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Comparison Of Nerve Injury In Scalp Block Performed On Male Wistar Rats (Rattus Norvegicus) Using Sharp Versus Blunt Needles

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ABSTRACT

Background: Scalp block is a regional anesthesia technique commonly used in neurosurgical procedures such as craniotomy to reduce perioperative pain, decrease opioid requirements, and maintain hemodynamic stability. However, complications such as nerve injury may occur, and the needle type used plays a critical role. Sharp needles can directly penetrate the fasciculus, leading to axonal injury, while blunt needles tend to cause milder compressive trauma.

Objective: To compare the degree of nerve injury caused by sharp and blunt needles in scalp block using Wistar rats (Rattus norvegicus) as an experimental model.

Methods: A randomized post-test only experimental study was performed on 22 healthy male Wistar rats (6–8 weeks, 150–200 g), divided into sharp and blunt needle groups. Bilateral scalp block was performed at the supraorbital, auriculotemporal, and occipital nerves using 0.2% ropivacaine. After 24 hours, nerve tissue was harvested and examined histopathologically with Hematoxylin–Eosin staining. Injury severity was graded using Steinfeldt's scoring system (0–4).

Results: The sharp needle group showed significantly higher nerve injury scores than the blunt group. Sharp needles more frequently caused grade 3–4 injuries, particularly at the supraorbital and auriculotemporal sites ($p=0.031$ and $p=0.001$), while blunt needles mostly resulted in grade 2 injuries. No significant difference was observed in the occipital block ($p=0.108$). Overall, injury severity was significantly greater in the sharp needle group ($p=0.005$).

Conclusion: The type of needle plays a role in determining the degree of nerve injury in scalp block procedures. Blunt needles have been shown to cause less severe nerve damage compared to sharp needles.

KEYWORDS: Scalp block, nerve injury, sharp needle, blunt needle, histopathology, Wistar rats.

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INTRODUCTION

Scalp block is a regional anesthesia technique commonly used in craniotomy procedures and various other neurosurgical interventions. This technique aims to minimize perioperative pain and reduce opioid consumption, which may interfere with postoperative neurological monitoring (Chen et al., 2022). Scalp block has been shown to significantly decrease postoperative pain scores and prolong the duration of analgesia without increasing the risk of systemic complications (Pasa et al., 2020). In addition, the use of scalp block with ropivacaine has also been shown to reduce the inflammatory response, as indicated by decreased levels of interleukin-1β (IL-1β), as well as lower Critical-Care Pain Observation Tool (CPOT) scores and postoperative fentanyl requirements (Karamoy et al., 2024). Scalp block with ropivacaine has been shown to inhibits the release of inflammatory mediators, including nitric oxide (NO), prostaglandin E_2 (PGE_2), as well as proinflammatory cytokines such as TNF-α, IL-6, and IL-1β (Desiree et al., 2024).

Despite its significant analgesic benefits, scalp block carries a potential risk of complications, including nerve injury. Nerve injury following a nerve block is defined as postoperative neurological symptoms or dysfunction attributable to the procedure (Bais et al., 2024). The American Society of Regional Anesthesia and Pain Medicine reported that the incidence of nerve injury after regional anesthesia ranges from 1% to 2.2% within the first three months after injury, decreasing to 0%–0.2% after one year (Neal et al., 2015).

These injuries may occur through several mechanisms, such as mechanical trauma due to needle penetration, local anesthetic neurotoxicity, vascular compromise, excessive injection pressure, or post-procedural inflammatory responses (O'Flaherty et al., 2018).Among these, mechanical trauma is one of the primary causes of nerve injury in scalp block procedures, where penetration of the needle into or too close to nerve fibers may damage the epineurium, perineurium, and endoneurium. Such structural disruption can impair nerve impulse conduction and increase the risk of neuropathic pain (Brull et al., 2015).

This study aims to compare the degree of nerve injury resulting from scalp block using sharp versus blunt needles in a rat model. The parameters evaluated include histological changes in nerve tissue, inflammatory signs, and the extent of nerve damage associated with each anesthetic technique. The findings of this study are expected to contribute to the development of safer and more effective nerve block techniques and help reduce the risk of neurological complications following regional anesthesia.

MATERIAL AND METHODS

Study Design

This study was an experimental (true experimental) research employing a randomized post-test only control group design with random allocation (Randomized Controlled Trial). Ethical approval was obtained from the Ethics Committee for Basic and Clinical Research, Faculty of Veterinary Medicine, Universitas Airlangga, Surabaya, Indonesia (No. 2.KEH.105.07.2025). All data were processed and analyzed using SPSS.

Animal Sample

A total of 22 healthy male Wistar rats (Rattus norvegicus), weighing 150–200 grams and aged 6–8 weeks, were included in this study. Animals were selected based on normal physical condition and were randomly assigned into two groups, group I receiving scalp block using a sharp needle and group II receiving scalp block using a blunt needle.

Intervention

Two types of needles were used for the scalp block procedure in the rat model:

a. Sharp needle: A standard hypodermic needle with a pointed tip, designed for direct tissue penetration.
b. Blunt needle: A needle with a rounded, non-cutting tip, typically used to minimize tissue and nerve trauma.

Bilateral scalp blocks were performed using 0.2% ropivacaine at three anatomically determined sites corresponding to the sensory innervation of the rat's scalp. The supraorbital and supratrochlear nerves were blocked at points located 3 mm posterior to the mid-pupillary line. The auriculotemporal and zygomatic nerves were blocked 2 mm anterior and inferior to the tragus. The minor and major occipital nerves were blocked 4 mm lateral to the posterior midline of the head. Injections were administered using a 1 mL syringe equipped with a 30G needle (sharp or blunt) at a 45° angle to optimize anesthetic distribution. All groups received identical volumes and doses of ropivacaine to ensure that any observed differences were attributable solely to the needle type used.

At 24 hours post-procedure, animals were euthanized by anesthetic overdose. Tissue sample from the injection site was harvested, fixed in 10% neutral-buffered formalin, processed via paraffin embedding, sectioned using a microtome, and stained with H&E. Histological examination focused on identifying signs of nerve damage, including axonal degeneration, edema, inflammatory cell infiltration, and neuronal morphological alterations.

Pain and Nerve Injury Assessment

Post-procedural nerve injury was evaluated through histopathological examination using hematoxylin–eosin (H&E) staining and, when indicated, immunohistochemistry to assess morphological and inflammatory changes in the nerve fiber. The degree of nerve injury was graded on a histopathological scale as follows:

a. 0 = no evidence of nerve injury or inflammation
b. 1 = mild accumulation of inflammatory cells with minimal perivascular infiltration and intact myelin
c. 2 = moderate inflammatory infiltration around the nerve without myelin damage
d. 3 = marked inflammation with perineural hematoma but preserved myelin
e. 4 = severe inflammation with evident myelin degeneration, characterized by loose and swollen myelin sheaths.

For the supraorbital, auriculotemporal, and zygomaticotemporal nerves, two histological samples were collected from both the right and left hemispheres, while for the occipital nerve, only one sample was obtained.

RESULT

A total of 22 male Wistar rats (Rattus norvegicus) aged 6–8 weeks and weighing 150–200 g were included and evenly randomized into two groups: sharp needle (S) and blunt needle (B). All animals completed the study without mortality or observable systemic complications. Baseline body weight was comparable between groups (mean ± SD: 174.45 ± 10.32 g vs. 172.27 ± 9.87 g; $p = 0.709$). Shapiro–Wilk tests confirmed normal distribution of data ($p > 0.05$).

The degree of nerve injury following scalp block was assessed based on the histopathological scoring system described previously. Comparisons were made between the two treatment groups, sharp needle and blunt needle, across three major anatomical regions corresponding to the blocked nerves: the supraorbital, auriculotemporal –zygomaticotemporal, and occipital regions. The distribution of nerve injury scores and their statistical comparisons are summarized in Table 2

Table 1. Comparison between Sharp and Blunt Needle In Scalp Block

Grade	Sharp needle [n (%)]	Blunt needle [n (%)]	p-Value*
Supraorbital			
1	0 (0.0%)	3 (13.6%)	0.031
2	15 (68.2%)	3 (13.6%)	
3	7 (31.8%)	14 (63.6%)	
4	0 (0.0%)	2 (9.1%)	
Auriculotemporal and *Zygomaticotemporal*			
1	0 (0.0%)	3 (13.6%)	0.001
2	18 (81.8%)	1 (4.5%)	
3	4 (18.2%)	14 (63.6%)	
4	0 (0.0%)	4 (18.2%)	
Occipital			
1	0 (0.0)	2 (18.2)	0.108
2	3 (27.3)	4 (36.4)	
3	7 (63.6)	5 (45.5)	
4	1 (9.1)	0 (0.0)	
All sites			
1	0 (0.0%)	3 (13.6%)	0.005
2	18 (81.8%)	3 (13.6%)	
3	4 (18.2%)	15 (68.2%)	
4	0 (0.0%)	1 (4.5%)	

**Significant if p < 0,05*

The comparison of nerve injury scores between the use of sharp and blunt needles in scalp block procedures is presented in Table 1. Histopathological evaluation of the supraorbital region revealed a statistically significant difference between groups (p = 0.031). The majority of rats in the sharp needle group demonstrated mild nerve injury (Grade 2; 68.2%), while the blunt needle group showed a higher proportion of moderate to severe injury (Grade 3–4; 72.7%).

In the auriculotemporal and zygomaticotemporal regions, the difference between groups was also statistically significant (p = 0.001). Most rats in the sharp needle group exhibited mild nerve injury (Grade 2; 81.8%), whereas in the blunt needle group, the predominant finding was moderate injury (Grade 3; 63.6%).

In contrast, the occipital region showed no statistically significant difference between groups (p = 0.108). Both groups demonstrated varying degrees of injury, with the sharp needle group predominantly showing moderate injury (Grade 3; 63.6%) and the blunt needle group showing similar findings (Grade 3; 45.5%).

When all sites were analyzed collectively, a significant difference was observed between the two groups (p = 0.005). The sharp needle group exhibited primarily mild injury (Grade 2; 81.8%), whereas the blunt needle group showed a greater tendency toward moderate to severe injury (Grade 3–4; 68.2%). These findings suggest that the use of a blunt needle in scalp block procedures may increase the risk of nerve injury compared with the sharp needle

DISCUSSION

Scalp block offers substantial postoperative analgesic benefits. A meta-analysis by Chen et al. (2022), involving 12 randomized controlled trials, demonstrated that scalp block significantly reduced postoperative pain scores and opioid consumption within the first 24 hours, with a low incidence of systemic complications. However, despite its safety, the technique carries an inherent risk of nerve injury related to needle penetration or inadvertent intraneural injection. Nerve injury mechanisms are multifactorial, including mechanical trauma, ischemia, and local anesthetic neurotoxicity (Bais et al., 2024; O'Flaherty et al., 2018).

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This study compared histopathological nerve injury induced by sharp and blunt needles during scalp block in a rat model. When all injection sites were analyzed collectively, sharp needles produced significantly more severe nerve injury compared with blunt needles ($p = 0.005$). Regionally, significant differences were found in the supraorbital ($p = 0.031$) and auriculotemporal–zygomaticotemporal ($p = 0.001$) blocks, where sharp needles predominantly caused grade 3–4 injuries, while blunt needles mostly resulted in grade 2 lesions. No significant difference was observed in the occipital region ($p = 0.108$), likely due to anatomical depth variation and the technical limitations of landmark-based approaches.

These findings support the hypothesis that blunt or atraumatic needles reduce direct fascicular trauma by displacing rather than cutting tissue. Similar evidence has been reported in clinical studies, where atraumatic or pencil-point needles significantly reduced post-dural puncture headache and intravascular injection rates compared with cutting needles(Kim et al., 2019; Nath et al., 2018; Yaseen et al., 2025). Sharp bevels facilitate perineural or intraneural penetration, increasing the risk of axonotmesis or neurotmesis (Brull et al., 2015), whereas blunt needles generally induce milder epineurial compression injuries.

Technical factors also influence injury severity. Injection pressure above 15 psi has been associated with intraneural delivery and nerve damage, whereas controlled pressure and flow rates minimize risk (Carassiti et al., 2019). Moreover, ultrasound guidance improves accuracy and reduces mechanical trauma compared to landmark techniques(Tafrishinejad, 2025; Zetlaoui et al., 2020). Although this study supports the use of blunt needles for safer regional anesthesia, several limitations must be acknowledged . The rat model may not fully represent human neuroanatomy, and histopathological evaluation alone cannot determine the functional impact or reversibility of injury (Robinson, 2022). Future studies incorporating electrophysiological assessment and long-term regeneration analysis in larger animal models are warranted to validate these findings for clinical trial

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CONCLUSION

The use of a blunt-tipped needle in scalp block procedures proved to be safer for nerve tissue, producing less mechanical trauma and inflammation compared to a sharp needle. Histological findings indicated that sharp needles caused more severe structural and inflammatory damage, while blunt needles resulted in milder injury. Therefore, blunt atraumatic needles are recommended to minimize nerve injury risk. Further studies incorporating electrophysiological assessments are warranted to correlate histological damage with functional outcomes.

REFERENCES

1. Bais, K., Guirguis, F., & Guirguis, M. (2024). Nerve Injury Following Regional Nerve Block: A Literature Review of Its Etiologies, Risk Factors, and Prevention. Current Pain and Headache Reports, 28(9), 863–868. https://doi.org/10.1007/s11916-024-01268-w
2. Brull, R., Hadzic, A., Reina, M. A., & Barrington, M. J. (2015). Pathophysiology and Etiology of Nerve Injury Following Peripheral Nerve Blockade. Regional Anesthesia and Pain Medicine, 40(5), 479–490. https://doi.org/10.1097/AAP.0000000000000125
3. Carassiti, M., De Filippis, A., Palermo, P., Valenti, C., Costa, F., Massaroni, C., & Schena, E. (2019). Injection pressures measuring for a safe peripheral nerve block. Minerva Anestesiologica, 85(9). https://doi.org/10.23736/S0375-9393.19.13518-3
4. Chen, Y., Ni, J., Li, X., Zhou, J., & Chen, G. (2022). Scalp block for postoperative pain after craniotomy: A meta-analysis of randomized control trials. Frontiers in Surgery, 9. https://doi.org/10.3389/fsurg.2022.1018511
5. Desiree, P., Airlangga, P. S., Kriswidyatomo, P., Waloejo, C. S., Hamzah, Santosa, D. A., Semedi, B. P., Susila, D., Karamoy, O. O., Komarullah, N. S., Lestari, P., & Pandi, M. G. R. (2024). Effect of scalp block with 0.5% ropivacaine on interleukin-6 and neutrophil lymphocyte ratio in elective craniotomy. Bali Medical Journal (Bali MedJ) 2024, Volume 13, Number 1: 668-674
6. Karamoy, O. O., Airlangga, P. S., Kriswidyatomo, P., Waloejo, C. S., Hamzah, Santosa, D. A., Semedi, B. P., Susila, D., Komarullah, N. S., Desiree, P., Lestari, P., & Pandi, M. G. R. (2024). Effect of scalp nerve block with ropivacaine on interleukin-1β, critical-care pain observation tool (CPOT), and fentanyl dose in elective craniotomy patients. Bali Medical Journal, 14(1), 51–58. https://doi.org/10.15562/bmj.v14i1.5331
7. Kim, J. Y., Kim, S. N., Park, C., Lim, H. Y., & Kim, J. H. (2019). Effect of needle type on intravascular injection in transforaminal epidural injection: a meta-analysis. The Korean Journal of Pain, 32(1), 39. https://doi.org/10.3344/kjp.2019.32.1.39
8. Moharari, R. S., Emami, P., Neishaboury, M., Sharifnia, S. H., Kianpour, P., Hatam, M., Etezadi, F., Khajavi, M., Najafi, A., Pourrashidi, A., & Pourfakhr, P. (2024). Scalp Nerve Block for Enhanced Pain Control and Analgesic Optimization in Elective Craniotomy: A Randomized Controlled Trial with Analgesia Nociception Index Monitoring. World Neurosurgery, 189, e55–e60. https://doi.org/10.1016/j.wneu.2024.05.144
9. Nath, S., Koziarz, A., Badhiwala, J. H., Alhazzani, W., Jaeschke, R., Sharma, S., Banfield, L., Shoamanesh, A., Singh, S., Nassiri, F., Oczkowski, W., Belley-Côté, E., Truant, R., Reddy, K., Meade, M. O., Farrokhyar, F., Bala, M. M., Alshamsi, F., Krag, M., … Almenawer, S. A. (2018). Atraumatic versus conventional lumbar puncture needles: a systematic review and meta-analysis. The Lancet, 391(10126), 1197–1204. https://doi.org/10.1016/S0140-6736(17)32451-0
10. Neal, J. M., Barrington, M. J., Brull, R., Hadzic, A., Hebl, J. R., Horlocker, T. T., Huntoon, M. A., Kopp, S. L., Rathmell, J. P., & Watson, J. C. (2015). The Second ASRA Practice Advisory on Neurologic Complications Associated With Regional Anesthesia and Pain Medicine. Regional Anesthesia and Pain Medicine, 40(5), 401–430.

https://doi.org/10.1097/AAP.0000000000000286
11. O'Flaherty, D., McCartney, C. J. L., & Ng, S. C. (2018). Nerve injury after peripheral nerve blockade—current understanding and guidelines. BJA Education, 18(12), 384–390. https://doi.org/10.1016/j.bjae.2018.09.004
12. Pasa, M. A., Waloejo, C. S., Sulistiawan, S. S., Utariani, A. (2020). Effects Of Regional Scalp block With Ropivacaine 0.5% Preincision As A Preemptive Analgesia After Craniotomy Surgery. Jurnal Widya Medika Vol. 6 No 1 April 2020
13. Robinson, L. R. (2022). Traumatic injury to peripheral nerves. Muscle & Nerve, 66(6), 661–670. https://doi.org/10.1002/mus.27706
14. Tafrishinejad, A. (2025). Navigating scalp nerve blocks: A comparative study of ultrasound vs. landmark methods. Ağrı - The Journal of The Turkish Society of Algology, 191–200. https://doi.org/10.14744/agri.2025.49358
15. Tönge, Ç. (2023). Scalp block Model in Sprague-Dawley Rats; In Vivo Experimental Study and Model Identification. Somalia Turkiye Medical Journal (STMJ), 2(2), 1–12. https://doi.org/10.58322/stmj.v2i2.22
16. Yaseen, T., Rizvi, S. A. M., Malik, U. E., Khan, A., Mahmood, K., & Tarat, H. M. (2025). Effectiveness of Atraumatic Needle to Avoid Post-Dural Puncture Headache. Pakistan Armed Forces Medical Journal, 75(2), 325–327. https://doi.org/10.51253/pafmj.v75i2.10413
17. Zetlaoui, P. J., Gauthier, E., & Benhamou, D. (2020). Ultrasound-guided scalp nerve blocks for neurosurgery: A narrative review. Anaesthesia Critical Care & Pain Medicine, 39(6), 876–882. https://doi.org/10.1016/j.accpm.2020.06.019