e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com

International Journal of Pharmaceutical Quality Assurance 2025; 16(2); 81-86

Original Research Article

A Study to Determine the Minimum Effective Volume of Bupivacaine 0.5% for Ultrasound Guided Supraclavicular Brachial Plexus Block

Twinkle Kewalramani[1], R. P. Kaushal[2], Sanket Site[1], Neelesh Nema[3]

[1]PG resident, Department of Anaesthesiology, Gandhi Medical College, Bhopal, Madhya Pradesh, India

[2]HOD & Professor, Department of Anaesthesiology, Gandhi Medical College, Bhopal, Madhya Pradesh, India

[3]Assistant professor, Department of Anaesthesiology, Gandhi Medical College, Bhopal, Madhya Pradesh, India

Received: 27-12-2024 / Revised: 25-01-2025 / Accepted: 27-02-2025

Corresponding Author: Dr. Neelesh Nema

Conflict of interest: Nil

Abstract:

Peripheral nerve blocks have certain advantages over central neuraxial anaesthesia and general anaesthesia, hence they have become increasingly popular for the management of pain during surgery. The development of ultrasonographyin regional anaesthesia made it possible to confirm precise needle placement and appropriate local anaesthetic administration. Furthermore, it is possible to prevent problems such as intravascular and intraneuronal injections. Real-time ultrasound not only lowers the amount of local anaesthetic needed for a successful nerve block but also enhances the quality of the block. Ultrasonographic guidance is beneficial in reducing intra neural injection and targets the neural sheath where drug can be deposited and block can be achieved with minimum possible volume. This study attempts to determine minimum possible volume of bupivacaine 0.5% to achieve adequate motor and sensory blockade by using ultrasound guided brachial plexus block.

Methodology: The study was conducted in Department of Anaesthesiology, Gandhi Medical Collegeand associated Hamidia Hospital, Bhopal during August 2022 to December 2023 after approval from institutional ethics committee. It was an Observational hospital-based study. The study was an observational study comprising of 75 patients between age group18-60 years of either sex belonging to ASA grade I or II, scheduled for elective upper limb surgery. Patients with neurologic deficit in upper limb, Diaphragm palsy, Respiratory distress and Allergy to the local anaesthetics were excluded. Under all aseptic precautions ultrasonography was done at the level of supraclavicular region and structures traced from cephalic to caudal direction. theprobe was placed in the coronal plane to visualize the subclavian artery and the brachial plexus in a transverse sectional view. Once the needle penetrated the brachial plexus, the bupivacaine 0.5% was injectedafter negative aspiration for blood or air just next to the artery, then the needle wasrepositioned to inject on the upper pole of the artery. Twenty five patients received10 ml Drug (group A), next 25 patients received 15 ml Drug (group B) and next 25 patients received 20 ml Drug (group C) each.

Result: Based on our findings, we determined that a volume of 15 ml of bupivacaine 0.5% reliably achieves effective sensory and motor blockade in the patients undergoing upper limb surgeries. This volume provides adequate anaesthesia while potentially reducing the risk of systemic toxicity associated with higher volume.

Introduction

Peripheral nerve blocks are gaining popularity for perioperative pain management due to their advantages over general and central neuraxial anesthesia, such as avoiding side effects like drowsiness, nausea, and hemodynamic instability. Patients can be discharged earlier without needing a recovery room. Brachial plexus block is commonly used for upper extremity surgeries, with various approaches like supraclavicular, axillary, and interscalene. The traditional blind techniques have risks, such as pneumothorax and nerve injury, but ultrasound guidance has reduced these complications [4]. Ultrasonography guidance is beneficial in reducing intra neural injection and targets the neural sheath where drug can be deposited and block and be achieved in minimum possible doses Ultrasound-guided supraclavicular block offers reliable anesthesia for upper limb surgery, ensuring accurate needle placement and reducing complications like intraneural and intravascular injections. It also minimizes the local anesthetic volume and improves block quality [5]. Various ultrasound-guided approaches exist, each with different success rates and complications [6].

Aims and Objectives

Primary Objectives:

1. To determine minimum effective volume of local anaesthetic bupivacaine 0.5% for ultrasound guided supraclavicular brachial plexus nerve block
2. The duration of sensory and motor blockade with minimum dose of the drug used.

Secondary Objectives:

1. To study the quality of motor and sensory block when minimum dose of bupivacaine 0.5 % is used.
2. To study adverse effects, if any.

Materials and Methods

- **Place of Work**- Department of Anaesthesiology, Gandhi medical college and associated Hamidia Hospital, Bhopal
- **Duration-** August 2022 to December 2023

Design of study- This is an observational hospital-based study (aftergetting permission from Institutional ethic committee).

Inclusion Criteria	Exclusion Criteria
Patients of ASA grade - I, ASA grade II	Diaphragm palsy, Respiratory distress
Age group 18-60 years of either sex.	Neurologic deficit or/and anatomic abnormality in upper limb
All patients scheduled for upper limb surgeries	Allergy to the local anaesthetics

Study Protocol

75 patients of ASA grade I and II was equally divided into 3 groups of 25 patients each.

Methodology

The study was observational research involving 75 patients, aged 18-60 years of either sex, classified as ASA grade I to II, scheduled for elective upper limb surgery. Written informed consent was obtained from all patients prior to participation.

Patients were instructed to remain nil by mouth for 6 hours before surgery. An intravenous line was established using an 18/20-gauge cannula, and Ringer Lactate infusion was started at a rate of 6-8 ml/kg/hr. Continuous monitoring of heart rate, non-invasive blood pressure, peripheral oxygen saturation (SpO2), and ECG was carried out throughout the procedure.

Proper patient positioning, crucial for the success of the block, was ensured by placing the patient in the following manner:

- Supine position
- Pillow under the shoulders
- Head turned to the opposite side
- Arm adducted and drawn downward to depress the shoulder

Technique

In this study, supraclavicular brachial plexus block was performed using ultrasound guidance with a linear probe (6–12 MHz). A total of 75 patients were randomly divided into three groups, with each group receiving a different volume of 0.5% bupivacaine: 10 mL (Group A), 15 mL (Group B), and 20 mL (Group C).

The patients were placed in a supine position with the head turned 45° to the contralateral side. The ultrasound probe was positioned in the coronal plane over the supraclavicular fossa to visualize the **subclavian artery** and the **brachial plexus** in a transverse sectional view. The subclavian artery appeared as a pulsating hypoechoic structure, and the brachial plexus appeared as a cluster of hypoechoic nodules lateral to it. The needle was inserted in-plane from the lateral end of the transducer and directed towards the plexus while continuously visualizing the needle's position on the ultrasound screen in real-time.

Once the needle penetrated the brachial plexus, **bupivacaine 0.5%** was injected after ensuring negative aspiration for blood or air. The injection was done next to the artery, and after repositioning the needle, the drug was injected on the upper pole of the artery. Local anesthetic dispersion was monitored via ultrasound.

Sensory block was assessed using the pinprick test and graded as follows:

- **Grade 0:** Sharp pin felt
- **Grade 1:** Analgesia and dull sensation
- **Grade 2:** No sensation felt

The **duration of sensory block** was defined as the time between complete sensory block and the first postoperative pain.

Motor block was assessed using a modified Bromage scale for the upper extremities:

- **Grade 0:** Normal motor function
- **Grade 1:** Decreased motor strength (fingers only move)
- **Grade 2:** Complete motor block (unable to move fingers)

The **duration of motor block** was recorded from the onset of motor paralysis until complete recovery of motor function.

Intra-operative vital parameters like heart rate, mean blood pressure, and oxygen saturation were monitored every 5 minutes for the first 30 minutes and then every 15 minutes until the end of surgery. Oxygen was administered at 5 L/min throughout the procedure.

The ultrasound machine used was a Mindray system with a linear transducer (7-10 Hz). The depth (5-10 cm), gain, and scanning mode (superficial/musculoskeletal) were adjusted to ensure optimal visualization of the structures during the procedure.

Study Overview and Statistical Analysis:

The study observed patients for any complications like arterial puncture, local anesthetic toxicity, nerve injury, and pneumothorax during both the intra-operative and postoperative periods. The following parameters were measured:

1. **Number of Attempts**: Recorded for each block procedure.
2. **Successful Block**: Defined as achieving analgesia in the areas supplied by the median, ulnar, musculocutaneous, and radial nerves.
3. **Onset of Sensory Block**: Evaluated by pinprick using a 23G needle, defined as decreased sensation to the pinprick.
4. **Onset of Motor Block**: Measured as the time from drug injection to attaining Bromage scale 1.
5. **Duration of Motor Block**: Defined as the duration between Bromage scale 2 and return to Bromage scale 0.
6. **Duration of Sensory Block**: Defined as the time between the onset of sensory block and the first report of pain in the anesthetized limb (Visual Analog Scale [VAS] > 3).
7. **Complications**: These included arterial puncture, local anesthetic toxicity, nerve injury, and pneumothorax.

Statistical Analysis:

- Categorical variables were presented as **number** and **percentage** (%).
- Quantitative data were presented as **mean ± standard deviation (SD)**.
- **Independent t-test** was used to analyze quantitative variables.
- **Chi-square test** was used for qualitative variables. If any expected value was less than 5, **Fisher's exact test** was applied.
- Data entry was done in **Microsoft Excel**, and the final analysis was performed using **Epi Info** software.
- A **p-value** of **less than 0.05** was considered statistically significant.

Sample Size Calculation:

- Considering an alpha error of 5% and 80% power, the sample size was calculated to be 26 patients per group. This was rounded up to 30 per group to account for possible dropouts and block failures.
- Using Epi Info software and considering a medium effect size of 0.5 and 90% confidence limits, the final sample size for the study was 75 patients (n = 75). The formula used for this calculation was: $n=M2Z2\times P\times(1-P)$

where **Z** is the Z-value, **P** is the estimated proportion, and **M** is the margin of error.

Result

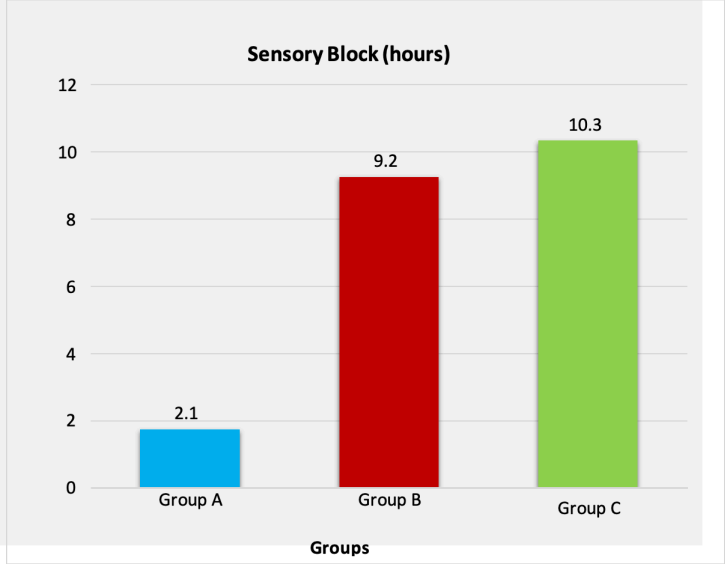
In this study, Group A (10 mL of 0.5% bupivacaine) demonstrated a significantly shorter sensory block duration, with a mean of 2.14 ± 1.39 hours. Group B (15 mL) and Group C (20 mL) showed significantly longer sensory block durations, with Group B lasting 9.26 ± 1.42 hours and Group C lasting 10.34 ± 2.53 hours. The one-way ANOVA test revealed a significant difference between the groups ($F = 158.979$, $p < 0.001$)

.

Table 1: Sensory Block Duration Following Ultrasound-Guided Supraclavicular Brachial Plexus Block

Parameter	Group	No.	Mean±SD	F value	P value
Sensory Block	Group A	25	2.14±1.39	158.979	<0.001
	Group B	25	9.26±1.42		
(in hours)	Group C	25	10.34±2.53		

This significant difference indicates that the volume of bupivacaine strongly influences the sensory block duration. **Groups B and C**, with longer sensory blocks, may offer better postoperative pain management due to prolonged analgesia. However, the shorter block duration in **Group A** may be beneficial in cases where shorter procedural times or quicker recovery of sensory function are required after surgery.



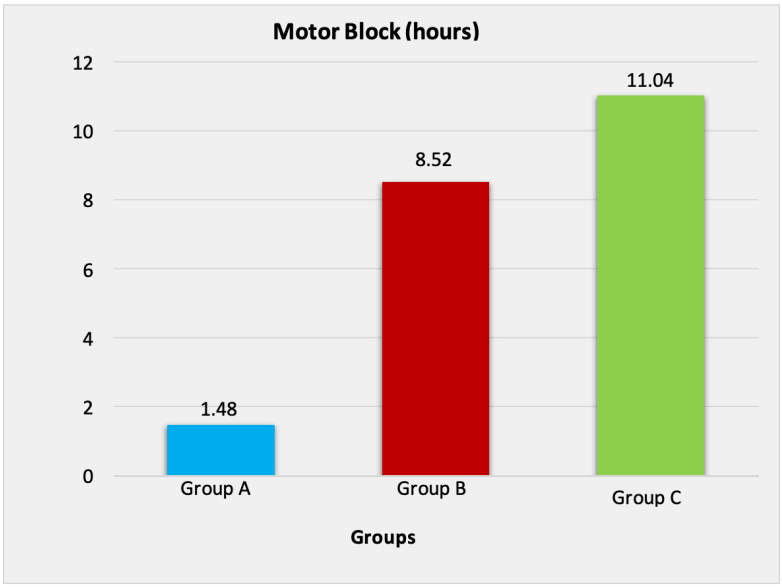
Graph 1: Graph Showing Sensory Block Duration In The Three Groups

Table 2: Motor Block Duration Following Ultrasound-Guided Supraclavicular Brachial Plexus Block

Parameter	Group	No.	Mean±SD	F-value	P-Value
Motor Block (in hours)	Group A	25	1.48±1.03	147.828	<0.001
	Group B	25	8.52±2.01		
	Group C	25	11.04±2.42		

The study analyzed the duration of motor block in three groups following ultrasound-guided supraclavicular brachial plexus block. Group A (10 mL of bupivacaine 0.5%) showed a significantly shorter motor block duration, with a mean of 1.48 ± 1.63 hours. In contrast, Group B (15 mL) and Group C (20 mL) had significantly longer motor block durations, with Group B lasting 8.52 ± 1.71 hours and Group C lasting 11.04 ± 2.62 hours. One-way ANOVA revealed a significant difference ($F = 147.828$, $p < 0.001$).

The results highlight that the volume of anesthetic significantly affects the motor block duration. Groups B and C, with longer motor blocks, may provide extended postoperative pain relief but could delay the recovery of motor function. On the other hand, Group A's shorter block duration may be advantageous in cases where rapid recovery of motor function is required, or when minimizing postoperative immobilization is a priority.



Graph 2: Graph Showing Motor Block Duration In The ThreeGroups

Discussion

This study aimed to determine the minimum effective volume (MEV) of 0.5% bupivacaine for an ultrasound-guided supraclavicular brachial plexus block in upper limb surgeries. It found that a higher volume of bupivacaine resulted in longer sensory and motor block durations.

- **Groups and Findings**:
  - **Group A (10 mL)**: Shortest block duration (sensory: 2.14 ± 1.39 hrs, motor: 2.12 ± 1.03 hrs).
  - **Group B (15 mL)**: Longer block durations (sensory: 9.26 ± 1.42 hrs, motor: 8.52 ± 2.01 hrs).
  - **Group C (20 mL)**: Longest block durations (sensory: 10.34 ± 2.53 hrs, motor: 11.04 ± 2.02 hrs).
- **Hemodynamics**: Group A showed significant fluctuations in heart rate and blood pressure due to shorter block duration. Groups B and C had more stable readings.
- **Comparison**: Results are consistent with other studies, which show that larger volumes of local anesthetics provide longer block durations.
- **Limitations**: The study had a small sample size, and ethical concerns about administering sub-therapeutic doses were noted.

In conclusion, a higher volume of bupivacaine leads to a longer block duration, providing effective anesthesia with minimal side effects in upper limb surgeries. Further studies with larger samples are recommended.

Conclusion

Our study aimed to determine the minimum effective volume of 0.5% bupivacaine for ultrasound-guided supraclavicular brachial plexus blocks. We found that 15 ml of bupivacaine effectively provides both sensory and motor blockade in patients undergoing upper limb surgeries. This volume ensures adequate anesthesia while minimizing the risk of systemic toxicity associated with larger doses.

The mean duration of sensory block was 9.26 ± 1.42 hours, and motor block lasted 8.52 ± 2.01 hours, providing effective pain relief for up to 9 hours.

These findings optimize anesthesia management for supraclavicular blocks, focusing on both safety and efficacy in clinical practice.

Summary

This study, conducted at the Department of Anaesthesiology, Gandhi Medical College, Bhopal, aimed to determine the minimum effective volume of 0.5% bupivacaine in ultrasound-guided supraclavicular brachial plexus block. The sample included 75 patients, aged 18 to 60 years, of ASA grade I or II, randomly assigned to three groups (A, B, and C), each with 25 patients. Group A received 10 mL, Group B received 15 mL, and Group C received 20 mL of 0.5% bupivacaine.

Key parameters observed included hemodynamic changes, sensory and motor block durations, and complications such as pneumothorax, nerve injury, vessel puncture, and local anesthetic toxicity. The data were analyzed using one-way ANOVA for quantitative variables and Pearson Chi-Square test for qualitative variables.

The results revealed that 15 mL of bupivacaine 0.5% reliably provided effective sensory and motor blockade in upper limb surgeries. This volume offers adequate anesthesia while minimizing the risks of systemic toxicity, such as hypotension, bradycardia, dizziness, and nerve injury.

In conclusion, the study suggests that using 15 mL of bupivacaine 0.5% for supraclavicular brachial plexus blocks optimizes anesthesia management by ensuring both safety and efficacy. This finding could influence clinical practice by promoting the use of smaller volumes, thereby reducing the risk of adverse reactions while maintaining effective pain control.

References

1. Gupta PK, Hopkins PM. Effect of concentration of local anaesthetic solution on the ED_{50} of bupivacaine for supraclavicular brachial plexus block. Br J Anaesth. 2013 Aug;111(2):293-6. doi: 10.1093/bja/aet033. Epub 2013 Mar 26. PMID: 23533252.
2. Fang G, Wan L, Mei W, Yu HH, Luo AL. The minimum effective concentration (MEC 90) of ropivacaine for ultrasound-guided supraclavicular brachial plexus block Anaesthesia.2016 Jun;71(6):700- 5.doi:10.1111/anae.13445. Epub 2016 Mar 4. PMID: 26945818.
3. Gupta K, Jain M, Gupta PK, Rastogi B, Zuberi A, Pandey MN. Nalbuphine asan adjuvant to 0.5% bupivacaine for ultrasound-guided supraclavicular brachial plexus blockade. Indian J Pain 2016; 30:176-80.
4. Masanori Nakayama, Yu Sakuma, Hitoshi Imamura, Koichiro Yano, Takao Kodama , Katsunori Ikari A comparison of the dose of anesthetic agents and the effective interval from the block procedure to skin incision for ultrasound- guided supraclavicular brachial plexus block in upper extremity surgery. Asian Journal of Anesthesiology; Volume 55, Issue 4, December 2017, Pages 83- 86.
5. Mona Mohamed Mogahed and Mohamed Samir Abd El Ghafar. Ultrasound Guided Supraclavicular Brachial Plexus Block for Arterio-venous Shunt Surgery in Chronic Renal

Failure, Comparative Study between Two Volumes of Bupivacaine, Research Article - (2017) Volume 8, Issue 7.
6. Rajan SA, Bhavani M, Murugan T. Comparative study of lateral approach and subclavian perivascular approach of supraclavicular brachial plexus block using the peripheral nerve stimulators. IAIM, 2018; 5(5): 57-62
7. Kavakli AS, Kavrut Ozturk N, Arslan U. Minimum effective volume of bupivacaine 0.5% for ultrasound-guided retroclavicular approach to infraclavicular brachial plexus block. Braz J Anesthesiolgy. 2019 May- Jun;69(3): 253-258.doi: 10.1016/j.bjan.2018.11.011. Epub 2019 Apr 25. PMID: 31030903; PMCID: PMC9391849.
8. Vadagandla K, Jahagirdar V, Rama K, Qavi D. Minimum Effective Volume of 0.75% Ropivacaine for Ultrasound-Guided Axillary Brachial Plexus Block. Cureus. 2020 Dec 22;12(12):e12229. doi: 10.7759/cureus.12229. PMID: 33409105; PMCID: PMC7779144.
9. Hemlata Kamat, Vaibhavi Hajariwala, Smiral Desai. Supraclavicular brachial plexus block under ultrasound guidance by "in-plane" approach using two- point injection technique: An observational study, MedPulse International Journal of Anesthesiology, Volume 15 Issue 3 - September 2020.
10. Hapugoda M. Ultrasound Guided Supraclavicular Brachial Plexus Block with 0.5% Bupivacaine and Additives: Case Series at Teaching Hospital Anuradhapura. Open Journal of Anesthesiology. 2021 Apr 2;11(4):112-27.
11. Başkan S, Vural Ç, Erdoğmuş NA, Aytaç İ. Determination of the minimum effective volume of bupivacaine for ultrasound-guided infraclavicular brachial plexus block: a prospective, observer-blind, controlled study. Braz J Anesthesiol. 2022 Mar-Apr;72(2):280-285. doi: 10.1016/j.bjane.2021.12.008. Epub 2021 Dec 29. PMID: 34973304; PMCID: PMC9373085.
12. Kyizom T, Parag K, Negi AS, Khandelwal H, Govil N. Ultrasonography Guided Supraclavicular Brachial Plexus Block: Comparison of Sensori-motor Blockade and Duration of Postoperative Analgesia Between Ropivacaine and Levobupivaine: A Prospectivetriple Blind Randomized Control Study. International Journal of Health Sciences. (III):4157-68.
13. Coşarcan SK, Doğan AT, Koyuncu Ö, Gurkan Y, Erçelen Ö. The Minimum Effective Analgesic Volume of 0.5% Bupivacaine for Ultrasound-Guided Anterior Suprascapular Nerve Block. Cureus. 2022 Nov 10;14(11):e31350. doi:10.7759/cureus.31350. PMID: 36514616; PMCID: PMC9741702.
14. Falcão LF, Perez MV, de Castro I, Yamashita AM, Tardelli MA, Amaral JL. Minimum effective volume of 0.5% bupivacaine with epinephrine in ultrasound-guided interscalene brachial plexus block. Br J Anaesth. 2013 Mar;110(3):450-5. doi: 10.1093/bja/aes419. Epub 2022 Nov 29. PMID: 23195326.
15. R S, T S, Rajadurai D, et al, Equal mixture of 2% lidocaine with adrenaline and 0.5% bupivacaine 20 mL provided faster onset of complete conduction blockade during ultrasound-guided supraclavicular brachial plexus block than 20 mL of 0.5% bupivacaine alone: a randomized double-blinded clinical trial. Regional Anesthesia & Pain Medicine 2024; 49:104-10.