Original Article

DOI: 10.7860/JCDR/2025/77021.20750

Efficacy of USG-guided Supraclavicular Block with Plain Bupivacaine, Bupivacaine-Dexamethasone and Bupivacaine-Sodium Bicarbonate: A Prospective Interventional Study

Anaesthesia Section

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ABSTRACT

Introduction: The brachial plexus block has evolved from a blind technique to ultrasound-guided approaches, becoming the gold standard for upper limb surgeries due to better patient outcomes and fewer complications. Various approaches (interscalene, supraclavicular, infraclavicular, and axillary) can be used, and different adjuncts, such as opioids, steroids, ketamine, α-agonists, and sodium bicarbonate, can be added to local anaesthetic drugs to enhance block effectiveness.

Aim: To compare the efficacy of the Supraclavicular Block (SCB) using plain bupivacaine versus bupivacaine combined with either dexamethasone or sodium bicarbonate.

Materials and Methods: This was a prospective interventional study at the Department of Anaesthesia and Critical Care, SKIMS Medical College and Hospital, Bemina, Srinagar, India, over a period of 24 months, from January 2021 to December 2023 involving 99 patients (aged 18-80, ASA I/II, BMI $\leq$35 kg/m^2) who were randomly divided into three equal groups of 33 each: Group-PB (plain bupivacaine), group-BD (bupivacaine+dexamethasone), and group-BB (bupivacaine+sodium bicarbonate). The study compared various parameters, including demographics, procedure metrics, block characteristics, pain scores, and patient satisfaction, using specific questionnaire evaluation parameters across these groups.

Results: Demographic data showed no significant differences in age (PB: 36.2, BD: 39.5, BB: 37.6 years), gender distribution, weight (PB: 67.1, BD: 69.4, BB: 67.8 kg), or American Society of Anaesthesiologists (ASA) status across groups ($p>0.05$ for all). For block characteristics, sodium bicarbonate significantly reduced the onset time compared to both PB and BD ($p<0.05$), while dexamethasone had no significant effect ($p=0.367$). The duration of analgesia was longest with BD (15.3 hours), compared to PB (8.2 hours) and BB (7.9 hours), with significant differences between PB vs. BD and BD vs. BB ($p<0.05$). The addition of dexamethasone notably prolonged analgesia compared to both other groups.

Conclusion: The present study concludes that adding dexamethasone to bupivacaine significantly prolonged the duration of postoperative analgesia, enhancing its efficacy for SCB. Meanwhile, sodium bicarbonate reduced the onset time of the motor block but did not extend the duration of analgesia, indicating distinct advantages of each additive depending on the clinical goal.

Keywords: Analgesia duration, Dexamethasone efficacy, Motor block onset, Sodium bicarbonate properties, Ultrasound-guided techniques

INTRODUCTION

Brachial plexus block is a regional anaesthesia technique used as an alternative to, or in conjunction with, general anaesthesia for upper extremity surgery. This procedure involves injecting local anaesthetic drugs near the brachial plexus to temporarily block sensation and movement in the upper extremity. The brachial plexus block is associated with excellent patient outcomes for upper limb surgery, including superior postoperative analgesia and recovery compared to general anaesthesia [1,2] and opioid analgesia [3]. The postoperative analgesia of the brachial plexus block is of comparable quality to that of epidural analgesia [4].

Brachial plexus blocks can be performed using the interscalene, supraclavicular, infraclavicular, or axillary approach. The introduction of ultrasonography and the peripheral nerve stimulator has enhanced the safety of the procedure [5] compared to the blind approach, allowing for a faster and more comprehensive block. Among local anaesthetic drugs, bupivacaine is one of the most commonly used agents for brachial plexus block. The addition of additives to bupivacaine is intended to expedite the onset and extend the duration of the block [6]. Commonly used additives include sodium bicarbonate [7], dexamethasone [8], and lidocaine [9].

Several studies have explored the effects of adding dexamethasone and sodium bicarbonate to local anaesthetics in regional blocks, such as the work by Rai S, Kedareshvara KS, and Hapugoda M, which demonstrated the efficacy of dexamethasone in prolonging the duration of analgesia in supraclavicular brachial plexus blocks [10,11]. However, limited research has directly compared the combined impact of these additives on bupivacaine in the context of ultrasound-guided supraclavicular blocks [11]. This gap in the literature, particularly regarding the comparative onset and duration of sensory and motor blocks, prompted the authors to conduct the present study.

Thus, the present study was designed to compare ultrasound-guided supraclavicular blocks using plain bupivacaine with bupivacaine combined with dexamethasone and bupivacaine combined with sodium bicarbonate in terms of sensory and motor block onset, duration of postoperative analgesia, associated complications, and patient satisfaction with the overall supraclavicular block and its outcomes in patients undergoing upper extremity surgery.

MATERIALS AND METHODS

The present prospective interventional study was conducted at the Department of Anaesthesia and Critical Care, SKIMS Medical College and Hospital, Bemina, Srinagar, India, over a period of

24 months, from January 2021 to December 2023. Ethical clearance was obtained from the Institutional Ethics Committee under reference number EC/NEW/INST/2021/1556, and informed written consent was acquired from all participants.

Sample size calculation: The sample size was calculated based on previous literature [10]. The required sample size was 99 patients.

Inclusion and Exclusion criteria: Patients aged 18 to 80 years, with ASA physical status I or II, undergoing upper limb surgeries, and having a Body Mass Index (BMI) ≤35 kg/m² were included in the study. Patients were excluded if they were pregnant, had ASA status III or above, significant coagulopathy, pre-existing sensory or motor deficits in the operative limb, local infection at the injection site, known allergies to local anaesthetics, a BMI >35 kg/m², mental incapacity, or inability to cooperate during the procedure. Among 120 patients screened, 99 were included, and 21 were excluded due to failure to meet the eligibility criteria.

Study Procedure

Methodology and parameters studied: Patients were randomly assigned using computer-generated random numbers into three groups of 33 each. Group-PB received 0.5% plain bupivacaine (maximum 2 mg/kg), group-BD received 0.5% bupivacaine with 8 mg dexamethasone, and group-BB received 0.5% bupivacaine with 7.5% sodium bicarbonate in a 200:1 volume ratio. The dosages were referenced from prior studies, including those by Rai S and Kedareshvara KS; Hapugoda M; and Chalapathy P and Jayasundaram E [10-12]. Ultrasound-guided supraclavicular brachial plexus blocks were performed using a 22-gauge needle, adhering to standard aseptic protocols.

The parameters studied included demographic characteristics, onset times for sensory and motor blocks, duration of analgesia, procedural pain, intraoperative pain, patient satisfaction, and complications. Preemptive analgesics were avoided to evaluate the direct efficacy of the study drugs.

Sensory block was evaluated by comparing the cold sensation (elicited by ice) in the central sensory region of each nerve dermatome of the affected arm with the contralateral arm. Sensory block was evaluated as follows: normal sensation=no block, reduced sensation=partial block, and total loss of cold sensation=complete block.

The motor block was gauged by examining the selective movements at the shoulder, elbow, wrist, and fingers, which corresponded to the motor components of the median, radial, ulnar, axillary, and musculocutaneous nerves. Motor block was evaluated and scored as follows: no loss of force (5/5)=no block, reduced force compared with the contralateral arm (4-3/5)=partial block, and incapacity to overcome gravity (2-0/5)=complete block [11].

Pain assessment: Pain was assessed using a Visual Analogue Scale (VAS) [11], where:

0=No pain.

10=Worst imaginable pain.

Pain scores were recorded at regular intervals, and intramuscular diclofenac 75 mg was administered as rescue analgesia if the VAS score exceeded 4.

Patient satisfaction assessment: All patients who received SCBs were followed-up four weeks later for potential long-term neurologic complications and to assess patient satisfaction regarding the supraclavicular nerve block via a telephone interview. Satisfaction was noted in terms of whether the patient was satisfied or unsatisfied with the overall SCB and its outcome, and whether they would prefer to undergo surgery under the same regional block procedure in the future and recommend it to others [11].

STATISTICAL ANALYSIS

The data were analysed using Statistical Package for Social Sciences (SPSS) software version 25.0. Continuous variables, such as onset times and duration of analgesia, were expressed as means±standard deviations and analysed using one-way Analysis of Variance (ANOVA) and independent t-tests. Categorical variables, including patient satisfaction and complications, were expressed as frequencies and percentages and analysed using Chi-square tests. A p-value of <0.05 was considered statistically significant.

RESULTS

The demographic characteristics among the groups exhibited marked similarities and were comparable with respect to mean age, gender distribution, weight, ASA status, and duration of surgery (p>0.05) [Table/Fig-1].

Parameters	Group-PB (n=33)	Group-BD (n=33)	Group-BB (n=33)	p-value
Age (years)	36.2±2.152	39.5±2.669	37.6±2.452	0.621
Weight (kg)	67.1±1.563	69.4±1.642	67.8±1.763	0.603
Gender (M/F)	18/15	21/12	20/13	0.587
ASA (I/II)	23/10	20/13	22/11	0.627
Duration of surgery (min)	121.5±7.08	126.7±4.51	116.8±7.92	0.657

[Table/Fig-1]: Demographic characteristics of the study participants (N=99).

The mean onset of sensory block in minutes for groups PB, BD, and BB was 21.24±0.356, 20.82±0.302, and 20.63±0.271, respectively. The group comparison among these groups was statistically insignificant (p=0.368). The mean onset of motor block in minutes for groups PB, BD, and BB was 26.09±0.397, 25.61±0.356, and 21.6±0.329, respectively. The comparison between group BD and group BB was statistically significant (p-value=0.001). The comparison between group BB and group PB was also statistically significant (p-value=0.001). However, the group comparison between group PB and group BD was statistically insignificant (p-value=0.367). Thus, bupivacaine with Sodium Bicarbonate (BB) enhances the onset of motor block in minutes compared to Bupivacaine with Dexamethasone (BD).

The mean duration of analgesia (in hours) for groups PB, BD, and BB was 8.2±0.238, 15.3±0.345, and 7.9±0.236, respectively. The comparison between group PB vs. group BD and group BD vs. group BB was statistically significant (p-value=0.001). Therefore, Bupivacaine with Dexamethasone (BD) prolongs the duration of analgesia compared to Plain Bupivacaine (PB) and Bupivacaine with Sodium Bicarbonate (BB) [Table/Fig-2].

Parameters	Group-PB (n=33)	Group-BD (n=33)	Group-BB (n=33)	Overall p-value	Group comparisons	p-value
Onset of sensory block (min)	21.24±0.356	20.82±0.302	20.63±0.271	0.368	PB vs BD BD vs BB BB vs PB	0.368 0.656 0.181
Onset of motor block (min)	26.09±0.397	25.61±0.356	21.76±0.329	<0.001	PB vs BD BD vs BB BB vs PB	0.367 <0.001 <0.001
Duration of analgesia (hours)	8.2±0.238	15.3±0.345	7.9±0.236	<0.001	PB vs BD BD vs BB BB vs PB	<0.001 <0.001 0.446

[Table/Fig-2]: Block characteristics in the three groups (N=99).

There was no statistically significant difference in procedural pain and pain during surgery, with p-values of 0.449 and 0.291, respectively. A total of 32 (96.96%) patients out of 33 were satisfied in group PB, all patients were satisfied in group BD, and 31 (93.93%) were satisfied in group BB. There was no statistically significant difference in patient satisfaction among the three groups, with a p-value of 0.357 [Table/Fig-3]. There were no complications or adverse effects reported in any group.

Parameters	Group-PB (n=33)	Group-BD (n=33)	Group-BB (n=33)	p-value
Procedural pain (VAS)	2.48±0.124	2.76±0.131	2.73±0.099	0.449
Pain during surgery (VAS)	0.24±0.076	0.31±0.081	0.36±0.085	0.291
Patient satisfaction n (%)	32 (96.96%)	33 (100.0)	31 (93.93)	0.357

[Table/Fig-3]: Patient experience in all the three groups (N=99).

DISCUSSION

The present study compared the efficacy of ultrasound-guided supraclavicular brachial plexus blocks using plain bupivacaine, bupivacaine with dexamethasone, and bupivacaine with sodium bicarbonate. The addition of dexamethasone significantly prolonged the duration of analgesia compared to both plain bupivacaine and bupivacaine with sodium bicarbonate. The onset time for the sensory block did not differ significantly among the groups; however, the onset of the motor block was significantly faster with bupivacaine and sodium bicarbonate compared to plain bupivacaine and bupivacaine with dexamethasone. Patient satisfaction was uniformly high across all groups, with no adverse effects such as unintended vascular puncture or Postoperative Nausea and Vomiting (PONV). No long-term neurological complications were reported.

The significantly prolonged duration of analgesia with dexamethasone observed in this study aligns with the findings of Rai S and Kedareshvara KS, who reported extended sensory and motor blockade durations when dexamethasone was added to bupivacaine in Sciatic Nerve Blocks (SCBs) [10]. Similarly, Vieira PA et al., demonstrated that dexamethasone effectively prolongs analgesia by reducing perineural inflammation and oedema [13]. Marks R et al., attributed this prolonged effect to steroid-induced vasoconstriction, which decreases systemic absorption of the local anaesthetic, thereby sustaining its action [14]. These results correlate well with the present findings, which showed a nearly twofold increase in the duration of analgesia in the dexamethasone group compared to the plain bupivacaine group. Zhang S et al., also found a mean analgesia duration of 14.2 hours with a similar dexamethasone dose [15]. A systematic review by El-Boghdadly K et al., of 12 Randomised Controlled Trials (RCTs) also confirmed dexamethasone's significant role in prolonging analgesia [16].

The significant reduction in motor block onset time with sodium bicarbonate in this study supports the findings of McMorland GH et al., who highlighted that alkalinisation of local anaesthetics accelerates the onset of action by increasing the non ionised fraction of the drug, facilitating faster nerve penetration [17,18]. However, unlike the observations of McMorland GH et al., regarding a prolonged duration of anaesthesia with sodium bicarbonate, the present study did not show a significant extension of analgesic duration in the sodium bicarbonate group. This discrepancy may stem from differences in pH adjustment techniques or the specific concentrations of sodium bicarbonate used [17,18].

High patient satisfaction rates and minimal complications in the present study corroborate the findings of Perlas A et al., who reported excellent safety profiles and patient satisfaction with ultrasound-guided SCBs [19]. No cases of pneumothorax, prolonged neurological deficits, or other major complications were observed, consistent with the low complication rates reported in large-scale studies of ultrasound-guided peripheral nerve blocks. The present study study is supported by Voskeridjian AC et al., who reviewed 713 cases and found very low (0.6%) complication rates, and a quality assessment study by Wong DM et al., which confirmed the safety profile with modern techniques [20,21].

The present study reinforces the benefits of dexamethasone and sodium bicarbonate as adjuvants in regional anaesthesia, highlighting their distinct roles in enhancing block characteristics.

Limitation(s)

The study faced several methodological constraints that warrant consideration when interpreting its results. A primary limitation was the inability to verify pH elevation following the alkalisation of bupivacaine with 7.5% sodium bicarbonate (0.1 mL per 20 mL of plain bupivacaine), which may have influenced the assessment of its effectiveness. Furthermore, the study population was restricted to ASA I and ASA II patients only, potentially limiting the generalisability of the results to higher-risk patients. While the sample size of 33 patients per group provided adequate statistical power for basic analysis, larger-scale validation would strengthen the findings.

CONCLUSION(S)

The study demonstrates that while all three formulations achieved high patient satisfaction and safety, each offers distinct advantages. Dexamethasone, as an adjuvant to bupivacaine, significantly prolonged the duration of post-block analgesia, while sodium bicarbonate specifically enhanced the onset of motor block. These findings suggest that clinicians can select the most appropriate formulation based on specific procedural requirements—choosing dexamethasone when extended pain control is needed and sodium bicarbonate when rapid motor blockade is prioritised, all without compromising patient comfort or safety.

Author's contribution: AR, BA, and RJ are the principal investigators and conceived this study. AR, BA, and RJ collected and managed the data. AR and RJ wrote this manuscript and are part of the authorship. WA, RSS, SA, and TA collected the references did proofreading, and checked for plagiarism. All AR authors read and approved the final manuscript.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Nov 28, 2024
- Manual Googling: Jan 17, 2025
- iThenticate Software: Jan 25, 2025 (14%)

ETYMOLOGY: Author Origin

EMENDATIONS: 8

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Nov 27, 2024**
Date of Peer Review: **Dec 26, 2024**
Date of Acceptance: **Jan 28, 2025**
Date of Publishing: **Mar 01, 2025**