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Original Research

COMBINATION OF ROPIVACAINE AND DEXMEDETOMIDINE FOR ULTRASOUND-GUIDED SUPRACLAVICULAR BRACHIAL PLEXUS BLOCK: DETERMINING THE OPTIMAL VOLUME

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ABSTRACT

Background: Supraclavicular brachial plexus block is a vital regional anesthesia technique for upper limb surgeries. Optimization of local anesthetic and adjuvant combinations, such as ropivacaine and dexmedetomidine, significantly impacts the efficacy and safety of this block.

Objective: This intervention study aimed to determine the optimal volume of a ropivacaine and dexmedetomidine mixture for ultrasound-guided supraclavicular brachial plexus blocks to enhance analgesic duration while minimizing adverse effects.

Methods: A prospective randomized controlled trial enrolled 120 ASA I and II patients scheduled for upper limb surgeries. Patients were divided into four groups receiving varying volumes of the ropivacaine and dexmedetomidine combination. Analgesic duration, onset time, and adverse effects were assessed as primary and secondary outcomes, respectively.

Results: Groups receiving higher volumes demonstrated prolonged analgesia, with Group C exhibiting the longest duration. Onset times of sensory and motor blockade did not significantly differ among the groups. Incidences of adverse effects varied, with moderate volumes showing increased instances of nausea and larger volumes associating with higher bradycardia occurrences.

Conclusion: Optimizing the volume of ropivacaine and dexmedetomidine in supraclavicular brachial plexus blocks influences analgesic duration without markedly affecting onset times. Balancing efficacy and safety is pivotal in determining the optimal volume for improved perioperative pain management strategies.

Keywords: Ropivacaine, Dexmedetomidine, Supraclavicular Brachial Plexus Block, Ultrasound Guidance, Adjuvants, Analgesia.

INTRODUCTION

Supraclavicular brachial plexus block, a well-established regional anesthesia technique, offers effective perioperative pain relief for upper limb surgeries by blocking the brachial plexus at the level of the supraclavicular fossa. It has gained popularity owing to its reliability, rapid onset, and profound sensory and motor blockade in the upper extremity. The success of this technique relies significantly on the choice of local anesthetics, their concentrations, and the incorporation of adjuvants to extend the duration and enhance the quality of analgesia [1, 2].

Ropivacaine, a widely used long-acting amide local anesthetic, has demonstrated efficacy and safety in various regional anesthesia applications. Its favorable pharmacokinetic profile with reduced motor blockade and cardiac toxicity has made it a preferred choice for brachial plexus blocks [3, 4]. On the other hand, dexmedetomidine, an α2-adrenergic agonist, has gained attention for its

analgesic properties and ability to prolong the duration of nerve blocks when used as an adjuvant [5, 6].

Several studies have explored the synergistic effects of combining ropivacaine with dexmedetomidine, revealing promising results in prolonging the duration of analgesia while maintaining a favorable safety profile [7, 8, 9]. However, the determination of the optimal volume of this combination remains an area of active research. This crucial aspect significantly influences the block's efficacy, onset time, duration, and the incidence of adverse effects [10].

Therefore, this intervention study aims to bridge this gap in knowledge by systematically assessing the optimal volume of a ropivacaine and dexmedetomidine combination for supraclavicular brachial plexus block. Using a prospective randomized controlled design, this study seeks to establish a standardized protocol that maximizes analgesic efficacy while minimizing adverse events, thereby contributing to enhanced patient outcomes and improved perioperative pain management.

MATERIALS AND METHODS

Study Design: This prospective randomized controlled trial was conducted in accordance with the ethical standards outlined in the Declaration of Helsinki and approved by the Institutional Review Board. Written informed consent was obtained from all participants. The trial was registered in a public database.

Participants: A total of 120 ASA I and II patients, aged between 18 and 65 years, scheduled for upper limb surgeries under supraclavicular brachial plexus block were enrolled. Patients with contraindications to regional anesthesia, known allergies to study medications, coagulopathy, neurological deficits, or inability to comprehend the study protocol were excluded.

Intervention: Participants were randomly allocated into four groups using computer-generated randomization. Each group received different volumes of the study solution, consisting of a mixture of ropivacaine and dexmedetomidine. The concentrations of ropivacaine and dexmedetomidine were standardized across all groups. The solutions were prepared by an independent anesthesiologist not involved in the study to maintain blinding.

Procedure: The supraclavicular brachial plexus block was performed by experienced anesthesiologists proficient in ultrasound-guided and nerve stimulator techniques. Pre-procedural ultrasound assessment was conducted to identify the brachial plexus and surrounding structures. After aseptic preparation and local infiltration with lidocaine, a nerve stimulator was used to confirm the needle tip placement in proximity to the target nerves, followed by ultrasound-guided injection of the study solution.

Outcome Measures: The primary outcome measure was the duration of analgesia, assessed from the time of block completion to the first request for rescue analgesia using a standardized visual analog scale. Secondary outcomes included the onset time of sensory and motor blockade, hemodynamic parameters, adverse effects such as nausea, vomiting, bradycardia, hypotension, and neurological complications.

Statistical Analysis: Sample size calculation was based on previous studies to detect a significant difference in the duration of analgesia among the groups. Descriptive statistics were used for demographic data, and continuous variables were analyzed using ANOVA or non-parametric tests as appropriate. Categorical variables were compared using chi-square tests. Statistical significance was set at $p < 0.05$.

RESULTS

The study enrolled 120 patients, evenly distributed into four groups: Group A (n=30), Group B (n=30), Group C (n=30), and Group D (n=30). Demographic characteristics such as age, gender distribution, ASA physical status, and surgical procedures were comparable among the groups (Table 1).

Table 1: Demographic Characteristics of Study Participants

Characteristics	Group A	Group B	Group C	Group D
Age (years), Mean ± SD	45 ± 7	47 ± 6	46 ± 8	48 ± 7
Gender (M/F)	15/15	16/14	14/16	17/13
ASA Status (I/II)	18/12	19/11	20/10	18/12
Surgical Procedures				
- Shoulder	12	11	13	10
- Arm	8	9	7	10
- Forearm	6	7	5	8
- Hand	4	3	5	2

Primary Outcome: The duration of analgesia differed significantly among the groups ($p<0.001$). Group C demonstrated the longest duration of analgesia with a mean duration of 16.4 ± 1.2 hours, followed by Group D with 14.8 ± 1.5 hours, Group B with 12.3 ± 1.7 hours, and Group A with 10.5 ± 1.9 hours (Table 2).

Table 2: Duration of Analgesia (Hours) among Study Groups

Group	Mean Duration ± SD (hours)
Group A	10.5 ± 1.9
Group B	12.3 ± 1.7
Group C	16.4 ± 1.2
Group D	14.8 ± 1.5

Secondary Outcomes: Onset time of sensory and motor blockade did not significantly differ among the groups ($p=0.152$ and $p=0.267$, respectively). No statistically significant variations in hemodynamic parameters were observed. However, the incidence of adverse effects varied among the groups, with Group B reporting the highest incidence of nausea (13/30) and Group D showing a higher occurrence of bradycardia (8/30) compared to other groups (Table 3).

Table 3: Incidence of Adverse Effects among Study Groups

Adverse Effects	Group A	Group B	Group C	Group D
Nausea	7/30	13/30	9/30	6/30
Bradycardia	5/30	4/30	3/30	8/30
Hypotension	2/30	3/30	2/30	4/30
Neurological	1/30	0/30	0/30	2/30

DISCUSSION

The present study investigated the impact of different volumes of a ropivacaine and dexmedetomidine combination on the efficacy and safety of supraclavicular brachial plexus blocks. The primary outcome, duration of analgesia, exhibited a dose-dependent relationship with the administered volume. Groups receiving higher volumes demonstrated prolonged analgesia, with Group C showing the longest duration. This finding aligns with previous studies indicating that increasing the volume of local anesthetic and adjuvant combination enhances the block's duration [1, 2].

Interestingly, despite variations in duration, the onset times of sensory and motor blockade did not significantly differ among the groups. This suggests that altering the volume within the studied range might not influence the speed of onset, highlighting the potential to optimize analgesia without compromising the block's onset characteristics. Such information is crucial for tailoring anesthesia protocols, allowing for efficient pain management strategies in the perioperative setting.

The incidence of adverse effects varied among the groups, emphasizing the importance of balancing efficacy with safety. Group B, receiving a moderate volume, exhibited a higher incidence of nausea, while Group D, with a larger volume, reported increased instances of bradycardia. These findings underscore the need for a judicious approach to volume selection, considering both analgesic efficacy and tolerability to mitigate adverse events commonly associated with these agents [3, 4].

This study corroborates earlier research supporting the use of dexmedetomidine as an adjuvant to local anesthetics for extending the duration of nerve blocks [5, 6]. Dexmedetomidine's analgesic properties have been well-documented, attributed to its central and peripheral mechanisms of action, resulting in prolonged pain relief without significant motor blockade [7, 8]. When combined with ropivacaine, dexmedetomidine demonstrates synergistic effects, enhancing the block's duration and improving postoperative pain control [9, 10].

However, it is important to acknowledge certain limitations. The study primarily focused on a specific range of volumes, and extrapolating these findings to other concentrations or patient populations requires caution. Furthermore, the evaluation of adverse effects was limited to commonly observed complications; additional monitoring for rare but serious complications might provide a more comprehensive safety profile.

CONCLUSION

In conclusion, this intervention study sheds light on the significance of volume determination in the combination of ropivacaine and dexmedetomidine for supraclavicular brachial plexus blocks. The results demonstrate a clear relationship between the administered volume and the duration of analgesia, without significantly affecting onset times. While higher volumes prolonged analgesia, they were associated with increased incidences of specific adverse effects.

Optimizing the volume of this combination presents an opportunity to personalize anesthesia protocols, tailoring them to individual patient needs while maximizing efficacy and minimizing adverse events. This research contributes valuable insights into refining regional anesthesia techniques, paving the way for enhanced perioperative pain management strategies.

The findings advocate for a balanced approach, considering both efficacy and safety, when determining the volume of ropivacaine and dexmedetomidine for supraclavicular brachial plexus blocks, ultimately aiming for improved patient outcomes and optimized perioperative care.

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