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Research Article

Comparison of Perineural Versus Intravenous Dexamethasone as an Adjuvant to Bupivacaine in Ultrasound-Guided Supraclavicular Brachial Plexus Block: A Prospective Randomized Controlled Study

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ABSTRACT

BACKGROUND: Supraclavicular brachial plexus block provides effective anaesthesia and postoperative analgesia for upper-limb surgery, but the duration of bupivacaine analgesia is limited. Dexamethasone can be administered perineurally or intravenously, and the optimal route remains uncertain. **METHOD:** This randomized controlled study was conducted at a teaching hospital over 18 months. Adults aged ≥18 years with ASA physical status I–II undergoing elective upper-limb surgery under supraclavicular block were randomized to receive 8 mg dexamethasone either perineurally with 20 mL of 0.5% bupivacaine (Group P) or intravenously, with 20 mL of 0.5% bupivacaine plus saline perineurally (Group I). Primary outcome was duration of analgesia. Secondary outcomes included block onset, pain scores, rescue analgesic requirement, haemodynamic changes and adverse events. **RESULTS:** A total of 126 patients were analysed, with 63 in each group. Perineural dexamethasone resulted in faster sensory block onset (8.63 ± 1.52 vs. 10.72 ± 2.09 min; P<0.001) and motor block onset (12.84 ± 1.83 vs. 14.83 ± 2.44 min; P<0.001). Duration of postoperative analgesia was longer with perineural dexamethasone (19.22 ± 2.44 vs. 15.39 ± 2.44 h; mean difference 3.83 h; P<0.001). Rescue analgesia was required in 20.6% of patients in Group P versus 50.8% in Group I (P<0.001). Adverse effects were comparable between groups. **CONCLUSION:** Perineural dexamethasone 8 mg, compared with intravenous dexamethasone 8 mg, was associated with faster block onset, longer

postoperative analgesia and lower rescue analgesic requirements after supraclavicular brachial plexus block, without increased in short-term adverse effects.

KEYWORDS: Supraclavicular brachial plexus block; perineural dexamethasone; intravenous dexamethasone; bupivacaine; postoperative analgesia; regional anaesthesia.

INTRODUCTION

Effective postoperative pain management is an integral component of perioperative care, as inadequate analgesia may result in delayed rehabilitation, prolonged hospital stay, increased opioid consumption, and reduced patient satisfaction. Regional anaesthesia plays a key role in multimodal analgesia by providing effective pain control, minimizing opioid requirements, and attenuating the surgical stress response. [1]

Ultrasound-guided supraclavicular brachial plexus block is a widely used and reliable regional anaesthetic technique for upper limb surgeries, providing dense surgical anaesthesia and effective postoperative analgesia. However, the duration of analgesia provided by long-acting local anaesthetics such as 0.5% bupivacaine is limited, often necessitating additional postoperative analgesia. Various adjuvants have therefore been investigated to enhance block duration and improve postoperative pain outcomes. [2-3]

Dexamethasone is one of the most commonly studied adjuvants for peripheral nerve blocks due to its anti-inflammatory and analgesic properties. It may prolong block duration through modulation of inflammatory pathways, reduction of ectopic neuronal activity, and effects on neural ion channels. Dexamethasone can be administered either perineurally or intravenously; however, the optimal route of administration remains debated. While perineural administration may provide a direct local effect, intravenous administration offers systemic analgesic benefits without concerns related to perineural drug administration. [3,6,8]

Previous studies comparing perineural and intravenous dexamethasone have demonstrated variable results, with much of the available evidence focusing on interscalene brachial plexus blocks. Differences in anatomical location, local anaesthetic spread, and pharmacological response limit the direct applicability of these findings to supraclavicular brachial plexus blocks. [4-8]

Therefore, this prospective randomized controlled study was conducted to compare the efficacy of perineural versus intravenous dexamethasone as an adjuvant to 0.5% bupivacaine in ultrasound-guided supraclavicular brachial plexus block for upper limb surgeries. The primary objective was to evaluate the duration of postoperative analgesia, while secondary objectives included assessment of block characteristics, rescue analgesic requirements, haemodynamic changes, and adverse effects.

MATERIALS AND METHODS

Study Design and Setting

This prospective, randomized, controlled study was conducted in the Department of Anaesthesiology at a tertiary care teaching hospital after approval from the Institutional Ethics Committee (IEC Approval No. MPGI/IEC/Outward No. 69/2024). The study was conducted in accordance with the ICMR National Ethical Guidelines for Biomedical and Health Research Involving Human Participants (2017), the Declaration of Helsinki (2013 revision), and institutional ethical standards. Written informed consent was obtained from all participants before enrolment.

Study Population

Adult patients of either sex, aged ≥18 years, with ASA Physical Status I–II, scheduled for elective upper limb surgeries under ultrasound-guided supraclavicular brachial plexus block, were included in the study.

Inclusion Criteria

- Age ≥18 years
- ASA Physical Status I or II
- Elective upper limb surgery requiring ultrasound-guided supraclavicular brachial plexus block
- Written informed consent for participation

Exclusion Criteria

- Known hypersensitivity to bupivacaine, dexamethasone, or study medications
- Contraindications to regional anaesthesia, including coagulopathy or local infection at the injection site
- Pregnancy or lactation
- Neurological or psychiatric disorders affecting pain assessment or cooperation
- Pre-existing neuropathy or neurological deficit in the operative limb

Sample Size Calculation

The sample size was calculated based on a previous study comparing perineural and intravenous dexamethasone as adjuvants for peripheral nerve blocks. Considering a mean difference of 5 hours in postoperative analgesia duration, standard deviation of 10 hours, 80% power, and a 5% level of significance, the required sample size was calculated as 63 patients in each group. Thus, a total of 126 participants were enrolled. [5]

Randomization and Blinding

Participants were randomized into two equal groups using a computer-generated randomization sequence. Allocation concealment was maintained using sequentially numbered opaque sealed envelopes. Study medications were prepared by an independent anaesthesia technician who was not involved in patient management or outcome assessment. Patients and postoperative outcome assessors were blinded to group allocation.

Study Intervention

Following standard pre-anaesthetic evaluation, patients were kept fasting according to institutional guidelines. Intravenous access was established, baseline haemodynamic parameters were recorded, and premedication with intravenous midazolam (1–2 mg) and ondansetron (4 mg) was administered.

Patients were allocated into two groups:

Group P (Perineural dexamethasone group): Patients received 20 mL of 0.5% bupivacaine with dexamethasone 8 mg (2 mL) administered perineurally (total volume 22 mL).

Group I (Intravenous dexamethasone group): Patients received 20 mL of 0.5% bupivacaine with 2 mL normal saline perineurally (total volume 22 mL), along with intravenous dexamethasone 8 mg administered immediately before block performance.

Block Technique

Ultrasound-guided supraclavicular brachial plexus block was performed by an experienced anaesthesiologist using a high-frequency linear ultrasound probe and an in-plane lateral-to-medial approach with a 22-gauge echogenic needle. Following negative aspiration, the study solution was injected incrementally under real-time ultrasound guidance to achieve adequate spread around the brachial plexus. Block assessment was performed after 20 minutes. Patients with inadequate block requiring conversion to general anaesthesia were excluded from final analysis. [2]

Outcome Assessment

Sensory blockade was assessed using pin-prick testing in the C5–T1 dermatomal distribution. Motor blockade was assessed using the Modified Bromage Scale for upper limb motor function. Haemodynamic parameters including heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, and oxygen saturation (SpO_2) were recorded at predefined intraoperative intervals. [2]

The primary outcome was the duration of postoperative analgesia, defined as the

interval from block administration to the first request for rescue analgesia (VAS ≥4). The secondary outcomes included:

- Onset of sensory block
- Onset of motor block
- Duration of sensory block
- Duration of motor block
- Postoperative VAS scores at 0, 2, 4, 6, 8, 10, 12, and 24 hours
- Time to first rescue analgesia
- Haemodynamic changes and adverse events

Rescue analgesia consisted of intravenous paracetamol 1 g administered when VAS score was ≥4. Patients were monitored for 24 hours postoperatively.

Data Collection

Data were collected prospectively using a predefined case record form approved by the Institutional Ethics Committee. Recorded variables included demographic characteristics, ASA physical status, baseline haemodynamic parameters, block characteristics, postoperative pain scores, rescue analgesic requirement, block failure, and adverse events.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequency and percentage. Normality of distribution was assessed using the Shapiro–Wilk test.

Normally distributed continuous variables were analysed using the independent samples t-test, while non-normally distributed variables were analysed using the Mann–Whitney U test. Categorical variables were compared using the Chi-square test or Fisher's exact test, as appropriate. A two-sided P value <0.05 was considered statistically significant.

RESULTS

A total of 126 patients were analysed, with 63 in each group. Perineural dexamethasone resulted in faster sensory block onset (8.63 ± 1.52 vs. 10.72 ± 2.09 min; P<0.001) and motor block onset (12.84 ± 1.83 vs. 14.83 ± 2.44 min; P<0.001). Duration of postoperative analgesia was longer with perineural dexamethasone (19.22 ± 2.44 vs. 15.39 ± 2.44 h; mean difference 3.83 h; P<0.001). Rescue analgesia was required in 20.6% of patients in Group P versus 50.8% in Group I (P<0.001). Adverse effects were comparable between groups.

TABLE 1: DEMOGRAPHIC DETAILS

Characteristic	Group P (Perineural) (n = 63)	Group I (Intravenous) (n = 63)	P value
Age (years), Mean ± SD	38.57 ± 9.92	37.17 ± 9.40	0.422
Age Group, n (%)			
18–29 years	10 (15.9)	11 (17.5)	
30–39 years	19 (30.2)	20 (31.7)	
40–49 years	22 (34.9)	21 (33.3)	
50–60 years	12 (19.0)	11 (17.5)	
Sex, n (%)			0.279
Male	33 (52.4)	40 (63.5)	
Female	30 (47.6)	23 (36.5)	
ASA Physical Status, n (%)			0.843
ASA I	31 (49.2)	33 (52.4)	
ASA II	32 (50.8)	30 (47.6)	

A total of 126 patients were enrolled and equally randomized into Group P (perineural dexamethasone; n = 63) and Group I (intravenous dexamethasone; n = 63). The baseline demographic and clinical characteristics of the two groups were comparable (Table 1). The

mean age was 38.57 ± 9.92 years in Group P and 37.17 ± 9.40 years in Group I (P = 0.422). There were no significant differences in age distribution, sex distribution, or ASA physical status between the groups (P > 0.05 for all), indicating successful randomization and baseline comparability. (TABLE 1)

TABLE 2: PREOPERATIVE HEMODYNAMICS

Parameter	Group P(Perineal) (n=63)	Group I(intravenous) (n=63)	p-value
Pulse rate (/min)	78.94 ± 7.72	78.94 ± 7.22	1.000 NS
SBP (mmHg)	121.03 ± 8.56	119.44 ± 8.17	0.293 NS
DBP (mmHg)	77.51 ± 5.53	76.51 ± 5.67	0.322 NS
MAP (mmHg)	92.01 ± 4.64	90.83 ± 4.63	0.157 NS

Pre-operative SBP, MAP, and pulse rate were within normal physiological limits and were comparable between groups. SBP was 121.03 ± 8.56 mmHg in Group P versus 119.44 ± 8.17 mmHg in Group I (p=0.2930), MAP was 92.01 ± 4.64 versus 90.83 ± 4.63 mmHg (p=0.1568), and pulse rate was 78.94/min in both groups (p=1.000). Thus, both groups demonstrated comparable baseline haemodynamic status. (TABLE 2)

TABLE 3: SENSORY AND MOTOR BLOCKADE

Parameter	Group P (Perineural) (n = 63)	Group I (Intravenous) (n = 63)	Mean difference (95% CI)	P value
Onset of sensory block (min)	**8.63 ± 1.52**	**10.72 ± 2.09**	−2.09 (−2.73 to −1.45)	<0.001
Onset of motor block (min)	**12.84 ± 1.83**	**14.83 ± 2.44**	−1.99 (−2.75 to −1.23)	<0.001

The onset of sensory and motor blockade was significantly faster in Group P compared with Group I (Table 2). The mean onset time of sensory block was 8.63 ± 1.52 minutes in Group P versus 10.72 ± 2.09 minutes in Group I (P<0.001). Similarly, motor block onset was significantly earlier in Group P (12.84 ± 1.83 minutes) compared with Group I (14.83 ± 2.44 minutes; P<0.001). (TABLE 3)

Figure 1. Onset of sensory and motor blockade.

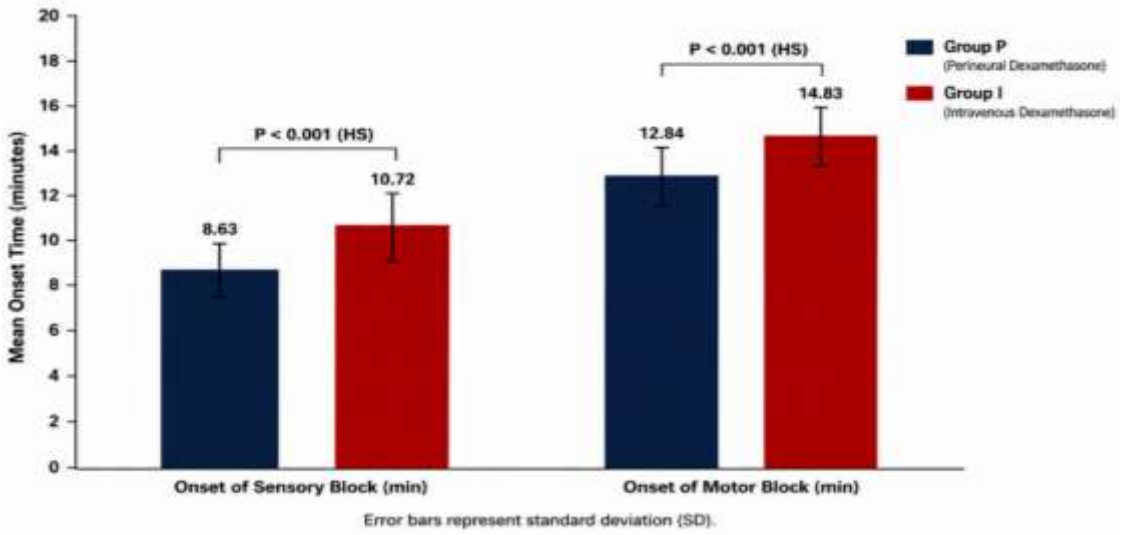

TABLE 4: DURATION OF POSTOPERATIVE ANALGESIA

Duration Bin (hrs)	Group P n (%)	Group I n (%)
< 12 hours	0 (0.0%)	2 (3.2%)
12 – <15 hours	4 (6.3%)	18 (28.6%)
15 – <18 hours	16 (25.4%)	28 (44.4%)
18 – <21 hours	33 (52.4%)	13 (20.6%)
≥ 21 hours	10 (15.9%)	2 (3.2%)
Mean ± SD	**19.22 ± 2.44 hrs**	**15.39 ± 2.44 hrs**
P value	**<0.001**	

The duration of postoperative analgesia was significantly longer in Group P (19.22 ± 2.44 hours) compared with Group I (15.39 ± 2.44 hours), with a mean difference of 3.83 hours (P<0.001). A higher proportion of patients in Group P achieved analgesia lasting 18–21 hours (52.4%) and ≥21 hours (15.9%) compared with Group I (20.6% and 3.2%, respectively). (TABLE 4)

Figure 2. Duration of postoperative analgesia.

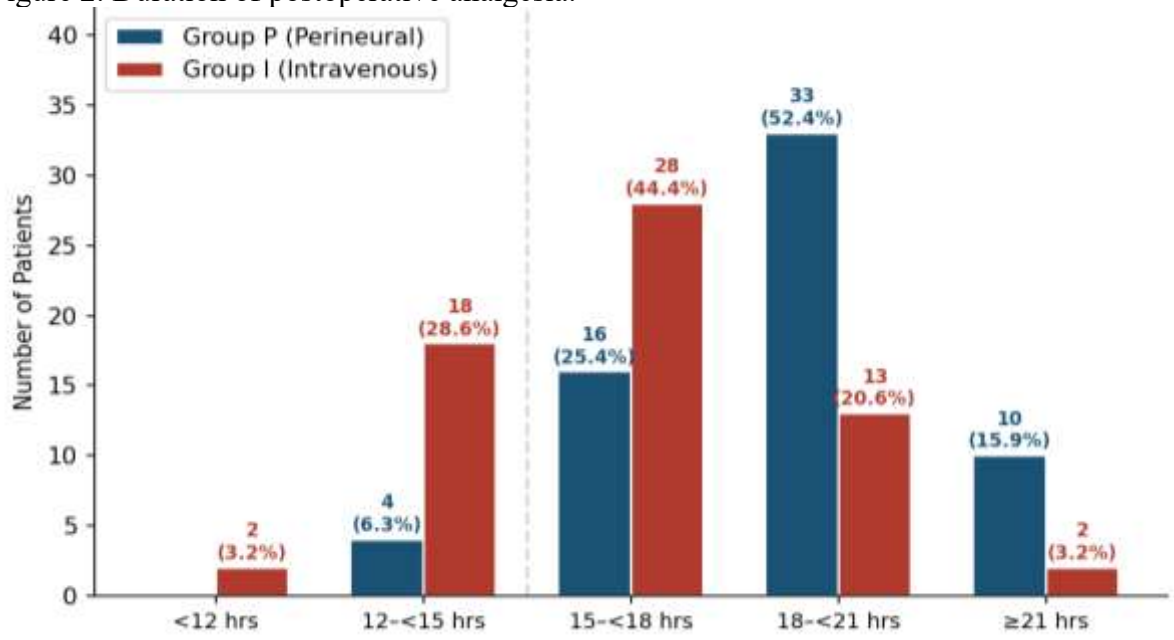

TABLE 5: POSTOPERATIVE VAS SCORE

Time Point	Group P (Mean ± SD)	Group I (Mean ± SD)	p-value
0 hr	1.10 ± 0.77	1.27 ± 0.78	0.1933
2 hr	1.37 ± 0.67	1.29 ± 0.70	0.5329
4 hr	1.22 ± 0.74	1.22 ± 0.74	1.0000
6 hr	1.35 ± 0.67	1.13 ± 0.72	0.0842
8 hr	1.00 ± 0.80	1.27 ± 0.96	0.1379
10 hr	1.30 ± 0.70	1.29 ± 1.06	0.5320
12 hr	**1.13 ± 0.75**	**2.05 ± 1.44**	<0.001

24 hr	**4.10 ± 1.44**	**3.60 ± 0.85**	0.0449

Rescue Analgesia	**Group P n (%)**	**Group I n (%)**
Required (VAS ≥4)	13 (20.6%)	32 (50.8%)
Not Required	50 (79.4%)	31 (49.2%)
Total	**63 (100%)**	**63 (100%)**
P value	**<0.001 (HS)**	

Postoperative VAS scores were comparable between groups from 0–10 hours (P>0.05). At 12 hours, Group P demonstrated significantly lower VAS scores compared with Group I (1.13 ± 0.75 vs. 2.05 ± 1.44; P<0.001). At 24 hours, VAS scores increased in both groups, with a statistically significant difference between groups (4.10 ± 1.44 vs. 3.60 ± 0.85; P=0.0449). (TABLE 5)

Figure 3. Postoperative VAS scores.

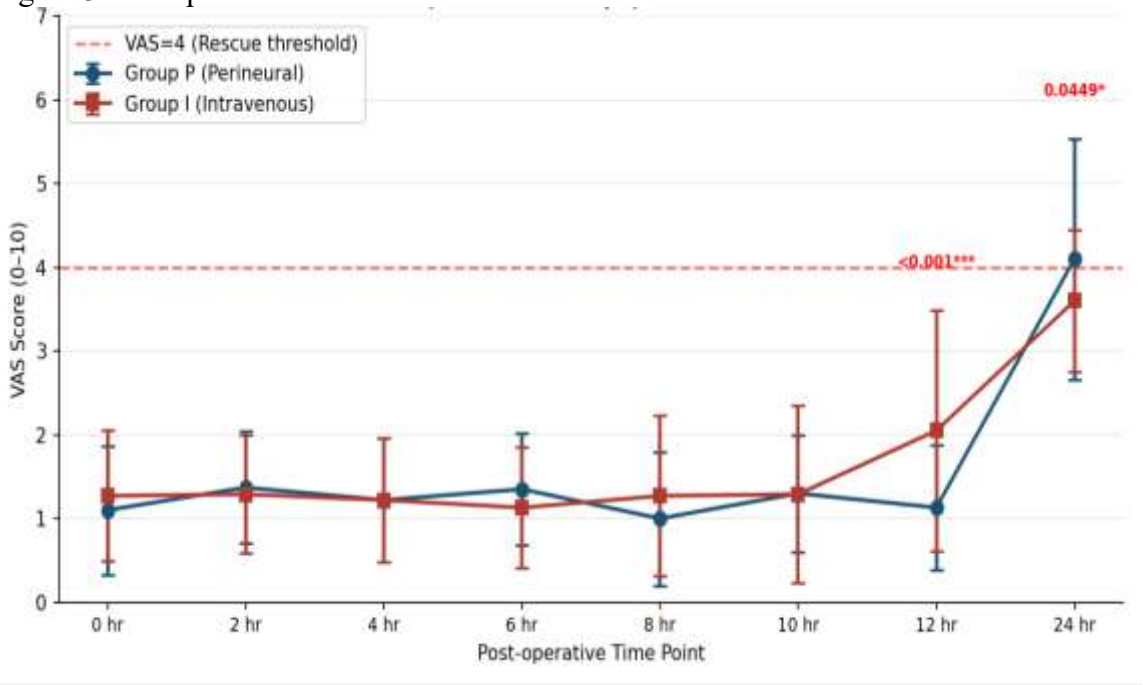

TABLE 6: RESCUE ANALGESIA REQUIREMENT

The requirement for rescue analgesia was significantly lower in Group P compared with Group I (20.6% vs. 50.8%; P<0.001). Accordingly, 79.4% of patients in Group P did not require rescue analgesia during the first 24 postoperative hours compared with 49.2% in Group I. (TABLE 6)

The incidence of adverse effects, including nausea, vomiting, hypotension, and bradycardia, was comparable between the groups (P>0.05). No block-related complications such as pneumothorax, Horner's syndrome, phrenic nerve palsy, or neurological deficits were observed in either group.

DISCUSSION

The present prospective randomized controlled study compared the efficacy of perineural versus intravenous dexamethasone as an adjuvant to 0.5% bupivacaine in ultrasound-guided supraclavicular brachial plexus block for upper limb surgeries. The major findings of this study were that perineural dexamethasone resulted in faster onset of sensory and motor blockade, prolonged postoperative analgesia by approximately 3.8 hours, and reduced rescue analgesic requirements, with a safety profile comparable to intravenous dexamethasone.

The demographic characteristics, ASA physical status, and baseline haemodynamic parameters were comparable between the two groups, indicating effective randomization and minimizing potential confounding factors. Similar baseline comparability has been reported in previous randomized studies evaluating different routes of dexamethasone administration as an adjuvant for peripheral nerve blocks. [4-5]

In the present study, perineural dexamethasone significantly accelerated the onset of sensory and motor blockade compared with intravenous administration. This earlier onset may be related to enhanced local anaesthetic action through direct perineural effects, including modulation of neuronal potassium channels and reduction of local inflammatory responses. Previous studies have reported variable findings, with some demonstrating faster onset with perineural dexamethasone, while others have shown no significant difference between the two routes. These variations may be attributed to differences in block techniques, anatomical location, local anaesthetic dose, volume, and study methodology. [3,6]

The primary outcome demonstrated a significant prolongation of postoperative analgesia with perineural dexamethasone. The approximately 3.8-hour increase in analgesic duration observed in the present study may be explained by local anti-inflammatory effects, suppression of nociceptive signalling, reduction of perineural inflammation, and prolonged local anaesthetic action. Previous studies comparing the two routes have predominantly focused on interscalene brachial plexus blocks and have reported inconsistent results. The present findings suggest that anatomical differences and local drug distribution in the supraclavicular approach may influence the magnitude of benefit achieved with perineural administration. [5-8]

Postoperative VAS scores were comparable between groups from 0–10 hours. At 12 hours, the perineural group had lower VAS scores than the intravenous group (1.13 ± 0.75 vs. 2.05 ± 1.44; $P<0.001$), consistent with the longer duration of analgesia. At 24 hours, VAS scores were 4.10 ± 1.44 in Group P and 3.60 ± 0.85 in Group I ($P=0.0449$). This late difference should be interpreted in the context of the 24-hour observation period and the time at which the single-shot block effect had waned.

Both groups demonstrated comparable haemodynamic stability and similar incidence of adverse effects. No major block-related complications or neurological deficits were observed. These findings support the short-term safety of perineural dexamethasone at the studied dose; however, larger studies with extended follow-up are required to further evaluate long-term neurological safety. [6-8]

STRENGTHS OF THE STUDY

The strengths of this study include its randomized controlled design, adequate sample size, standardized ultrasound-guided block technique, and evaluation of multiple clinically relevant outcomes including block characteristics, analgesic duration, pain scores, rescue analgesic requirement, haemodynamic parameters, and adverse events. Furthermore, the study contributes comparative evidence regarding perineural and intravenous dexamethasone specifically in

supraclavicular brachial plexus block, where available literature remains limited.

LIMITATIONS OF THE STUDY

This study has certain limitations. It was conducted at a single centre, which may limit the generalizability of the findings. Only ASA physical status I and II patients were included; therefore, results may not be applicable to higher-risk populations. The postoperative follow-up period was limited to 24 hours, preventing assessment of long-term analgesic outcomes and delayed neurological complications. Additionally, postoperative blood glucose monitoring was not performed, and pain assessment using VAS remains subjective despite being widely validated.

CONCLUSION

Perineural dexamethasone 8 mg, compared with intravenous dexamethasone 8 mg, was associated with faster block onset, longer postoperative analgesia and lower rescue analgesic requirements after ultrasound-guided supraclavicular brachial plexus block, with no observed increase in short-term adverse effects.

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