plus lidocaine. Mean HR did not significantly change from scalp block administration up to 15 minutes after scalp incision. Hypotension was the most frequent hemodynamic change. A few patients had at least one episode of hypertension, tachycardia or bradycardia during the observation period.

Limitations

This study was limited only to adult patients undergoing cranial neurosurgery, and we only looked at the hemodynamic responses of the patients to ropivacaine and lidocaine. Children who undergo the same procedures for the same indications may have different hemodynamic response patterns. Systemic responses to the anesthetic agents may include neurotoxicity and cardiotoxicity, which we did not directly measure in this study. Moreover, this was a non-interventional study. The study had only one treatment arm using the same anesthetic cocktail. The decision to use the scalp block procedure on top of the standard anesthesia for cranial neurosurgery was made by the patients' respective attending

Table 2 Mean systolic blood pressure, diastolic blood pressure, mean arterial pressure, and heart rate across time

Characteristics	Baseline n=44	5BI n=44	UI n=44	5AI n=44	10AI n=44	15AI n=44	p-value
Mean systolic blood pressure ± SD, *mmHg*	137.32 ± 26.45	113.30 ± 24.05	111.02 ± 21.82	110.07 ± 19.72	107.52 ± 20.29	104.07 ± 17.30	<0.0001
Mean diastolic blood pressure ± SD, *mmHg*	76.80 ± 16.06	62.86 ± 15.07	61.09 ± 14.80	61.18 ± 14.78	58.72 ± 12.76	57.36 ± 12.76	<0.0001
Mean mean arterial pressure ± SD, *mmHg*	96.97 ± 18.46	79.67 ± 17.26	77.73 ± 16.49	77.48 ± 15.57	74.99 ± 14.64	72.93 ± 13.37	<0.0001
Mean heart rate ± SD, *beats per minute*	89.07 ± 25.01	83.32 ± 21.58	82.05 ± 21.35	80.69 ± 21.34	78.68 ± 20.27	78.82 ± 22.45	0.2446

Baseline—at the time of scalp block administration; 5BI—5 minutes before scalp incision; UI—upon scalp incision; 5AI—5 minutes after incision; 10AI—10 minutes after incision; 15AI—15 minutes after incision.

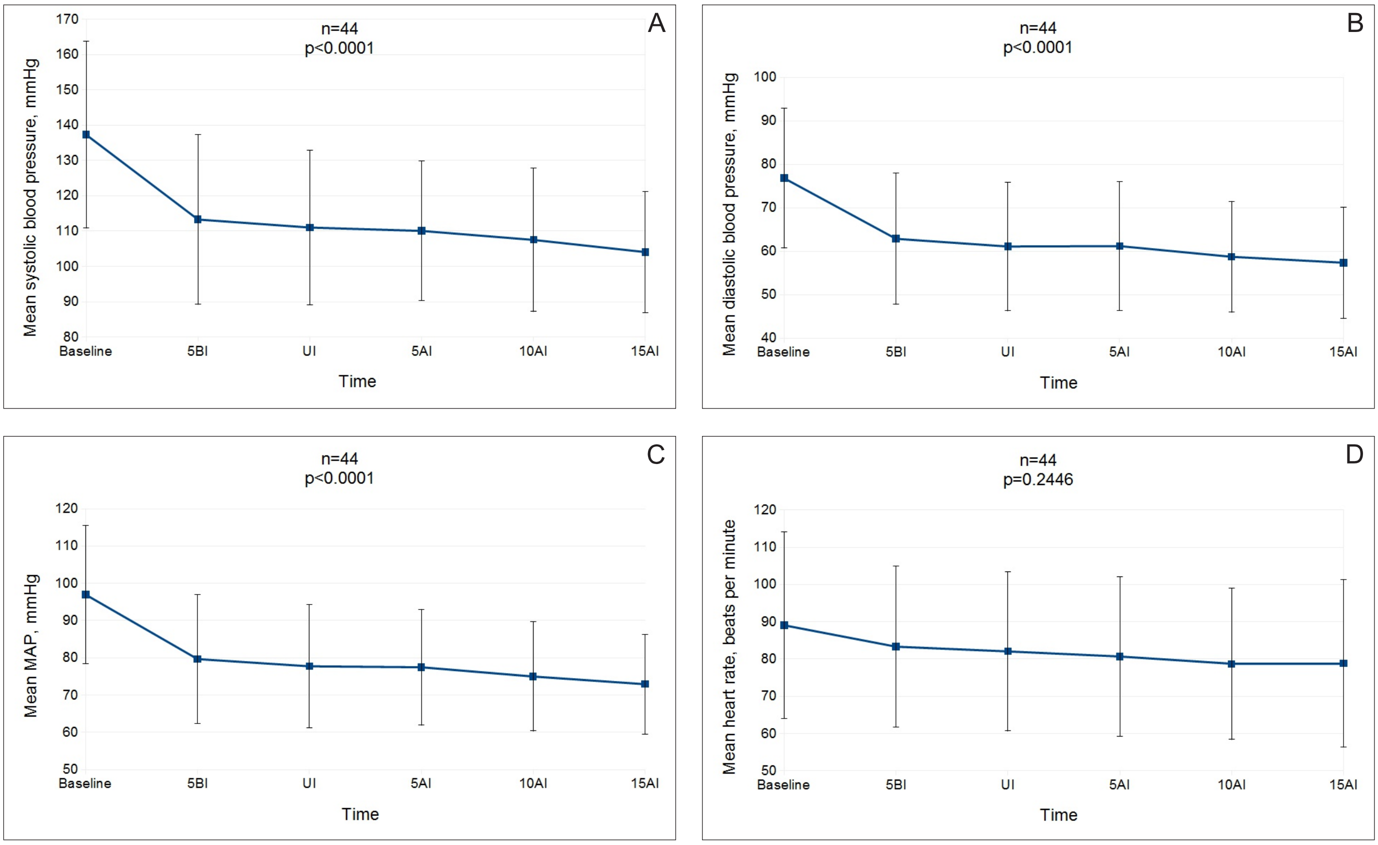

Figure 1 Systolic (A) and diastolic (B) blood pressures, mean arterial pressure (MAP; C), and heart rate (D) graphs of patients who underwent cranial neurosurgery at the time of scalp block administration (Baseline), 5 minutes before incision (5BI), upon incision (UI), 5 minutes after incision (5AI), 10 minutes after incision (10AI), and 15 minutes after incision (15AI).

anesthesiologists, and we merely observed the outcomes after the procedures.

Interpretation

HR and MAP, as well as the levels of the stress hormones adrenocorticotropic hormone (ACTH) and cortisol, significantly increase upon insertion of skull pins into the periosteum during neurosurgery.[2] Pain associated with scalp incision, head pinning, periosteum detachment, and dural opening may result in tachycardia and hypertension.[16] In one study among patients given scalp block before head pinning for craniotomy, 53.3% of patients who received placebo scalp block required additional medications to control intraoperative hypertension and tachycardia, while only 3.3% of patients given bupivacaine scalp block and 6.6% of patients given levobupivacaine scalp block needed the extra medications.[8]

Scalp block using bupivacaine with or without epinephrine helps stabilize hemodynamics and decreases plasma cortisol and ACTH levels during neurosurgery.[2,4-6,8,17-19] On the other hand, either direct infiltration of bupivacaine at pin insertion sites or opioid administration alone, without scalp block, significantly increases HR, MAP, cortisol, and ACTH during neurosurgery.[2] However, bupivacaine is cardiotoxic.[20-23]

The combination of lidocaine and ropivacaine provides faster onset and longer duration of anesthetic action, resulting in better pain control. The onset of action of lidocaine is approximately 2-10 minutes,[11,13] and its duration of action is up to 2 hours if given alone[11,13] and up to 5 hours if administered with epinephrine.[12] The onset of action of ropivacaine, a long acting amide,[14]

Table 3 Hemodynamic changes

Outcomes*	Values n=44
Bradycardia, *frequency (%)*	8 (18.18)
Tachycardia, *frequency (%)*	7 (15.91)
Hypotension, *frequency (%)*	27 (61.36)
Hypertension, *frequency (%)*	3 (6.82)

*At least one episode from scalp block administration to 15 minutes after scalp incision.

occurs at 10-15 minutes, and the duration of action lasts for 3 to 12 hours.[13] Compared to bupivacaine, ropivacaine acts faster when used as peripheral nerve block and is less cardiotoxic.[14]

Among the patients in this study, 15.91% had at least one episode of tachycardia, and 6.82% had at least one episode of hypertension during the observation period. Scalp block involves administration of local anesthesia around the nerves of the scalp. This provides analgesia for a certain period of time.[24] The addition of local anesthesia to decrease the impact of local nerve stimulation at the start of cranial neurosurgery attenuates the anticipated hemodynamic responses in many patients.[25]

Some of the patients had at least one episode of bradycardia, and 61.36% had at least one episode of hypotension during the observation period. Mild hypotension is observed in general anesthesia due to the reduction of cardiac output and systemic vascular resistance brought about by intravenous and inhalational agents.[26] More rarely, severe bradycardia and hypotension after scalp block can happen as a result of the stimulation of any branch of the trigeminal nerve[27]—including the supraorbital, supratrochlear, zygomaticotemporal, and auriculotemporal nerves—during anesthetic infiltration. The mechanical compression or stretch of these nerves during local anesthetic infiltration can trigger the trigeminal cardiac reflex, which manifests as bradycardia and hypotension.[27 28]

In this study, only three patients needed postoperative rescue analgesia. C nerve fibers richly innervate the scalp, and ropivacaine has selective action on sensory Aδ and C fibers.[29] Moreover, scalp block with ropivacaine has been shown to decrease postcraniotomy pain.[30]

None of the patients in this study experienced complications of the procedure around the infiltration site. Scalp block complications, which are few and rare, include hematoma at the site of infiltration, swelling of the upper eyelid, and undesired facial nerve block.[31 32] Hematoma formation and swollen upper eyelids are direct consequences of blood and fluids that accumulate along the aponeuroses during local anesthesia infiltration. Undesired facial nerve block occurs when, upon blockade of the auriculotemporal nerve, the adjacent facial nerve is also inadvertently blocked.[31 33]

Generalizability

This study was done among patients who underwent cranial neurosurgery under general anesthesia with scalp block. We included male and female patients who were, on average, within middle age. The ranges of indications for neurosurgery and ASA classifications across all patients were broad. The use of ropivacaine plus lidocaine on patients for scalp block prior to scalp incision, on top of general anesthesia, provided acceptable hemodynamic stability during the part in the surgery when tachycardia and hypertension would have been expected in most of the patients. The use of both the technique and the local anesthetic combination can be reasonably applied to adult patients undergoing similar procedures.

CONCLUSION

Compared to the mean baseline MAP upon scalp block administration using lidocaine and ropivacaine, the mean MAP of patients who underwent cranial neurosurgery significantly decreased from 5 minutes before scalp incision to 15 minutes after scalp incision. There was no significant change in mean HR from administration of scalp block up to 15 minutes after incision. The most common hemodynamic change was hypotension. Some patients experienced at least one episode of hypertension, tachycardia or bradycardia.

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Ethics approval

This study was reviewed and approved by the Department of Health XI Cluster Ethics Review Committee (DOH XI CERC reference P16030901).

Reporting guideline used

STROBE Checklist (http://www.strobe-statement.org/fileadmin/Strobe/uploads/checklists/STROBE_checklist_v4_combined.pdf)

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REFERENCES

1. Olsen KS, Pedersen CB, Madsen JB, Ravn LI, Schifter S. Vasoactive modulators during and after craniotomy: relation to postoperative hypertension. J Neurosurg Anesthesiol. 2002;14(3):171-9.

2. Geze S, Yilmaz AA, Tuzuner F. The effect of scalp block and local infiltration on the haemodynamic and stress response to skull-pin placement for craniotomy. Eur J Anaesthesiol. 2009;26(4):298-303.

3. Bala I, Gupta B, Bhardwaj N, Ghai B, Khosla VK. Effect of scalp block on postoperative pain relief in craniotomy patients. Australian Society of Anaesthetists. 2006;34(2).

4. Lee EJ, Lee MY, Shyr MH, Cheng JT, Toung TJ, Mirski MA, et al. Adjuvant bupivacaine scalp block facilitates stabilization of hemodynamics in patients undergoing craniotomy with general anesthesia: a preliminary report. J Clin Anesth. 2006;18(7):490-4.

5. Bloomfield EL, Schubert A, Secic M, Barnett G, Shutway F, Ebrahim ZY. The influence of scalp infiltration with bupivacaine on hemodynamics and postoperative pain in adult patients undergoing craniotomy. Anesth Analg. 1998;87(3):579-82.

6. Abbass O, Hussien G, Aboeldahab H, Othman S, Fareed M. Does scalp block with general anesthesia in craniotomy affect the intraoperative course and outcome in geriatric patients? Ain-Shams J Anesthesiol. 2015;8(1):25-30.

7. Sebeo J, Osborn I. The use of "scalp block" in pediatric patients. OJanes. 2012; 2:70-73.

8. Can BO, Bilgin H. Effects of scalp block with bupivacaine versus levobupivacaine on haemodynamic response to head pinning and comparative efficacies in postoperative analgesia: A randomized controlled trial. J Int Med Res. 2017;45(2):439-50.

9. Bala I, Gupta B, Bhardwaj N, Ghai B, Khosla VK. Effect of scalp block on postoperative pain relief in craniotomy patients. Anaesth Intensive Care. 2006;34(2):224-7.

10. Uchino H, Ushijima K, Ikeda Y, editors. Neuroanesthesia and cerebrospinal protection. Tokyo: Springer; 2015.

11. Clinicaltrials.gov [Internet]. Vancouver: University of British Columbia; c2015 [cited 2017 December 31]. Bupivacaine versus lidocaine local anesthesia. Available from: https://clinicaltrials.gov/ct2/show/NCT01751347.

12. Gadsden J. Local anesthetics: clinical pharmacology and rational selection [Internet]. New York: The New York School of Regional Anesthesia; c2017 [cited 2017 December 31]. Available from: https://www.nysora.com/local-anesthetics-clinical-pharmacology-and-rational-selection.

13. Koupparis, L. Pharmacology of regional anesthesia [Internet]. AnestheisaUK. 2007 [cited 2017 December 31]. Available from: http://www.frca.co.uk/article.aspx?articleid=100816.

14. Kuthiala G, Chaudhary G. Ropivacaine: A review of its pharmacology and clinical use. Indian J Anaesth. 2011;55(2):104-10.

15. Singh G. Comparison of the effects of ropivacaine scalp block versus dexmedetomedine infusion on haemodynamic response to skull pin insertion in neurosurgical patients [dissertation]. Kerala, India: Sree Chitra Tirunal Institute for Medical Sciences and Technology. 2012. 81 p.

16. Kumar M, Levine J, Schuster J, Kofke WA, editors. Neurocritical Care Management of the Neurosurgical Patient. 1st ed. Philadelphia: Elsevier Saunders; 2017.

17. Manal el Gohary M, Gamil K, Nabil G, Nabil S. Scalp nerve block in children undergoing a supratentorial craniotomy; A randomized con-trolled study. Asian J Sci Res. 2009; 2:105-112.

18. Pinosky ML, Fishman RL, Reeves ST, Harvey SC, Patel S, Palesch Y, et al. The effect of bupivacaine skull block on the hemodynamic response to craniotomy. Anesth Analg. 1996;83(6):1256-61.

19. Mohammadi SS, Shahbazian E, Shoeibi G, Almassi F. Effect of scalp infiltration with Bupivacaine on early hemodynamic responses during craniotomy under general anesthesia. Pak J Biol Sci. 2009;12(7):603-6.

20. Albright GA. Cardiac arrest following regional anesthesia with etidocaine or bupivacaine. Anesthesiology. 1979;51(4):285-287.

21. Vijay BS, Mitra S, Jamil SN. Refractory cardiac arrest due to inadvertent intravenous injection of 0.25% bupivacaine used for local infiltration anesthesia. Anesth Essays Res. 2013;7(1):130-2.

22. Beilin Y, Halpern S. Focused review: ropivacaine versus bupivacaine for epidural labor analgesia. Anesth Analg. 2010; 111(2):482-7.

23. Levsky ME, Miller MA. Cardiovascular collapse from low dose bupivacaine. Can J Clin Pharmacol. 2005;12(3):e240-5.

24. Tonkovic D, Stambolija V, Lozic M, Martinovic P, Pavlovic DB, Sekulic A, et al. Scalp block for hemodynamic stability during neurosurgery. Period Biol. 2015;117(2):247-50.

25. Vacas S, Van de Wiele B. Designing a pain management protocol for craniotomy: A narrative review and consideration of promising practices. Surg Neurol Int. 2017;8:291.

26. Bryant H, Bromhead H. Intraoperative hypotension. Anaesthesia tutorial of the week 148. 2009 Aug.

27. Meuwly C, Golanov E, Chowdhury T, Erne P, Schaller B. Trigeminal cardiac reflex: new thinking model about the definition based on a literature review. Medicine (Baltimore). 2015;94(5).

28. Singh G, Chowdhury T. Brain and heart connections: The trigeminocardiac reflex! J Neuroanaesthesiol Crit Care. 2017;4(2):71-77.

29. Haldar R, Kaushal A, Gupta D, Srivastava S, Singh P. Pain following craniotomy: reassessment of the available options. Biomed Res Int. 2015 Apr;2015.

30. Nguyen A, Girard F, Boudreault D, Fugere F, Ruel M, Moumdjian R, et al. Scalp nerve blocks decrease the severity of pain after craniotomy. Anesth Analg. 2001;93(5):1272-76.

31. McNicholas E, Bilotta F, Titi L, Chandler J, Rosa G, Koht A. Transient facial nerve palsy after auriculotemporal nerve block in awake craniotomy patients. A A Case Rep. 2014;2(4):40-3.

32. Guilfoyle M, Helmy A, Duane D, Hutchinson A. Regional scalpblock for postcraniatomy analgesia: a systemic review and meta-analysis. Anesth Analg. 2013 May;116(5):1093-102.

33. Bebawy JF, Bilotta F, Koht A. A modified technique for auriculotemporal nevre blockade when performing selective scalp nerve block for craniotomy. J Neurosurg Anesthesiol 2014;26(3):271-2.