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Ropivacaine/Dexmedetomidine Scalp Block (Ro-Dex Technique) for Awake Surgery and Functional Stereotactic Surgery

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ABSTRACT

Introduction: In the realm of neurosurgery, optimizing patient comfort and procedural precision is paramount. Awake surgery, particularly in eloquent brain areas, demands meticulous pain management without compromising patient cooperation. The scalp block technique, specifically utilizing ropivacaine/dexmedetomidine, shows promise in this context. This study explores the Ro-Dex technique's efficacy in awake surgery and stereotactic procedures, aiming to improve outcomes and patient satisfaction.

Material and Methods: This prospective observational study, conducted at CMN "20 de Noviembre," assesses the Ro- Dex technique's impact on perioperative outcomes. Patients undergoing awake surgery or stereotactic procedures received the Ro-Dex technique, while a control group received standard care. Data collection included pain scores, surgical duration, and patient satisfaction using the CRES-4 scale. Statistical analyses were performed using R Studio software.

Design: The study enrolled patients aged 12 to 65 undergoing awake surgery or stereotactic procedures from January 2020 to June 2022. Exclusion criteria included psychiatric disorders, cardiac arrhythmias, and renal dysfunction. The Ro-Dex technique was administered preoperatively, and outcomes were compared with a control group.

Discussion: The Ro-Dex technique demonstrated efficacy in reducing pain, surgical duration, and anesthetic requirements. Patient satisfaction was notably higher, indicating improved perioperative experiences. These findings suggest the Ro-Dex technique's potential to enhance awake surgery and stereotactic procedures.

Conclusion: The Ro-Dex technique holds promise as an adjunct in neurosurgical practice, offering improved pain management and patient satisfaction. Further multicenter studies are warranted to validate its efficacy and establish standardized protocols.

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Since the inception of medical practice, combating formidable adversaries such as death, infections, and pain has been a perpetual endeavor. Pain could be considered a global health problem that particularly affects the demographically growing adult population [1]. This pursuit has driven the development of numerous techniques and pharmaceuticals aimed at enhancing medical care quality and improving patient experiences.

In neurosurgical practice, awake-patient surgery has emerged as a valuable approach for managing lesions in eloquent areas of the cerebral cortex, epilepsy surgery, and deep brain stimulation, particularly when associated with stereotaxy (Figure 1) [2]. This technique aims to mitigate or prevent post-surgical neurological sequelae. Although the term "awake-patient surgery" might imply complete consciousness throughout the procedure, contemporary practice incorporates varying levels of sedation or anesthesia, ranging from fully awake to asleep- awake-asleep sequences [3,4]. Maintaining patient alertness becomes imperative during cortical mapping and lesion resection [5]. The literature has also explored its application, albeit less frequently, in cerebrovascular neurosurgery, notably for critical interventions such as aneurysm or arteriovenous malformation clipping [6].

The concept of stereotactic surgery, introduced by Horsley and Clarke in 1908, has undergone significant evolution, with modern adaptations including frameless systems alongside traditional stereotactic frames [7]. Despite advancements, the principle remains consistent: precise localization via Cartesian coordinates and secure skull fixation, often achieved with sharp- pointed pins. However, this fixation method can evoke considerable discomfort due to stimulation of pain receptors.

Figure 1: Patient Wearing the Stereotactic Frame

Notably, the practice of awake craniotomies predates modern anesthesia, evident in cultural practices of various societies worldwide. The benefits of employing awake techniques in functional neurosurgery include enhanced tumor resection and reduced damage to eloquent cortex regions, consequently minimizing postoperative neurological dysfunction and improving overall quality of life [8]. Debates persist regarding the ethical and functional merits of awake versus general anesthesia for such procedures.

Scalp block techniques have emerged as adjuncts for pre- and post-operative pain management in these surgeries. Traditional methods have been associated with discomfort, prompting exploration of alternative strategies. Literature suggests that combining local anesthetics with selective alpha-2 agonists like Dexmedetomidine offers significant advantages, including improved pain control during frame placement and throughout the perioperative period [9].

Meta-analyses have demonstrated superior pain control and reduced opioid usage in patients receiving scalp blocks compared to those receiving placebo or no intervention, particularly within the initial six hours post-surgery [10,11].

Noteworthy parameters indicating the efficacy of scalp blocks include heart rate, blood pressure, visual analog scale (VAS) scores, and reduced need for additional local infiltration [12]. Studies have evaluated various local anesthetics for scalp blockade, including lidocaine, lidocaine with sodium bicarbonate, bupivacaine, levobupivacaine, ropivacaine, or combinations thereof, seeking optimal efficacy and safety profiles [13,14].

The integration of awake-patient surgery, stereotaxy, and scalp block techniques represents a paradigm shift in neurosurgical practice, offering enhanced precision, patient comfort, and postoperative outcomes. Continued research into novel approaches and pharmacological agents holds promise for further improving the care and experiences of neurosurgical patients. The comparative analysis between bupivacaine, levobupivacaine, and ropivacaine reveals distinct advantages of ropivacaine, particularly in settings with a low hypotension threshold, such as ambulatory care and certain surgical procedures [15-17]. Ropivacaine, an amide-type local anesthetic, acts by blocking nerve impulse initiation and conduction, thereby inhibiting neuronal depolarization. Its onset and duration vary based on administration site, with an onset of 6 to 8 minutes and duration ranging from 210 to 322 minutes for general surgical procedures [18].

The synergistic effects of combining different drugs have been observed to enhance therapeutic outcomes [19]. Dexmedetomidine, a selective alpha-2 agonist, has demonstrated potential in improving analgesic efficacy when used in conjunction with ropivacaine. Dexmedetomidine exhibits specific affinity for alpha-2 receptors, resulting in sedation, anxiolysis, and analgesia. Its metabolism occurs predominantly in the liver, with renal excretion of metabolites. Dexmedetomidine augmentation has been associated with reduced analgesic rescue requirements and prolonged postsurgical analgesia [20].

Studies indicate that dexmedetomidine supplementation decreases block latency, prolongs analgesia and motor block durations, and reduces opioid consumption [21-23].

Based on these findings, our chosen regimen includes ropivacaine and dexmedetomidine at specified dosages. Patient preparation involves comprehensive informed consent, allergy assessment, and age-related considerations, with a focus on patients under 65 years old and over 12 years old. Pre-procedural evaluation should also encompass risk assessments for difficult airway and considerations for potential conversions to general anesthesia, particularly in high-risk cardiovascular patients or those with sleep apnea syndrome.

Scalp block execution necessitates a thorough understanding of scalp innervation, notably the contributions of trigeminal nerve branches to frontal scalp sensation. Adequate anatomical knowledge is essential for precise localization and administration of the block. Further research is warranted to refine dosing strategies and expand the application of these techniques across diverse patient populations.

It is imperative to exercise caution when considering the use of both ropivacaine and dexmedetomidine in scalp block techniques. Specific contraindications, such as hypersensitivity to ropivacaine or amide-type anesthetics, cardiac arrhythmias, cardiovascular dysfunction, and hepatic or renal impairment, must be carefully assessed prior to administration. Adverse reactions, including hypotension, fetal bradycardia, pruritus, nausea, vomiting, and headache, have been documented. Additionally, although transient and reversible complications have been reported, close monitoring and vigilance are necessary to mitigate any potential risks associated with these medication

The trigeminal nerve, specifically its ophthalmic division (V1), plays a pivotal role in scalp innervation. Among its branches, the frontal nerve emerges as the longest, branching into the supratrochlear and supraciliary nerves, crucial for sensation in the forehead and anterior scalp. Upon exiting the supraorbital foramen, the nerve further divides into superficial and deep branches, with the latter providing sensory innervation to the coronal scalp region. Understanding the anatomy of these nerve structures is paramount for performing a successful scalp block [24,25].

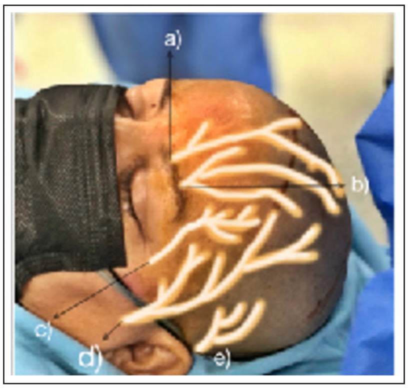

Figure 2: The main neural branches involved in the innervation of the scalp are indicated. a) Supratrochlear nerve, b) Supraorbital nerve, c) Zygomatic nerve, d) Auriculotemporal nerve, e) Greater auricular nerve.

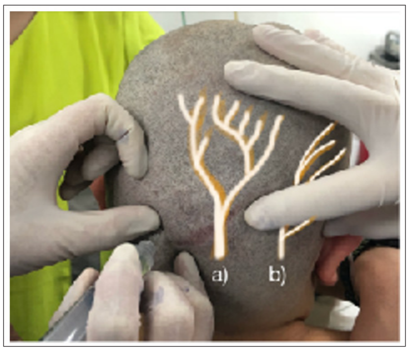

Figure 3: The main branches of the occipital and retroauricular region involved in scalp innervation are shown: a) Greater occipital nerve, b) Lesser occipital nerve

Understanding the anatomical structures related to the innervation of the scalp is crucial for the success of this technique.

Materials and Methods

The pharmacological mixture utilized comprised dexmedetomidine (1 ml presentation) at a concentration of 100 mcg, with a recommended dosage of 0.85 mcg/kg and a maximum dosage of 80 mcg. Additionally, ropivacaine (7.5 mg/ml presentation) was administered at a dosage of 1.9 mg/kg.

Upon calculation of this mixture, if the resulting quantity falls below 20 ml, it should be supplemented to reach a total volume of 20 ml with injectable water. This ensures ease in calculating the dosage to be administered per craniometric point. This practice is particularly advantageous in patients with lower body weight. For patients weighing over 80 kg, it is imperative to adhere to the maximum dosage of 80 mcg for dexmedetomidine and 160 mg for ropivacaine. This protocol aims to maintain the patient in a state of alertness conducive to their proper assessment and interaction during the surgical procedure.

Below, We Describe the Technique used to Perform the Scalp Block

- **Patient Positioning:** The patient is placed in a supine position with the head slightly extended and turned to the opposite side of the planned block.
- **Preparation and Anesthesia:** The area of the scalp must be cleaned and sterilized. Identification of Landmarks: These are the neural structures to be infiltrated and the steps for their localization.
- **Supratrochlear Nerve:** Inject 1 ml of the drug mixture just medial to the supraorbital nerve injection site, extending the block in a medial direction above the eyebrow line.
- **Supraorbital Nerve:** Palpate the supraorbital notch and insert the needle perpendicularly, injecting 1 ml of the drug mixture.
- **Temporal Zygomatic Nerve:** Inject 1 ml of the drug mixture to cover both superficial and deep planes of the temporal muscle, beginning at the lateral border of the supraorbital margin and continuing up to the distal aspect of the zygomatic arch.
- **Auriculotemporal Nerve:** Inject 1 ml of the drug mixture approximately 1 cm in front of the auricle, above the level of the temporomandibular joint, ensuring careful palpation of the temporal artery to avoid intraarterial injection.
- **Lesser Occipital Nerve:** Subcutaneously inject 1 ml of the drug mixture behind the auricular pavilion, proceeding downwards to the auricular lobe, then continue infiltrating along the superior nuchal line towards the greater occipital nerve.
- **Greater Occipital Nerve:** Identify the occipital artery by palpation, located approximately 3-4 cm lateral to the external occipital protuberance along the superior nuchal line, then inject 1 ml of the drug mixture medial to the occipital artery.
- **Greater Auricular Nerve:** Inject 1 ml of the drug mixture about 2 cm behind the pinna, at the level of the tragus.

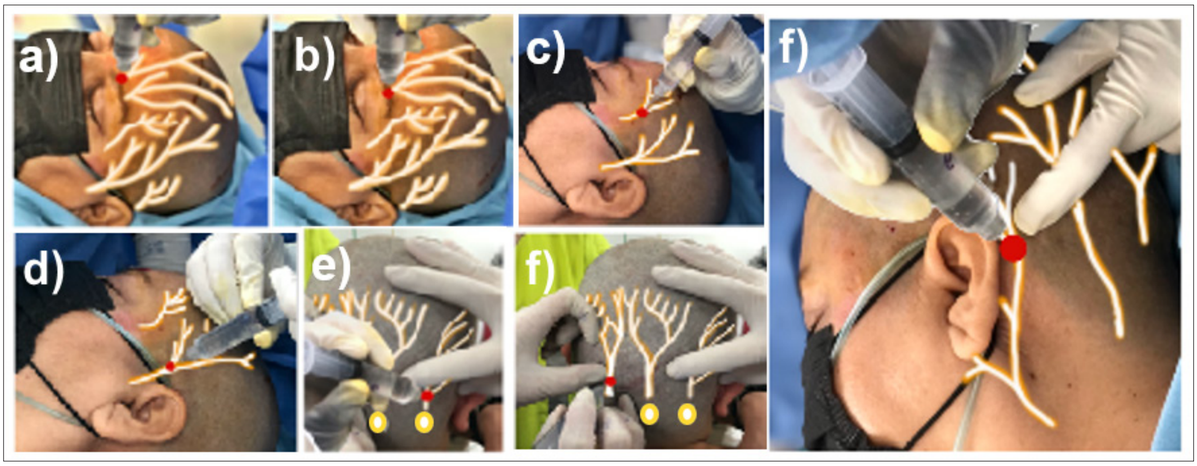

Figure 4: Blocking technique for: a) Supratrochlear nerve, b) Supraorbital nerve, c) Temporal zygomatic nerve, d) Auriculotemporal nerve, e) Lesser occipital nerve, f) Greater occipital nerve, g) Greater auricular nerve

Visualizing a line connecting the periciliary points with the external occipital protuberance can aid in delimiting the reference points for the block.

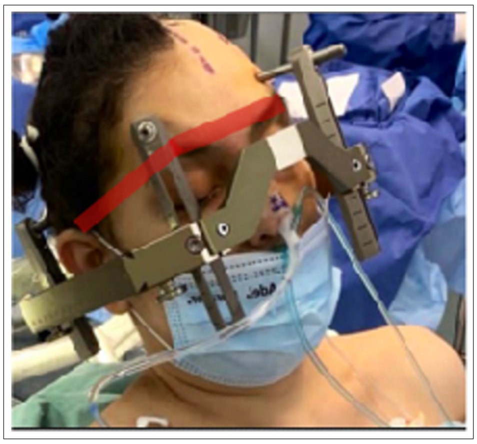

Figure 5: It May be Helpful to Imagine a Line that Connects the Periciliary Points with the External Occipital Protuberance to more Easily Delimit the Previous References

Additionally, it's crucial to reserve the remaining 6 ml of the drug mixture for use during stereotactic frame placement. This remaining solution can be utilized to deposit 0.5 - 1 ml at the periosteum level before definitive pin fixation or as reinforcement in specific areas of the block as needed.

By adhering to these anatomical landmarks and techniques, the scalp block can be effectively performed, contributing to enhanced patient comfort and perioperative pain management.

This prospective observational study was conducted on patients from the Neurosurgery service of the CMN "20 de Noviembre" undergoing awake patient surgery, with or without the use of a stereotactic frame, aged 12 years and above, between January 01, 2020, and June 30, 2022. Exclusion criteria comprised patients with psychiatric disorders, cardiac arrhythmia, cardiovascular dysfunction, hepatic or renal dysfunction, patients with a history of prolonged opioid use, those younger than 12 years, or older than 65 years, and those who

declined the procedure after receiving comprehensive information. This resulted in a total of 34 patients who underwent the RODEX technique.

The control group consisted of 25 patients with similar characteristics managed under Balanced General Anesthesia, with baseline characteristics recorded for data comparison. Measurements of anesthetic amounts were performed, with the fentanyl rate serving as a reference. Statistical analysis was carried out using R Studio R 3.5 software. Continuous variables were assessed for normality using the Shapiro-Wilk test and expressed as mean ± standard deviation or median [interquartile range], while categorical variables were presented as absolute values and percentages. The Student t-test or Mann-Whitney U test was employed for continuous variables, while the Chi-square or Fisher exact test was used for categorical variables.

Patient satisfaction with the procedure was evaluated using the Consumer Reports Effectiveness Scale (CRES-4) (Spanish version) [26]. Three components were derived from these questions, corresponding to the perception of change in emotional state, satisfaction, and problem-solving. Further details on the scale can be found in the original article.

This methodology allowed for comprehensive assessment of patient outcomes and treatment efficacy, providing valuable insights into the effectiveness of the RODEX technique compared to Balanced General Anesthesia.

Results

A total of 59 patients were recruited, of whom 34 underwent the RODEX technique, with similar baseline characteristics in the control group. The mean age was 46 years, with an average weight of 72.2 kg, and a significantly lower heart rate was recorded at the middle and end of the procedure in the RODEX group.

Of the 59 patients, 38 were male (74.5%) and 21 were female (25.5%). Thirty-four patients (57%) were included in the RODEX technique group, while the remaining 25 (43%) underwent the usual technique. Table 1 shows the clinical and hemodynamic characteristics of the patients. The main surgical cause was tumor pathology in 42 patients (71%), followed by functional surgery in 14 patients (23.7%). Seven patients had previous allergies, none of which were manifested during the present study.

In the bivariate analysis, comparing patients with and without the RODEX technique, no statistical differences were found in baseline characteristics such as sex, weight, and initial heart rate.

In response to the general objective, it was found that the fentanyl rate used in the RODEX group was significantly lower than in the control group (2.8 [0.7] vs. 1 [0.5], $P < 0.05$). Additionally, it was found that the heart rate at the middle and end of surgery, surgical time, and postoperative nausea and vomiting were significantly lower in the RODEX group.

Using the CRES-4 Satisfaction Scale, the degree of patient satisfaction with the procedure was evaluated, with a mean of 9.3 ± 0.8. Likewise, the change in initial fear of the procedure and the degree of satisfaction after it were assessed.

Finding with CRES-4 that the perception of the procedure was more satisfactory in patients in whom the RODEX technique was used compared to those who did not, likewise, they reported experiencing less fear during surgery and the postoperative period.

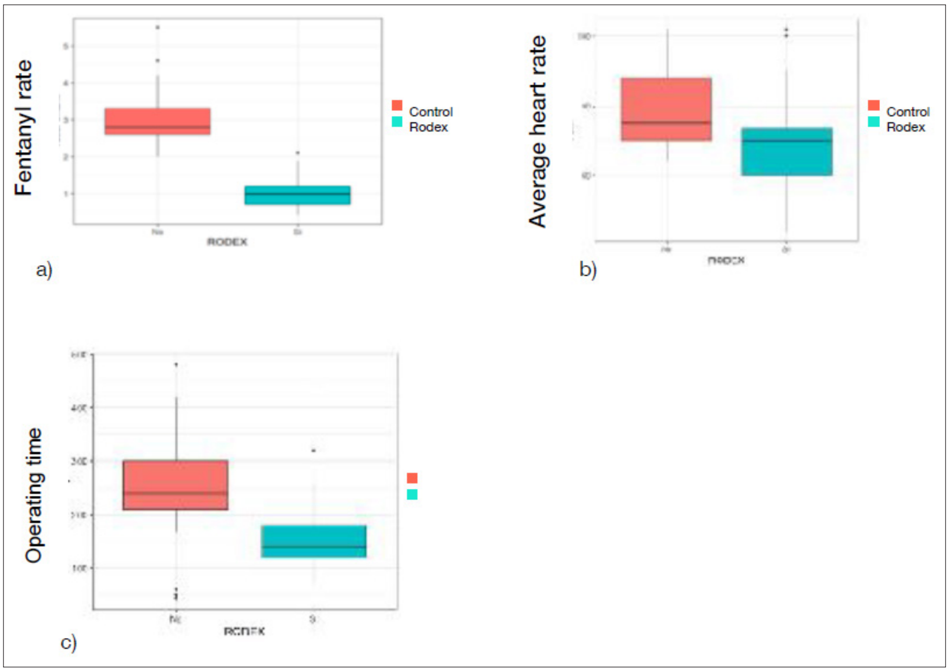

Figure 6: a) Graph demonstrating the difference found in the fentanyl rate using the 'rodex' technique and the control group, b) The difference in average heart rate is exemplified in both groups, c) Graph representing the operating room time with both groups

Discussion

The standardized scalp block technique used in awake neurosurgical procedures, such as stereotaxy, tumor resection, and epilepsy surgery, often may be associated with discomfort, pain, and anxiety in patients undergoing it. Post-procedural perception in awake surgery with the use of stereotaxy may entail discomfort caused by pain or stress during the procedure. The RODEX technique emerged as an effective method in mitigating pain, reducing surgical time associated with patient mobilization, and minimizing the requirement for anesthetics during the surgical event, particularly evidenced by the reduced rate of fentanyl usage, with minimal adverse effects. Furthermore, assessment via the CRES-4 satisfaction scale revealed high patient acceptance of the procedure, leading to improved pain management and decreased preoperative and intraoperative anxiety.

Conclusion

The RODEX technique for scalp block demonstrates promising outcomes in decreasing the necessity for anesthetics, shortening operative time, and enhancing overall patient experience during neurosurgical procedures. However, further multicenter studies involving a larger patient cohort are warranted to establish its widespread adoption as a standardized protocol for such surgical interventions.

Conflicts of Interest

The author affirms no personal, financial, institutional, or affiliation conflicts of interest with any pharmaceutical industry, surgical materials, or devices discussed in this article. There are no conflicts of interest that might influence adherence to ethical guidelines.

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