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Comparison of Bupivacaine Alone Versus Bupivacaine–Dexamethasone Combination for Ultrasound Guided Supraclavicular Brachial Plexus Block

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Abstract

Background: Ultrasound-guided supraclavicular brachial plexus block is widely used for anesthesia and postoperative analgesia in upper-limb surgery. Although bupivacaine provides effective sensory and motor blockade, adjuvant drugs such as dexamethasone have been investigated to prolong block duration and improve postoperative analgesia. The present study compared the efficacy and duration of analgesia produced by bupivacaine alone versus bupivacaine combined with dexamethasone.

Methods: This prospective, randomized, comparative observational study included 100 adult patients undergoing elective upper-limb surgery under ultrasound-guided supraclavicular brachial plexus block. Patients were randomly allocated into two equal groups of 50 each. Group B received bupivacaine with normal saline, while Group BD received bupivacaine with dexamethasone. Onset and duration of sensory and motor block, duration of postoperative analgesia, postoperative pain scores, rescue analgesic requirement, and adverse events were assessed.

Results: Demographic characteristics and duration of surgery were comparable between groups. The mean duration of sensory block was significantly longer in Group BD than Group B (1138.4 ± 145.7 vs. 731.6 ± 128.9 minutes; $p < 0.001$). Motor block duration was also significantly prolonged with dexamethasone (918.7 ± 126.4 vs. 587.2 ± 109.8 minutes; $p < 0.001$). Duration of effective postoperative analgesia was significantly greater in Group BD (1212.6 ± 154.3 vs. 768.5 ± 136.2 minutes; $p < 0.001$). Twenty-four-hour rescue analgesic consumption was lower in the dexamethasone group (76.0 ± 48.9 mg vs. 138.0 ± 61.7 mg tramadol equivalent; $p < 0.001$). No serious complications attributable to the block or dexamethasone were observed.

Conclusion: Addition of dexamethasone to bupivacaine significantly prolonged sensory and motor blockade, extended postoperative analgesia, and reduced rescue analgesic requirements following ultrasound-guided supraclavicular brachial plexus block.

Keywords: Bupivacaine; dexamethasone; supraclavicular block; brachial plexus; ultrasound; postoperative analgesia.

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Introduction

Regional anesthesia has become an important component of modern perioperative care because it provides effective surgical anesthesia while reducing systemic opioid requirements and facilitating early postoperative recovery. Blocks of the brachial plexus are commonly utilized for upper limb surgeries. Of the several methods, the supraclavicular approach is especially useful for surgery below the shoulder because it offers dense anesthesia of the brachial plexus at a relatively compact anatomical position. The increasing accessibility of ultrasound has enhanced local anesthetic dissemination, brain structure visualization, and needle placement accuracy while perhaps lowering problems. [1-4]

Peripheral nerve blocking is a popular application for bupivacaine, a long-acting amide local anesthetic. It is helpful for postoperative analgesia due to its comparatively extended duration. However, in the later postoperative phase, even long-acting local anesthetics may not be sufficient to provide analgesia, increasing the need for opioids or other rescue analgesics. In order to extend the duration of peripheral nerve blocks, a number of adjuvants have been tested in conjunction with local anesthetics. [5,6]

The powerful glucocorticoid dexamethasone has garnered a lot of attention as a peripheral nerve block adjuvant. Perineural or intravenous dexamethasone has been shown in numerous clinical investigations and systematic reviews to prolong analgesia following peripheral nerve blocking. We still do not fully understand the precise mechanism. Local anti-inflammatory effects, vasoconstrictive effects, nociceptive transmission modification, and suppression of ectopic neuronal discharge are some of the suggested mechanisms. [7-10]

Direct comparisons are challenging due to variations in local anesthetic agents, dosages, block techniques, surgical procedures, and definitions of block length, despite evidence supporting the analgesic advantage of dexamethasone. Furthermore, there is also ongoing clinical interest in the best use of dexamethasone as an adjuvant in ultrasound-guided supraclavicular block.

For ultrasound-guided supraclavicular brachial plexus block, the current study was created to evaluate bupivacaine alone with bupivacaine–dexamethasone combination. Comparing the length of postoperative analgesia was the main goal. Comparing the start and duration of sensory and motor blockage, postoperative pain levels, the use of rescue analgesics, and side events were secondary goals.

Materials and Methods

A prospective, randomized, comparative study was conducted in the Department of Anaesthesiology of a tertiary-care hospital. The study included 100 adult patients scheduled for elective upper-limb surgical procedures requiring supraclavicular brachial plexus block.

Study population

Patients aged 18–60 years belonging to American Society of Anesthesiologists (ASA) physical status I or II and scheduled for elective upper-limb surgery were eligible.

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Inclusion criteria

1. Age 18–60 years.
2. ASA physical status I or II.
3. Elective upper-limb surgery suitable for supraclavicular brachial plexus block.
4. Ability to understand the visual analogue pain scale.
5. Written informed consent.

Exclusion criteria

Patients were excluded if they had allergy to local anesthetics or dexamethasone, pre-existing neurological deficits affecting the operative limb, coagulopathy, infection at the injection site, severe hepatic or renal dysfunction, uncontrolled diabetes mellitus, pregnancy, significant cardiopulmonary disease, or contraindication to regional anesthesia.

Randomization and intervention

One hundred patients were randomly divided into two equal groups:

- **Group B (n=50):** ultrasound-guided supraclavicular block with bupivacaine 0.5% plus equivalent volume of normal saline.
- **Group BD (n=50):** ultrasound-guided supraclavicular block with bupivacaine 0.5% plus dexamethasone 8 mg.

A standardized total injectate volume was used in both groups.

All patients received standard ASA monitoring, including non-invasive blood pressure, electrocardiography, pulse oximetry, and respiratory rate monitoring.

Block technique

The patient was positioned supine with the head turned away from the operative side. After aseptic preparation, a high-frequency linear ultrasound transducer was placed in the supraclavicular fossa to identify the subclavian artery and the brachial plexus. A 22-gauge block needle was introduced using an in-plane approach. After careful aspiration to exclude intravascular placement, the study solution was administered incrementally around the brachial plexus under continuous ultrasound visualization.

The onset of sensory and motor blockade was assessed at regular intervals following injection.

Assessment of sensory and motor block

Sensory blockade was assessed in the distributions of the median, radial, ulnar, and musculocutaneous nerves using cold sensation. Motor blockade was evaluated by assessing appropriate movements of the wrist, fingers, and elbow.

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Onset of sensory block was defined as the time from completion of injection to complete loss of cold sensation in the relevant nerve territories.

Onset of motor block was defined as the time required to achieve complete motor blockade.

Duration of sensory block was calculated from onset of sensory blockade until return of normal cold sensation.

Duration of motor block was calculated from onset of motor blockade until complete recovery of motor function.

Postoperative analgesia

Pain was assessed using a 10-cm visual analogue scale (VAS), with 0 representing no pain and 10 representing the worst imaginable pain. VAS scores were recorded at regular postoperative intervals for 24 hours.

The duration of analgesia was defined as the time from completion of block administration to the first request for rescue analgesia or VAS ≥4.

Rescue analgesia was administered when clinically indicated according to the institutional postoperative analgesia protocol.

Statistical analysis

Data were entered into a structured database and analyzed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. Student's independent t-test was used for comparison of continuous variables, while the chi-square test or Fisher's exact test was used for categorical variables. A p-value <0.05 was considered statistically significant.

Results

A total of 100 patients were included and completed the study, with 50 patients in each group. Baseline demographic characteristics were comparable between the two groups.

Table 1: Comparison of demographic and perioperative characteristics

Parameter	Group B (n=50)	Group BD (n=50)	p-value
Age (years), mean ± SD	41.6 ± 10.2	40.9 ± 9.8	0.73
Male/Female	32/18	34/16	0.67
BMI (kg/m²)	24.8 ± 2.7	25.1 ± 2.9	0.59
ASA I/II	29/21	31/19	0.68
Duration of surgery (min)	91.4 ± 18.6	89.7 ± 17.9	0.64
Right/Left-sided block	28/22	30/20	0.68

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There was no statistically significant difference between the groups with respect to age, sex, BMI, ASA physical status, duration of surgery, or operative side ($p>0.05$ for all parameters).

Table 2: Comparison of onset and duration of sensory and motor blockade

Parameter	Group B	Group BD	p-value
Sensory block onset (min)	14.8 ± 3.6	13.9 ± 3.2	0.19
Motor block onset (min)	19.6 ± 4.1	18.7 ± 3.8	0.26
Sensory block duration (min)	731.6 ± 128.9	1138.4 ± 145.7	<0.001
Motor block duration (min)	587.2 ± 109.8	918.7 ± 126.4	<0.001

The onset of sensory and motor blockade was comparable between the two groups. However, the duration of both sensory and motor blockade was significantly prolonged in patients receiving dexamethasone ($p<0.001$).

Table 3: Comparison of postoperative analgesic outcomes

Parameter	Group B (n=50)	Group BD (n=50)	p-value
Duration of analgesia (min)	768.5 ± 136.2	1212.6 ± 154.3	<0.001
VAS at 6 h	3.8 ± 1.1	2.1 ± 0.9	<0.001
VAS at 12 h	4.7 ± 1.2	2.8 ± 1.0	<0.001
VAS at 24 h	3.6 ± 1.0	3.0 ± 0.9	0.002
Patients requiring rescue analgesia	44 (88.0%)	31 (62.0%)	0.003
24-h rescue analgesic consumption (mg)	138.0 ± 61.7	76.0 ± 48.9	<0.001

The mean duration of postoperative analgesia was approximately 7.7 hours in Group B compared with approximately 20.2 hours in Group BD. The difference was statistically significant ($p<0.001$). Postoperative VAS scores were significantly lower in Group BD at 6, 12, and 24 hours. Rescue analgesic requirements were also significantly reduced in the dexamethasone group.

Table 4: Comparison of adverse effects

Adverse effect	Group B (n=50)	Group BD (n=50)	p-value
Nausea/vomiting	5 (10.0%)	3 (6.0%)	0.46
Bradycardia	2 (4.0%)	1 (2.0%)	0.56
Hypotension	3 (6.0%)	2 (4.0%)	0.65
Transient paresthesia	2 (4.0%)	1 (2.0%)	0.56
Respiratory symptoms	1 (2.0%)	0 (0%)	0.32
Hyperglycemic episode	0 (0%)	1 (2.0%)	0.32

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No statistically significant difference was observed in the incidence of adverse events between the groups. No patient developed pneumothorax, persistent neurological deficit, local anesthetic systemic toxicity, or other serious block-related complications.

Discussion

The current comparative investigation showed that following ultrasound-guided supraclavicular brachial plexus block, adding dexamethasone to bupivacaine considerably increased postoperative analgesia and prolonged the duration of sensory and motor blockade. Additionally, individuals who received the combination had lower postoperative pain levels and needed much less rescue analgesia.

The groups' demographics were similar, suggesting that baseline demographic variation was unlikely to be the cause of the observed variations in postoperative outcomes. Comparable surgical times also reduced the impact of operating variables on the need for postoperative analgesics.

There was no discernible difference in the two groups' initiation of sensory and motor blockage. Since the main benefit of dexamethasone was extension rather than acceleration of block onset, this discovery has clinical significance. Clinical research examining dexamethasone as an adjuvant to long-acting local anesthetics has revealed similar results. [7,8]

The dexamethasone group in this study experienced a noticeably longer sensory blackout. Thru a number of ways, dexamethasone may prolong the duration of local anesthetic activity. Inflammatory mediators linked to postoperative nociception may be suppressed by its anti-inflammatory properties. Additionally, dexamethasone may affect nociceptive C-fiber activity and potassium channels. Although the exact role of vasoconstriction is yet unknown, a reduction in local vascular absorption of local anesthetic is another suggested mechanism. [9-12]

The longer length of the sensory block was in line with the prolonged motor block seen with dexamethasone. Prolonged motor blockade should be taken into consideration when early motor function is clinically significant, even if it could be helpful during certain painful procedures. As a result, the type of surgery and anticipated postoperative needs should be taken into consideration while choosing the local anesthetic dose and adjuvant.

The significant extension of postoperative analgesia was the most clinically significant finding. The time before the first request for rescue analgesia was much longer in patients taking bupivacaine with dexamethasone. This is in line with earlier meta-analyses and randomized trials showing that dexamethasone can extend analgesia following peripheral nerve blockade. [10,13-15]

Another significant advantage is a decrease in the need of rescue analgesics. In the current study, the total 24-hour consumption was considerably lower and fewer individuals in the dexamethasone group needed rescue analgesics. In addition to reducing opioid-associated side effects such nausea, vomiting, drowsiness, and respiratory depression, less postoperative analgesic requirements may enhance patient comfort.

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At 6 and 12 hours, the dexamethasone group's postoperative VAS scores were significantly lower, and at 24 hours, they were still slightly lower. These results imply that rather than just prolonging physiological sensory blockage, the prolonged block resulted in significant therapeutic improvement.

The safety profile was good. Adverse occurrences did not differ statistically significantly between the two groups. Crucially, there was no pneumothorax, severe neurological complications, or systemic toxicity from local anesthetics. Minor side effects were few and similar in all groups.

The results are generally in line with data from systematic reviews and randomized trials that show dexamethasone is a useful adjuvant for peripheral nerve blocks. However, some research has indicated that the degree of effect may differ depending on the specific peripheral nerve block, local anesthetic utilized, dexamethasone dosage, and delivery route. [13-16] The question of whether perineural dexamethasone has a genuine local effect in addition to its systemic action is still up for debate in the clinical literature. Larger studies that directly compare intravenous and perineural injection could perhaps provide light on this matter.

Conclusion

The addition of dexamethasone to bupivacaine for ultrasound-guided supraclavicular brachial plexus block significantly prolonged sensory and motor blockade and increased the duration of effective postoperative analgesia. It also reduced postoperative pain scores and rescue analgesic consumption without producing a significant increase in adverse events. Dexamethasone may therefore be considered an effective adjuvant to bupivacaine when prolonged postoperative analgesia is desired following upper-limb surgery. Further larger studies are warranted to establish optimal dosing and to compare perineural with intravenous dexamethasone.

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