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COMPARISON OF POTASSIUM CHLORIDE AND DEXAMETHASONE AS ADJUVANTS TO BUPIVACAINE IN ULTRASOUND-GUIDED SUPRACLAVICULAR BRACHIAL PLEXUS BLOCK FOR UPPER LIMB SURGERIES.

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ABSTRACT

Background: Supraclavicular brachial plexus block is a widely used regional anaesthetic technique for upper limb surgeries. Various adjuvants have been investigated to enhance the efficacy of local anaesthetics by improving block characteristics and prolonging postoperative analgesia. Dexamethasone is an established adjuvant, whereas potassium chloride has been explored for its potential to accelerate the onset of nerve blockade. This study compared the efficacy of potassium chloride and dexamethasone as adjuvants to bupivacaine in supraclavicular brachial plexus block. The objective is to compare the onset and duration of sensory and motor blockade, duration of postoperative analgesia, postoperative analgesic requirements, haemodynamic parameters, and adverse effects following the addition of potassium chloride or dexamethasone to bupivacaine in supraclavicular brachial plexus block for upper limb surgeries. **Materials and Methods:** This prospective, randomized, comparative study included 60 patients (ASA physical status I–II) aged 18–65 years undergoing elective upper limb surgeries under supraclavicular brachial plexus block. Patients were randomly allocated into two groups of 30 each. Group P received bupivacaine with potassium chloride, while Group D received bupivacaine with dexamethasone. The onset and duration of sensory and motor blockade, duration of analgesia, postoperative Visual Analogue Scale (VAS) pain scores, rescue analgesic consumption, haemodynamic parameters, and adverse events were recorded and analysed. Statistical analysis was performed using the independent Student's t-test and Chi-square test. A p-value <0.05 was considered statistically significant. **Result:** Baseline demographic characteristics and duration of surgery were comparable between the groups ($p>0.05$). Group P demonstrated a significantly faster onset of sensory block (10.1 ± 1.8 vs. 13.2 ± 2.1 minutes; $p<0.001$) and motor block (14.0 ± 2.3 vs. 16.4 ± 2.4 minutes; $p<0.001$). However, Group D exhibited a significantly longer duration of sensory block (10.8 ± 1.5 vs. 7.2 ± 1.1 hours; $p<0.001$), motor block (9.4 ± 1.3 vs. 6.5 ± 1.0 hours; $p<0.001$), and postoperative analgesia (13.6 ± 1.8 vs. 8.1 ± 1.3 hours; $p<0.001$). Patients in Group D had significantly lower postoperative VAS scores from 4 hours onwards and reduced 24-hour rescue analgesic consumption (76.7 ± 24.3 mg vs. 123.5 ± 31.4 mg; $p<0.001$). Haemodynamic parameters and the incidence of adverse events were comparable between the groups. **Conclusion:** Dexamethasone was superior to potassium chloride as an adjuvant to bupivacaine in supraclavicular brachial plexus block by providing significantly prolonged sensory and motor blockade, extended postoperative analgesia, lower postoperative pain scores, and reduced analgesic requirements. Potassium chloride produced a faster onset of blockade but did not provide the prolonged analgesic benefits observed with dexamethasone. Both adjuvants were safe and well tolerated.

INTRODUCTION

Supraclavicular brachial plexus block is one of the most commonly employed regional anaesthetic techniques for surgeries involving the upper limb below the shoulder. It provides excellent intraoperative anaesthesia, effective postoperative analgesia, reduced opioid consumption, early mobilization, and improved patient satisfaction. Compared to general anaesthesia, brachial plexus block offers the advantages of avoiding airway manipulation, minimizing postoperative nausea and vomiting, providing superior pain control, and facilitating day-care surgical procedures. The supraclavicular approach is often referred to as the "spinal of the upper extremity" because of its ability to produce rapid, dense, and reliable anaesthesia by targeting the brachial plexus at the level of the trunks and divisions.[1,2]

Bupivacaine is a long-acting amide local anaesthetic widely used for peripheral nerve blocks owing to its prolonged duration of sensory and motor blockade. However, despite its favourable pharmacological profile, the duration of postoperative analgesia provided by bupivacaine alone may not be sufficient for prolonged pain relief following upper limb surgeries. Consequently, various adjuvants have been investigated to enhance the quality of nerve blockade, shorten the onset time, prolong the duration of analgesia, reduce postoperative analgesic requirements, and improve patient comfort.[3]

Among the numerous adjuvants studied, dexamethasone has emerged as one of the most effective and widely accepted agents. Dexamethasone is believed to prolong the duration of peripheral nerve blockade through its anti-inflammatory effects, suppression of ectopic neuronal discharge, and modulation of potassium channel activity in nociceptive C-fibres. Several clinical studies have demonstrated that the addition of dexamethasone to local anaesthetics significantly prolongs sensory and motor blockade and extends postoperative analgesia without increasing the incidence of adverse effects.

Potassium chloride has also been investigated as a potential adjuvant to local anaesthetics. The mechanism of action is based on increasing the extracellular potassium concentration around nerve fibres, which partially depolarizes the nerve membrane and enhances the blockade produced by local anaesthetics. Experimental studies suggest that potassium ions may facilitate local anaesthetic penetration and improve the depth of neural blockade, potentially resulting in a faster onset and prolonged duration of anaesthesia. Although preliminary studies have reported encouraging results, the clinical evidence regarding the efficacy and safety of potassium chloride as an adjuvant in peripheral nerve blocks remains limited compared with dexamethasone.[4,5]

The search for an ideal adjuvant continues because it should provide rapid onset, prolonged postoperative analgesia, stable haemodynamic, minimal adverse effects, and a favourable safety profile. While dexamethasone has gained widespread acceptance, potassium chloride remains relatively underexplored despite its theoretical pharmacological advantages. Direct comparative studies between these two adjuvants are scarce, creating a need for further clinical evaluation.[5]

Therefore, the present study was undertaken to compare the efficacy of potassium chloride and dexamethasone as adjuvants to bupivacaine in supraclavicular brachial plexus block for upper limb surgeries. The study aims to evaluate the onset and duration of sensory and motor blockade, duration of postoperative analgesia, postoperative analgesic requirements, haemodynamic parameters, and adverse effects associated with both adjuvants. The findings of this study may help identify a more effective adjuvant for improving the quality of regional anaesthesia and postoperative pain management in patients undergoing upper limb surgeries.

MATERIALS AND METHODS

Aim of the Study: To compare the efficacy of the addition of potassium chloride to bupivacaine and dexamethasone to bupivacaine in supraclavicular brachial plexus block for upper limb surgeries.

Objectives:

Primary Objectives

- To compare the onset time of sensory blockade between the two groups.
- To compare the onset time of motor blockade between the two groups.
- To compare the duration of sensory blockade.
- To compare the duration of motor blockade.
- To compare the duration of postoperative analgesia.

Secondary Objectives

- To compare postoperative analgesic consumption within the first 24 hours.
- To compare intraoperative and postoperative haemodynamic parameters.
- To assess the incidence of adverse effects and complications associated with the study drugs.
- To evaluate the overall quality of the supraclavicular brachial plexus block.

Study Design: The present study was a prospective, randomized, comparative study conducted in the Department of Anaesthesiology at a tertiary care teaching hospital after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrolment.

Study Population: Patients scheduled for elective upper limb surgeries under supraclavicular brachial plexus block were screened for eligibility.

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Sample Size: A total of 60 patients were included in the study. Patients were randomly allocated into two groups comprising 30 patients each.

- Group P (n = 30): Received bupivacaine with potassium chloride.
- Group D (n = 30): Received bupivacaine with dexamethasone.

Randomization: Patients were randomly assigned to either group using a computer-generated randomization sequence. Allocation concealment was maintained using sealed opaque envelopes.

Inclusion Criteria

- Patients aged 18–65 years.
- Either sex.
- American Society of Anaesthesiologists (ASA) physical status I or II.
- Scheduled for elective upper limb surgeries below the shoulder under supraclavicular brachial plexus block.
- Patients willing to participate and provide written informed consent.

Exclusion Criteria

- Patient refusal.
- Known allergy to local anaesthetics, dexamethasone, or potassium chloride.
- Coagulopathy or anticoagulant therapy.
- Infection at the site of injection.
- Pre-existing peripheral neuropathy.
- Severe hepatic, renal, pulmonary, or cardiac disease.
- Pregnancy or lactation.
- Body mass index >35 kg/m².
- Incomplete block requiring conversion to general anaesthesia.

Preoperative Assessment: All patients underwent a detailed pre-anaesthetic evaluation including history, physical examination, airway assessment, and routine laboratory investigations. Patients were kept fasting according to institutional guidelines and were explained the Visual Analogue Scale (VAS) for pain assessment.

Anaesthetic Technique: Upon arrival in the operating room, standard monitors including electrocardiography, non-invasive blood pressure, pulse oximetry, and heart rate monitoring were attached. Intravenous access was secured and baseline vital parameters were recorded. Under strict aseptic precautions, the supraclavicular brachial plexus block was performed using a peripheral nerve stimulator. After eliciting an appropriate distal motor response, the study drug was injected following negative aspiration.

Group P received 30 mL of 0.5% bupivacaine with potassium chloride.

Group D received 30 mL of 0.5% bupivacaine with dexamethasone.

The total volume of injectate was kept identical in both groups.

Outcome Measures

Primary Outcomes

- Onset of sensory block.
- Onset of motor block.
- Duration of sensory block.
- Duration of motor block.
- Duration of postoperative analgesia.

Secondary Outcomes

- Visual Analogue Scale (VAS) pain scores.
- Total postoperative rescue analgesic requirement during the first 24 hours.
- Heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, respiratory rate, and oxygen saturation.
- Incidence of adverse effects such as nausea, vomiting, hypotension, bradycardia, local anaesthetic toxicity, pneumothorax, Horner's syndrome, and neurological complications.

Assessment of Block:

Sensory blockade was assessed in the distribution of the median, radial, ulnar, and musculocutaneous nerves using pin-prick sensation and graded as:

- Grade 0 – Normal sensation
- Grade 1 – Loss of pin-prick sensation (analgesia)
- Grade 2 – Complete loss of sensation (anaesthesia)

Motor blockade was evaluated using the Modified Bromage Scale for the upper limb:

- Grade 0 – Normal motor function.
- Grade 1 – Decreased motor strength with ability to move fingers only.
- Grade 2 – Complete motor paralysis.

Sensory onset was defined as the time from completion of drug injection to complete sensory loss.

Motor onset was defined as the time from completion of injection to complete motor paralysis.

Duration of sensory block was defined as the time from complete sensory block until return of normal sensation.

Duration of motor block was defined as the time from complete motor block until complete recovery of motor function.

Duration of analgesia was defined as the interval between completion of injection and the first request for rescue analgesia or VAS score ≥4.

Rescue Analgesia: Intravenous diclofenac 75 mg was administered as rescue analgesia when the VAS score was ≥4. The time to first rescue analgesia and total analgesic consumption over 24 hours were recorded.

Statistical Analysis: The collected data were entered into Microsoft Excel and analysed using Statistical Package for the Social Sciences (SPSS) software version 25.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. Comparison of continuous variables between the two groups was performed using the independent Student's t-test. Categorical

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variables were analysed using the Chi-square test or Fisher's exact test wherever appropriate. Repeated haemodynamic variables were analysed using repeated measures analysis of variance. A p-value <0.05 was considered statistically significant.

RESULTS

Sixty patients undergoing upper limb surgeries were randomized into two equal groups receiving potassium chloride or dexamethasone as an adjuvant to bupivacaine for supraclavicular brachial plexus block. Baseline demographic characteristics were comparable between the groups. Potassium chloride resulted in a significantly faster onset of both sensory and motor blockade ($p < 0.001$). However, dexamethasone significantly prolonged the duration of sensory block (10.8 ± 1.5 vs. 7.2 ± 1.1 hours), motor block (9.4 ± 1.3 vs. 6.5 ± 1.0 hours), and postoperative analgesia (13.6 ± 1.8 vs. 8.1 ± 1.3 hours) (all $p < 0.001$). Patients in the dexamethasone group also experienced significantly lower postoperative VAS pain scores, delayed requirement for rescue analgesia, and reduced 24-hour analgesic consumption ($p < 0.001$). Hemodynamic parameters remained stable in both groups, and the incidence of complications was low with no significant intergroup differences.

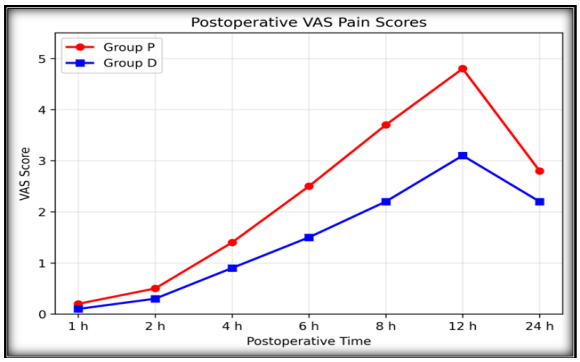

Figure 1: Comparison of Post-operative VAS score among the groups

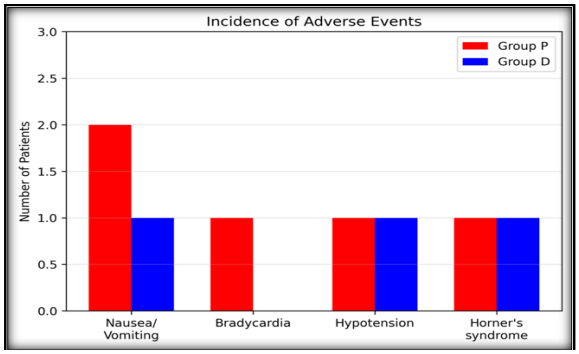

Figure 2: Comparison of adverse effects among the groups.

DISCUSSION

The present study compared the efficacy of potassium chloride and dexamethasone as adjuvants to bupivacaine in supraclavicular brachial plexus block for upper limb surgeries. The study demonstrated that the addition of potassium chloride resulted in a significantly faster onset of sensory and motor blockade, whereas dexamethasone significantly prolonged the duration of sensory blockade, motor blockade, and postoperative analgesia. Patients receiving dexamethasone also experienced lower postoperative pain scores and reduced rescue analgesic requirements without an increase in adverse effects.

The demographic characteristics, ASA physical status, and duration of surgery were comparable between the two groups, indicating adequate randomization and minimizing the influence of confounding variables. Similar baseline comparability has been reported in several randomized controlled trials evaluating adjuvants in brachial plexus blocks, including the studies by Cummings et al., Movafegh et al., and Biradar et al.[1-3]

In the present study, potassium chloride produced a significantly faster onset of both sensory and motor blockade compared to dexamethasone. The accelerated onset may be attributed to increased extracellular potassium concentration, which partially depolarizes nerve membranes, thereby enhancing sodium channel blockade by local anaesthetics. Although clinical evidence regarding potassium chloride as an adjuvant remains limited, the findings are consistent with the experimental observations of Butterworth and Strichartz, who demonstrated that elevated extracellular potassium potentiates local anaesthetic action by altering nerve membrane excitability. Similar observations were also reported by Trivedi et al,[4] who found that potassium chloride reduced the onset time of peripheral nerve blockade when combined with bupivacaine.

One of the most important findings of the present study was the significantly prolonged duration of sensory and motor blockade observed in the dexamethasone group. Patients receiving dexamethasone experienced sensory blockade for approximately 10.8 hours compared with 7.2 hours in the potassium chloride group, while motor blockade was prolonged to 9.4 hours compared with 6.5 hours. These findings closely agree with those reported by Movafegh et al,[1] who demonstrated that the addition of dexamethasone to lidocaine significantly prolonged the duration of axillary brachial plexus block. Similarly, Cummings et al.[2] reported that dexamethasone added to long-acting local anaesthetics significantly increased the duration of analgesia following interscalene brachial plexus block.

The duration of postoperative analgesia was significantly longer in the dexamethasone group, resulting in delayed requirement for rescue analgesia and significantly reduced postoperative analgesic consumption during the first 24 hours. These observations are consistent with the findings

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of Choi et al,[5] whose systematic review and meta-analysis concluded that perineural dexamethasone consistently prolongs postoperative analgesia by several hours when used as an adjuvant to peripheral nerve blocks. Similarly, Albrecht et al6. reported that dexamethasone significantly extends analgesic duration irrespective of the type of local anaesthetic employed.

Postoperative pain scores measured using the Visual Analogue Scale were significantly lower in the dexamethasone group from the fourth postoperative hour onwards. Lower pain scores translated into better patient comfort and reduced opioid or non-opioid analgesic requirements. Comparable improvements in postoperative pain control have been reported by Parrington et al., Vieira et al., and Desmet et al., all of whom demonstrated superior analgesic efficacy with dexamethasone as an adjuvant to peripheral nerve blocks.[7-9]

Haemodynamic parameters remained stable throughout the perioperative period in both study groups. No statistically significant differences were observed in heart rate, blood pressure, or oxygen saturation. These findings are in agreement with those of Biradar et al,[3] and Cummings et al,[2] who also reported excellent haemodynamic stability following brachial plexus blockade using dexamethasone as an adjuvant.

The incidence of adverse effects was low and comparable between the two groups. Occasional episodes of nausea, vomiting, hypotension, bradycardia, and Horner's syndrome were observed without significant differences between the groups. No patient developed local anaesthetic systemic toxicity, pneumothorax, or persistent neurological deficit. Similar safety profiles have been described in previous randomized trials and systematic reviews evaluating dexamethasone as a peripheral nerve block adjuvant. Current evidence indicates that preservative-free dexamethasone is safe when administered perineurally in recommended doses.

Although potassium chloride demonstrated the advantage of a faster onset of block, it failed to provide the prolonged analgesia achieved with dexamethasone. This finding suggests that potassium chloride may be useful when rapid establishment of surgical anaesthesia is desired, whereas dexamethasone remains the superior adjuvant for extending postoperative analgesia and reducing postoperative analgesic requirements. The present study therefore supports the growing body of evidence favouring dexamethasone as one of the most effective adjuvants to long-acting local anaesthetics in brachial plexus blocks.

The strengths of the present study include its prospective randomized design, comparable baseline characteristics, standardized anaesthetic technique, and comprehensive assessment of block characteristics and postoperative analgesia. However, the study had certain limitations. The sample size was relatively small, and the study was conducted at a single centre, which may limit the generalizability of the findings. Long-term neurological follow-up was not performed, and different doses of potassium chloride and dexamethasone were not evaluated. Larger multicentre randomized trials are warranted to further establish the efficacy and safety of potassium chloride as an adjuvant in peripheral nerve blocks.

CONCLUSION

The addition of dexamethasone to bupivacaine in supraclavicular brachial plexus block significantly prolonged the duration of sensory and motor blockade, extended postoperative analgesia, reduced postoperative pain scores, and decreased rescue analgesic requirements compared with potassium chloride. In contrast, potassium chloride provided a faster onset of sensory and motor blockade. Both adjuvants were associated with stable haemodynamic parameters and a low incidence of adverse effects. Overall, dexamethasone proved to be the more effective adjuvant for improving the quality and duration of postoperative analgesia in patients undergoing upper limb surgeries.

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