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CONTENTS 2025-4

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ORIGINAL ARTICLE

Navigating scalp nerve blocks: A comparative study of ultrasound vs. landmark methods

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SUMMARY

Objectives: Scalp block is a regional anesthesia technique involving the administration of anesthetic around the scalp nerves for head and neck surgeries and pain management. Two primary methods for performing scalp blocks are ultrasound guidance and anatomical landmarks. This study aimed to compare the success rates of scalp blocks using these two methods, assessing pain absence, anesthesia occurrence during surgery, and complications.

Methods: A total of 50 eligible craniotomy candidates were evaluated at Shohadaye Tajrish Hospital over a 6-month period. Patients were divided into two groups: ultrasound-guided block and landmark-guided block. The ultrasound group received blocks under ultrasound guidance, while the landmark group relied on anatomical landmarks for block administration. Both groups were administered a scalp nerve block with 0.5% ropivacaine prior to surgery.

Results: The overall success rate of scalp blocks was higher with ultrasound guidance compared to anatomical landmarks (ultrasound success rate=72%, landmarks success rate=24%). However, when analyzing success rates for individual nerves, the differences were not statistically significant (supraorbital p=0.357, supratrochlear 100% success, zygomaticotemporal p=0.977, auriculotemporal p=0.107, occipital major p=0.151, occipital minor p=0.199). No complications were observed in either group.

Conclusion: Ultrasound-guided scalp blocks demonstrated a higher success rate than landmark-guided blocks in craniotomy candidates. Further research is recommended to optimize scalp block methods for each nerve, compare drug consumption, and increase sample sizes.

Keywords: Anatomical landmarks; craniotomy; scalp block; scalp nerves; success rate; ultrasound guidance.

Introduction

Regional anesthesia, a dynamic and rapidly evolving branch of anesthesiology, has gained significant attention and widespread adoption in recent years. The growing recognition of its efficacy, coupled with heightened awareness of systemic side effects associated with traditional anesthetic drugs, has propelled regional anesthesia to the forefront of clinical practice. As our patient population ages and comorbidities become more prevalent, optimizing postoperative pain control and patient satisfaction has become paramount.[1]

Scalp blocks, specifically cranial nerve blocks, play a pivotal role in achieving these goals. By strategically administering local anesthetic agents at precise points on the scalp, sensory and motor nerve conduction in various areas of the skull can be effectively modulated. Consequently, surgery within the head and skull region can be performed without relying solely on systemic anesthetics. The versatility of scalp blocks extends beyond surgical anesthesia; they are now utilized for acute and chronic pain management, including the treatment of specific headache types such as migraines.[2]

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Despite significant recent advancements in pharmacological and neuromodulatory therapies for managing migraines, there are still several considerations that may render these treatments suboptimal for certain patients. Coexisting conditions such as cardiovascular or cerebrovascular diseases, renal or hepatic dysfunction, pregnancy, psychiatric comorbidities, or potential drug interactions can limit the suitability of these available treatment options.[3]

The mechanisms underlying the analgesic effects of peripheral nerve blocks (PNBs) remain incompletely understood. It is suggested that these effects are attributed to the targeted blockade of sensory fibers, preserving motor function, and subsequently eliciting central pain modulation through second-order neurons within the trigeminocervical complex.[4]

A preoperative scalp nerve block has the potential to mitigate hemodynamic instability and alleviate postoperative pain.[5] Notably, scalp blocks find particular utility in craniotomy cases, especially during awake craniotomy procedures. Surgeons across diverse medical specialties increasingly embrace this technique, appreciating its benefits in terms of patient outcomes and safety.

The pain associated with craniotomy primarily arises from skin incisions and muscle disruption rather than direct manipulation of the brain parenchyma. The scalp receives its innervation primarily from the trigeminal nerve along with the second and third cervical nerve roots.[6]

Scalp blocks can be performed in two ways

1. Using Anatomical Landmarks: Traditionally, regional anesthesia methods relied on anatomical and empirical landmarks, and scalp blocks were no exception. Anatomical landmarks are identifiable points based on touch and sight. With their guidance, an anesthesiologist can perform a scalp block without requiring specialized equipment.[1]
2. Using Ultrasonography: Over time, advances in medical engineering introduced ultrasonography, which found applications in various medical fields. Anesthesiologists increasingly use ultrasonography to perform regional anesthesia procedures, sometimes even surpassing traditional methods based on anatomical landmarks. By using ultrasonography, precise nerve and vessel locations can be identified, allowing for injections with higher accuracy and reduced risk.[5]

The aim of this study was to compare the efficacy and success rate of ultrasound-guided scalp nerve blocks versus traditional landmark-based techniques.

Materials and Methods

Study Design and Data Collection

This randomized clinical trial involved 50 eligible patients scheduled for elective craniotomy at Shohadaye Tajrish Hospital. Data were collected through questionnaires and recorded evaluation results and observations.

Sampling Method

Purposive sampling was employed, selecting individuals who could provide the necessary information effectively.

Sample Size Calculation

The sample size was determined based on results from similar studies.

Significance Level

A p-value<0.05 was considered statistically significant.

Patient Eligibility Criteria

Patients eligible for the study were required to exhibit the following characteristics:

1. Scheduled for elective craniotomy
2. Visited Shohadaye Tajrish Hospital

Eligibility Criteria for Study Participants

To ensure the validity and safety of the study, the following eligibility criteria were established:

1. Age Range: Individuals aged 18 to 65 years were eligible. This age range allowed for conscious consent and active participation.
2. No Substance Abuse or Alcohol: Long-term drug and alcohol use can alter anesthetic requirements. Participants with a history of substance abuse had to inform the anesthesiologist to ensure appropriate anesthesia levels.

3. No Allergy to Anesthetic Drugs: Given the inevitable use of local anesthetic drugs in the study, awareness of potential allergies within this drug group was crucial.
4. Absence of Diabetes: Individuals with diabetes have an increased risk of neuropathy and potential complications. Therefore, only participants without diabetes were included.
5. No Coagulation Disorders: Coagulation disorders may elevate the risk of complications related to nerve blocks. Participants with such disorders were excluded from the study.

Exclusion Criteria

To maintain the integrity of the research results, individuals were not included in the study under the following conditions:

1. Patient's Disagreement During the Block: If a patient chose not to continue cooperating with the research during the block procedure, they were excluded from the study.
2. Patient's Non-Cooperation During Block or Evaluation: Patients who did not actively cooperate with the anesthesiologist during the block procedure or its subsequent evaluation were excluded.
3. Surgeon's Disagreement: The participation of each patient in the study was contingent upon the surgeon's consent. If the surgeon did not agree, the case was removed from the study.

Study Methodology

Patient Selection and Consent

Fifty eligible patients scheduled for craniotomy were enrolled. After explaining the scalp block procedure for intraoperative analgesia, written consent was obtained from willing patients. The study was performed in accordance with the Declaration of Helsinki.

The study was approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences.

Group Allocation

Fifty patients were randomly assigned to two groups (landmark, sonography) using a random number table and SPSS software. The group allocation was not blinded to the block provider or patients, but the surgeon, anesthetic providers, and postoperative outcome assessor were blinded.

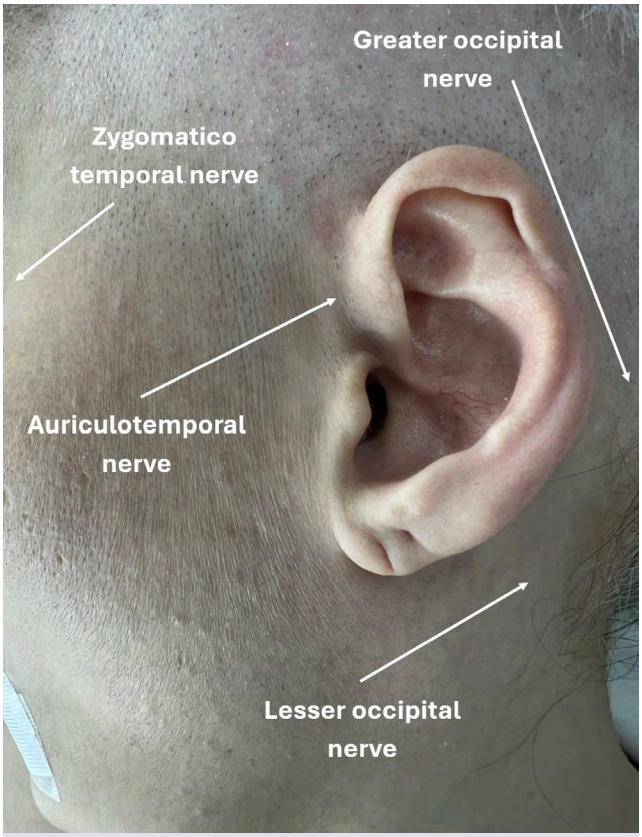

Figure 1. Anatomical landmarks of scalp block.

All patients were positioned on the operating table before anesthesia induction. Patients underwent routine monitoring for oxygen saturation, electrocardiography, and noninvasive blood pressure. Prior to induction into the block groups, patients were premedicated with midazolam, and a series of blocks was then performed by an independent anesthesiologist. The skin was sterilized with 2% chlorhexidine after protecting the patient's eye with gauze. A 0.5% solution of ropivacaine was prepared as the local anesthetic.

Nerve Identification

The surgical team determined the precise incision location for each patient. The anesthesiologist identified the nerves required for the scalp block based on the surgical incision site. Among the 12 known nerves involved in scalp blocks, the specific nerves were targeted.

Anatomical Landmarks (Fig. 1)

1. Superficial Temporal Nerve (STN):

Landmark: 2–3 cm (0.8–1.2 inches) anterior to the tragus (the small flap in front of the ear canal).

Target: The STN is located about 1–2 cm (0.4–0.8 inches) deep to the landmark.

2. Supraorbital Nerve (SON):

Landmark: The midpoint of the eyebrow (supraorbital notch).

Target: The SON is located about 1–2 cm (0.4–0.8 inches) deep to the landmark.

3. Greater Occipital Nerve (GON):

Landmark: 2–3 cm (0.8–1.2 inches) lateral to the external occipital protuberance (a bony landmark at the back of the skull).

Target: The GON is located about 1–2 cm (0.4–0.8 inches) deep to the landmark, just below the superior nuchal line (a bony ridge at the base of the skull).

4. Lesser Occipital Nerve (LON):

Landmark: 2–3 cm (0.8–1.2 inches) lateral to the mastoid process (the bony prominence behind the ear).

Target: The LON is located about 1–2 cm (0.4–0.8 inches) deep to the landmark.

5. Posterior Auricular Nerve (PAN):

Landmark: The posterior aspect of the ear, about 1–2 cm (0.4–0.8 inches) posterior to the tragus.

Target: The PAN is located about 1–2 cm (0.4–0.8 inches) deep to the landmark.

6. Zygomaticotemporal Nerve (ZTN):

Landmark: The posterior aspect of the zygomatic bone (cheekbone), about 1–2 cm (0.4–0.8 inches) anterior to the ear.

Target: The ZTN is located about 1–2 cm (0.4–0.8 inches) deep to the landmark.

Sonographic Landmarks

1. Superficial Temporal Nerve (STN) (Fig. 2):

Sonographic landmark: The temporal artery, which appears as a pulsatile, hypoechoic structure.

Target: The STN is located just superficial to the temporal artery, about 1–2 mm deep to the skin.

Ultrasound appearance: The STN appears as a small, hyperechoic structure (brighter than surrounding tissue).

2. Supraorbital Nerve (SON) (Fig. 3):

Sonographic landmark: The supraorbital notch, which appears as a hypoechoic depression in the frontal bone.

Target: The SON is located just below the supraorbital notch, about 1–2 mm deep to the skin.

Ultrasound appearance: The SON appears as a small, hyperechoic structure.

3. Greater Occipital Nerve (GON):

Sonographic landmark: The occipital bone, which appears as a hyperechoic (bright) curved line.

Target: The GON is located in the fascial plane between the trapezius muscle and the occiput, about 1–2 cm deep to the skin.

Ultrasound appearance: The GON appears as a small, hyperechoic structure.

4. Lesser Occipital Nerve (LON):

Sonographic landmark: The mastoid process, which appears as a hyperechoic (bright) bony prominence.

Target: The LON is located just posterior to the mastoid process, about 1–2 cm deep to the skin.

Ultrasound appearance: The LON appears as a small, hyperechoic structure.

5. Posterior Auricular Nerve (PAN):

Sonographic landmark: The posterior aspect of the auricle (ear), which appears as a hyperechoic (bright) curved line.

Target: The PAN is located just posterior to the auricle, about 1–2 cm deep to the skin.

Ultrasound appearance: The PAN appears as a small, hyperechoic structure.

Intervention

- Group 1 (Anatomical Landmarks): An injection of 0.5% ropivacaine (1–3 cc) was administered to the identified nerves using anatomical landmarks and a G29 needle. Epinephrine 1:200,000 was

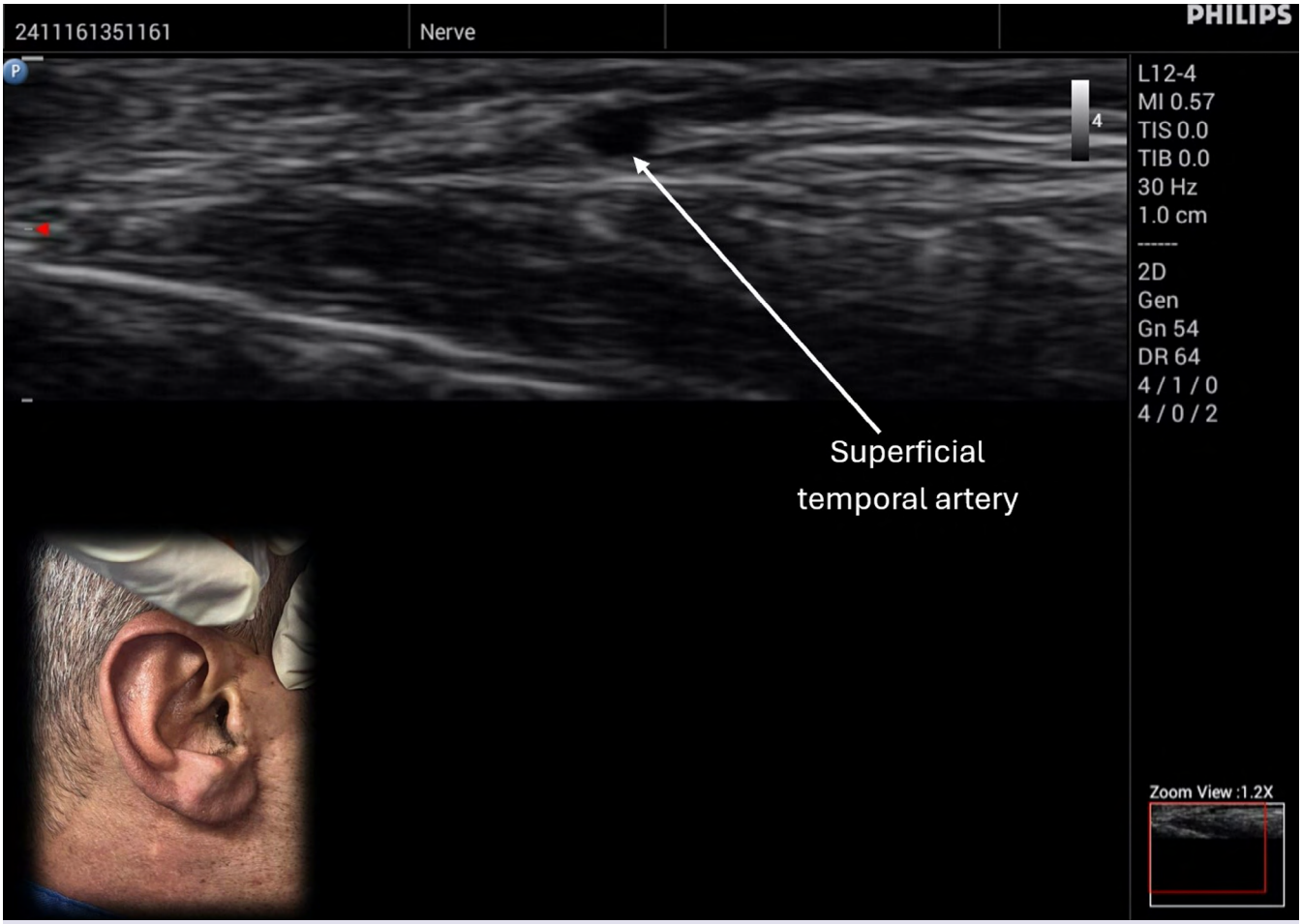

Figure 2. Sonographic vs anatomical landmark of superficial temporal nerve (STN) block.

added to the local anesthetic for patients without cardiovascular conditions such as a history of percutaneous coronary intervention or angina.

- Group 2 (Ultrasound Guidance): The same steps were followed, but drug injection was guided by ultrasound.

After the intervention was concluded, the sensory blockade in the forehead, upper neck, and occipital regions was evaluated. Block success was determined by the absence of sensation to cold stimuli at all sites.

General anesthesia was induced using propofol (effect-site target-controlled infusion (TCI) of 5 µg/mL) and remifentanil (effect-site TCI of 3 ng/mL). Following loss of consciousness, 0.6–0.8 mg/kg of atracuronium was administered intravenously, and the patient was manually ventilated with 100% oxygen. Tracheal intubation was performed after 2 minutes using a 7.5 mm (internal diameter) endotracheal tube (ETT) for women and an 8.0 mm ETT for men. With the use of a hand pressure gauge, cuff pressure was 20–25 mmH2O. End-tidal carbon dioxide (EtCO2) and invasive arterial blood pressure through a radial artery catheter were measured.

Anesthesia was maintained with effect-site TCI of propofol and remifentanil to keep blood pressure and heart rate within 20% of their baseline values. Hypotension (baseline mean arterial pressure<20%) was managed with 5 mg of ephedrine, bradycardia (baseline heart rate<20%) with 0.5 mg of atropine, and hypertension (baseline mean arterial pressure>20%) with 250 µg of nitroglycerine IV administration. Mechanical ventilation was sustained with a tidal volume of 8 mL/kg, and ventilator frequency was adjusted to maintain $EtCO_2$=35–40 mmHg.

The neuromuscular block was reversed by IV administration of neostigmine (0.03–0.07 mg/kg) and atropine (15 µg/kg). The patient was extubated and transferred to the intensive care unit (ICU). All procedures were identical between the two groups.

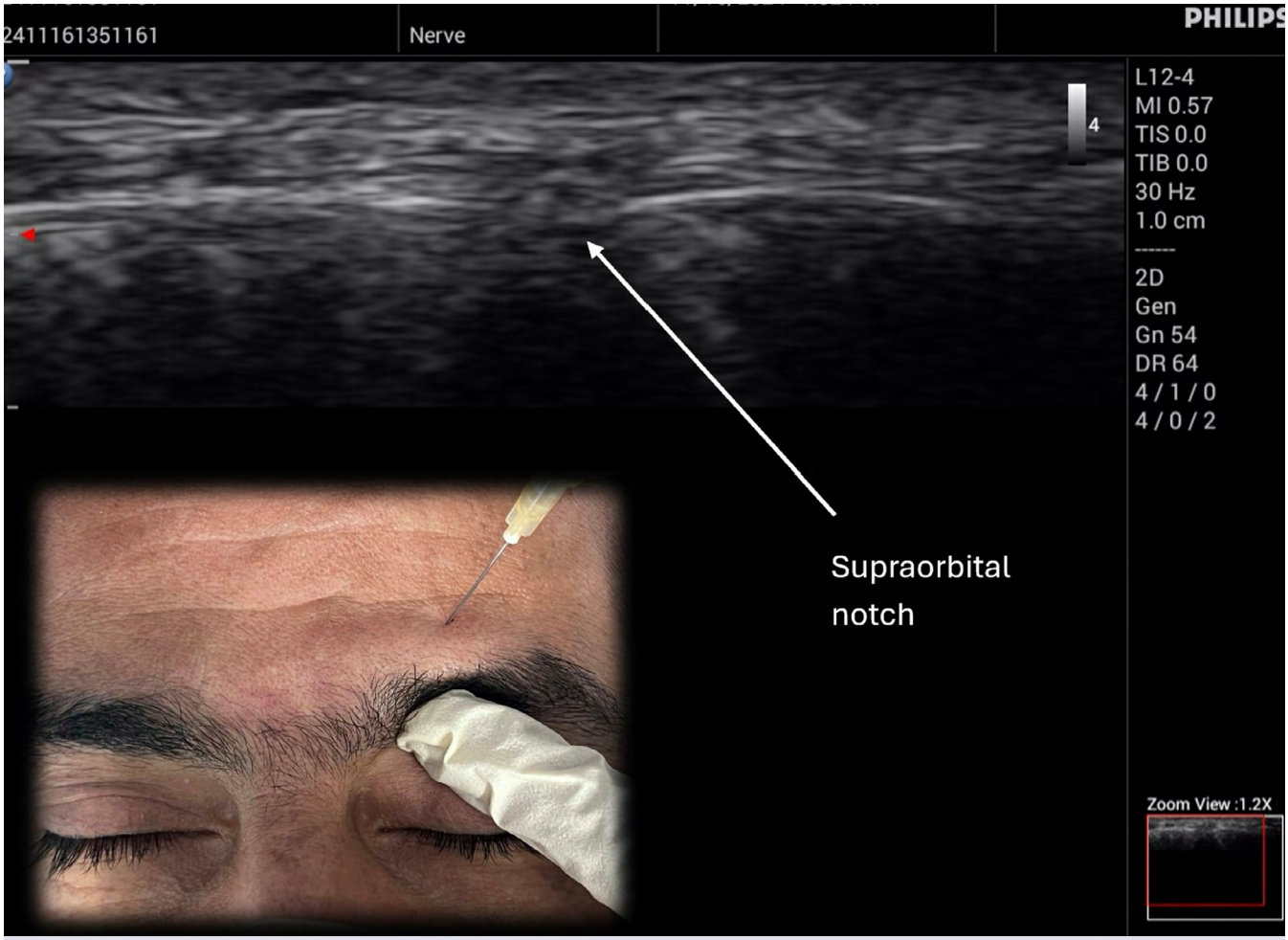

Figure 3. Sonographic vs anatomical landmark of supraorbital nerve block.

Data Collection

- Each blocked nerve's name and injected drug volume were recorded.
- Block success was evaluated by an anesthesiologist blinded to the method.
- In case of unsuccessful blocks, repeat injections were performed for adequate analgesia.
- Unintended block-related complications (such as bleeding, hematoma, or nerve injury) were promptly assessed and documented for up to 12 hours post-block.

Statistical Analysis

SPSS software was used for statistical analysis. Qualitative data were compared using the chi-square test, while quantitative data were analyzed using the t-test. Data were analyzed by a blinded statistical analyst, and results were reported.

Results

This randomized, comparative, prospective study was conducted on 50 patients aged between 18–65 years scheduled for craniotomy to compare conventional and ultrasound-guided scalp block in terms of sensory blockade in the forehead, upper neck, and occipital regions. Block success was determined by the absence of sensation to cold stimuli at all sites. There were no clinical or statistically significant differences in the demographic profile of patients in either group (Table 1, 2).

The results of the chi-square test showed that the two groups did not differ in terms of the gender variable (p=0.774). No significant sex predominance was seen in either group (Table 1).

The average age was 53.60±10 years in group LM and 55.96±12.01 years in group US. The results of the independent t-test showed that the two groups did not differ in terms of age and body mass index (p>0.05) (Table 2).

Table 1. Gender distribution (p=0.774)

	Groups	
	Landmark	**Sonography**
Gender		
Man		
Count	10	11
Percent	40	44
Woman		
Count	15	14
Percent	60	56
Total		
Count	25	25
Percent	100	100

Table 2. Distribution of age and BMI

Group	Count	Average	SD	p
Age				0.454
Landmark	25	53.60	10	
Sonography	25	55.96	12.01	
BMI				0.740
Landmark	25	25.67	3.24	
Sonography	25	25.97	3.28	

SD: Standard deviation; BMI: Body mass index.

Table 3. Supraorbital nerve block success rate in two methods using ultrasound and anatomical landmarks (p=0.357)

	Groups	
	Landmark	**Sonography**
Supraorbital		
Successful		
Count	32	35
Percent	91.4	97.2
Unsuccessful		
Count	3	1
Percent	8.6	2.8
Total		
Count	35	36
Percent	100	100

The results of Fisher's test showed that there was no significant difference between the percentage of success in supraorbital block between the two groups (p=0.357) (Table 3).

Table 4. Supratrochlear nerve block success rate in two methods using ultrasound and anatomical landmarks (p=NA)

	Groups	
	Landmark	**Sonography**
Supratrochlear		
Successful		
Count	35	36
Percent	100	100
Total		
Count	35	36
Percent	100	100

Supratrochlear block success rate was 100% in both groups (Table 4).

Table 5. Zygomaticotemporal nerve block success rate in two methods using ultrasound and anatomical landmarks (p=0.977)

	Groups	
	Landmark	**Sonography**
Zygomaticotemporal		
Successful		
Count	33	34
Percent	94.3	94.4
Unsuccessful		
Count	2	2
Percent	5.7	5.6
Total		
Count	35	36
Percent	100	100

In terms of zygomaticotemporal sensory block, the results of Fisher's test showed no significant difference between the two groups (p=0.977) (Table 5).

No significant differences in the percentage of success were seen between the two groups in auriculotemporal block, lesser occipital block, and greater occipital block (p=0.107, p=0.199, p=0.155, respectively) (Table 6–8).

Table 6. Success rate of Auriculotemporal nerve block in two methods using ultrasound and anatomical landmarks (p=0.107)

	Groups	
	Landmark	Sonography
Auriculotemporal		
Successful		
Count	30	35
Percent	85.7	97.2
Unsuccessful		
Count	5	1
Percent	14.3	2.8
Total		
Count	35	36
Percent	100	100

Table 7. The success rate of Lesser Occipital nerve block in two methods using ultrasound and anatomical landmarks (p=0.199)

	Groups	
	Landmark	Sonography
Lesser occipital		
Successful		
Count	31	35
Percent	88.6	97.2
Unsuccessful		
Count	4	1
Percent	11.4	2.8
Total		
Count	35	36
Percent	100	100

Even a single failure in either the sonographic or landmark block was considered indicative of an unsuccessful attempt. Therefore, the success rates in each group were as follows: ultrasound success rate=72%, landmark success rate=24%. There was a statistically significant difference between the success rates of the two groups (p=0.02) (Table 9).

Discussion

The research, investigation, and statistical analysis conducted on cranial blocks reveal that utilizing ultrasonography for performing blocks yields a higher success rate compared to relying on anatomical landmarks. Therefore, the importance of ultrasonography lies in its ability to provide real-time imaging and precise distribution of the anesthetic substance around the nerve, resulting in a significant statistical advantage. An essential aspect of the research is assessing the success rates of cranial nerve blocks using ultrasonography and anatomical landmarks separately. Notably, the study highlighted the success rate of the zygomaticotemporal block, which, contrary to previous beliefs of its complexity, demonstrated a success rate comparable to blocks in other areas using both methods.[2]

Sato et al.[7] revealed that the failure rate for zygomaticotemporal nerve blocks was found to be higher compared to other nerve blocks. The zygo-

Table 8. Greater Occipital nerve block success rate in two methods using ultrasound and anatomical landmarks (p=0.155)

	Groups	
	Landmark	Sonography
Greater occipital		
Successful		
Count	29	34
Percent	82.8	94.4
Unsuccessful		
Count	6	2
Percent	17.2	5.6
Total		
Count	35	36
Percent	100	100

Table 9. Ultrasound success rate vs landmarks success rate. (p=0.02)

	Groups	
	Landmark	Sonography
Successful		
Count	6	18
Percent	24	72
Total		
Count	25	25
Percent	100	100

maticotemporal nerve is located deep beneath the skin surface and may exhibit anomalies,[7–9] making it challenging to anesthetize using the anatomical landmark approach. Patients frequently experience headaches during awake craniotomy, and the zygomaticotemporal nerve, responsible for sensation in the temple region,[8] could potentially contribute to temporal pain during awake craniotomy.

However, as regional techniques gain popularity and evolve, the expertise of physicians in performing these blocks plays a crucial role in achieving successful outcomes. While no specific complications were reported among the study participants, the use of ultrasonography may offer additional reassurance in this aspect. Furthermore, the study revealed a significant reduction in the amount of drug used for nerve blocks with ultrasonography compared to anatomical landmarks, suggesting the need for further investigation into this aspect in future studies.[5]

Scalp blocks are typically carried out using bony or superficial landmarks as a guide. However, various studies have highlighted significant variations in the position or number of foramina, as well as the course of nerves. These variations can sometimes make blind placement of these blocks risky.[10]

The scalp sensory nerves present a challenge due to their thin nature and limited visibility on ultrasonography. Accurate identification of these nerves necessitates ultrasound-assisted localization of anatomical landmarks such as bone and blood vessels. Ultrasound-guided scalp nerve blocks for precise anatomical localization have been shown to be beneficial in reducing surgery-induced stress and optimizing local anesthetic dosage in pediatric patients with craniosynostosis undergoing cranial suture reconstruction.[5]

The results of Paule's study[10] were consistent with our findings. It revealed that employing ultrasound guidance for scalp nerve blocks is a straightforward technique that can enhance patient safety by minimizing the total amount of local anesthetic used. This is achieved by blocking the nerves with small volumes (2–3 mL for each nerve) and reducing the risk of vascular puncture through the visualization of arteries near the nerves using color Doppler. Additionally, given the numerous variations in nerve foramina or courses that have been documented, ultrasound guidance may offer a more accurate localization of nerves.[10] Thallaj et al.[11] found no failures when using only 0.1 mL of 1% mepivacaine for blocking the greater auricular nerve. When blocking the greater occipital nerve, Flamer et al.[12] did not report any instances of block failure. Furthermore, USG helps to avoid an unintended block to another nerve running close, such as the facial nerve, when blocking the greater auricular nerve.[13] In contrast, Pingree et al.[14] reported a success rate of 86% for their blocks.

The limitations of our study were as follows

1. The study had a small sample size, which may limit the generalizability of the findings and the statistical power to detect differences between the two methods.
2. Assessment of the sensation absence to cold stimuli and subjective outcomes may vary between patients, making it challenging to draw definitive conclusions.
3. The patients were awake and could not be blinded to their block status because we had to confirm that the block was completely performed. The block was thus performed before general anesthesia induction for the wound area and pin placement during surgical manipulation.

Conclusion

In summary, ultrasound-guided scalp blocks demonstrated a higher success rate than landmark-guided blocks in craniotomy candidates. Further research is recommended to optimize scalp block methods for each nerve, compare drug consumption, and increase sample sizes.

Ethics Committee Approval: The study was approved by Shahid Beheshti University of Medical Sciences Ethics Committee (date: 02.05.2023, number: IR.SBMU.MSP.REC.1402.012).

Informed Consent: Written consent was obtained from willing patients.

Conflict of Interest: The authors declare that there is no conflict of interest.

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Peer-rewiew: Externally peer-reviewed.

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ORIGINAL ARTICLE

Non-invasive peripheral nerve neuromodulation in diabetic neuropathic pain: A randomised controlled trial

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SUMMARY

Objectives: Diabetic neuropathic pain (DNP) is one of the most common and challenging complications of diabetes mellitus and often results in significant distress and impaired quality of life. Pulsed radiofrequency (pRF) treatment has gained traction in recent years as an effective intervention for the management of chronic pain. Therefore, non-invasive pRF (NipRF) has been introduced as an innovative treatment that promises to provide pain relief without invasiveness. In this study, we aimed to evaluate the efficacy of NipRF in the treatment of DNP.

Methods: This double-blind, randomized, controlled study included 64 patients with DNP and distal symmetric polyneuropathy refractory to multiple medical therapies, as confirmed by electroneuromyelography (ENMG). Participants were divided into two groups: one received NipRF treatment via a transcutaneous electrode (treatment group) and the other received a sham electrode (sham group) without radiofrequency. Pain levels were measured using the visual analog scale (VAS) and Self Leeds Assessment of Neuropathic Symptoms and Signs (S-LANSS) before treatment and at 4 and 12 weeks after treatment.

Results: The treatment group experienced significant reductions in the VAS and S-LANSS scores at 1 and 3 months post-treatment ($p<0.001$). The sham group showed a moderate, but not statistically significant, decrease at week 4, with scores reverting to baseline by week 12.

Conclusion: NipRF therapy may be a good option for DNP management. Its non-invasiveness and low risk of adverse events make it a good alternative to interventional and drug therapies.

Keywords: Chronic pain; diabetes mellitus; diabetic neuropathies; neuralgia; polyneuropathies; pulsed radiofrequency treatment.

Introduction

Diabetic polyneuropathy is a prevalent complication of diabetes mellitus (DM) that affects up to 50% of patients. Distal symmetric polyneuropathy (DSPN) is the most common type of diabetic neuropathy (DN). DSPN is a debilitating condition that causes severe neuropathy and significantly diminishes quality of life. Treatment options for this condition primarily involve medical combination therapies. These include gabapentinoids, tricyclic antidepressants, serotonin-norepinephrine reuptake inhibitors, and lidocaine infusion combinations. However, in cases where there is resistance to treatment or the dose cannot be further increased owing to side effects, interventional treatments are necessary. These advanced procedures include sympathetic blockade, botulinum toxin injection, spinal cord stimulation, and surgical decompression of the peripheral nerves. It is important to note that, while these interventions offer potential benefits, they also carry risks and have variable success rates.[1]

Pulsed radiofrequency (pRF) is a nondestructive neuromodulation technique that reduces inflammation and pain. It is based on transferring waves from the current radiofrequency provider to tissues using a cannula or transcutaneous electrode

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(1-8 Hz, 10-30 ms, and 500 KHz). pRF elicits electric field effects, resulting in changes in the neural cellular substrates.[2] Consequently, inflammatory cytokines are suppressed and endogenous opioids increase.[3,4]

Non-invasive pRF (NipRF) treatment is the delivery of pulsed radiofrequency current to biological tissues using electrodes. The electrodes are placed over the skin on the area to be treated. A cable connects the electrodes to the current generator. After the device is set to the desired parameters, it is activated and RF current is transmitted through the electrodes to the skin. This current is transmitted from the skin to deeper tissues, just as in transcutaneous electrical nerve stimulation (TENS) devices. However, because RF current can penetrate deeper, its neural stimulation is higher than TENS current. This allows for more effective treatment. Neuromodulation with NipRF is a novel treatment for neuropathic pain caused by conditions such as carpal tunnel syndrome.[5] And this is the first study to examine the use of NipRF in the treatment of DN, and there is currently no existing literature on this subject.

Our aim was to modulate and desensitize the PTN (posterior tibial nerve), the peripheral nerve that receives the sensation of the sole of the foot. Neuropathic complaints such as felting, numbness, and burning were perceived less by the patient. PTN's superficial course in the ankle would allow the pRF current delivered by transcutaneous electrode to reach the nerve easily. The primary objective of this study was to evaluate the improvement in pain severity in patients with DSPN using the visual analog scale (VAS) score, especially basal-12 week change; the secondary objectives were to evaluate the efficacy of NipRF treatment on neuropathic pain and to observe any adverse events related to the electrode pad.

Material and Methods

Ethics Approval and Registration

Approval from the Ethics Committee of the local hospital was obtained on 22.03.2021 (Decision no: 107/23). This study was registered at ClinicalTrials.gov (Register Number: NCT05480527). The first patient enrollment date was 01.06.2023. All patients were informed of the study, and written informed consent was obtained from all patients. The Declaration of Helsinki was followed in this study.

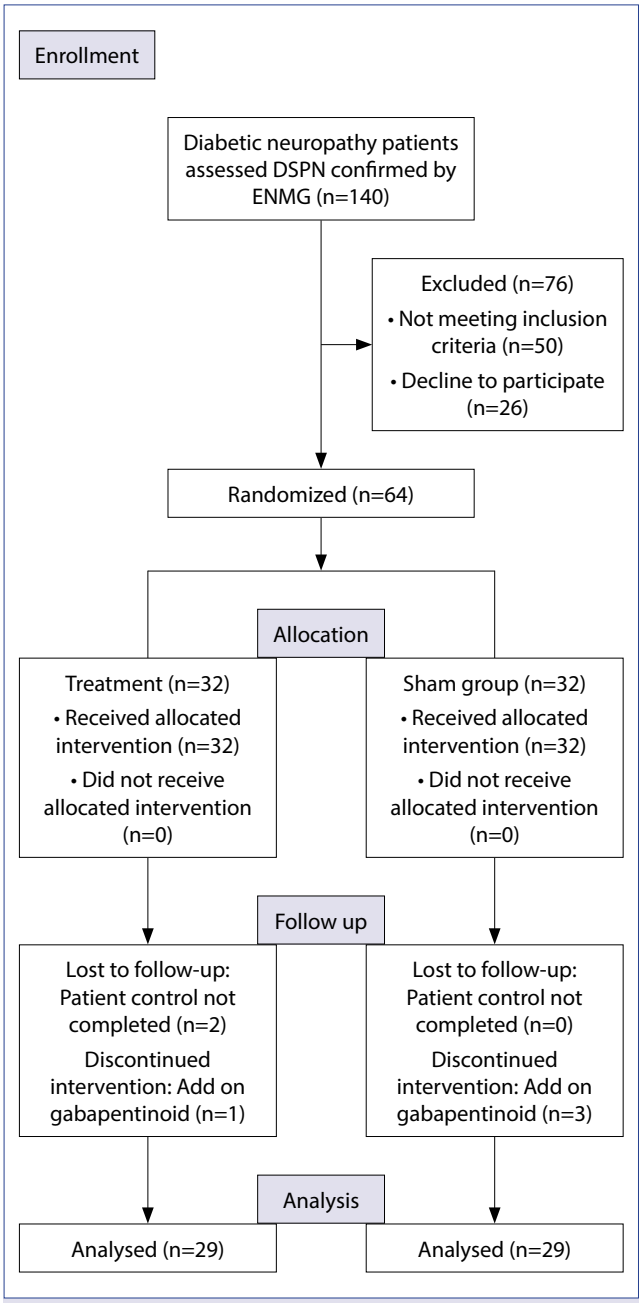

Figure 1. Flow chart diagram.

Study Design and Participants

This study was designed as a single-blind, placebo-controlled, randomized clinical trial. The inclusion criteria were as follows: diagnosis of type 2 DM; complaint of neuropathic pain in the distal lower extremity for at least two years; diagnosis of DSPN confirmed by ENMG; failure or minimal response to medical therapy despite at least dual combination therapy and maximum tolerated doses; and a visual analog scale (VAS) score >5.

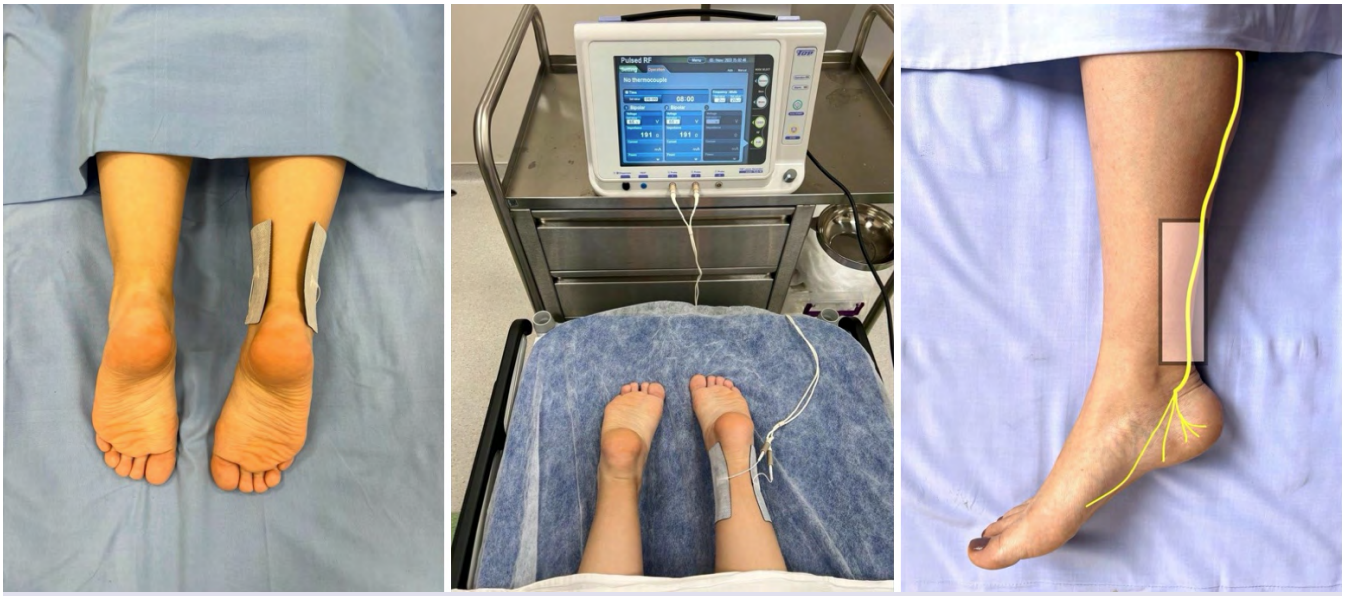

Figure 2. Electrode placement and RF transducer device.

The exclusion criteria were as follows: motor deficits in the lower extremities and diabetic scars; malignancy; pregnancy; B12-folic acid deficiency; presence of other causes of DSPN (chronic liver or kidney disease; chronic toxin exposure such as alcohol; presence of autoimmune diseases such as rheumatoid arthritis and lupus; drug use such as chemotherapy, amiodarone, and colchicine; infectious causes such as HIV, Hepatitis C; and hereditary diseases such as Charcot-Marie-Tooth and Familial Amyloidosis).

The study design is depicted in Figure 1.

Randomization and Blinding

In the current study, randomization of the participants was performed using a computerized method, maintaining a balanced 1:1 allocation ratio. An independent statistician who was not involved in the recruitment of participants generated a random allocation sequence. The sequence was obtained using a web-based platform. To maintain allocation concealment, sealed opaque envelopes containing allocation details were used. Participants were then assigned to their respective intervention groups by a different researcher, according to the established sequence. To eliminate assessment bias, blinding of the outcome assessor was strictly maintained throughout the duration of the study. Patients were informed that the discomfort could be caused by the pads and not by the pRF current. Thus, it was ensured that the patients did not know whether symptoms such as redness or paresthesia were caused by the current or the pad. In addition, patients were treated separately, and we aimed to mask any symptoms, such as mild warming, burning, and redness, in the active electrode group. The investigators who assessed the patients at the three-month follow-up and those who analyzed the data were also blinded.

Intervention

Non-invasive Pulsed Radiofrequency Procedure

We used a transcutaneous electrode-compatible pRF generator (TOP Lesion Generator TLG-10 Sluijter Teixeira Pulse [STP], Equip Medikey BV, the Netherlands) and 44×98 mm transcutaneous neurostimulation electrodes (Equip, FIAB SPA, Via P. Costoli, Italy). For each patient, the device was first applied to the right lower extremity, and then to the left lower extremity. One of the electrodes was placed on the posterior tibial nerve tract at the level of the medial malleolus, and the other on the opposite lateral malleolus. The RF transducer was operated in silent mode to prevent the patients from knowing whether the device was active or inactive. The electrodes were placed on both feet for 8 min each. The treatment group received a pRF (80 volts, 2 Hz, 20 ms). The sham group did not receive a pRF current. Each patient underwent two sessions with a one-week interval (The treatment was depicted in Fig. 2).

Table 1. Demographic data, between and within group analyses of VAS and S-LANSS scores

	Treatment Group			Sham Group				
	Mean±SD	Median (min–max)	Mean rank	Mean±SD	Median (min–max)	Mean rank	Test st.	p*
Age	58.9±8.4	59 (36–75)		57.9±8.2	60 (40–60)		0.439	0.662[a]
Gender, n (%)					20 (69)			0.283[b]
Female		15 (51.7)			9 (31)			
Male		14 (48.3)						
VAS								
Basal	8.3±1.2	8 (6–10)	2.84	7.5±1.8	8 (5–10)	2.00	1.712	0.078[c]
Week 4	4.4±2.3	4 (0–10)	1.19	6.9±2.2	7 (2–10)	1.83	4.195	**<0.001[c]**
Week 12	5.9±2	6 (2–10)	1.97	7.5±1.7	8 (5–10)	2.17	3.093	**0.002[c]**
p**		**<0.001**			0.114			
SLANSS								
Basal	16.4±4.2	16 (8–24)	2.72	18.6±7	19 (6–38)	2.10	1.712	0.087[c]
Week 4	9.3±5.8	8 (0–24)	1.24	17.4±6.7	19 (6–30)	1.90	3.763	**<0.001[c]**
Week 12	12.9±5.7	12 (2–25)	2.03	18.1±6.4	19 (6–30)	2.00	3.092	**0.002[c]**
p**		**<0.001**			0.223			

p*: A Independent Samples t-Test; b: Chi-Square Fischer Exact Test; c: Mann-Whitney U-test. p**: Friedman test; SD Standard deviation; VAS Visual Analog Scale; S-LANSS: Self-Leeds Assessment of Neuropathic Symptoms and Signs Pain Score.

Assessment

All patients were assessed using the VAS and Self-Leeds Assessment of Neuropathic Symptoms and Signs (S-LANSS) scores before and at 1 and 3 months after treatment. The VAS is a psychometric response scale that is commonly used in pain assessment. It measures the intensity of the pain experienced by a patient on a continuum. The scale is typically a 10 cm line anchored by two descriptors representing the extremes of 'no pain' and 'worst imaginable pain.' Patients marked a point on the line corresponding to their pain level, which was then measured and recorded. The S-LANSS score is used to identify pain of predominantly neuropathic origin. It is based on patient self-reports and includes questions about pain quality and the presence of sensory abnormalities in the area of pain. S-LANSS assesses parameters such as pain location, pain characteristics (e.g., burning, tingling), autonomic changes (e.g., sweating, flushing), evoked pain (e.g., touch or pressure), and sensory dysfunction.[6] The presence of these symptoms and signs contributes to a score that indicates a neuropathic component of pain above a certain threshold. Our primary objective was to determine the effect of treatment on pain intensity, specifically using VAS scores from baseline to 12-week change. Our secondary objectives were to examine the effect of treatment on neuropathic pain using the S-LANSS score, and to reveal procedure-related adverse events.

Statistical Analyses

Sample calculation was performed by G*Power software. The effect size is 0.917, α=0.05, and power (1-β)=0.95. For each group, 27 participants were identified. The four-week resting pain VAS score (mean and standard deviation values) of Taverner et al.[7] was used for analysis.

All analyses were conducted using Jamovi Project (2022, Jamovi Version 2.3, Computer Software, https://www.jamovi.org). The findings of this study are expressed as frequencies and percentages. Normality analysis was performed using the Shapiro-Wilk test, skewness, kurtosis, and histograms. Normally distributed variables are presented as means and standard deviations (SD). Categorical variables were compared using the chi-squared test. Numerical dependent variables were compared between the groups using an independent

sample t-test. Repeated measures with normal distribution, such as VAS and S-LANSS scores, were analyzed using a two-way ANOVA. Statistical significance was set at $p<0.05$.

Results

In total, 140 patients with DSPN were screened for eligibility. Sixty-four patients who met the inclusion criteria were included in this study. Since six patients were lost to follow-up, fifty-eight participants completed the 12 weeks of follow-up.

No significant differences in age, sex, or baseline scale scores were observed between groups.

The VAS and S-LANSS scores were compared between the groups. No differences were found in baseline measurements. However, at 4 and 12 weeks, the treatment group showed a significant improvement in both scale scores compared with the control group ($p<0.001$, $p=0.002$) (Table 1).

We analyzed changes in the VAS and S-LANSS scores of both groups over time. The treatment group showed a significant decrease in VAS and S-LANSS scores at 4 and 12 weeks compared with baseline ($p<0.001$). The change in both scale scores was analyzed using Bonferroni correction. A significant difference was found in the VAS and S-LANSS scales measured at three different times in the treatment group (p values respectively; basal-4 week, 4-12 week, basal-12 weeks; VAS: $p<0.001$, 0.009, 0.002; S-LANSS: $p<0.001$, 0.008, 0.026) (Table 1, Fig. 3).

The sham group showed a moderate decrease in the VAS and S-LANSS scores at week 4, but this was not statistically significant. By week 12, both scores had returned to baseline values. No statistical difference was found between the VAS and S-LANSS scores measured at the three different time points in the sham group (Table 1, Fig. 3).

The number of patients with at least 50% reduction in pain was analyzed. This rate was 66% at four weeks and 22.2% at 12 weeks in the treatment group. In the sham group, 11.1% pain reduction was seen at week 4, while none at week 12. The treatment group showed mild hyperaemia in seven participants, but no serious adverse effects were observed.

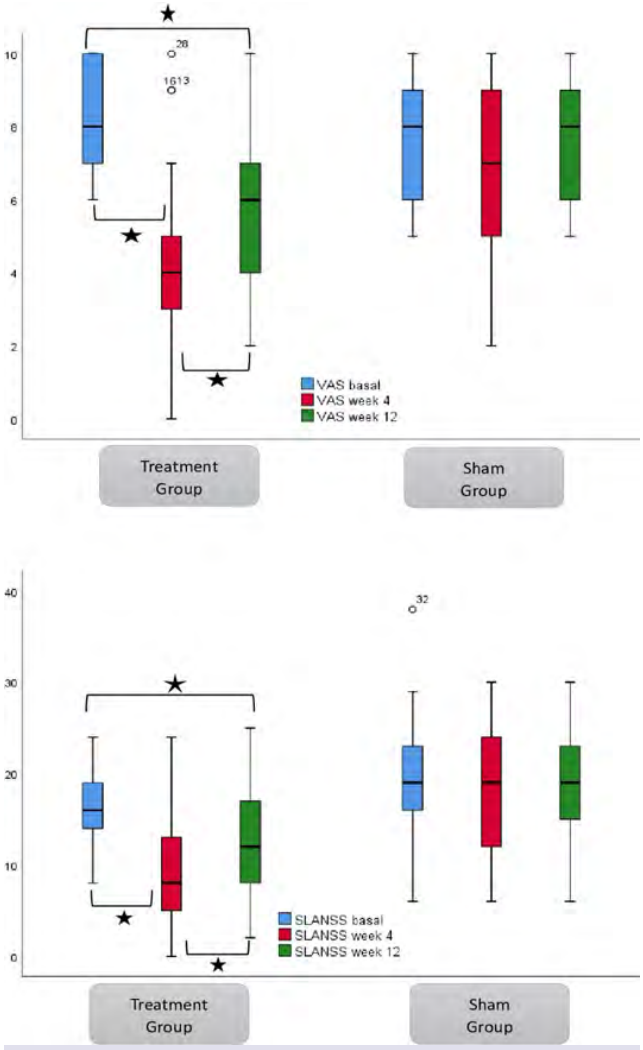

Figure 3. VAS and S-LANSS changes in Treatment and Sham groups.

Black Star: $p<0.005$ between two time points. x-axis: shows measurement times. Blue: basal, Red: 4th week, Green: 12th week. y-axis: scale scores. Upper graphic: VAS score, lower graphic: S-LANSS score.

Discussion

NipRF treatment provided effective analgesia for neuropathic pain, with significant improvements in S-LANSS and VAS scores compared to the sham group at weeks 4 and 12 in our study. In addition, while providing this improvement, transient minimal side effects were observed that did not require treatment.

PTN is the main nerve that provides sensations to the heel and sole of the foot. PTN divides into the medial plantar, lateral plantar, and medial calcaneal nerves, and the branches provide sensory innervation to the entire sole and heel area, except for the lateral heel. [8] Therefore, PTN blockade or pRF therapy has been used to treat a variety of conditions such as calcane-

al spur and plantar fasciitis, which cause pain in the sole and heel.[9,10] To our knowledge, pRF via cannula or transcutaneous electrodes on the PTN has never been studied for the treatment of diabetic neuropathic pain (DNP). This is the first study to evaluate NipRF therapy for the treatment of diabetic neuropathic pain.

In the non-drug treatment of DNP, methods such as transcutaneous electrical nerve stimulation (TENS) therapies, sympathetic blockade, botulinum toxin, and surgical decompression are used. Pain symptoms are improved by surgical decompression of the peripheral nerves in the treatment of DNP.[1] Dellon et al.[11] followed 628 patients with DM who underwent medial and lateral plantar nerve decompression with PTN branches for 3.5 years; a significant decrease in VAS scores was observed over this period.

Electrotherapy methods applied in the form of low- and high-frequency TENS have been reported by the authors as effective methods for the treatment of DNP.[12,13] The effects of TENS are explained by gate control theory and endorphin release, which are partially similar to pRF.[14]

NipRF (500 kHz) is an electrical stimulation therapy that is capable of reaching deeper tissues than TENS (150 kHz). Consequently, it has greater neuromodulation ability.[15,16] The system is based on the principle of transmitting pRF current generated from a transducer to biological tissues through electrodes attached to the skin with a cable connection.

Our aim was to reduce neuropathic plantar pain by modulating the PTN, which provides sensory innervation to this region, with NipRF. pRF is usually applied with a needle electrode close to the nerve, but this requires ultrasound visualization and is an invasive and painful process. The administration method is irrelevant, whether transcutaneous electrode or needle, in neuropathic pain, pRF, which has a complex mechanism of action, exerts its effects via biological pathways. The modification mechanisms of pRF in nociceptive signalling have been included, and occur through various mechanisms, such as neurotransmitters, ion channels, postsynaptic receptors, immune activity, microglial markers, inflammatory cytokines, and intracellular proteins. These microstructural changes in the peripheral nerve result in a prolonged depression of C-fiber-associated spinal sensitivity, consequently blocking the pain signal from the peripheral nerve to the central nervous system (Fig. 4).[3]

NipRF is a relatively new treatment method with limited experience. Favorable results in different anatomical locations and pain syndromes have been reported for NipRF treatment. In a double-blind placebo study, Taverner et al.[17] showed a statistically significant decrease in VAS scores in the active treatment group with NipRF treatment for knee pain. In a retrospective study published by Taverner et al.[18] in 2013, NipRF treatment for shoulder pain showed a significant reduction in 10 of 15 painful shoulders lasting longer than three months. In another double-blind, placebo-controlled study by Taverner et al.[7] evaluating the efficacy of TPRF for shoulder pain, the active electrode group showed improvement at 12 weeks. In a report of 4 cases by Stall, headache frequency decreased in 3 patients with TPRF applied from the occipital region.[19] A prospective, double-blind, placebo-controlled study by Lin et al.[16] compared NipRF with TENS for shoulder pain. Treatment in the NipRF group was found to be significantly more effective and comfortable than in the TENS group at weeks 4 and 12. Ilfeld reported two case series using a portable ambulatory pRF device to treat post-amputation residual limb and postoperative pain after amputation. Continuous pRF current was delivered for 30 days, and pain was reduced to the point where opioids were no longer required.[20,21]

In our study, we found that the treatment group experienced a 47% improvement in VAS scores at week 4 and a 29% improvement at week 12. The corresponding rates for S-LANSS scores were 43% and 21%, respectively. Previous studies on NipRF have shown successful results in the treatment of chronic migraine and carpal tunnel syndrome. One of these studies compared the effectiveness of two sessions of NipRF applied to the median nerve trajectory with wrist splint therapy in patients with carpal tunnel syndrome. Although there was no significant difference in the Boston Carpal Tunnel Syndrome Questionnaire scores between the groups, a 43% improvement was observed at week 4 and a 28% improvement at week 12 in the NipRF group.[5] In another study, the results of two sessions of NipRF treatment applied to

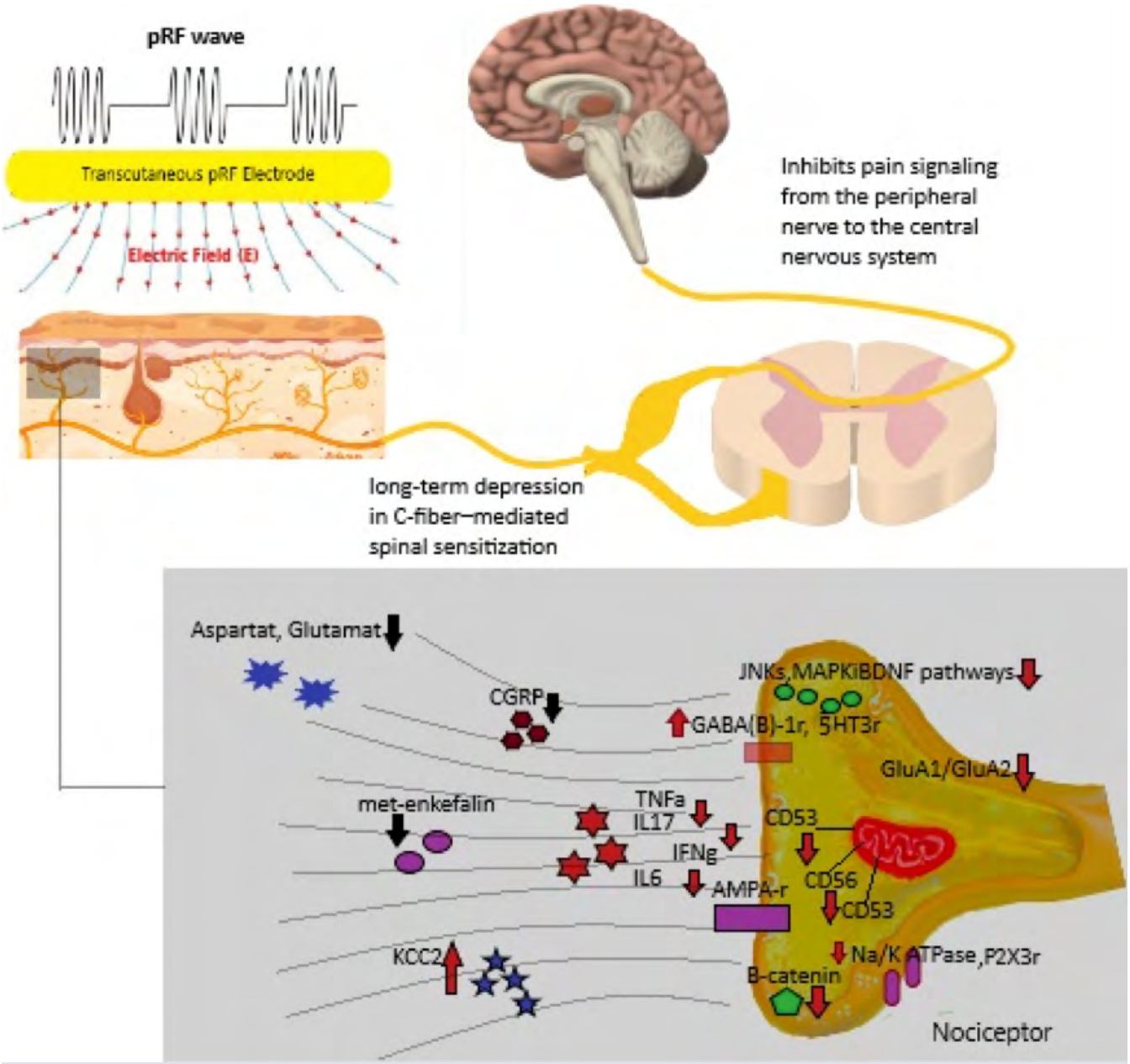

Figure 4. Cellular and molecular mechanisms of action of pulsed radiofrequency.

the greater occipital nerve trace in chronic migraine were compared with those of a control group with greater occipital nerve blockade. After four weeks of follow-up, there was no significant difference in the VAS scores between the two groups. However, the NipRF group showed a 32% improvement at week 4.[22] When examining the results of these studies, similar effectiveness rates were observed.

No serious adverse events were reported. Seven patients experienced mild redness and burning that resolved without treatment. No serious adverse events related to electrode-mediated NipRFs have been reported in previous studies.

Unlike conventional RF, which heats up to 70-80°C, pRF does not cause thermocoagulation and is considered safe. Although it is thought to act by neuromodulation without causing destruction of nerve tissue, Erdine, Podhajsky, and Cahana have shown that a pRF current applied at 42–43 degrees causes significant destruction of the cellular structure of the dorsal root ganglion, sciatic nerve, and thalamic neurons.[23–25] In this respect, transcutaneous application of pRF via electrodes appears to be safer than cannula-mediated application. However, further studies are required to compare cannula-mediated and transcutaneous electrode-mediated pRF treatments and to draw definitive conclusions.

Limitations

Our study has several limitations. First, the treatment period was limited to 2 sessions. Second, the follow-up period was limited to 12 weeks. Third, although the method used to calculate the sample size of the study was NipRF treatment with sham and active electrodes, the patient group studied was shoulder pain.

Conclusion

In this study, with two sessions of NipRF treatment, we observed sustained improvement in diabetic neuropathic pain complaints for 12 weeks. pRF via transcutaneous electrodes offers non-invasive and easy-to-use, effective pain control without serious side effects. More frequent use may provide greater and longer-lasting pain relief; however, further studies are needed to confirm this.

Ethics Committee Approval: The University of Health Sciences Dışkapı Yıldırım Beyazıt Training and Research Hospital Ethics Committee granted approval for this study (date: 22.03.2021, number: 107/23).

Informed Consent: Written informed consents were obtained from patients who participated in this study.

Conflict of Interest: The authors declare that there is no conflict of interest.

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Peer-rewiew: Externally peer-reviewed.

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ORIGINAL ARTICLE

Preventing spinal anesthesia headache in cesarean section: Randomized clinical trial

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SUMMARY

Objectives: Post-dural puncture headache (PDPH) is a common complication following neuraxial block in cesarean sections, typically occurring 12–72 hours postoperatively and leading to considerable challenges and financial costs. We aimed to compare dexamethasone and paracetamol for preventing spinal anesthesia headaches in cesarean sections.

Methods: A double-blind randomized clinical trial was conducted from December 2019 to April 2020. This study included 215 singleton pregnant women scheduled for elective cesarean section. To prevent PDPH, the patients were allocated to intravenous dexamethasone (n=70), paracetamol (n=75), and normal saline (n=70) groups. The primary outcomes were the incidence and severity of PDPH and VAS score evaluations. Secondary outcomes included recovery time, frequency of painkiller use, newborn Apgar scores, and patient satisfaction.

Results: Significant time ($p<0.001$) and group ($p=0.020$) effects were observed on PDPH. At 48 hours postoperatively, patients receiving dexamethasone or paracetamol reported significantly lower PDPH severity compared to the normal saline group ($p=0.009$). The incidence of PDPH was also higher in the control group at 48 hours ($p=0.033$). No significant differences were observed among the groups in recovery time, analgesic use, Apgar scores at 1 and 5 minutes, or patient satisfaction ($p>0.05$).

Conclusion: Both paracetamol and dexamethasone had a positive impact on reducing the incidence and severity of PDPH compared to the normal saline group in cesarean sections (with dexamethasone showing a stronger effect). Recovery time, painkiller use, newborn Apgar scores, and patient satisfaction did not differ significantly between the groups. Further research is needed to validate these findings and ensure reproducibility.

Keywords: Cesarean section; dexamethasone; paracetamol; post-dural puncture headache; spinal anesthesia.

Introduction

Post-dural puncture headache (PDPH), or spinal headache, a common and severe complication of neuraxial block, results from dural rupture typically arising 12–72 hours post-operation[1] and occurs in 0.5–1.6% of cesarean sections. PDPH significantly hinders maternal self-care and newborn care, imposing substantial financial burdens on healthcare systems and escalating obstetric and gynecological emergency visits.[2–7] PDPH occurrence and severity are influenced by various factors, including BMI (body mass index), previous migraine history, needle-related factors (such as multiple attempts, tip designs, gauge, and orientation), young age, obstetric conditions, needle type, gender, and spinal fluid leakage.[3,8–11]

PDPH treatment focuses on symptom relief, as its main cause remains unclear. Empirical and ineffective interventions include hydration, acetaminophen, non-steroidal anti-inflammatory drugs, opioids, DDAVP (desmopressin acetate), caffeine, gabapentin, hydrocortisone, and theophylline.[12,13] Prevention involves addressing predisposing factors, using proper needle size and type, and exploring supportive and pharmacological methods. However, no specific protocol or guidelines have been established.[14]

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In a Swedish study, three needle types (22G atraumatic, 25G atraumatic, and 25G cutting) were used for spinal anesthesia. The 22G atraumatic needles had a lower incidence of PDPH compared to the other groups.[14] Evidence for the effectiveness of complete bed rest and fluid therapy in preventing PDPH is inconclusive.[15] In a 2020 study, intrathecal morphine prophylaxis did not significantly differ from intrathecal saline in terms of PDPH incidence and severity.[16] Another study in pregnant women compared epidural saline, IV cosyntropin, and epidural morphine after unintentional dural puncture, showing reduced PDPH incidence in all intervention groups compared to the control.[17] Administering dexamethasone 8 mg (2 ml) on the first and fourth postoperative days significantly reduced PDPH incidence and severity compared to the control group (p=0.01 and p=0.001, respectively).[18]

In this double-blind, randomized controlled trial, we compared the analgesic effects of intravenous paracetamol and dexamethasone with a control group on PDPH incidence and severity. Our hypothesis is that paracetamol can effectively reduce PDPH occurrence and severity, as well as medication requirements for its management. Notably, intravenous administration of paracetamol during labor is safe and devoid of side effects.[19]

Materials and Methods

A double-blind randomized clinical trial was conducted in accordance with the Declaration of Helsinki at Hafez Hospital affiliated with Shiraz University of Medical Sciences, from December 2019 to April 2020. This study included 219 singleton pregnant women with term pregnancies and ASA physical status classifications I and II, scheduled for elective cesarean section. The allocation ratio was one for three studied groups. The study received approval from the Ethics Committee of Shiraz University of Medical Sciences (IR.SUMS.MED.REC.1396.130), with the IRCT code (IRCT20141009019470N80) (https://www.irct.ir/trial/), and informed consent was obtained from all participants.

Exclusion criteria included contraindications to spinal anesthesia, patient refusal, local infection at the lumbar region, use of antiplatelet and anticoagulant medications, known anesthesia sensitivity, comorbidities (diabetes, renal dysfunction [creatinine level >2], coagulation disorders, liver disease, heart disease, seizures, neurological disease), extreme blood pressure levels, intrauterine fetal growth retardation (IUGR), weight >100 kg, height <150 cm or >180 cm, pre-eclampsia, fetal anomalies, low hemoglobin levels (level <8 g/liter), history of post-cesarean migraine headaches, and more than three previous cesarean sections.

Patients received preoperative explanations about PDPH and its associated symptoms. They were informed that PDPH is a headache in the frontal or occipital area with a throbbing nature. It is usually accompanied by photophobia, blurred vision, double vision, decreased hearing with tinnitus, dizziness, nausea, and vomiting.[12] To distinguish between PDPH and migraine headaches, patients were advised to observe how their headache responds to changes in position—PDPH is generally aggravated by an upright position and relieved by a decumbent posture.

After surgery, a nurse anesthetist who was not involved in the procedure documented the nature and severity of the patients' headaches using a VAS score.

Sample Size and Randomization

The sample size was determined based on a previous study conducted by Hamzai et al.[20] Considering a 25% dropout rate and comparing the incidence of headache after spinal anesthesia between the sample and control groups during the first week, with proportions of p1=11.3% and p2=32.5% respectively, a sample size of 75 patients in each group was calculated to achieve 80% power with a 0.05 alpha error. To ensure randomization, eligible patients were divided into three groups (treatment and control) using the block randomization method. The randomization process was performed using 25 blocks, each consisting of 9 patients (www.sealedenvelope.com). A staff member with access to the randomization list prepared sealed envelopes containing the names of each group of patients. To maintain blinding throughout the study, other colleagues involved, such as anesthesiologists, surgeons, and data collection members, were unaware of the patient study groups and the block sizes.

Sampling

Participants' medical history was obtained, and clinical and airway examinations were conducted. They were positioned supine with a slight left tilt on the operating room bed. Oxygen was administered through a mask at 5 liters per minute. Patient monitoring included non-invasive blood pressure measurement, pulse oximetry, and electrocardiography. Intravenous access was established using an angiocath number 18, and hydration began with normal saline at 8 ml/kg.

Blinding Method

A nurse anesthetist, not involved in the study, prepared a blinded microset containing dexamethasone, paracetamol, or normal saline for injection during patient hydration. The administering researcher remained unaware of the medication's identity throughout the process.

Medications and Dosage

- Dexamethasone Group: Administered 8 mg of dexamethasone in 100 ml of normal saline over 15 minutes.
- Paracetamol Group: Administered 1000 mg of paracetamol in 100 ml of normal saline over 15 minutes.
- Control Group: Administered 100 ml of normal saline over 15 minutes.

Spinal anesthesia was administered in the sitting position using a 25-gauge needle at the L3-4 and L4-5 intervertebral spaces. An anesthesia assistant delivered 9 mg of Marcaine (bupivacaine) and 10 mg of pethidine in a total volume of 3 ml. After the procedure, patients were repositioned semi-laterally with left uterine displacement to prevent supine hypotension. Continuous monitoring of blood pressure, heart rate, arterial oxygen saturation, nausea, and vomiting was performed every two minutes for the initial 20 minutes and then every five minutes until discharge from the recovery room.

Measurement Tools and Indicators

Primary Outcome

Post-dural puncture headache (PDPH) severity was assessed using the Visual Analog Score (VAS) on a scale of 0–10. Evaluations were conducted 6, 12, 48, and 72 hours after anesthesia induction. A non-study nurse performed these assessments. PDPH pain intensity was measured using the VAS, ranging from 0 to 10 cm. A score of 0 indicated no pain, 1–3 represented mild headache, 4–7 indicated moderate headache, and a score>7 indicated severe headache.

Secondary Outcome

The secondary outcomes included the amount of pain relief patients required, newborn Apgar scores at 1 and 5 minutes, and patient satisfaction. Nurses not involved in the study were responsible for measuring these outcomes.

If a patient experienced bradycardia, itching, shivering, nausea, vomiting, or postoperative pain, specific steps were followed. Bradycardia (heart rate<44 beats per minute) was treated with atropine, starting with 0.6 mg and repeated every 3–5 minutes if needed, up to a maximum of 2 mg. If systolic blood pressure decreased by>20% from baseline or dropped<90 mmHg, 5 mg of intravenous ephedrine was administered. Persistent nausea and vomiting were treated with intravenous ondansetron at 0.15 mg/kg, while severe itching was managed with 25 mg of intravenous promethazine. Shivering was treated with 10 mg of intravenous pethidine. For postoperative surgical pain, patients initially received diclofenac suppositories, and if pain persisted, they were given 25 mg of intravenous pethidine. Patients experiencing PDPH with a score >3 were treated with rehydration, acetaminophen, NSAIDs, opioids, caffeine, sumatriptan, and epidural patches.

Statistical Analysis

Continuous variables were presented as mean±standard deviation, while categorical variables were reported as numbers and percentages. Nonparametric variables were analyzed using the Kruskal-Wallis test with Dunn's post hoc test for group comparisons. For categorical data, the chi-squared test was applied to detect significant differences between groups. Repeated measures analysis was used to evaluate VAS scores over time within groups. Statistical analyses were performed using SPSS software (version 22, SPSS Inc., Chicago, IL) and GraphPad Prism 9. Results were considered statistically significant if $p<0.05$. If needed, Bonferroni correction was applied to ensure accuracy of conclusions.

Results

From December 2019 to April 2020, a total of 240 patients were assessed. Nine did not meet the inclusion criteria, and six declined participation. As a result, 225 patients were randomized into three groups: dexamethasone (n=75), paracetamol (n=75), and normal saline (n=75). During follow-up, ten patients were excluded (five from the dexamethasone group and five from the normal saline group) due to loss to follow-up. Ultimately, 215 patients successfully completed the study (Fig. 1).

No significant differences were observed in demographic and baseline data, including age, BMI, MAP, heart rate, and recovery time, among the three groups (Table 1).

Pain levels (VAS scores) in patients experiencing PDPH after receiving dexamethasone, paracetamol, or normal saline are shown in Table 2. At 6 hours, participants in the normal saline group reported higher pain levels compared to those in the dexamethasone and paracetamol groups (p=0.002). This difference was likely related to general postoperative pain rather than PDPH, which usually develops 12–72 hours after lumbar puncture. Further analysis confirmed significant differences between the normal saline and paracetamol groups (p=0.002), as well as between the normal saline and dexamethasone groups (p=0.038). By 48 hours, patients in the normal saline group reported significantly higher pain scores compared to those in the dexamethasone and paracetamol groups (p=0.009). However, no significant differences were observed at 12 or 72 hours post-surgery.

Figure 2 illustrates changes in pain scores over time across the three groups. A significant time effect was observed (p<0.001), indicating that pain scores changed notably over time. However, the interaction between time and groups was not significant (p=0.299). Although the trend of VAS scores was similar across groups, the group effect was significant (p=0.020). Post hoc analysis revealed significant differences between the normal saline and dexamethasone groups (p=0.006).

Table 3 compares the incidence and severity of PDPH across the three groups from 6 to 72 hours after cesarean section. Significant differences were found at 6 hours (p=0.003) and 48 hours (p=0.03). At 6 hours, 69.3% of patients in the paracetamol group and 67.1% in the dexamethasone group reported moderate headaches, while 54.3% of patients in the normal saline group experienced severe headaches. This early difference was likely due to immediate post-procedural discomfort rather than PDPH. By 48 hours, 50% of patients in the dexamethasone group and 49.3% in the paracetamol group reported mild headaches, compared to 65.7% in the control group who experienced moderate headaches.

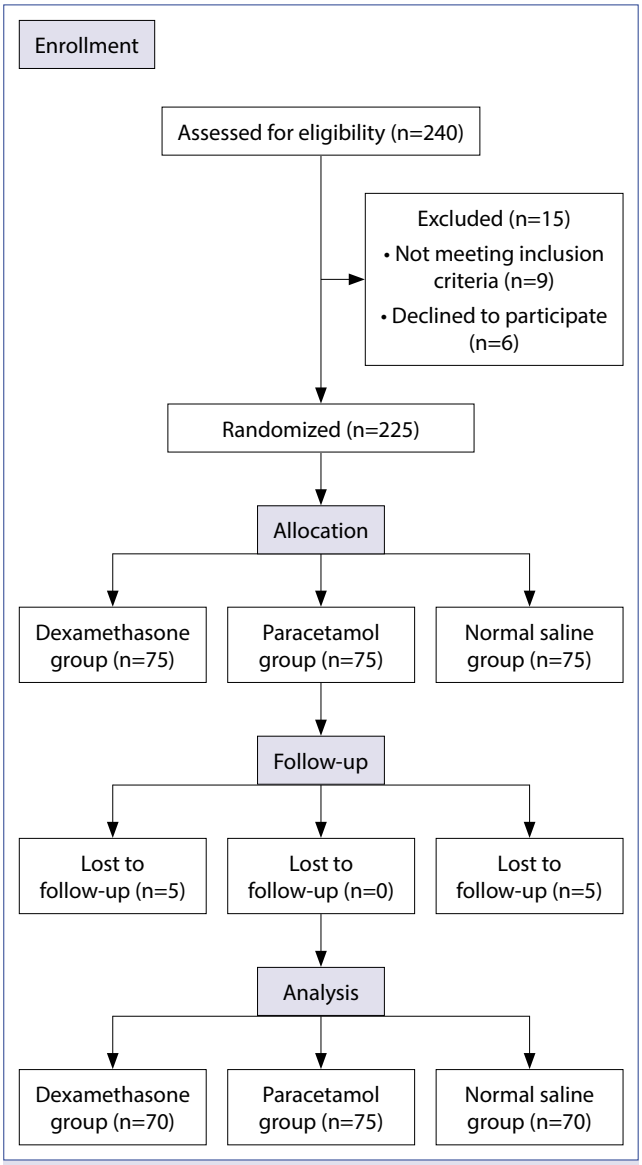

Figure 1. CONSORT flow diagram of the patient enrolment process.

Table 4 presents recovery time (in hours), frequency of painkiller use, and Apgar scores at 1 and 5 minutes. Recovery time was similar across groups (p=0.87).

Table 1. Demographic and Baseline data of studied groups

	Dexamethasone (n=70) Mean (SD)	Paracetamol (n=75) Mean (SD)	Normal saline (n=70) Mean (SD)	p
Age (year)	31.31±5.89	32.01±5.54	30.53±5.22	0.27
BMI (kg/m^2)	31.35±3.82	31.49±4.01	30.73±3.56	0.45
MAP	89.42±7.88	87.81±7.91	87.66±8.08	0.34
Heart rate	87.10±13.36	86.20±10.58	86.94±13.14	0.89

SD: Standard deviation; BMI: Body mass index.

Table 2. Comparing VAS score regarding PDPH in studied groups

	Dexamethasone (n=70)	Paracetamol (n=75)	Normal saline (n=70)	p
VAS 6hr	7.09±0.16^N	6.91±0.15^N	7.58±0.15^{DP}	0.002*
VAS 12hr	6.19±0.20	6.55±0.21	6.74±0.21	0.154
VAS 48hr	3.47±0.15^N	3.76±0.18 ^{N}	4.16±0.15 ^{DP}	0.009*
Vas 72hr	2.46±0.13	2.69±0.19	3.00±0.18	0.110

VAS: Visual Analog Score; PDPH: Post-dural puncture headache; SD: Standard deviation. Based on the Bonferroni correction in comparing with a significant level of 0.012. VAS 6hr is significant: Dexamethasone and Normal Saline (p=0.038), Paracetamol and Normal Saline (p=0.002). VAS 48hr is significant: Dexamethasone and Normal Saline (p=0.012), Paracetamol and Normal Saline (p=0.048).

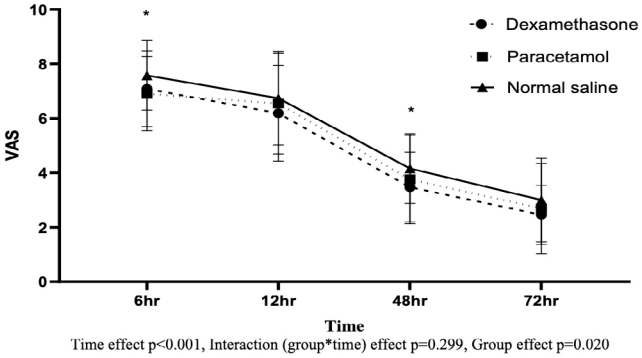

Figure 2. Change in pain over time in the three groups according to the Visual Analogue Scale (VAS).

*: Indicates a significant p-value.

No significant differences were observed among the groups in terms of recovery time, painkiller use, or Apgar scores (p>0.05).

Table 5 shows patient satisfaction levels. No statistically significant differences were found among the groups (p=0.08). Notably, 50% of patients in the dexamethasone group, 56% in the paracetamol group, and 34% in the normal saline group reported being completely satisfied.

Importantly, none of the groups experienced significant harm or adverse side effects from the medications.

Discussion

After spinal anesthesia, some individuals may experience a headache known as PDPH. This can be particularly challenging for women undergoing cesarean section. Although the reported incidence ranges from 0.5% to 1.6%, PDPH can significantly hinder maternal recovery, affect mother–infant bonding, and burden healthcare systems. The causes of PDPH are diverse, involving both patient- and procedure-related factors.

The pathophysiology of PDPH is multifactorial, with several patient-related and procedural factors implicated in its development and severity. These include BMI, migraine history, number of dural puncture attempts, needle gauge and tip design, patient age, obstetric comorbidities, and cerebrospinal fluid (CSF) leakage.[3,8–11] Despite decades of research, the precise mechanism remains incompletely understood, and most clinical strategies remain symptomatic rather than preventive. While interventions such as bed rest, aggressive hydration, and needle modifications have been proposed to reduce PDPH risk, their effectiveness remains controversial.[21–25]

Table 3. Comparing the incidence of PDPH and the severity in the studied groups

	Dexamethasone (n=70) Frequency (percentage)	Paracetamol (n=75) Frequency (percentage)	Normal saline (n=70) Frequency (percentage)	p
6hr				0.003*
No headache	0 (0)	0 (0)	1 (1.4)	
Mild	0 (0)	0 (0)	1 (1.4)	
Moderate	47 (67.1)	52 (69.3)	30 (42.9)	
Severe	23 (32.9)	23 (30.7)	38 (54.3)	
12hr				0.428
No headache	0 (0)	0 (0)	1 (1.4)	
Mild	2 (2.9)	4 (5.3)	1 (1.4)	
Moderate	53 (75.7)	49 (65.3)	46 (65.7)	
Severe	15 (21.4)	22 (29.3)	22 (31.4)	
48hr				0.033*
No headache	2 (2.9)	1 (1.3)	1 (1.4)	
Mild	35 (50)	37 (49.3)	21 (30)	
Moderate	33 (47.1)	35 (46.7)	48 (68.6)	
Severe	0 (0)	2 (2.7)	0 (0)	
72hr				0.687
No headache	3 (4.3)	4 (5.3)	3 (4.3)	
Mild	56 (80)	53 (70.7)	49 (70)	
Moderate	11 (15.7)	17 (22.7)	18 (25.7)	
Severe	0 (0)	1 (1.3)	0 (0)	

*: Indicates a significant p-value.

Table 4. Comparing clinical variables during the study between three groups

	Dexamethasone (n=70)	Paracetamol (n=75)	Normal saline (n=70)	p
Recovery time (hr.)	1.22±0.32	1.25±0.36	1.22±0.36	0.87
Painkiller use	49 (33.1)	50 (33.8)	49 (33.1)	0.41
Apgar 1	9±0.00	8.95±0.36	8.96±0.20	0.38
Apgar 5	9.95±.20	9.96±0.20	9.94±0.23	0.87

Values indicate Mean±SD or number (percentage). SD: Standard deviation.

In this study, the primary outcome revealed significant differences in headache intensity between groups at 6 and 48 hours postoperatively. The higher pain scores observed in the normal saline group at 6 hours may reflect surgical discomfort rather than true PDPH, which typically appears 12–72 hours after dural puncture. By 48 hours—generally the peak period for PDPH—patients in the dexamethasone and paracetamol groups demonstrated significantly lower pain scores compared to placebo. These results highlight the potential of these agents in reducing PDPH during the critical 24–72-hour postoperative window.

Dexamethasone proved to be the most effective, particularly in reducing moderate to severe PDPH, consistent with previous studies pointing to its anti-inflammatory and membrane-stabilizing properties.[18,26,27] Paracetamol also significantly reduced PDPH severity, though its effect was slightly less pronounced than dexamethasone, consistent with its

Table 5. Patient satisfaction

	Dexamethasone (n=70) n (%)	Paracetamol (n=75) n (%)	Normal saline (n=70) n (%)	p
Completely satisfied	35 (50)	42 (56)	24 (34.2)	0.08
Satisfied	7 (10)	10 (13.4)	7 (10)	
Neutral	9 (12.9)	9 (12)	15 (21.4)	
Unsatisfied	6 (8.6)	3 (4)	12 (17.2)	
Completely unsatisfied	13 (18.5)	11 (14.6)	12 (17.2)	

known analgesic mechanism through central COX inhibition and serotonergic modulation.[19] In contrast, patients in the placebo group experienced the most pronounced and persistent symptoms.

The literature on pharmacologic PDPH prophylaxis remains mixed. While some studies support the benefit of corticosteroids and acetaminophen in reducing PDPH incidence,[27,28] others, such as Yang et al.,[29] have reported contradictory findings, even suggesting a potential increase in PDPH with dexamethasone. In line with our results, Yousefshahi et al.[26] conducted a study on 372 women and found that the overall incidence rate of PDPH was 10.8%, with 28 cases from the dexamethasone group compared with 11 subjects from the placebo group (p=0.006). Similarly, Khraise et al.[22] reported a lower incidence of PDPH in the dexamethasone group compared to the control group. On the other hand, Yang and colleagues found that dexamethasone as a preventive measure did not reduce PDPH. In fact, it might have led to more cases of PDPH occurring within the first 24 hours after spinal anesthesia.[29] These discrepancies may be due to differences in study design, patient populations, timing and method of drug administration, and outcome measurement criteria.

No adverse effects were observed with either dexamethasone or paracetamol in our study, underscoring their safety for women undergoing cesarean section. Other factors such as recovery time, need for additional analgesia, newborn Apgar scores, and patient satisfaction did not significantly differ among the groups. However, patients in the treatment groups tended to be more satisfied, particularly those in the paracetamol group, which had the highest number of "completely satisfied" individuals. Postoperative pain management may have contributed to this sense of satisfaction. Analgesics can influence the incidence of PDPH as well as patients' perceptions of headache type. Since analgesic use was distributed evenly across all three groups (approximately 33%), the comparison of PDPH rates remains valid.

It is noteworthy that few studies have directly compared dexamethasone and paracetamol in preventing PDPH. Our findings indicate that both medications are beneficial, with dexamethasone appearing more effective. However, the lack of significant differences in other outcomes highlights the complexity of PDPH prevention and the need for multimodal strategies.

Overall, our study contributes to the growing evidence that prophylactic administration of dexamethasone or paracetamol may reduce the severity of PDPH. Nonetheless, these results require confirmation in larger, multicenter studies with longer follow-up and more diverse patient populations.

Conclusion

In this study, both intravenous dexamethasone and paracetamol significantly reduced the incidence and severity of headaches following spinal anesthesia during cesarean sections. Dexamethasone was particularly effective in lessening moderate to severe headaches within the first 24–48 hours after surgery, while paracetamol also provided protection with minimal risk. Although no significant differences were observed in recovery time, analgesic use, newborn health, or patient satisfaction, the reduction in headache severity suggests that these medications may be beneficial in preventing PDPH. Given the multifactorial causes of PDPH and the variability of results across studies, larger multicenter trials are needed to confirm these findings, refine treatment strategies, and establish specific guidelines for PDPH prevention in obstetric anesthesia.

Ethics Committee Approval: The Shiraz University of Medical Sciences Ethics Committee granted approval for this study (date: 08.04.2018, number: IR.SUMS.MED.REC.1396.130).

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Conflict of Interest: None declared.

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ORIGINAL ARTICLE

Analysis of the algology field in Türkiye: A cross-sectional study

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SUMMARY

Objectives: This study examines the professional satisfaction levels of algology specialists, their expectations regarding their educational processes, their academic careers, their experiences of violence in healthcare, their future expectations, and the challenges they face. In addition, it explores the impact of algology on the family and social life of physicians working in this field, its contribution to academic and personal rights, and its effect on economic situations.

Methods: Participants in this study were physicians who switched from neurology, anesthesiology and reanimation, and physical medicine and rehabilitation branches to the algology subspecialty. The study was conducted by volunteer participants who completed a 30-question survey.

Results: A total of 91.5% of the participants worked in tertiary healthcare institutions, 76.6% were between the ages of 30 and 40, 66% were male, and 57.4% were physicians who had transitioned from anesthesiology and reanimation.

Conclusion: The findings highlight the need for regulations to improve the working conditions of algology specialists, eliminate existing difficulties, strengthen the training curriculum, and prevent violence in healthcare. This study aims to raise awareness about the problems and expectations of algology specialists in Türkiye, to develop a solution-oriented road map, and to provide insights into what can be done to deliver higher-quality healthcare services and train qualified and satisfied physicians. Our study fills an important gap in the literature in this field, as it is the first study conducted among specialties in this context.

Keywords: Algology; pain; specialty of algology.

Introduction

Algology is the medical field concerned with pain. The first pain unit in Türkiye was established in 1986 at Istanbul University Faculty of Medicine. In 1990, the Higher Education Council decided to establish algology as a scientific discipline. The first algology department in Türkiye was established under the Department of Anesthesiology and Intensive Care at Istanbul University Faculty of Medicine. [1] In 2011, algology was designated by the Ministry of Health as a subspecialty under three main branches (Anesthesiology, Physical Medicine and Rehabilitation, Neurology), and the training period was set at two years. Thus, subspecialty training in algology began in 2013.

The aim of this study is to evaluate the professional experiences, working conditions, and expectations of algology subspecialists in Türkiye for the future of algology. The study aims to identify the status and future development areas in this field by analyzing the educational processes, clinical practices, professional satisfaction levels, and challenges faced by algology specialists.

Materials and Methods

The study was approved by the Ankara Training and Research Hospital Clinical Research Ethics Committee with decision number 199/2024, dated July 24, 2024. The study was conducted in accordance with the principles of the 2008 Declaration of Helsinki.

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Participants were selected from physicians who are anesthesiology, physical medicine and rehabilitation (PMR), and neurology specialists and had an algology subspecialty certificate. Physicians were contacted through face-to-face interviews following meetings, symposiums, and conferences, as well as through online surveys on scientific networks. Participation in the study was voluntary. The confidentiality of participants was ensured, and survey data were collected anonymously. The data obtained were used solely for scientific purposes. A total of 47 algology subspecialists participated in the research. The calculation was performed assuming a type 1 error of 0.05, power of 80%, effect size of 0.2, and prevalence of 50%, and the minimum sample size was found to be 37. As a data collection tool, a questionnaire designed to evaluate the professional experiences of algology subspecialists and their expectations for the future of algology was used. The survey consisted of 30 questions covering demographic information (age, gender, major, working conditions, etc.) and opinions of participants about the subspecialty of algology. The survey topics and questions were inspired by issues raised by algology specialists at congresses, symposiums, and other scientific meetings. The questions of the survey used in the study and the results of the frequency analysis are shown in Appendix 1.

Statistical Analysis

SPSS version 20 software was used to analyze the data. Nominal data are presented as numbers and percentages, and numerical data are presented as mean±standard deviation. The Kolmogorov-Smirnov test was used to assess normal distribution. Parametric tests were applied to normally distributed data, whereas non-parametric tests were used for non-normally distributed data. The chi-square test was used to compare categorical variables. When the minimum expected value in 2x2 tables was <5, Fisher's exact test was preferred; when it was in the range of 5–25, Yates' chi-square test was preferred; and when it was >25, Pearson's chi-square test was preferred. The Pearson chi-square test was used in the MXN tables. An exact correction was made if the minimum expected value was <1 or if more than 20% of the expected values were >5. P<0.05 was considered statistically significant.

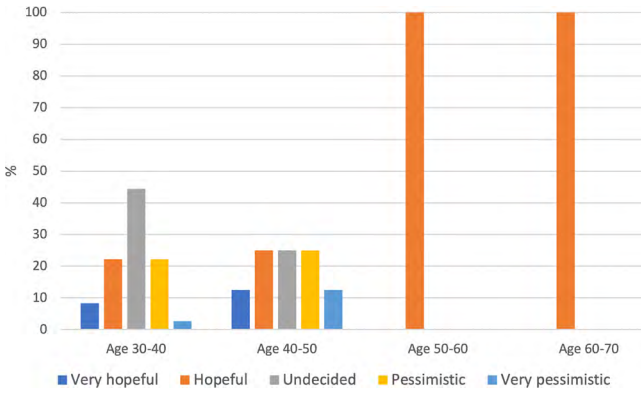

Figure 1. Percentage distribution of participants' thoughts on the future of algology according to age.

Results

When examining the relationship between thoughts on the future of algology according to age, no statistically significant difference was observed (Fig. 1).

In algology subspecialty preferences, professional satisfaction and economic reasons were statistically significant in women compared to men. No significant difference was found between genders in factors such as academic progress and the intensity of calls, on-call, and consultations within the major. No statistically significant difference was found between women and men in terms of the course of violent incidents in the subspecialty branch and experiences of mobbing (Table 1).

It was found that assignment in subspecialty specialization increased in those with anesthesiology and PMR, while it decreased in neurology (Table 2). It was observed that the incidence of verbal/physical violence or white code numbers (a system for the official reporting of workplace violence incidents against healthcare workers) increased among those whose main specialty was anesthesiology and intensive care, while it decreased among those whose main specialty was neurology (Table 2).

The impact of algology subspecialty training on active time spent with family and social life did not show a significant difference according to the level of healthcare service provided. In addition, no significant difference was found between the levels of health institutions in terms of salary satisfaction in the subspecialty, radiation leave entitlement, access to equipment, and provision of a suitable working environment in the operating room (Table 3).

Table 1. Reasons for choosing algology as a subspecialty and violence–mobbing experiences by gender

	Gender n (%)		p
	Male	Female	
Reasons for choosing algology subspecialty			
Professional satisfaction			**0.020**
Yes	26 (83.9)	8 (50)	
No	5 (16.1)	8 (50)	
Economic reasons			**0.010**
Yes	10 (32.3)	0 (0.0)	
No	21 (67.7)	16 (100)	
Academic advancement			0.848
Yes	14 (45.2)	6 (37.5)	
No	17 (54.8)	10 (62.5)	
High on-call, shift, and consultation workload in the main specialty			0.615
Yes	17 (54.8)	10 (62.5)	
No	14 (45.2)	6 (37.5)	
Change in frequency of violence/white code incidents from main to subspecialty			0.685
Increased	10 (32.3)	5 (31.3)	
Decreased	9 (29)	3 (18.8)	
No change	12 (38.7)	8 (50)	
Have you experienced mobbing in your subspecialty?			0.273
Yes	9 (29)	8 (50)	
No	22 (71)	8 (50)	

Table 2. Changes in workload, exposure to violence, and professional commitment during subspecialty training according to main specialty

	Main specialty n (%)			p
	Anesthesiology and intensive care	Physical medicine and rehabilitation	Neurology	
How has your workload changed during your subspecialty practice?				**<0.001**
Increased	17 (63)	5 (55.6)	1 (9.1)	
Decreased	7 (25.9)	1 (11.1)	10 (90.9)	
No change	3 (11.1)	3 (33.3)	0 (0.0)	
How has the frequency of verbal/physical violence or "white code" incidents changed during your subspecialty practice?				**<0.001**
Increased	14 (51.9)	1 (11.1)	0 (0.0)	
Decreased	1 (3.7)	3 (33.3)	8 (72.7)	
No change	12 (44.4)	5 (55.6)	3 (27.3)	
How has your professional commitment, motivation, and determination changed?				0.224
Increased	13 (48.1)	8 (88.9)	8 (72.7)	
Decreased	5 (18.5)	0 (0.0)	1 (9.1)	
No change	9 (33.3)	1 (11.1)	2 (18.2)	

Table 3. Impact of algology subspecialty training on family, social life, and academic activities, and satisfaction with salary, radiation leave, device access, and operating room conditions

	At which level of healthcare institution do you work? n (%)		p
	Secondary care	Tertiary care	
Change in time dedicated to family during algology subspecialty training			0.338
Increased	1 (25)	22 (51.2)	
Decreased	1 (25)	12 (27.9)	
No change	2 (50)	9 (20.9)	
Impact of algology subspecialty training on social life			0.818
Positive	2 (50)	27 (62.8)	
Negative	1 (25)	6 (14)	
Unchanged	1 (25)	10 (23.3)	
Change in time dedicated to academic work during algology subspecialty training			0.836
Increased	3 (75)	23 (53.5)	
Decreased	0 (0.0)	6 (14)	
No change	1 (25)	14 (32.6)	
Satisfaction with subspecialty salary			0.178
Yes	2 (50)	6 (14)	
No	1 (25)	19 (44.2)	
Undecided	1 (25)	18 (41.9)	
Institutional provision of radiation leave			0.260
Yes	0 (0.0)	15 (34.9)	
No	4 (100)	21 (48.8)	
Not aware	0 (0.0)	7 (16.3)	
Accessibility barriers to medical devices			0.121
None	1 (25)	27 (62.8)	
Ultrasonography	0 (0.0)	5 (11.6)	
Fluoroscopy	0 (0.0)	4 (9.3)	
Radiofrequency	1 (25)	2 (4.7)	
Do you experience difficulties in scheduling operating room time for interventional pain procedures?			0.171
Never	0 (0)	26 (60.5)	
Very rarely	0 (0)	1 (2.3)	
Rarely	0 (0)	1 (2.3)	
Sometimes	1 (25)	9 (20.9)	
Frequently	3 (75)	6 (14)	

When examining the change in work motivation according to the duration of subspecialty training, no significant difference was found (Table 4).

While professional satisfaction and workload in the major play an important role in determining the choice of an algology minor, economic reasons and academic progress appear to be less effective (Table 5).

Discussion

This study was conducted to comprehensively evaluate the professional satisfaction levels, educational processes, working conditions, exposure to violent incidents, and expectations regarding the future of algology among algology subspecialists in Türkiye. This is the first study to address this issue among

Table 4. Impact of algology subspecialty training on medical practice and levels of hope regarding its future

	Duration of practice as an algology subspecialist, n (%)			p
	≤5 years	5–10 years	>10 years	
How has your commitment, motivation, and determination toward the medical profession changed with algology subspecialty training?				0.621
Increased	22 (66.7)	5 (50)	2 (50)	
Decreased	4 (12.1)	2 (20)	0 (0)	
No change	7 (21.2)	3 (30)	2 (50)	
Would you recommend algology subspecialty training to physicians in your main specialty?				0.633
Definitely recommend	13 (39.4)	4 (40)	3 (75)	
Recommend	14 (42.4)	3 (30)	0 (0)	
Undecided	5 (15.2)	2 (20)	1 (25)	
Do not recommend	1 (2.9)	1 (10)	0 (0)	
How hopeful are you about the future of algology in general, and how do you assess its future prospects?				0.100
Very hopeful	3 (9.1)	1 (10)	0 (0)	
Hopeful	8 (24.2)	2 (20)	3 (75)	
Neutral	15 (45.5)	3 (30)	0 (0)	
Pessimistic	6 (18.2)	4 (40)	0 (0)	
Very pessimistic	1 (3)	0 (0)	1 (25)	

Table 5. Reasons for choosing algology as a subspecialty by main specialty

	Main specialty, n (%)			p
	Anesthesiology and intensive care	Physical medicine and rehabilitation	Neurology	
Professional satisfaction				**0.004**
Yes	21 (77.8)	9 (100)	4 (36.4)	
No	6 (22.2)	0 (0)	7 (63.6)	
Economic reasons				0.227
Yes	8 (29.6)	0 (0)	2 (18.2)	
No	19 (70.4)	9 (100)	9 (81.8)	
Academic advancement				0.615
Yes	10 (37)	5 (55.6)	5 (45.5)	
No	17 (63)	4 (44.4)	6 (54.5)	
High intensity of on-call duties, night shifts, and consultations in the main specialty				**<0.001**
Yes	17 (63)	0 (0)	10 (90.9)	
No	10 (37)	9 (100)	1 (9.1)	

algology and other subspecialties. The majority of participants (76.6%) were between the ages of 30 and 40, and 66% were male physicians. Furthermore, most of the survey participants specialized in anesthesiology (57.4%), and 91.5% worked in tertiary healthcare institutions.

In the literature, there are conflicting results regarding the relationship between physician satisfaction and age or years of experience.[2,3] However, some studies indicate that older and more experienced physicians have higher levels of professional satisfaction.[4,5] In our study, no significant difference was found in opinions regarding the future of algology according to age groups (p=0.477) (Fig. 1). This indicates that physicians in different age groups share a similar perspective on the future of algology.

When the effect of gender on the reasons for choosing an algology subspecialty was examined, the professional satisfaction rate of physicians was found to be 50% in women and 83.9% in men; economic reasons were found to be 0.0% in women and 32.3% in men. The findings reveal that male physicians are more likely than female physicians to choose algology for reasons of professional satisfaction and economic factors. There was no significant difference in terms of academic advancement; both gender groups attached similar importance to this issue (p=0.848).

When violence experiences were evaluated within the main specialty, verbal and physical violence incidents were found to increase by 31.9% in algology. Fifty percent of female physicians had experienced mobbing, compared to 29% of male physicians (p=0.273). In our study, 63% of physicians working in anesthesiology and intensive care and 55.6% in PMR reported an increase in workload, while this rate was only 9.1% in neurology (p<0.001). Similarly, the rates of violent incidents also varied by department; they were found to be 51.9% in anesthesiology and intensive care, 11.1% in PMR, and 0% in neurology (p<0.001).

The most common experience of violence among participants was due to drug requests from addicted patients (80.9%), followed by requests for examination without an appointment (70.2%) and requests not to wait in line for examination (61.7%).

These data reveal the fundamental causes of violence encountered when providing healthcare services in the field of algology. Preventing mobbing incidents and raising awareness on this issue are particularly important for female doctors. Studies can be conducted based on these data to identify the reasons for the increase in violence, prevent it, and increase physician satisfaction. It should be noted that research has shown that increased psychological stress and workload in the workplace significantly decrease physician satisfaction.[2,6,7] Changes in commitment to the profession, motivation to work, and perseverance are similar across specialties (Table 2).

When examining the effects of algology subspecialists' working conditions on their family life, social life, and academic work, 33.3% of those working in secondary care and 51.2% of those working in tertiary care reported an increase in the time they spent with their families (p=0.338). The impact on social life was reported as positive by 62.8% of respondents working in tertiary care and by 50% of those in secondary care (p=0.818). The proportion of specialists who reported an increase in time devoted to academic studies was 75% in secondary care and 53.5% in tertiary care (p=0.836). These data indicate that the effects of algology subspecialists' working conditions on family and social life differ between levels but are not statistically significant. The fact that the radiation permit rate is 34.9% in tertiary care and 0% in secondary care indicates that algology physicians working in secondary care are at risk regarding radiation safety and face various difficulties in accessing their personal rights. Physicians working in tertiary care stated that 62.8% had no problems with access to medical devices and 60.5% had no problems with taking time off in the operating room (Table 3). We observe that specialists working in secondary healthcare institutions face greater difficulties in accessing equipment and using operating theatres.

A study examining individual and work environment factors affecting employee motivation levels showed that, in addition to individual factors such as age, length of service, and work-related thoughts, work environment-related reasons such as status and conditions also significantly affected satisfaction.[8] When examining the commitment to the profession and the level of optimism about the future of algology among algology subspecialists, 66.7% of those with five years or less of experience reported an increase in their commitment to

the profession, whereas this rate decreased among those with longer experience. When examining levels of optimism regarding the future of algology, 33.3% of those who had been working for five years or less expressed a positive view, while 21.2% had a negative outlook. However, those who had been working for ten years or more appeared to have a more optimistic outlook (p=0.100) (Table 4).

In choosing algology as a subspecialty, professional satisfaction, economic reasons, academic advancement, and the intensity of on-call duties and consultations in the main specialty played a significant role in the decision-making process. For example, 36.4% of neurology specialists, 77.8% of anesthesiology and intensive care specialists, and 100% of PMR specialists chose the algology subspecialty for professional satisfaction (p=0.004). Although there was no significant difference according to major branches, it was seen that economic reasons were not an important source of motivation in the choices of most physicians in all branches (p=0.227). The intensity of on-call and consultation requests within the main specialty stood out as a significant factor influencing the choice of subspecialty in algology. While no physician in the PMR branch chose this subspecialty due to this intensity, it was cited as a reason for preference by 63% in anesthesiology and 90.9% in neurology (p<0.001) (Table 5).

In the subspecialty, according to the majority of participants (89.4%), violations of algology in main specialties are the biggest problem, while safety-violence issues ranked second (40.4%). A total of 68.1% of participants viewed on-call duties and consultations as the biggest problem in the main branch, while increased workload ranked second at 57.4%. Additionally, in assessments regarding employment rights alongside subspecialty training, 44.7% of participants stated that their employment rights had increased, while 12.8% stated that they had decreased. In light of these data, clearly defining the scope of procedures to be performed in the core curricula of the main branches and implementing regulations in the field of safety will resolve a significant portion of the issues faced by algology specialists. A study has shown that doctors with low job satisfaction are more likely to change jobs. The most obvious consequence of an unsatisfactory job is that doctors leave their jobs to work elsewhere, which disrupts patient-doctor continuity.[9] When our study is examined in this regard, it is seen that 59.6% of the participants had thought about working as an algology specialist abroad at least once due to the difficulties they experienced. When examining the tendency to return to their main specialties, 83% of participants said they had never considered this option. Furthermore, 76.5% of participants recommended subspecialty training in algology to physicians in their main specialties.

When the satisfaction levels regarding the conferences, seminars, and training programs organized by the Turkish Algology Association were examined, 80.8% of the participants expressed a positive opinion. In the evaluations regarding the effectiveness of the association in contributing to legislative changes in the field of health policies and algology, 44.6% stated that it was very effective or effective, 27.7% stated that it was not effective, and 27.7% stated that they were undecided. These data show that the association provides a high level of satisfaction with its educational activities in general, but that there are higher rates of indecision and dissatisfaction regarding legislative changes and contribution to policy.

Participants recommended increasing external rotation opportunities, introducing a thesis requirement, and expanding the use of regional anesthesia under ultrasound guidance in the algology training curriculum. Additionally, recommendations included removing the main discipline rotation, adding a neurosurgery rotation, and granting algology specialists the authority to provide PMR programs.

Conclusion

In conclusion, the findings obtained in this study provide important information for understanding the professional satisfaction levels of algology subspecialists, their expectations regarding educational processes, experiences of violence, expectations for the future, and the challenges they face. We believe that future studies will be valuable in terms of examining these dynamics in more detail and developing recommendations to solve the difficulties physicians face and prevent violence.

Ethics Committee Approval: The Ankara Training and Research Hospital Clinical Research Ethics Committee granted approval for this study (date: 24.07.2024, number: 199/2024).

Informed Consent: Written informed consents were obtained from patients who participated in this study.

Conflict of Interest: The authors declare that there is no conflict of interest.

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Peer-rewiew: Externally peer-reviewed.

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Appendix 1. Survey questions applied in the study and frequency analysis results

	Questions	Options	Frequency	%
1.	Age?	☐30–40	36	76.6
		☐40–50	8	17
		☐50–60	1	2.1
		☐60–70	2	4.3
2.	Gender?	☐Male	31	66
		☐Female	16	34
3.	What is your main specialty?	☐Anesthesiology and intensive care	27	57.4
		☐FMR	9	19.1
		☐Neurology	11	23.4
4.	At which level of healthcare institution do you work?	☐Secondary care public institution	4	8.5
		☐Tertiary care public institution	43	91.5
		☐Primary care or private healthcare institutions	0	0
5.	Duration of working as an algology subspecialist?	☐≤5 years	33	70.2
		☐5–10 years	10	21.3
		☐>10 years	4	8.5
6.	What are the main reasons for choosing your subspecialty? (You may select more than one option)	☐Professional satisfaction	34	72.3
		☐Economic reasons	10	21.3
		☐Academic advancement	20	42.6
		☐High on-call duty, shift, and consultation workload in your main specialty	27	57.4
7.	How has your workload been during your work as an algology subspecialist?	☐Increased	23	48.9
		☐Decreased	18	38.3
		☐Unchanged	6	12.8
8.	How has your time with your family been during your work as an algology subspecialist?	☐Increased	24	51.1
		☐Decreased	11	23.4
		☐Unchanged	12	25.5
9.	How has your social life been affected by your algology subspecialty?	☐Positive	29	61.7
		☐Negative	7	14.9
		☐No change	11	23.4
10.	How much time do you dedicate to academic work alongside your algology subspecialty?	☐Increased	26	55.3
		☐Decreased	6	12.8
		☐Unchanged	15	31.9
11.	How has your economic purchasing power changed with your subspecialty?	☐Increased	25	53.2
		☐Decreased	6	12.8
		☐Unchanged	16	34
12.	Are you satisfied with the income you earn in your subspecialty?	☐Yes	8	17
		☐No	20	42.6
		☐Undecided	19	40.4
13.	How does the rate of verbal/physical violence or 'white code' incidents you experience in your subspecialty compare to your main specialty?	☐Increased	15	31.9
		☐Decreased	12	25.5
		☐Unchanged	20	42.6

Appendix 1 (cont). Survey questions applied in the study and frequency analysis results

	Questions	Options	Frequency	%
14.	What are the reasons for the verbal/ physical violence or 'white code' incidents you have experienced? (Select all that apply)	☐Requests for medication by dependent patients	38	80.9
		☐Walk-in consultation requests	33	70.2
		☐Avoiding waiting in line for examination	29	61.7
		☐Other	1	2.1
15.	Have you been subjected to mobbing in your subspecialty?	☐Yes	17	36.2
		☐No	30	63.8
16.	What were the most significant problems you faced in your main specialty? (Select all that apply)	☐Economic concerns	15	31.9
		☐Safety and violence issues	12	25.5
		☐Workload	27	57.4
		☐On-call duties, night shifts, and consultations	32	68.1
		☐Mobbing	4	85
		☐Other (e.g., professional dissatisfaction, academic career)	5	10.6
17.	What are the most significant problems you encounter in your subspecialty? (Select all that apply)	☐Economic concerns	10	21.3
		☐Safety and violence issues	19	40.4
		☐Workload	15	31.9
		☐Mobbing	5	10.6
		☐Encroachment on algology practice by other specialties	42	89.4
		☐Other (e.g., professional insufficiency)	1	2.1
18.	How has your commitment, motivation, and determination toward the profession changed after your subspecialty training	☐Increased	29	61.7
		☐Decreased	6	12.8
		☐Unchanged	12	25.5
19.	How have your employment rights/ benefits changed with your subspecialty?	☐My employment rights/benefits have increased	21	44.7
		☐My employment rights/benefits have decreased	6	12.8
		☐No opinion	20	42.6
20.	Has your annual radiation leave been granted by your hospital?	☐No	25	53.2
		☐Yes	15	31.9
		☐No opinion	7	14.9
21.	Are there any medical devices that are difficult to access when needed in your institution?	☐Ultrasonography	5	10.6
		☐Fluoroscopy device	4	8.5
		☐Radiofrequency device	3	6.4
		☐None	28	59.6
		☐All	7	14.9
		☐Other	0	0
22.	Do you experience difficulties in obtaining operating room time for algological procedures?	☐No, never	26	55.3
		☐Yes, very rarely	1	2.1
		☐Yes, rarely	1	2.1
		☐Yes, sometimes	10	21.3
		☐Yes, frequently	9	19.1

Appendix 1 (cont). Survey questions applied in the study and frequency analysis results

	Questions	Options	Frequency	%
23.	Have you considered returning to your main specialty as a result of the difficulties encountered in your subspecialty?	☐No, never	39	83
		☐Yes, very rarely	3	6.4
		☐Yes, rarely	1	2.1
		☐Yes, sometimes	3	6.4
		☐Yes, frequently	1	21
24.	Have you considered working abroad as an algology specialist?	☐No, I have not considered it	19	40.4
		☐Yes, very rarely	5	10.6
		☐Yes, rarely	12	25.5
		☐Yes, frequently	11	23.4
25.	Would you recommend algology subspecialty training to physicians practicing in your main specialty?	☐Definitely recommend	20	42.5
		☐Recommend	16	34
		☐Undecided	8	17
		☐Do not recommend	2	4.2
		☐Strongly do not recommend	1	2.1
26.	How satisfied are you with the conferences, seminars, and educational programs organized by the Turkish Algology Society?	☐Very satisfied	8	17
		☐Satisfied	30	63.8
		☐Undecided	6	12.8
		☐Dissatisfied	3	6.4
		☐Very dissatisfied	0	0
27.	How do you assess the effectiveness of the Turkish Algology Society in contributing to health policies and legislative changes in the field of algology?	☐Very effective	5	10.6
		☐Effective	16	34
		☐Undecided	13	2.7
		☐Ineffective	11	23.4
		☐Very ineffective	2	4.3
28.	How optimistic are you about the future of algology, and how do you evaluate its future prospects?	☐Very optimistic – it has a very bright future	4	8.5
		☐Optimistic – it has a bright future	13	27.7
		☐Neutral– neither bright nor poor	18	38.3
		☐Pessimistic	10	21.3
		☐Very pessimistic	2	4.3
29.	What are your perspectives on the future role and influence of algology specialists?	☐Their role and influence will increase	23	48.9
		☐Their role and influence will decrease	17	36.2
		☐Their role and influence will remain the same	7	14.9
30.	Do you think there are important changes needed in the algology training curriculum? Please provide your suggestions • External rotation opportunities should be introduced • A thesis requirement should be added • Training and practice in regional anesthesia and ultrasound-guided peripheral nerve and plexus blocks should be increased • The main specialty rotation should be removed, and the duration of rotations in other departments should be shortened. • A neurosurgery rotation should also be included in the program. • Algology specialists should be granted the competence to provide physical therapy to patients.			

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ORIGINAL ARTICLE

The effectiveness of intra-articular pulsed radiofrequency in patients with painful knee osteoarthritis: A randomized controlled trial

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SUMMARY

Objectives: This study aimed to compare the effects of intra-articular steroid injection (IASI) and IASI combined with intra-articular pulsed radiofrequency (IAPRF) on pain and functional activities in stage II–III knee osteoarthritis.

Methods: This randomized controlled trial included patients with knee pain persisting for more than 3 months. The participants were randomized into two groups: IAPRF + steroid injection (Group 1) and steroid injection only (Group 2). The injections were administered under fluoroscopic guidance, and the needle was advanced to the midline of the tibiofemoral joint. Group 1 received 8 mg of intra-articular dexamethasone after IAPRF application for 360 s at 45 V, with the temperature not exceeding 42°C. Group 2 received 8 mg of intra-articular dexamethasone only. Pain intensity and participation in daily activities were evaluated using the Numerical Rating Scale and the Western Ontario and McMaster Universities Arthritis Index, respectively, before the procedure and 1, 4, and 12 weeks after the procedure.

Results: A total of 54 patients were included in the study. Demographic data, baseline pain levels, and functional activities did not differ between the groups. Pain intensity at 4 and 12 weeks after the procedure was lower in Group 1. Participation in daily living activities was significantly higher in Group 1 at 12 weeks after the procedure.

Conclusion: IAPRF combined with intra-articular steroid significantly improves pain during the early-to-mid period and participation in daily living activities in the mid-term in stage II–III knee osteoarthritis.

Keywords: Intra-articular injection; knee osteoarthritis; pain management; pulsed radiofrequency treatment.

Introduction

Osteoarthritis (OA) of the knee, a leading cause of disability in the elderly population, is characterized by pain, stiffness, and limitations in the activities of daily living.[1,2] Several conservative methods have been introduced for the management of OA of the knee, such as symptomatic pain medications, physical therapy modalities, intra-articular steroid injections, platelet-rich plasma injections, visco-supplementation, and genicular nerve ablation methods. Surgical options, such as knee replacement, may also be considered in patients who do not benefit from conservative treatment, especially those with advanced OA.[2]

Radiofrequency ablation of the genicular nerves is widely performed by pain specialists, as pain signals in the knee are transmitted via the genicular nerves. The free nerve endings in the joint capsules have become a target for treatment in recent years. The application of intra-articular pulsed radiofrequency (IAPRF) to the knee joint was first reported in 2008,[3] with subsequent studies reporting promising results.[4–6] IAPRF is an easy-to-apply method with a low risk of side effects and complications. However, its mechanism of action remains to be clarified.

PRF is assumed to alter the transmission of pain through the pericapsular nerve endings, thereby reducing the severity of pain; however, further re-

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search is required to confirm its effectiveness. Therefore, this study aimed to investigate the additional effect of IAPRF on pain and functional activities in patients with grade II and III knee OA.

Materials and Methods

This single-center, single-blinded, randomized prospective trial received approval from the Ethics Committee of Başakşehir Çam and Sakura City Hospital and was conducted in accordance with the Declaration of Helsinki. The study was carried out between May and September 2022. After receiving ethical approval, 62 patients who were assessed for eligibility were referred to the Pain Medicine Outpatient Clinic of Başakşehir Çam and Sakura City Hospital. Among these 62 patients, six were excluded as they did not meet the inclusion criteria, and two declined participation. Thus, 54 patients were enrolled in the study after providing written and verbal consent.

The enrolled patients were randomized into two groups: Group 1 (IAPRF+steroid injection) and Group 2 (steroid injection only) (Fig. 1). Randomization was performed using a computerized program. Randomization, pre-injection assessments, and enrollment were carried out by the clinic nurse. Due to differences between the methods applied in the two groups, the operator and nurses were not blinded. However, post-injection assessments were performed by a blinded evaluator.

The inclusion criteria were as follows: (1) age over 18 years, (2) knee pain persisting for more than 3 months due to knee OA, (3) Kellgren–Lawrence Classification grades II and III OA, and (4) provision of written and verbal informed consent. Exclusion criteria included: (1) history of knee surgery and/or intra-articular knee injection within the previous 6 months, (2) local or systemic infections or a coagulation disorder, or (3) refusal to participate in the study.

All procedures were performed by a practitioner with more than 5 years of experience in an operating room under blood pressure and peripheral oxygen saturation monitoring. Patients were placed in the supine position with knees slightly flexed. For local anesthesia, 1–2 mL of 1% lidocaine was administered.

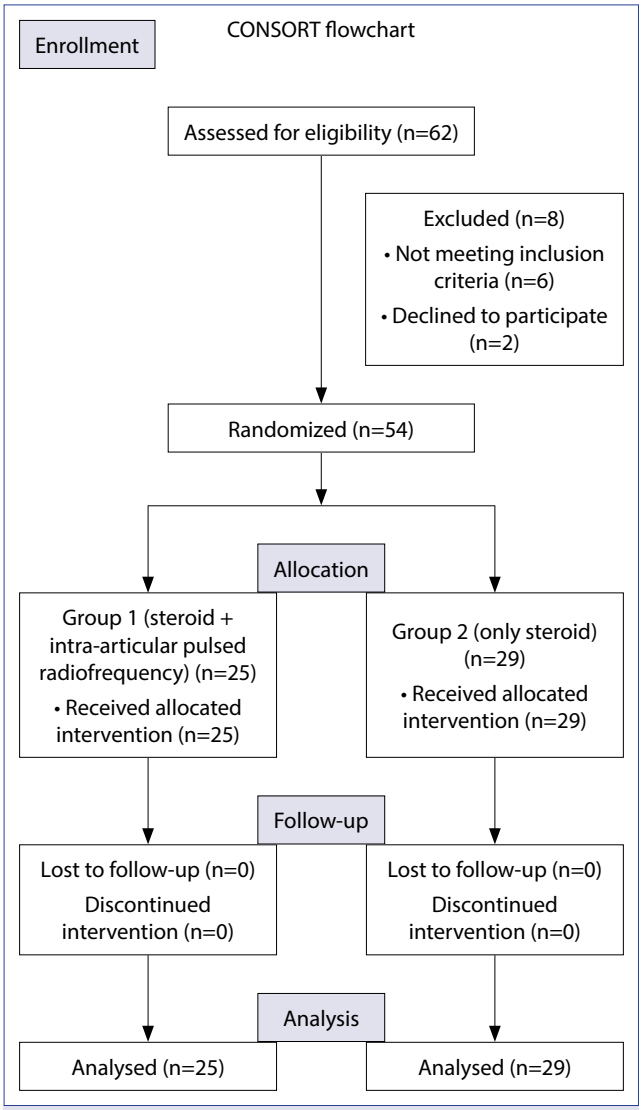

Figure 1. Flow diagram.

In Group 1, a 22-G 10-cm radiofrequency cannula with a 10-mm active tip was advanced to the mid-tibiofemoral joint under fluoroscopic guidance (Fig. 2). After needle insertion, paresthesia-pain and motor stimulation tests were performed using sensory (50 Hz) and motor (2 Hz, 1 V) stimulation to confirm the absence of stimulation. PRF was applied at 45 V with a 20-ms pulse width for 360 s, followed by a 480-ms silent phase. The tissue temperature was kept below 42°C. After confirmation of intra-articular contrast injection, 8 mg of dexamethasone was administered.

In Group 2, a 22-G needle was advanced to the mid-tibiofemoral joint, and 8 mg of dexamethasone was administered under fluoroscopic guidance.

Outcomes

Pre-injection evaluation and demographic data

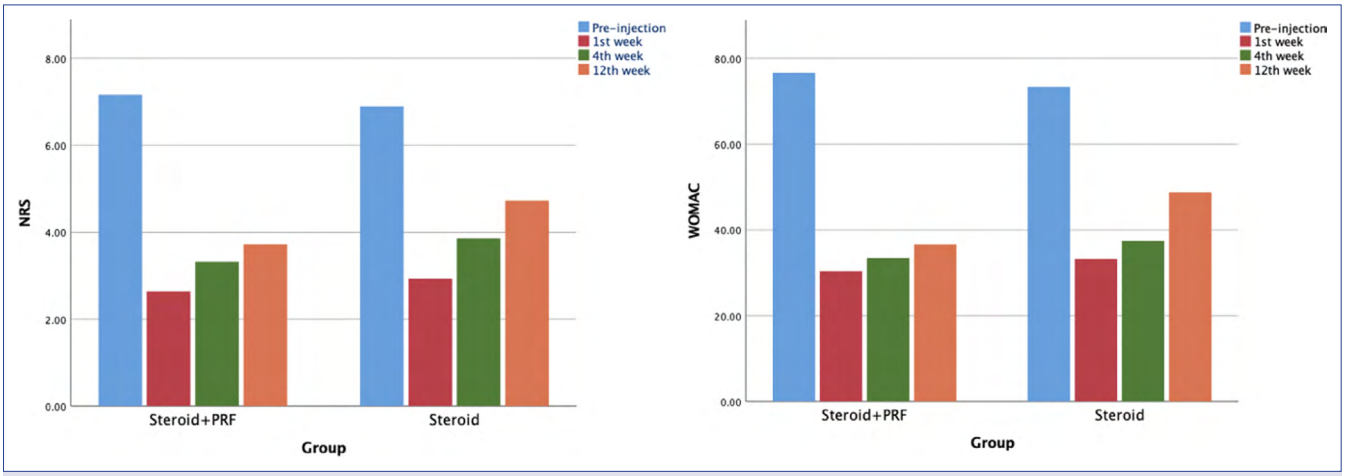

Figure 2. Numeric rating scale (NRS) and Western Ontario and McMaster Universities Arthritis Index (WOMAC) score graphs of patients.

collection were performed by the operator before randomization. Post-injection evaluations were performed by the patients under the guidance of a blinded evaluator at 1, 4, and 12 weeks after treatment.

Numeric Rating Scale

Knee pain was assessed using the numeric rating scale (NRS) at all evaluation points. Patients were instructed to score their pain intensity on a scale of 0 to 10, where 0 represents "no pain at all" and 10 represents "worst pain ever possible."

Western Ontario and McMaster Universities Arthritis Index

The Western Ontario and McMaster Universities Arthritis Index (WOMAC) was used to assess daily living activities at all evaluation points. The WOMAC consists of 24 items across three subscales: pain, stiffness, and physical function. All items were scored on a scale of 0 to 4, where 0 represents none, 1 represents mild, 2 represents moderate, 3 represents severe, and 4 represents extreme. The total score ranges from 0 to 96, with a higher score indicating poorer function in daily living activities.

Sample Size

The sample size was calculated using G*Power V.3.1.7 (University of Kiel, Kiel, Germany) based on data from Yuan et al.[7] According to their visual analog scale scores 4 weeks after treatment (corticosteroid group: 3.6±1.6, radiofrequency group: 2.1±1.4), with a power (β error)=0.95 and α error=0.05, the minimum sample size was calculated as 23 for each group, with an estimated drop-out of 10%. Thus, a minimum of 51 patients were planned to be enrolled in the study.

Statistical Analysis

All statistical analyses were performed using SPSS Statistics for Mac Version 25 (IBM, Armonk, NY). The Shapiro–Wilk test, histograms, and normality plots were used to evaluate the distribution of values. Descriptive statistics are presented as mean (standard deviation). Some data were not normally distributed; therefore, non-parametric tests were used to evaluate between- and within-group changes. Between-group comparisons were performed using the Mann–Whitney U test, within-group changes were evaluated using the Friedman test, and pairwise comparisons were performed using the Wilcoxon test with Bonferroni correction. Statistical significance was set at $p<0.05$.

Results

A total of 54 patients (44 females and 10 males) were included in the study. The mean age was 62.9 years in Group 1 and 61.9 years in Group 2. No significant differences were observed between the patient demographics, such as age, sex, weight, height, and body mass index (BMI), in the two groups (Table 1).

The baseline pain intensity measured using NRS (7.16±0.85; 6.9±0.9; p=0.242, respectively) and the functional level in daily living activities measured using the WOMAC scores (76.64±8.47; 73.31±8.46; p=0.124, respectively) were similar between the two groups (Table 2).

Table 1. Patient demographics

	Steroid+IAPRF group (n=25)	Steroid group (n=29)	p
Age (years)			0.531[a]
Mean±SD	62.9± 8	61.9±8.8	
Min–Max	45–79	46–78	
Sex (female/male)	21/4	23/6	0.658[b]
Height (cm)			0.074 [a]
Mean±SD	161.5±6.8	163.3±5.6	
Min–Max	152–180	156–180	
Weight (kg)			0.23[a]
Mean±SD	81.8±17.6	75.5±9.2	
Min–Max	57–135	58–95	
BMI (kg/m^2)			0.071[a]
Mean±SD	31.4±6.84	28.3±3.1	
Min–Max	22.8–54.1	23.8–35.9	
Side (Right/Left)	15/10	13/16	0.266[b]
Radiological grade			0.266[b]
Grade II	10	16	
Grade III	15	13	

IAPRF: Intra-articular pulsed radiofrequency; SD: Standard deviation; Min: Minimum; Max: Maximum; BMI: Body Mass Index; a: Mann–Whitney U test; b: Chi-Squared Test.

A significant decrease in pain levels and an increase in daily functionality were observed in both groups during follow-up. In addition, a substantial difference was observed between baseline and later evaluation timepoints, as well as between the first and 12th weeks. Compared with Group 2, pain levels were lower at 4 and 12 weeks in Group 1, while daily function was better only at the 12th week (Table 2, Fig. 3).

In patients who received steroid+IAPRF, 10 were grade II and 15 were grade III. Mann–Whitney U analysis was used to examine the effect of radiological stage of osteoarthritis on pain and functional level in patients who received pulsed RF treatment. No statistically significant difference was found between stage II and III in baseline, 1st, 4th, and 12th week VAS scores (p=0.182, 0.928, 0.951, 0.859, respectively). Similarly, no statistically significant difference was found between stage II and III in WOMAC values at baseline, 1st, 4th, and 12th week follow-ups (p=0.781, 0.824, 0.632, 0.889, respectively).

Table 2. Mean NRS and WOMAC scores before and 1, 4, 12 weeks after procedure in both groups

	Steroid+IAPRF group (n=25) Mean±SD	Steroid group (n=29) Mean±SD	p*
NRS			
Pre-injection	7.16±0.85	6.9±0.9	0.242
1st week	2.64±0.76	2.93±0.75	0.136
4th week	3.32±0.69	3.86±0.74	**0.004**
12th week	3.72±0.46	4.72±0.59	**<0.001**
p-value**	**<0.001**	**<0.001**	
p-value[a]	<0.001	<0.001	
p-value[b]	<0.001	<0.001	
p-value[c]	0.001	0.004	
WOMAC			
Pre-injection	76.64±8.47	73.31±8.46	0.124
1st week	30.36±6.81	33.2±6.79	0.125
4th week	33.48±6.65	37.41±8.15	0.054
12th week	36.64±5.63	48.76±7.79	**<0.001**
p-value**	**<0.001**	**<0.001**	
p-value[a]	<0.001	<0.001	
p-value[b]	<0.001	<0.001	
p-value[c]	0.001	0.006	

IAPRF: Intra-articular pulsed radiofrequency; SD: Standard deviation; NRS: Numeric Rating Scale; WOMAC,: Western Ontario and McMaster Universities Arthritis Index; *: Comparison between groups by Mann–Whitney U Test; **: Comparison within Groups by Friedman Test; a: Pre-injection to 1st week; b: Pre-injection to 4th week; c: Pre-injection to 12th week.

Discussion

Previous studies have demonstrated positive results regarding the effectiveness of IAPRF in recent years. However, few prospective randomized controlled studies have been conducted in this field. To the best of our knowledge, this is the first study to investigate the efficacy of IAPRF combined with steroids in patients with knee OA.

Various theories have been proposed regarding the mechanisms of action of IAPRF. According to Sluijter et al.,[3] pain is modulated by a dual effect. The PRF waves may affect the pericapsular nerve endings and suppress the excitatory C-fiber response, thereby reducing pain by regulating synaptic transmission when applied intra-articularly.[4] A second effect

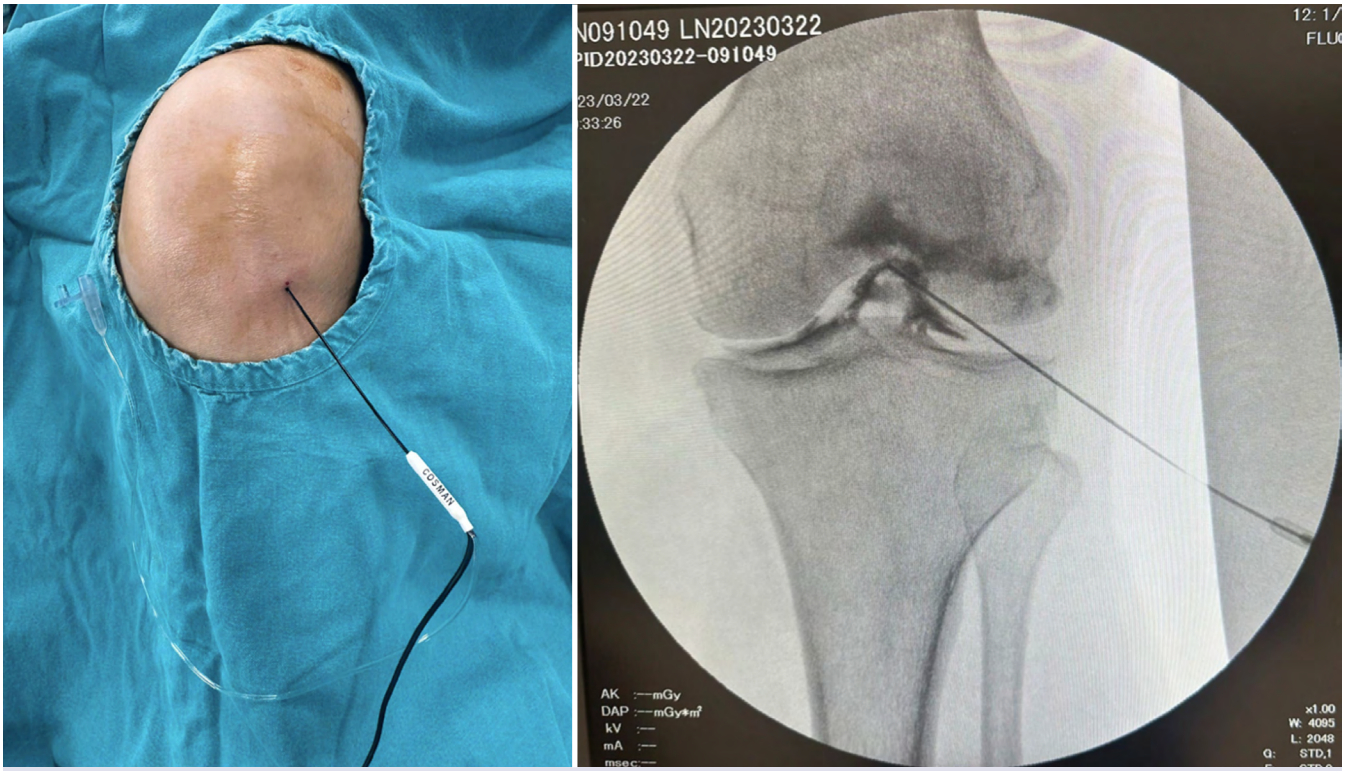

Figure 3. Fluoroscopic images of needle placement.

on the immune response has also been suggested. Tissue studies have shown that single and repetitive PRF applications decreased the concentrations of inflammatory mediators such as COX-2, IL-1B, IL-6, IL-10, and TNF-α (with enzyme-linked immunosorbent assays and western blots) in the synovial membrane and synovial fluid of the inflamed knee, resulting in decreased pain and improved function.[8,9]

The clinical effects of IAPRF on knee joint pain have been studied over the past decade. Karaman et al.[10] investigated the effect of IAPRF in 31 patients with early-stage gonarthrosis (Kellgren–Lawrence Classification grades 1–3) and reported a 32.8% reduction in pain levels for up to 6 months. Another study, which included patients with late-stage OA (grades 3–4) who received IAPRF, reported significantly lower pain levels for up to 12 months.[4] Papa et al.[6] retrospectively analyzed 129 patients who received IAPRF in 2021 and reported a significant reduction in pain at 1, 3, and 4 months after the procedure. However, these studies lacked control groups and were conducted retrospectively.

Another study investigating the effectiveness of IAPRF compared with intra-articular steroid injection, with 22 patients in the IAPRF group and 20 in the steroid group, was published by Yuan et al.[7] IAPRF was applied at a temperature of 42°C and a frequency of 2 Hz for 6 min in that study. Although both groups showed remarkable improvements, significantly lower pain levels and better WOMAC scores were observed in the IAPRF group at weeks 1, 4, 8, 12, and 24. A synovial fluid analysis revealed that pro-inflammatory cytokine levels such as TNF-α, MMP-3, and IL-1 decreased in both groups, with a significantly greater reduction in the IAPRF group.

In our study, consistent with previous reports, both the steroid and IAPRF + steroid groups showed improvements in pain levels and function within groups at all timepoints. Both groups showed a trend of increasing pain and worsening function after the first week but at different magnitudes. When the groups were compared across timepoints, pain levels were significantly lower in Group 1 at the first and third months, and WOMAC scores were significantly lower at the third month. Statistically insignificant differences at earlier timepoints may be attributed to the fact that both groups received steroid injections.

The appropriate duration and parameters for PRF application remain debated. Application times vary from 6 to 15 min in different studies, along with dif-

ferences in pulse duration and voltage. Moreover, the duration of effect remains unclear. Although positive effects were observed for up to 3 months in the short- and mid-term results, some studies with longer follow-up periods have shown improvements lasting up to 12 months. In the present study, IAPRF in combination with steroid injections was effective for up to 3 months.

Gulec et al.[11] studied the effects of unipolar and bipolar IAPRF in knee OA and reported a significant reduction in pain at 1, 4, and 12 weeks in both groups. At least 50% pain relief was observed in 84% of patients in the bipolar group and in 50% of patients in the unipolar group. Pain reduction and WOMAC scores were significantly higher in the bipolar PRF group, indicating that the application of a wider electromagnetic field may yield better clinical results.

Hong et al.[12] retrospectively analyzed 57 patients, among whom 29 received high-voltage IAPRF treatment and 28 received low-voltage IAPRF treatment. The NRS scores in the high-voltage group were significantly lower than those in the low-voltage group from the first week to 6 months. High-voltage PRF has been widely studied for the treatment of various chronic pain syndromes and pathologies in recent years.[13,14]

Hong et al.[15] retrospectively compared radiofrequency thermocoagulation of the genicular nerves (RFTC-GN), IAPRF, and intra-articular steroid injections. Post-treatment results were better than pre-treatment results in all three groups. Although pain scores were lower in the RFTC-GN group at baseline, there was no significant difference between the long-term results of RFTC-GN and IAPRF (3 and 6 months).[15] IAPRF is preferred over RFTC-GN, as it is not an ablative method, has a low risk of complications, and shows no significant difference in efficacy at long-term follow-up.

No major complications were observed in the present study. A short-term increase in pain occurred in some patients during the first 1–2 days after the procedure. These patients were advised to apply ice and take paracetamol if needed. IAPRF application has been found to be safe in the literature, and no major complications have been reported in previous studies.[7,10,15,16]

Limitations

The randomized controlled design of the present study, which evaluated the efficacy of IAPRF in combination with intra-articular steroid injection for the treatment of knee pain resistant to medical therapy, contributes to the literature. However, the absence of a true placebo/sham group due to ethical reasons is among its limitations. Patients were advised to continue the same analgesic treatments, and their analgesic prescriptions were not changed during the study. However, concomitant analgesic medication data were not collected during the trial, which may also represent a limitation. Further studies with longer follow-up periods and tissue or synovial fluid analyses will contribute to the literature.

Conclusion

Based on our findings, in stage II–III knee OA, IAPRF application in combination with intra-articular steroid may improve knee pain and participation in daily living activities during the early-to-mid period and is considered a safe method.

Ethics Committee Approval: The Başakşehir Çam and Sakura City Hospital Ethics Committee granted approval for this study (date: 01.04.2022, number: 2022.03.89).

Informed Consent: Written and verbal informed consent was obtained from all patients.

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ORIGINAL ARTICLE

Comparison of radiation doses of fluoroscopy-guided transforaminal epidural steroid injections and dorsal root ganglia pulsed-radiofrequency applications

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SUMMARY

Objectives: The study aims to determine procedure times and estimate the radiation doses for fluoroscopy-guided transforaminal epidural steroid injection (TFESI) and dorsal root ganglion pulsed radiofrequency (DRG RF) per intervention. The goal is to postulate radiation doses for potential utilization in plans to reduce radiation doses in future interventions.

Methods: An observational study was conducted on six hundred ninety-six patients with low back pain who underwent fluoroscopy-guided TFESI or DRG RF at an algology clinic of a training and research hospital. Procedure time and radiation dose per procedure were recorded.

Results: One hundred eighty-nine of the patients underwent DRG RF, and 507 of them underwent TFESI. A total of 1,069 procedures were performed. Procedure time and radiation dose per procedure were found to be 25.68 seconds (7–94) and 4.99 mGy (0.66–49.4), respectively. There was no difference between the DRG RF and TFESI groups in terms of diagnosis, age, gender, BMI, procedure level, and radiation dose. It was found that the procedure time was significantly lower in the DRG group.

Conclusion: Although no difference was detected between TFESI and DRG RF in terms of radiation dose, the procedure time was found to be significantly shorter in the DRG RF group. Pulsed radiofrequency may be preferred in necessary patients, considering the cost.

Keywords: Dorsal root ganglia; epidural; fluoroscopy; radiation doses; radiofrequency; transforaminal.

Introduction

Spinal interventions under fluoroscopy guidance are frequently used to ensure accurate injection into the target area. While it positively affects treatment outcomes, it can also prevent intravascular injections, dural tears, spinal cord infarction, and even death.[1] However, concerns about radiation exposure have come to the fore with the increasing frequency of use. Lumbar transforaminal epidural steroid injections (TFESI) and dorsal root ganglia (DRG) radiofrequency (RF) procedures are efficient techniques for patients suffering from low back radicular pain, and fluoroscopy guidance is required.

Epidural steroid injections are offered to deliver steroids or local anesthetics to the target area. TFESI is one of the most frequent epidural injections performed fluoroscopy-guided. The DRG plays a key role in the development of chronic pain, and DRG interventions for chronic pain management are an important part of its treatment. The DRG includes sensory neurons that are essential for the transmission of sensory information and non-neuronal cells such as macrophages and immune cells that are responsible for the modulation of neuronal function.[2] Cellular interactions between macrophages and neurons have been shown to regulate the pain signaling.[3] The recent study also showed that there was

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a decrease in serum TNF levels that continued until the 3rd month after combined DRG RF and TFESI.[4]

Both TFESI and DRG RF are performed by clinicians for low back and radicular pain. Some studies have shown that both procedures have similar effects in the short and long term.[5,6] But to our knowledge, the radiation dose and procedure time of these two procedures have not been compared yet. Therefore, the study aims to find out procedure times and estimate the radiation doses for two particular approaches of fluoroscopy-guided injections per intervention to postulate radiation doses for potential utilization for plans to reduce radiation dose in future interventions.

Materials and Methods

Design and Study Population

The research project protocol has been approved by the Ethics Committee at Health Sciences University Şişli Hamidiye Etfal Training and Research Hospital and is carried out in accordance with the ethical standards specified in the Helsinki Declaration (ethics approval number 4075). All individuals gave their informed consent before being included in the study. After receiving institutional ethics committee approval, patients who underwent lumbar TFESI or DRG RF under fluoroscopy were included. The primary outcome of the study is to calculate radiation dose per level and procedure time for fluoroscopy-guided TFESI and DRG-RF performed by experienced interventionists and to establish preliminary reference values for potential use.

After applying the exclusion and inclusion criteria, this study was conducted with 696 patients who had lumbar TFESI or DRG RF injections. A total of 1,069 interventional procedures between January 2022 and January 2023 were scanned from the hospital database system. Inclusion criteria were patients ≥18 years of age. Patients with a history of lumbar spine surgery and scoliosis, patients without procedure time, and radiation dose were excluded from the study. The procedure levels were determined as L4, L5, and S1, which are the most common hernia levels. Patients were divided into two groups as DRG RF or TFESI so that comparison could be made.

Procedures

Patients were placed prone, and a pillow was placed under their bellies to flatten lumbar lordosis. The injection site was cleaned three times with a povidone-iodine solution and covered with a sterile drape. The fluoroscopy device was given adequate angles to visualize the relevant foramen. The skin area at the needle entry point was anesthetized (5 cc 2% prilocaine) before advancing the tip of a 22-gauge, 10 cm Quincke or 10 cm 22-gauge radiofrequency needle under intermittent fluoroscopic guidance. When the epidural space was approached, for the Quincke needle, the lateral view confirmed whether the needle was in the target point. For the radiofrequency needle, the correct location was determined by sensory and motor stimulation in the AP view.

Radiopaque substances (1 cc iohexol) were used to confirm whether the needle was in the epidural area in both procedures. Patients were discharged one hour after the injection in case of any adverse effects.

All procedures were performed by a pain medicine specialist with at least 5 years of experience, with the same fluoroscopy unit (Ziehm Vision R) performing intermittent imaging. Collimation was used in all procedures to minimize radiation exposure according to ALARA rules.

Data Collection

Radiation doses and procedure times were obtained from the fluoroscopy device after the procedure. Procedure time was calculated as fluoro-time only during the entire procedure. Bringing the patient into the room, positioning him/her, or applying stimulation were not added to the total time. For multiple-level procedures or bilateral procedures, time and radiation dose were divided by the number of levels. Demographic data of the TFESI and DRG RF groups were compared. Additionally, the patient's diagnoses and procedure levels were compared.

Statistical Analysis

Based on the study conducted by Suresh et al.[7] to examine the radiation dose difference between the two groups, the number of patients was found to be 640, with a 95% confidence interval and 80% power. SPSS 22.0 software (IBM Corp., Armonk, NY) was used

Table 1. Demographic and procedural characteristics

Variable	Value (n=696)
Age (years)	52.22 (19–91)
BMI (kg/m^2)	28.54±4.92
Radiation dose	4.99 (0.66–49.4)
Procedure time (s)	25.68 (7–94)
Gender, n (%)	
Male	301 (42.4)
Female	395 (57.6)
Procedure	
TFESI	507 (72.8%)
	236 (47%) single-level
	271 (53%) multiple-level
DRG	189 (27.2%)
	87 (46%) single-level
	102 (54%) multiple-level
Diagnosis	
LDH	465 (66.9%)
LSS	231 (33.1%)
Procedure level (n=1069)	
L4	206 (19.3%)
L5	588 (55.1%)
S1	273 (25.6%)

BMI: Body mass index; LDH: Lumbar disc herniation; LSS: Lumbar spinal stenosis; TFESI: Transforaminal epidural steroid injection; DRG: Dorsal root ganglion.

for statistics. Continuous variables are expressed as mean and median. Categorical variables were defined as number and frequency. The Shapiro-Wilk test was used to determine the normal distribution of the data. The Mann-Whitney U test was used to compare non-normally distributed data, and the independent t-test was used to compare normally distributed data. The chi-square test was used for categorical variables. The $p<0.05$ was considered statistically significant.

Results

A total of 696 patients were included in the study. Demographic and procedural characteristics have been given in Table 1. One hundred eighty-nine of these were patients who underwent DRG-RF, and 507 were patients who underwent TFESI. The average age of the patients was 52.22 (19–91). The average BMI of all patients was 28.54±4.92. In terms of gender, there was female dominance (57.6%). A total of 1,069 procedures were performed. The most frequently performed procedure level was determined to be L5, with 55.1%. Procedure time and radiation dose per procedure were found to be 25.68 (seconds) (7–94) and 4.99 (mGy) (0.66–49.4), respectively.

Table 2. Comparison of the characteristics of the both groups

	TFESI (n=507)	DRG (n=189)	p
Age (years)	51.95±20.42	52.77±23.83	0.233
BMI (kg/m^2)	28.48±4.77	28.97±5.78	0.436
Radiation dose	4.90±4.71	5.24±3.95	0.383
Procedure time	26.60±11.04	23.22±10.09	<0.001
Gender			0.541
Male	217 (42.8%)	86 (45.5%)	
Female	290 (47.2%)	103 (54.5%)	
Diagnosis			0.246
LDH	356 (70.1%)	124 (65.5%)	
LSS	151 (29.9%)	65 (34.5%)	
Procedure level			0.116
L4	161 (20.7%)	48 (16.5%)	
L5	415 (53.5%)	169 (58.0%)	
S1	202 (25.8%)	74 (25.5%)	

BMI: Body mass index; LDH: Lumbar disc herniation; LSS: Lumbar spinal stenosis; TFESI: Transforaminal epidural steroid injection; DRG: Dorsal root ganglion.

There was no difference between DRG RF and TFESI groups in terms of diagnosis, age, gender, BMI, procedure level, and radiation dose. It was found that the procedure time was significantly lower in the DRG group (Table 2).

Discussion

Fluoroscopy assists in applying the needle to the accurate target by imaging bony landmarks, but the radiation exposure causes concerns. It is a well-known fact that radiation can impair the functioning of organs and generate acute and chronic side effects such as hair loss, local radiation injuries, and particular types of cancers. For these reasons, it is of great importance to find out the radiation dose exposed during the procedure. In the present study, there was no difference between radiation doses exposed during TFESI and DRG RF. However, the procedure time was found to be significantly lower in the DRG RF group. Therefore, the short procedure time may be a reason for preference in lumbar interventional procedures.

When conservative treatments have failed, TFESI and DRG RF are widely used as an option to surgery. Comparative studies on the effectiveness of TFESI and DRG RF have shown that both procedures cause similar outcomes in pain improvement and functionality in patients with low back pain.[4–6] According to our results, the amount of radiation exposure was similar in both interventions. This is probably because both procedures were performed at similar anatomical locations in the lumbar region. In both interventions, the C-arm is positioned around 20–30 degrees lateral oblique in order to visualize the intervertebral foramen while the patient lies supine. The accurate position is confirmed with two-way imaging after contrast injection. In both interventional methods, the intervertebral foramen is targeted and the images of the needle's movement are taken in order to reach the correct target. Since they are similar procedures that image similar areas, the amount of radiation exposure of both procedures is thought to be similar.

The dorsal root ganglia houses the cell bodies of neurons that transmit sensory data and have considerable importance in pain development.[2] Applications of radiofrequency to the DRG have been practiced for more than 40 years, and DRG RF is an alternative and widely accepted procedure in lumbar interventions. Pulsed RF is a non-ablative method that provides pain control without the destructive effect of high temperature and has a neuromodulation effect on synapses.[8] In the DRG RF approach, the needle is positioned close to the dorsal root ganglion by giving motor and sensory stimulation. The possibility of nerve root damage decreases as the progress is made by providing stimulation.[4] In the present study, when TFESI and DRG RF procedure times were compared, the procedure time of DRG RF was found to be shorter. The procedure may be completed in a shorter time due to the confidence created by progressing with motor and sensory stimulation. In this way, unnecessary shots may not be taken by advancing the needle until stimulation is received.

With the increasing use of fluoroscopy-guided spinal interventions, the radiation dose exposure raises concern, and many methods have been proposed to mitigate potential radiation hazards. The harmful effects of radiation on multiple organs range from mild changes to severe destructions, and it may even cause death.[9] Shielding with lead aprons, thyroid collars, gloves, and glasses, increasing the distance from the radioactive source, decreasing procedure time, avoiding magnification, and utilizing collimation and pulsed fluoroscopy are the essential approaches in order to lessen the amount of radiation exposure, concerning ALARA radiation safety recommendations. In a recent study, a C-arm tube covered with a lead apron was found to decrease the total amount of radiation exposure.[10–12]

Computed tomography (CT) is another reliable and safe alternative guide for lumbar spinal interventions. Although it has been shown that the radiation exposure was lower for patients and higher for interventionists, in a recent study, the radiation exposure of lumbar epidural injections under fluoroscopy and ultralow-dose CT was compared, and it has been shown that ultralow-dose CT can be a safer option for these interventions.[13,14] In the future, after technological developments, CT may replace fluoroscopy in spinal interventions and become a more reliable tool that causes less radiation exposure. However, for now, physicians need to be more careful about CT-guided interventional pain procedures.[15]

In a study about the comparison of radiation doses and duration of procedure in lumbar epidural steroid injection methods, no differences were found between contralateral oblique view and lateral view.[16] Cohen et al.[17] obtained reference radiation doses for lumbar transforaminal epidural (13 mGy, 30 s) and radiofrequency interventions (7 mGy, 17 s). In that study, a reference time and dose were specified rather than comparing them in both interventions. When we evaluate the results, similar to ours, the procedure time of radiofrequency was shorter, but differently, the radiation exposure dose was found to be less. Although the duration of DRG RF interventions in our study was short, this result may have occurred because we could not perform standardized collimation during each procedure and eliminate radiation-reducing factors.

Body mass index is one of the modifiable associated factors with the depth of the epidural space. A higher body mass index leads to a higher amount of radiation dose and procedure time.[18] Radiation doses need to be adjusted according to BMI, or doses per

BMI must be provided for each procedure to obtain a more precise approach.[9] In the present study, since BMI did not differ between groups, it did not require additional calculations.

Limitations

This study has some limitations. First of all, the procedure time and radiation dose of each level were not calculated separately; the cumulative radiation dose and radiation exposure were divided by the number of procedures. However, due to its high blood supply and difficult positioning, procedures performed at the S1 level may take longer procedure time and may generate more radiation exposure. Additionally, the procedures were not performed under sedation, and the patient's movement during the procedure may have caused the procedure time to be prolonged or extra images to be taken. Although the amount of radiation dose in the fluoroscopy was recorded, the radiation doses to which the physician was exposed were not separately reported. To calculate it, measuring the dosimeters on the performer following each procedure would have provided us with sufficient information.

Conclusion

Fluoroscopy-guided TFESI and DRG RF interventions have been found to cause similar radiation exposure, although the procedure time of DRG RF applications was shorter. It is essential to take adequate precautions to avoid side effects that may be caused by radiation exposure.

Ethics Committee Approval: The Health Sciences University Şişli Hamidiye Etfal Training and Research Hospital Ethics Committee granted approval for this study (date: 29.08.2023, number: 4075).

Informed Consent: All individuals gave their informed consent before being included in the study.

Conflict of Interest: The authors declare that there is no conflict of interest.

Financial Disclosure: The authors declared that this study has received no financial support.

Use of AI for Writing Assistance: None declared.

Authorship Contributions: Concept – GE, RS, TŞ; Design – RS, FU; Supervision – FU, TŞ; Resources – GE, RS, FU; Materials – TŞ; Data collection and/or processing – GE, RS; Analysis and/or interpretation – RS, TŞ, FU; Literature search – GE, RS; Writing – GE, RS; Critical review – GE, RS, FU, TŞ.

Peer-rewiew: Externally peer-reviewed.

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CASE SERIES

Efficacy of selective scalp nerve blocks for postoperative pain in craniotomy: A single-center experience

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SUMMARY

Supratentorial craniotomy is frequently performed for intracranial pathologies. Two critical aspects of anesthetic management are maintaining hemodynamic stability and controlling postoperative pain. Hypnotic agents and opioids, although commonly used, increase the risk of complications. Scalp block is a simple, safe technique that reduces opioid use and stabilizes perioperative hemodynamics. At our center, four patients undergoing craniotomy for aneurysm or intracranial tumor received selective scalp blocks. Minimal opioids were required, no hypertensive or tachycardic responses were observed, and opioid-related side effects were avoided. Our findings support the complementary role of scalp block alongside routine anesthesia in craniotomy.

Keywords: Craniotomy; nerve block; postoperative pain; scalp block.

Introduction

Supratentorial craniotomy is a standard procedure in neurosurgery. Effective anesthetic management is essential to maintain hemodynamic stability. Scalp incision and muscle dissection, rather than brain manipulation, are the primary sources of pain.[1] Even under deep anesthesia, incision may trigger acute hypertension and increased intracranial pressure, potentially impairing cerebral perfusion. Postoperative pain occurs in up to 60–80% of patients and, if untreated, activates the sympathetic system, raising blood pressure and morbidity.[2,3]

Opioids remain central to pain control but are limited by side effects such as sedation, nausea, and delayed neurologic assessment.[4] Scalp block, first described in 1996, is an established, safe technique providing intraoperative stability and effective postoperative analgesia.[5,6] Here, we report our initial experience with selective scalp block in four patients.

Case Reports

Case 1 – A 41-year-old male with sphenoid wing meningioma underwent frontotemporal craniotomy. After general anesthesia induction, 3 mL of 0.25% bupivacaine was administered to the supraorbital, supratrochlear, and auriculotemporal nerves. The tumor was completely excised.

Case 2 – A 67-year-old male with a distal middle cerebral artery aneurysm underwent craniotomy with an incision extending frontally to the occipital region (Fig. 1). Blocks included the greater occipital (5 mL of 0.25% bupivacaine), lesser occipital (2 mL of 0.25% bupivacaine), auriculotemporal (3 mL of 0.25% bupivacaine), supratrochlear (3 mL of 0.25% bupivacaine), and supraorbital (3 mL of 0.25% bupivacaine) nerves. The aneurysm was clipped via Sylvian dissection.

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Case 3 – A 74-year-old male with a pericallosal artery aneurysm underwent frontoparietal craniotomy. Each of the supraorbital, supratrochlear, and auriculotemporal nerves received 3 mL of 0.25% bupivacaine. The aneurysm was clipped using an interhemispheric approach.

Case 4 – A 69-year-old female with a middle cerebral artery aneurysm underwent frontotemporal craniotomy. The supraorbital, supratrochlear, and auriculotemporal nerves each received 3 mL of 0.25% bupivacaine. The aneurysm was clipped via Sylvian dissection.

Anesthesia Protocol

All four patients received standard induction (lidocaine 1 mg/kg, fentanyl 1 µg/kg, propofol 2 mg/kg, rocuronium 0.6 mg/kg). Arterial line and large-bore IV access were established. Monitoring included invasive and noninvasive blood pressure, oxygen saturation, ECG, and bladder catheterization. Selective scalp block was performed pre-incision with 0.25% bupivacaine, 2–5 mL per nerve, tailored to the incision site. To avoid intravascular injection, the superficial temporal and occipital arteries were identified, and ultrasound guidance was used.

Intraoperatively, remifentanil (0.05 µg/kg/min infusion) provided analgesia as needed. At closure, all patients received IV tramadol 1 mg/kg and paracetamol 1 g. Postoperatively, tramadol PCA was initiated (bolus 0.1 mg/kg, lockout 20 min, no basal infusion) for all patients. Paracetamol 1 g IV every 8 h was given routinely. Rescue analgesia was IM diclofenac 75 mg if NRS>4. Ondansetron 4 mg IV was administered for nausea or vomiting as required.

All blocks were completed successfully without complications. No patients developed hypertension or tachycardia during incision or craniotomy. Postoperative NRS scores were low and manageable with PCA. No additional opioid requirement, nausea, or respiratory depression was observed.

Discussion

Enhanced recovery after surgery emphasizes multimodal, opioid-sparing analgesia. Scalp block fits this approach by attenuating nociceptive surges during incision and stabilizing perioperative hemodynamics.[7–11]

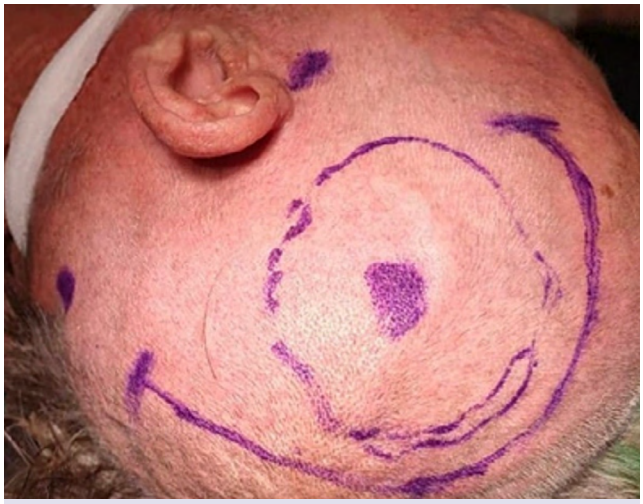

Figure 1. A 67-year-old male patient operated for distal middle cerebra artery aneurysm and planned surgical incision.

Opioid-based anesthesia deepening increases postoperative morbidity and mortality, while selective scalp block reduces the need for opioids and their side effects. Compared with infiltration, scalp block offers superior pain control and intraoperative stability. Previous studies found no significant difference between bupivacaine and levobupivacaine,[12,13] supporting our choice of bupivacaine.

Our selective approach—blocking only nerves corresponding to the planned incision—may reduce complications and minimize the total anesthetic dose. Pre-incision administration is particularly advantageous in aneurysm and mass surgery, where hemodynamic surges can raise intracranial pressure or risk rupture.[14–16]

Although our series is limited to four cases, the findings align with existing evidence that scalp block is underutilized in neurosurgical anesthesia.[17]

Conclusion

Selective scalp block is a safe and practical adjunct to routine anesthesia for craniotomy. It supports intraoperative hemodynamic stability and provides effective perioperative analgesia while minimizing opioid exposure.

Ethics Committee Approval: This is case series, and therefore ethics committee approval was not required in accordance with institutional policies.

Informed Consent: Written informed consent was obtained from all individual patients included in this case series for publication of their clinical data.

Conflict of Interest: The authors declare that there is no conflict of interest.

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Authorship Contributions: Concept – SS, AKK, AT; Design – SS, AKK, MT; Supervision – SS, AKK, MT; Resources – AT, MT, ND; Materials – SS, AKK, AT; Data collection and/or processing – KBT, ONA, ND; Analysis and/or interpretation – SS, AKK, MT; Literature search – SS, AKK, ONA; Writing – SS, AKK, ONA; Critical review – MT, ND, KBT, AT, SS, AKK, ONA.

Peer-rewiew: Externally peer-reviewed.

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CASE REPORT

Ultrasound-guided femoral and sciatic nerve block in a patient with shrinking lung syndrome: A case report

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SUMMARY

Shrinking lung syndrome (SLS) is a pulmonary complication mainly associated with systemic lupus erythematosus (SLE), although it is also seen in other rheumatologic conditions. Its prevalence is thought to be 0.5–1% among patients with SLE. This syndrome is characterized by progressive dyspnea, episodic pleuritic chest pain, a restrictive pattern on pulmonary function tests, bilateral diaphragm elevation, and reduced lung volumes with no evidence of parenchymal lung disease. General anesthesia in patients with SLS may be associated with increased mortality and morbidity, while neuraxial anesthesia or peripheral nerve blocks can be safe options. Herein, we report a case of ultrasound-guided femoral and sciatic nerve block for unilateral knee septic arthritis debridement in a patient with SLS. The patient was protected from both prolonged mechanical ventilation and pulmonary complications by performing the femoral and sciatic nerve block for this operation.

Keywords: Femoral block; restrictive lung disease; sciatic block; shrinking lung syndrome; systemic lupus erythematosus; ultrasound-guided.

Introduction

Shrinking lung syndrome (SLS) is a complication of systemic lupus erythematosus (SLE). It is often seen in patients with long-standing SLE diagnosis and is estimated to occur in 0.5–1% of patients.[1] SLS is a rare pulmonary manifestation of SLE, characterized by unexplained dyspnea, a restrictive pattern on pulmonary function tests, and radiographic evidence of diaphragm elevation. We would like to present a case of a successful femoral sciatic nerve block in a patient with SLE and SLS for right knee septic arthritis debridement operation. Written informed consent was obtained from the patient for publication of this case report.

Case Report

A 32-year-old female patient with a history of SLE, SLS, and Raynaud's disease was followed up by a rheumatology specialist for 18 years. She was taking methylprednisolone, hydroxychloroquine daily, and canakinumab once a month. She also used to be on warfarin therapy for left subclavian artery thrombosis until 15 days ago. Our patient was admitted to the intensive care unit postoperatively after cesarean section under general anesthesia 4 months ago. While investigating her dyspnea then, she was diagnosed with SLS by the pulmonologist and received pulse steroid and cyclophosphamide therapy.

The patient, who had been followed up in the rheumatology ward for 15 days due to uncontrolled fever (38 °C and above), pain, and swelling in her knee, was diagnosed with knee septic arthritis and scheduled for right knee septic arthritis debridement. In our preoperative anesthesia evaluation, she presented with dyspnea on exertion, her breath sounds were diminished in the lower lobes, and SpO_2 was

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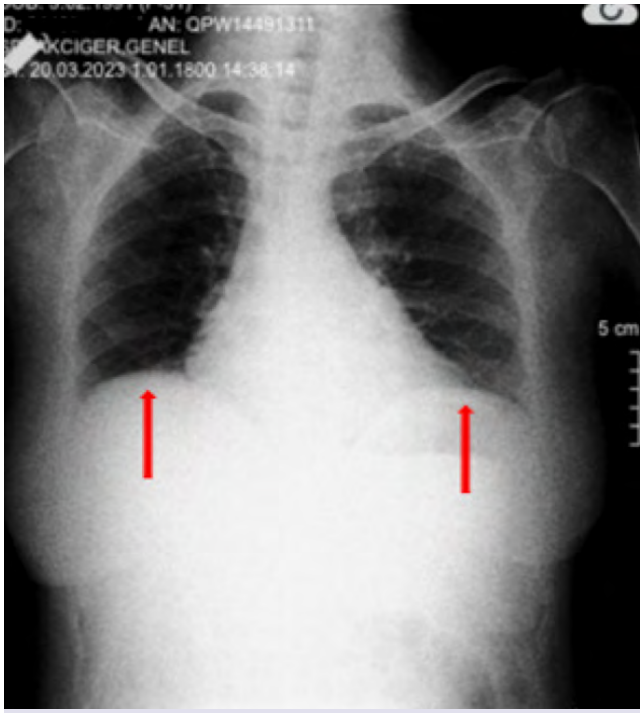

Figure 1. Posteroanterior chest X-ray. Bilateral diaphragm elevation and reduced lung volumes in lower lobes.

96%. Previous spirometry demonstrated a restrictive deficit with reduced FVC and DLCO, being 54% and 28%, respectively. Chest X-ray showed bilateral diaphragm elevation (Fig. 1).

On the day of the surgery, intravenous access was performed in the operating room, and standard monitors (ECG, pulse oximetry, and noninvasive blood pressure) were applied. The patient was sedated with 2 mg midazolam and 100 mcg fentanyl intravenously, and supplemental oxygen was administered via oxygen mask. With the patient in the supine position, the linear transducer of the ultrasound device (4–12 Hz) was positioned to identify the femoral nerve, artery, vein, and surrounding tissues in the femoral crease (Fig. 2). The needle was inserted in-plane and advanced towards the femoral nerve to obtain quadriceps muscle contractions with a current output of 1 mA. When patellar twitches attenuated between 0.3 and 0.5 mA, femoral nerve block was performed by injecting 5 ml of 2% lidocaine and 10 ml of 0.5% bupivacaine. With the patient in the lateral decubitus position, the sciatic nerve and surrounding structures were identified using a curvilinear probe (2–5 Hz) in a transverse plane over the subgluteal region (Fig. 3). The needle was inserted in-plane and advanced towards the sciatic nerve until hamstring twitches were obtained at 1 mA. When the twitches disappeared

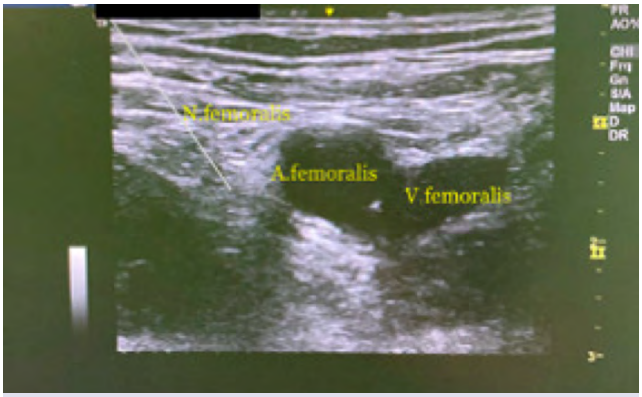

Figure 2. Ultrasound image of femoral nerve and surrounding structures.

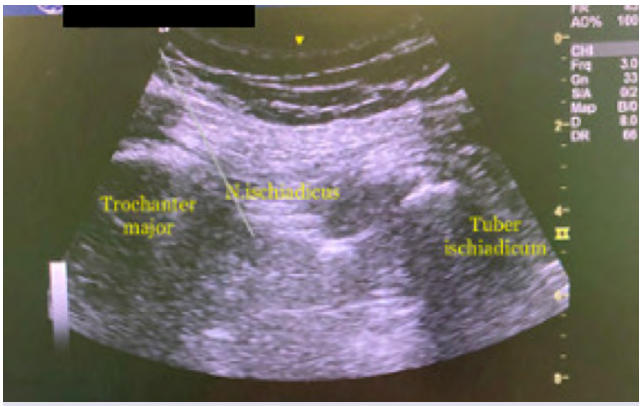

Figure 3. Ultrasound image of the sciatic nerve and surrounding tissues.

between 0.3 and 0.5 mA, sciatic nerve block was performed by injecting 5 ml of 2% lidocaine and 10 ml of 0.5% bupivacaine. The patient kept spontaneously breathing and remained hemodynamically stable throughout the procedure, which lasted 75 minutes. At the end of the surgery, the patient was admitted to PACU and transferred to her ward.

Discussion

The pathophysiology of SLS is still not known, and various theories have been suggested to explain this syndrome.[2] Some authors suggest that diaphragmatic myopathy plays a role in the pathophysiology of SLS. Although no accurate cause has yet been found, most authors suggest that SLS is caused by multiple pathological processes. These pathological processes include decreased diaphragm thickness, pleural adhesions, pleural inflammation, phrenic nerve palsy, and muscle inflammation.[3]

In the only case report of anesthesia management of a patient with SLS, thoracic epidural anesthesia was preferred for incisional hernia repair.[4] Our patient

had restrictive lung disease, and bilateral diaphragmatic elevation was present in the chest X-ray. In order to protect our patient from postoperative pulmonary complications, we did not prefer to apply general anesthesia for this surgery. Instead, we planned to perform a peripheral nerve block for unilateral knee septic arthritis debridement while preserving the spontaneous breathing of the patient. We protected our patient from both prolonged mechanical ventilation and pulmonary complications by performing femoral and sciatic nerve block for this operation.

Conclusion

In our experience, peripheral nerve blocks may enhance safety and recovery in patients at increased respiratory risk.

Ethics Committee Approval: This is a single case report, and therefore ethics committee approval was not required in accordance with institutional policies.

Informed Consent: Written informed consent was obtained from the patient for publication of this case report.

Conflict of Interest: The authors declare that there is no conflict of interest.

Financial Disclosure: The authors declared that this study has received no financial support.

Use of AI for Writing Assistance: Artificial intelligence tools were not used in this study.

Authorship Contributions: Concept – NC; Design – NC; Supervision – KK; Resources – NC, KK; Materials – NC, SA, KK; Data collection and/or processing – SA, NC; Analysis and/or interpretation – NC, SA, KK; Literature search – NC, SA, KK; Writing – NC, SA; Critical review – NC, SA, KK.

Peer-rewiew: Externally peer-reviewed.

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CASE REPORT

Baclofen toxicity in a patient with baclofen pump

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SUMMARY

Baclofen toxicity is a severe condition that can suppress brainstem reflexes, leading to coma and death. Therefore, emergency evaluation, correct diagnosis, and treatment are crucial to prevent any possible neurological sequelae. Here, we present a case of a patient with a previous baclofen pump, who was brought to the Emergency Department after being found unresponsive in bed. Brainstem reflexes were absent. The patient was taken to the emergency surgery room, and with the diagnosis of baclofen toxicity, the reservoir was removed from the pump, and cerebrospinal fluid drainage was initiated. The patient was discharged with a baseline neurological examination the following day without any complications.

Keywords: Baclofen pump; baclofen toxicity; coma.

Introduction

Intrathecal baclofen (Lioresal; Saol Therapeutics, Roswell, GA) is a commonly used and well-tolerated medication for the treatment of spasticity. It has an inhibitory effect on GABA-B receptors in presynaptic motor neurons in the spinal cord.[1–3] At therapeutic doses, baclofen acts at the spinal level. At higher dosages, such as in the case of baclofen toxicity, its action penetrates the blood-brain barrier and causes central nervous system depression. Baclofen toxicity may lead to central and respiratory depression, autonomic dysfunction, resulting in deep coma, loss of brainstem reflexes, hypotonia, areflexia, flaccid paralysis, seizures, cardiac arrhythmias, and arrest.[1,2,4]

Baclofen toxicity related to the baclofen pump is rarely reported in the literature, and it is usually iatrogenic.[1,5]

Case Report

A 59-year-old man was brought to the Emergency Department of Kyrenia University Hospital with depressed consciousness and breathing. His wife reported that she was not able to wake him up in the morning. The patient had a history of hypertension and coronary artery disease, and he had been on a baclofen pump for 3 years for the treatment of spastic paraparesis resulting from thoracic arteriovenous fistula. His wife also reported that the baclofen pump had been refilled and the dosage had been increased to improve his gait 5 days previously.

Initial vital signs included a blood pressure of 135/85 mmHg, a pulse of 44 beats per minute, a temperature of 37 °C, and a room air pulse oximetry of 80%. At the initial examination, he had a Glasgow Coma Scale score of 8 points, and his pupils were midsized

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and unresponsive to light. Corneal, oculocephalic, and gag reflexes, as well as deep tendon reflexes, were absent. There were no signs of trauma.

Complete blood count, electrolytes, renal and hepatic panels, and procalcitonin were unremarkable. An ECG showed sinus bradycardia. Cranial magnetic resonance (MR) imaging, including diffusion-weighted (DWI) and three-dimensional time-of-flight MR angiography, did not provide a clear cause for the coma etiology.

He was mechanically ventilated and taken to the surgery room, where 20 cc of baclofen in the pump was removed. Also, cerebrospinal fluid drainage was performed via lumbar catheter. The clinical condition regressed soon after the procedure. He returned to his initial neurological examination the following day.

Discussion

Rapidly progressing coma may present a diagnostic challenge in emergency services. The differential diagnosis is very broad, including toxic, metabolic, traumatic, vascular, neoplastic, and infectious etiologies. We present a unique case of baclofen toxicity presenting with coma. The pre-diagnosis was confirmed through anamnesis in this case. Information regarding the history of the baclofen pump and the increasing dosage was very important. These pump systems are generally considered safe, with reported complication rates between 0 and 5%. These intoxications are usually due to human errors during pump programming, refilling, or both.[3,6,7]

No correlation has been reported between baclofen serum levels and central nervous system depression in the case of baclofen toxicity.[1,8–10] We were not able to determine serum baclofen concentration in our case.

It is known that baclofen produces a global encephalopathy and coma similar to sedative hypnotics.[4] It may also mimic post-hypoxic encephalopathy.[1] A burst suppression pattern in EEG has been reported in patients with baclofen toxicity.[4,11]

In a recent review, baclofen was identified as the second most frequent cause, after neurotoxic snake envenomation, mimicking brain death.[12]

Conclusion

As there is no specific antidote available, management is primarily supportive. The half-life of baclofen in the CSF is 2–5 h.[5]

Another major problem with intrathecal baclofen intoxication is the timing to restart baclofen therapy, as baclofen withdrawal is another life-threatening condition.[13,14]

The presented case was re-transferred to the outpatient hospital, where he is followed with the baclofen pump after successful detoxification. He received a careful slow dosage titration again without further complications. Informed consent was obtained from the patient.

Ethics Committee Approval: This is a single case report, and therefore ethics committee approval was not required in accordance with institutional policies.

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Pectoserratus+interpectoral plane block is safe in patients receiving anticoagulant therapy?

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To the Editor,

Ultrasound (US)-guided regional anesthesia techniques have become increasingly prevalent for the effective management of analgesia during breast surgery. Research has demonstrated that the employment of US-guided pectoralis nerve block II (PECS II), now recognized as Pectoserratus+Interpectoral Plane Block (PSPB+IPPB) following a recent standardized nomenclature study,[1] is effective in providing sufficient analgesia for breast surgeries.[2] Despite an extensive search on PubMed yielding over 1400 publications on pectoral nerve block up to the year 2019, a limited number of these papers addressed complications. Based on contemporary sources assessing the bleeding risk following fascial plane blocks in anticoagulant-using patients, deep nerve blocks should adhere to guidelines established for neuraxial procedures, while there is no standardized recommendation for superficial nerve block procedures.[3] Herein, we aimed to share our experience concerning pectoral muscle hematoma in a patient receiving anticoagulant therapy after PSPB+IPPB administration.

Informed consent for publication was obtained from the patient. A 70-year-old female, standing at a height of 165 cm and weighing 80 kg, was slated to undergo a radical mastectomy due to a confirmed breast cancer diagnosis. The patient presented with a medical history marked by diabetes, hypertension, a prior cerebrovascular event, and coronary artery bypass grafting, and her pharmacological regimen included acetylsalicylic acid (ASA). Preceding the surgery, routine preoperative laboratory assessments and imaging studies yielded results within the normal range, indicating a hemoglobin level of 10.6 g/dL, a platelet count of 189000, and an international normalized ratio (INR) of 0.95. Following preoperative medical consultations, a consensus was reached to stop the administration of ASA five days prior to the scheduled surgical procedure. Additionally, it was determined that a regimen of low molecular weight heparin (LMWH) therapy should commence, utilizing a dosage of 2x8000 anti-Xa international units (IU). The patient, classified as ASA III, underwent surgery under general anesthesia. During surgery, a multimodal analgesic approach included 1 g of intravenous (IV) paracetamol and 20 mg of IV tenoxicam. At the end of surgery, US-guided PSPB+IPPB was performed uneventfully with 40 mL of a local anesthetic mixture (20 mL 0.25%bupivacaine+10 mL lidocaine+10 mL saline). The patient stayed hemodynamically stable in the postoperative care unit (PACU) with a VAS score <4 and was discharged to the ward without complications.

At the 12th hour after surgery, the patient received a dose of 8000 IU of LMWH and continued with subsequent doses at 12-hour intervals. However, on the second day after the surgery, the patient reported experiencing weakness, fatigue, and dizziness, and

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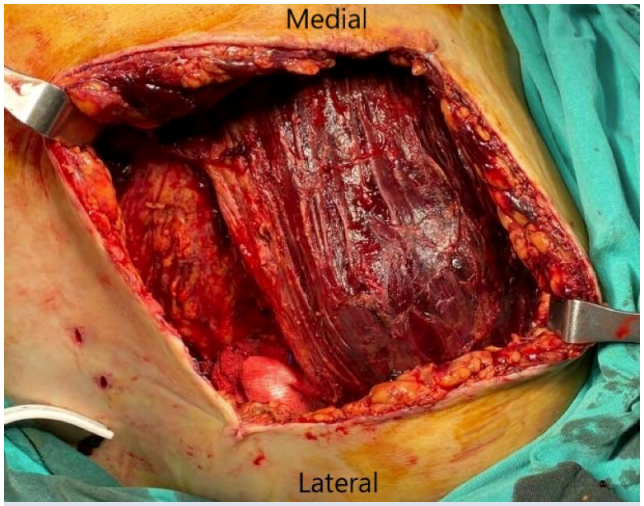

Figure 1. Image of the surgical site and pectoral hematoma during re-exploration.

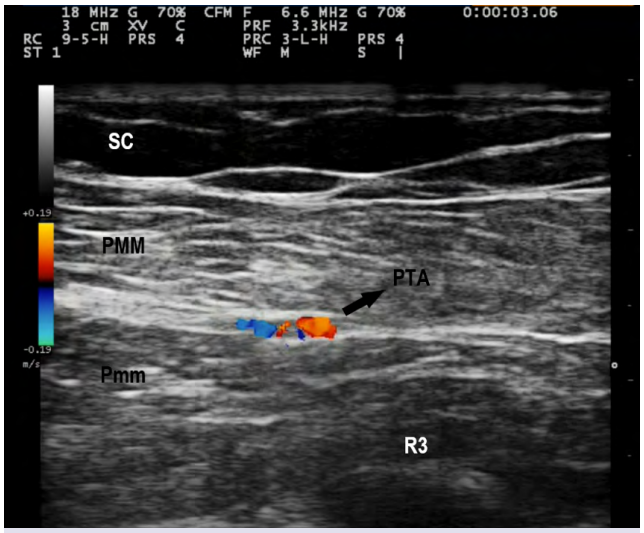

Figure 2. Doppler sonographic view of the thoracoacromial artery.

SC: Subcutaneous tissue; PMM: Pectoralis major muscle; Pmm: Pectoralis minor muscle; R3: Third rib; PTA: Pectoral branch of the thoracoacromial artery.

her overall condition started to deteriorate. Upon physical examination, it was noted that there was significant bleeding around the drain sites, along with areas of pronounced ecchymosis extending to the axillary region and forearm. Following the patient's clinical deterioration, the surgical team conducted a repetition of routine laboratory assessments. With a hemoglobin level of 5 g/dL, the patient underwent a second surgery for hemostasis control. Upon exploration of the surgical field during this intervention, extensive bleeding zones were identified, manifesting as subcutaneous tissue leakage, drain entry points, and involvement of the axillary region. Additionally, a substantial hematoma had formed between the pectoral muscles, as depicted in Figure 1. The hematoma was successfully evacuated by aspirating approximately 700 mL of blood. Subsequently, the patient was transferred to the intensive care unit (ICU) while being intubated and accompanied by inotropic drug support. A total of three units of erythrocyte suspension and three units of fresh frozen plasma were transfused in a 1:1 ratio in the operating room and ICU. After 24 hours, the patient was extubated and then transferred to a regular ward 48 hours later. Remarkably, on the fifth day, she exhibited a complete recovery, leading to her discharge from the hospital.

Emphasizing the importance of thorough training in mastering sonoanatomy, gaining ample experience, and prioritizing the use of Doppler ultrasound before administering any regional anesthesia technique is critical for mitigating these risks effectively, particularly considering factors such as the presence of the thoracoacromial artery in chest wall blocks (Fig. 2).

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The secret hero of the lumbopelvic region: A cite to gluteus medius muscle and its trigger point

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To the Editor,

The gluteus medius, the primary abductor muscle of the hip joint, has a critical role in the lumbopelvic junction. It has been suggested that decreased dynamic lateral stability of the pelvis and lumbar region, caused by the weakness of the gluteus medius, will change the movement pattern of the spine and increase the load on the discs.[1] Similarly, it is believed that decreased hip abductor muscle strength due to gluteus medius-related pathologies may increase valgus stress on the knee, consequently resulting in patellofemoral pain syndrome.[2]

Myofascial pain syndrome (MPS) is a condition stemming from trigger points within taut muscle bands, exhibiting a prevalence of 85% in pain clinics. Despite its frequent occurrence, MPS is often under-recognized and can manifest as pain in the lumbosacral area. Myofascial trigger points (MTrPs) of the gluteus medius muscle can cause pain reflected in the sacroiliac joint, gluteal and lumbosacral regions, iliotibial band trace, and thigh region. Therefore, it should be considered when establishing differential diagnoses of the pathologies in these regions. It has been reported that the MTrPs of this muscle play a role in chronic low back pain, anterior knee pain, greater trochanteric pain syndrome, and failed back surgery syndrome.[3] MTrPs of the gluteus medius may cause pain, joint range of motion restriction, and muscle weakness.[4]

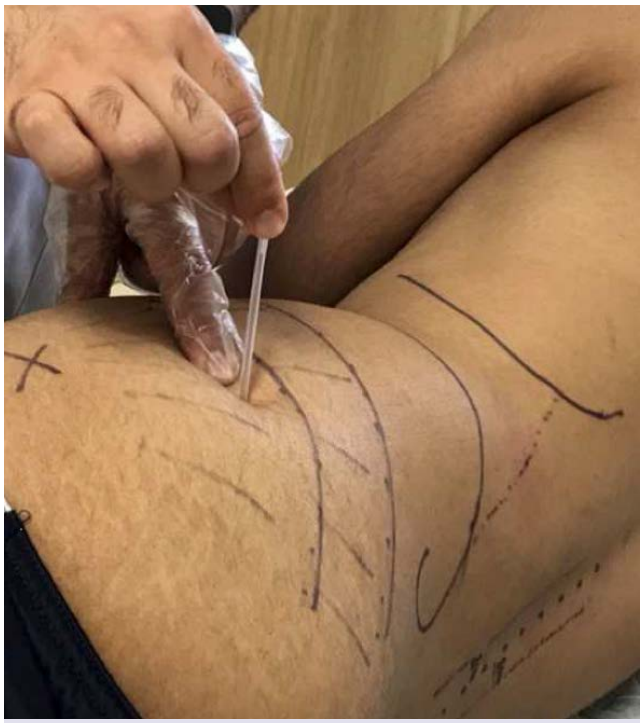

Figure 1. Dry needling technique of gluteus medius muscle.

No laboratory or imaging method is used in its diagnosis, which is established by palpation, demonstrating the importance of physical examination.[3] David G. Simons,[5] one of the authors of the MTrP concept, has expressed that skeletal muscles are not regarded as organs of any specialization and are treated as orphan organs, which is unfortunately the harsh reality. Myofascial trigger points are areas suitable for research, open to development, and increas-

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ingly arousing interest. Future studies on this topic will raise awareness of the subject.

Invasive techniques have been described for its treatment.[6] Dry needling, an increasingly popular treatment approach, is an easily applicable, safe, and inexpensive method used in outpatient practice. The patient's position, needle size, and skin penetration angle are vital in this treatment. Hence, it is recommended to administer the treatment based on the logic of "every muscle is special."

In the gluteus medius, needling is performed while the patient is lying on the side. The patient's hip and knee joints should be positioned in slight flexion.[6] Treatment is applied using the straight palpation technique. The skin should be penetrated with the needle at a perpendicular angle (Fig. 1). A sterile acupuncture needle with a size of 0.3×60 mm should be used. Considering the possible variations of the sciatic nerve, which is the adjacent anatomical structure, patients should be asked whether they feel sharp pain during treatment.

As physicians working with musculoskeletal pathologies, it should be noted that the concept of MTrP is a part of our professional lives, sometimes as a primary pathology or as a condition accompanying it. The first rule is that MTrP should always come to mind.

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