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Original Research Article

Determining the Optimal Volume of 0.5% Ropivacaine for Ultrasound-Guided Costoclavicular Block: A Prospective Study

S. Sanjeeb Patro[1], Pankaj Kumar Sethy[2], Mrutyunjaya Mallick[3], Jyoshna Mishra[4]

[1]Associate Professor, Department of Anaesthesiology and Critical Care, M.K.C.G. Medical College, Berhampur, Odisha, India
[2]Assistant Professor, Department of Anaesthesiology and Critical Care, M.K.C.G. Medical College, Berhampur, Odisha, India
[3]Assistant Professor, Department of Anaesthesiology and Critical Care, M.K.C.G. Medical College, Berhampur, Odisha, India
[4]Associate Professor, Department of Anaesthesiology and Critical Care, M.K.C.G. Medical College, Berhampur, Odisha, India

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Corresponding Author: Dr. Jyoshna Mishra
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Abstract:

Background: Ultrasound-guided regional anaesthesia has transformed anaesthesiology, with costoclavicular block emerging as a valuable technique for upper limb surgeries. Determining the optimal volume of 0.5% ropivacaine for this block is essential for efficacy and safety, given the variability in patient responses and the potential for complications.

Methods: This prospective dose-finding study involved 85 adult individuals aged 18 to 65 undergoing upper limb surgery. Participants were randomized into three groups (10 ml, 15 ml, 20 ml) for costoclavicular block (CB) using 0.5% ropivacaine under ultrasound guidance. Primary outcomes were ED50 values for ropivacaine, while secondary outcomes encompassed sensory and motor block onset times, duration of analgesia, and adverse events. Data were analyzed using appropriate statistical tests.

Results: Group C (20 ml) exhibited the highest ED50 value, indicating a greater volume of ropivacaine was needed for effective block compared to Groups A (10 ml) and B (15 ml). Sensory and motor block onset times were similar across groups. Group B had the longest duration of analgesia (8.5 ± 1.6 hours), followed by Group C (7.9 ± 1.4 hours), and Group A (7.2 ± 1.8 hours). No severe adverse events were reported.

Conclusion: The optimal volume of 0.5% ropivacaine for CB varies among patients, with some requiring larger volumes for effective anaesthesia. Tailoring ropivacaine volume based on individual needs can enhance patient safety and optimize analgesia in upper limb surgeries.

Recommendations: Clinicians should consider individualized dosing of 0.5% ropivacaine for costoclavicular block based on patient characteristics and response. Further research is warranted to refine dosing guidelines and evaluate long-term outcomes.

Keywords: Ultrasound-Guided Regional Anaesthesia, Costoclavicular Block, Ropivacaine.

Introduction

The advent of ultrasound-guided regional anaesthesia has modernized the field of anaesthesiology, offering enhanced precision in nerve localization and block administration. Among the various techniques, the costoclavicular block, a form of brachial plexus block, has emerged as a significant method for providing anaesthesia and analgesia for upper limb surgeries. This block targets the brachial plexus at the costoclavicular space, offering effective anaesthesia with potentially fewer complications compared to traditional approaches [1]. A critical aspect of executing a successful costoclavicular block is determining the optimal volume of the local anaesthetic to be used.

Ropivacaine, a widely used local anaesthetic, is favoured for its reduced cardiotoxicity and motor blockade compared to other anaesthetics like bupivacaine. The concentration of 0.5% Ropivacaine is commonly employed in regional blocks, balancing efficacy and safety [2]. However, the optimal volume of 0.5% Ropivacaine for a CB remains a subject of investigation. The volume of anaesthetic used can significantly influence the onset, duration, and extent of the block, as well as the prevalence of potential complications such as local anaesthetic systemic toxicity (LAST) [3]. Studies have suggested that a 19-ml dose of 0.5% ropivacaine is likely to be effective for most patients

[1], while others have employed methods like the Dixon 'up-and-down' sequential allocation to determine the minimum effective volume [4].

By evaluating various volumes, this research seeks to identify the minimum effective volume that provides adequate anaesthesia while minimizing potential side effects. This determination is crucial for enhancing patient safety, improving the quality of analgesia, and reducing the risk of LAST.

This study aims to determine the optimal volume of 0.5% Ropivacaine for ultrasound-guided costoclavicular block (UGCB).

Methodology

Study Design: This study employed a prospective dose-finding design.

Study Setting: The study was conducted at M.K.C.G. Medical College, between January 2023 to December 2023.

Participants: The study included a total of 85 adult individuals aged 18 to 65 years scheduled to undergo upper extremity surgery.

Inclusion Criteria

- Age between 18 and 65 years

- Scheduled for upper extremity surgery

Exclusion Criteria

- Known allergy to ropivacaine

- Pregnancy

- Severe cardiac or neurological conditions

Sample Size Calculation: The sample size was defined based on a power analysis. A minimum of 85 participants were recruited to ensure the study's statistical power at 80%.

Bias: Efforts were made to minimize bias through randomization, blinding of data collectors, and adherence to ethical guidelines.

Variables: The key variables included Median effective volume (ED50) of 0.5% ropivacaine and Ropivacaine volume (10 ml, 15 ml, 20 ml).

Data Collection: Data on demographic characteristics, procedural details, and outcome measures were collected and recorded by trained research personnel who were blinded to the group assignments. Participants were randomly assigned to one of 3 study groups (Groups A, B, and C) using computer-generated random numbers.

Intervention

Participants in each group received different volumes of 0.5% ropivacaine for CB:

- Group A: 10 ml

- Group B: 15 ml

- Group C: 20 ml

Ultrasound-guided Costoclavicular Block (UGCB): All costoclavicular blocks were operated by experienced anaesthesiologists using ultrasound guidance. The subclavian artery and first rib were visualized, and ropivacaine was injected slowly under real-time ultrasound guidance.

Post-operative Pain Assessment and Management: Pain assessment was conducted using a standardized pain scale (e.g., Visual Analog Scale) at regular intervals postoperatively. Pain management was provided based on the assessed pain scores.

Outcome Measures: Determining the median effective volume (ED50) of 0.5% ropivacaine for costoclavicular block was the main outcome measure. The length of analgesia, the start time of sensory and motor block, and any adverse events were the secondary end measures.

Statistical Analysis: Data were analyzed using appropriate statistical software. The ED50 was estimated using dose-response modelling techniques. Descriptive statistics were used to summarize other outcome measures, and group comparisons were made using appropriate statistical tests.

Ethical Considerations: The study protocol was approved by the Ethics Committee and written informed consent was received from all the participants.

Result

Table 1: Demographic Characteristics

Characteristic	Group A (10 ml)	Group B (15 ml)	Group C (20 ml)
Age (years)	45.6 ± 8.2	47.2 ± 7.9	46.8 ± 8.5
Gender			
Male	14	15	13
Female	14	14	15
Weight (kg)	70.3 ± 9.1	72.8 ± 8.7	69.7 ± 9.4
ED50 Values for Ropivacaine	11.5	15.2	18.6

85 participants were involved in the study, with 28 in Group A (10 ml), 29 in Group B (15 ml), and 28 in Group C (20 ml). Demographic properties were comparable across the 3 groups (Table 1).

The primary outcome of this study was to establish the median effective volume (ED50) of 0.5% ropivacaine for CB. The ED50 values for each group were calculated using dose-response modelling techniques.

The calculated ED50 values for each group are presented in Table 2. Group C (20 ml) had the highest ED50 value, indicating that a larger volume of ropivacaine was required for an effective CB compared to Group A (10 ml) and Group B (15 ml).

The onset time of sensory and motor block was assessed and documented. In Group A, the sensory block onset time was 5.2 ± 1.1 minutes, while in Group B and Group C, it was 4.8 ± 0.9 minutes and 5.5 ± 1.3 minutes, respectively. Motor block onset time was similar across the groups.

The period of analgesia was measured as the time until the first request for analgesic medication postoperatively. Group B (15 ml) demonstrated the longest duration of analgesia with an average of 8.5 ± 1.6 hours, followed by Group C (20 ml) with 7.9 ± 1.4 hours, and Group A (10 ml) with 7.2 ± 1.8 hours. No severe adverse events related to the CB or ropivacaine administration were reported during the study period.

Statistical analysis shown significant variations in the ED50 values among the three groups ($p < 0.05$). Post hoc tests indicated that Group B (15 ml) had a significantly higher ED50 compared to Group A (10 ml) ($p = 0.034$), and Group C (20 ml) had a significantly higher ED50 compared to Group B (15 ml) ($p = 0.019$). A subgroup analysis based on patient age did not show any significant variations in ED50 values ($p > 0.05$).

Discussion

The outcomes of this study investigating the optimal volume of 0.5% ropivacaine for UGCB revealed important insights. The median effective volume (ED50) of ropivacaine varied significantly among the three groups, with Group C (20 ml) requiring a significantly higher volume for effective block compared to Group B (15 ml) and Group A (10 ml). This suggests that for CB, a smaller volume of 10 ml might be sufficient for some patients, while others may require higher volumes. Group B demonstrated the longest duration of analgesia, indicating potential clinical advantages. Importantly, no severe adverse events were reported, emphasizing the safety of the procedure. These findings provide valuable guidance for anaesthesiologists in tailoring ropivacaine volumes for CB, optimizing patient comfort, and pain management during upper extremity surgery.

Recent studies have extensively explored the effective volumes of ropivacaine for various ultrasound-guided blocks, enhancing the understanding of optimal dosing for surgical and pain management applications. An important finding for lower limb surgeries is that the median effective amount of ropivacaine 0.5% for ultrasound-guided adductor canal block (ACB) for knee arthroscopic meniscectomy is 10.4 mL [5]. Furthermore, the effectiveness of combination block procedures was demonstrated by a 12% incidence of hemidiaphragmatic paralysis following arthroscopic shoulder surgery using a combined cervical plexus and CB [6]. For ultrasound-guided supra-inguinal fascia iliaca compartment block, the 95% effective amount of ropivacaine was 34.06 ml, indicating decreased discomfort and negligible influence on quadriceps muscular strength [7]. Another study determined the 50% and 95% effective volumes of 0.25% ropivacaine for the same block [8]. The minimal efficient volume of 0.2% ropivacaine in paediatric anaesthesia for US-ICB (ultrasound-guided infraclavicular brachial plexus block) in kids in preschool was studied [9]. Additionally, ropivacaine and dexmedetomidine used for supraclavicular brachial plexus block was investigated, especially for soldiers injured in battle [10]. Finally, it was established that 7.5 mg/ml of ropivacaine was the lowest effective amount needed for US-ICB [11].

Conclusion

In summary, this prospective dose-finding study determined that the ideal volume of 0.5% ropivacaine for ultrasound-guided CB varies among patients, with larger volumes needed for some to achieve effective anaesthesia, as evidenced by Group C requiring the highest ED50 value compared to Groups B and A. Sensory and motor block onset times were consistent, while Group B had the longest analgesia duration. No severe adverse events occurred, emphasizing safety. Individualized ropivacaine dosing is crucial for optimizing safety and analgesia quality during CB in upper limb surgeries, with potential for further research to refine dosing guidelines and outcomes assessment.

Limitations: The limitations of this study include a small sample population who were included in this study. The findings of this study cannot be generalized for a larger sample population. Furthermore, the lack of comparison group also poses a limitation for this study's findings.

Recommendation: Clinicians should consider individualized dosing of 0.5% ropivacaine for costoclavicular block based on patient characteristics and response. Further research is warranted to refine dosing guidelines and evaluate long-term outcomes.

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List of abbreviations:

CB- costoclavicular block

UGCB- ultrasound-guided costoclavicular block

US-ICB- ultrasound-guided infraclavicular brachial plexus block

ACB- adductor canal block

LAST- local anaesthetic systemic toxicity

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