Original Article

DOI: 10.7860/JCDR/2025/82211.22091

Anaesthesia Section

Analgesic Efficacy of Perineural versus Intravenous Dexamethasone and Paracetamol in Supraclavicular Block for Forearm Surgeries: A Randomised Control Trial

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ABSTRACT

Introduction: Supraclavicular brachial plexus block is commonly employed for forearm surgeries, but its duration of analgesia with local anaesthetics alone is limited. Enhancing adjuvants in regional anaesthesia can lead to better analgesia, decreased opioid consumption, and improved recovery and patient satisfaction.

Aim: To compare the onset and duration of sensory and motor blockade, time to rescue analgesia, and overall pain-relief effectiveness of perineural versus intravenous dexamethasone administered with paracetamol following supraclavicular block in forearm surgeries.

Materials and Methods: The present double-blind randomised control trial was conducted at Dr DY Patil Medical College, Hospital and Research Centre, Pune, Maharashtra, India, where 60 patients scheduled for forearm surgeries under supraclavicular block were randomly divided into two groups. In Group A, patients received 20 mL of 0.5% bupivacaine, 10 mL of 2% lignocaine with adrenaline, and 8 mg of dexamethasone. Group B received the same local anaesthetic with the addition of 2 mL of 0.9% normal saline, followed by intravenous administration of 8 mg dexamethasone and 1 gm paracetamol after the block. Parameters evaluated were sensory and motor block onset and duration. Postoperative pain relief duration and time to first rescue analgesia were assessed using the Visual Analogue Scale (VAS), and any adverse effects were documented. Data were analysed with student's t-test and Chi-square test; $p<0.05$ was significant, $p<0.001$ highly significant.

Results: The two groups were comparable with respect to demographic characteristics. The mean age was 43.07±11.6 years in Group A and 42.33±10.42 years in Group B (p=0.79). Both groups had a similar gender distribution, with no statistically significant difference. Group A had a faster onset of sensory block (4.93±0.82 min) compared to Group B (7.87±0.97 min) and a longer sensory block duration (511.4±31.4 min vs. 432.3±19.5 min). Motor block onset was also quicker in Group A (9.93±0.82 min) than in Group B (13.2±1.04 min), with a longer duration (401.4±30.3 min vs. 366.4±26.7 min). Group A experienced more extended analgesia (527.9±30.9 min vs. 447.4±19 min). Haemodynamic variables were stable in both groups, with no significant complications.

Conclusion: Perineural dexamethasone significantly prolonged the duration of sensory and motor blockade and delayed the requirement for rescue analgesia compared to intravenous dexamethasone with paracetamol. Both routes were safe and well-tolerated, making perineural dexamethasone a more effective adjuvant for enhancing postoperative analgesia in supraclavicular block for forearm surgeries.

Keywords: Adjuvants, Postoperative pain management, Regional Anaesthesia, Ultrasonography

INTRODUCTION

Regional anaesthesia, especially brachial plexus blocks, offers superior surgical conditions and postoperative analgesia compared with general anaesthesia [1,2]. The supraclavicular approach, originating from the early brachial plexus techniques of Kulenkampff [3], has been refined and is now commonly used for surgeries below the shoulder, as ultrasound has enhanced both the precision and safety of regional anaesthesia techniques [1,4]. However, when performed with local anaesthetic alone, block duration is limited, prompting interest in adjuvants to extend analgesia [1]. Effective postoperative pain control is central to anaesthetic care. Inadequate analgesia after forearm surgery can delay rehabilitation, increase opioid use, and diminish patient satisfaction [5].

Multiple adjuncts have been explored to enhance and prolong peripheral nerve blocks [1]. Among these, dexamethasone stands out. Movafegh A et al., showed that adding dexamethasone to lidocaine significantly prolonged axillary block duration [6]. Cummings KC et al., demonstrated that dexamethasone extended the duration of interscalene blocks with both bupivacaine and ropivacaine [7]. Kirkham KR et al., later quantified the effect, identifying dose- response features for perineural dexamethasone prolongation [8]. Pehora C et al., reviewed evidence suggesting local modulation of nociceptive fibre activity and anti-inflammatory effects that together account for the prolonged block and reduced postoperative analgesic requirements [9].

Within supraclavicular blocks specifically, several comparative studies support perineural dexamethasone. Mathew R et al., reported longer analgesia and delayed rescue requirements with perineural dosing versus intravenous administration [10], and Godbole MR et al., similarly observed longer motor block and time to rescue analgesia with the perineural route [11]. However, not all data favour perineural administration. Albrecht E et al., in a systematic review and meta-analysis, found that perineural and intravenous dexamethasone produced broadly similar prolongation of peripheral nerve block analgesia [12]. Rosenfeld DM et al., also reported no clear clinical superiority of one route over the other for shoulder surgery, though both were effective adjuncts [13]. Taken together, current evidence suggests that both routes are beneficial, with some studies indicating advantages for the perineural approach [11,13] and other studies indicating comparable effectiveness [12,14].

In parallel, paracetamol is a mainstay of multimodal perioperative analgesia. Sinatra RS et al., demonstrated the efficacy and safety of 1 g intravenous paracetamol in reducing postoperative pain after

major orthopaedic surgery [15], and the Faculty of Pain Medicine of the Australian and New Zealand College of Anaesthetists (ANZCA/FPM) evidence-based guidelines by Macintyre PE et al., endorse its opioid-sparing role within multimodal strategies [16].

These data expose practical gaps. First, the comparative efficacy of perineural vs intravenous dexamethasone remains unsettled, with both equivalence and marginal perineural advantages reported [11-14]. Secondly, the added value of pairing intravenous dexamethasone with intravenous paracetamol in this context is underexplored despite guideline support for multimodal analgesia [15,16]. Accordingly, the present study aimed to directly compared perineural dexamethasone with a systemic multimodal regimen (intravenous dexamethasone + intravenous paracetamol) in patients receiving a supraclavicular block for forearm surgery. The primary outcomes included onset and duration of sensory and motor block. Secondary outcomes included duration of analgesia and time to first rescue analgesia, and overall postoperative analgesic quality. These were documented with the help of the Visual Analog Scale (VAS) score.

MATERIALS AND METHODS

The present randomised control, double-blind clinical trial was conducted at Dr DY Patil Medical College, Hospital and Research centre, Pune, Maharashtra, India, over a period of six months (May 2024 - October 2024). Institutional Ethics Committee approval (IESC/PGS/2023/143) was obtained before the start of the study and the trial was registered under Clinical Trials Registry of India (CTRI/2024/05/067262). Informed written consent was secured from all participants.

Sample size calculation: Sample size was calculated was based on the study by Godbole MR et al., evaluating dexamethasone as an adjuvant in supraclavicular block [11]. In their study, the mean sensory block duration in Group BD was 14.63 hours with a standard deviation of 2.34. Using this data and Winpepi software version 11.3, with an acceptable difference of 1 at 95% confidence interval, the required sample size was calculated to be 48. To improve reliability, 60 patients were recruited (30 in each group).

Inclusion criteria: Patients aged between 18-60 years, of either gender, belonging to ASA physical status I or II, scheduled for forearm surgeries under supraclavicular brachial plexus block, who were hemodynamically stable with normal routine investigations, were included in the study.

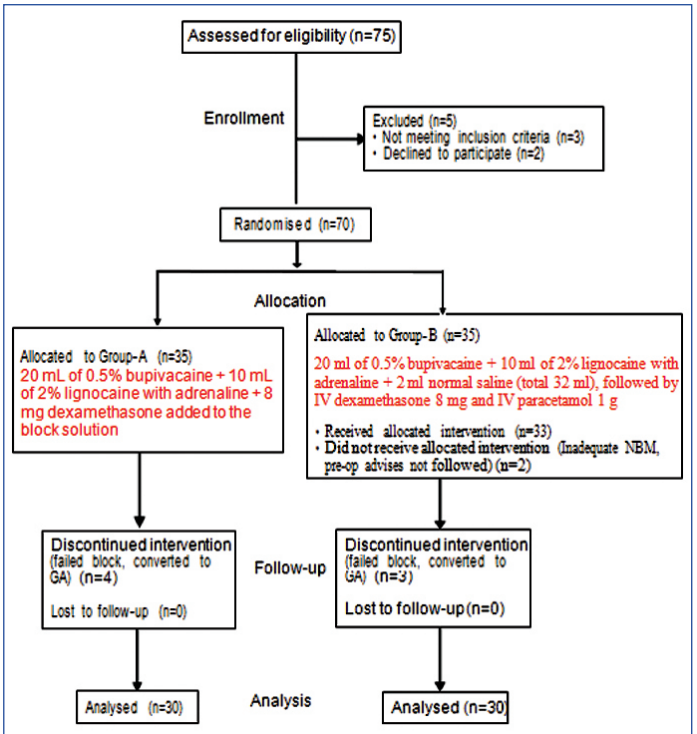
Exclusion criteria: Patients who refused consent, ASA grade III or higher, age <18 or >60 years, with known hypersensitivity to study drugs, pregnancy, or those on anticoagulant therapy were excluded.

Study Procedure

A total of 75 patients scheduled for forearm surgeries under supraclavicular block were assessed for eligibility. Five patients were excluded (three did not meet inclusion criteria, and two declined participation). The remaining 70 patients were randomised into two equal groups of 35 each using a computer-generated lottery method. Allocation concealment was maintained with sealed opaque envelopes, opened only in the preoperative holding area. Some patients did not follow the pre-operative advice and in some the intervention was discontinued so finally 60 patients were included in the analysis [Table/Fig-1]. Both the patient and the anesthesiologist performing the block were blinded to group assignment.

Group A (Perineural Dexamethasone group): Patients received 20 mL of 0.5% bupivacaine + 10 mL of 2% lignocaine with adrenaline + 8 mg dexamethasone added to the block solution (total volume 32 mL).

Group B (Intravenous Dexamethasone group): Patients received 20 mL of 0.5% bupivacaine + 10 mL of 2% lignocaine with adrenaline + 2 mL normal saline (total 32 mL), followed by i.v. dexamethasone 8 mg and i.v. paracetamol 1 g five minutes after the block. This was considered as the control group.



[Table/Fig-1]: CONSORT flow diagram

Bupivacaine 0.5% (20 mL) + Lignocaine 2% with Adrenaline (10 mL): Commonly used volumes for supraclavicular brachial plexus blocks have been reported in studies such as Kapral S et al., (ultrasound-guided supraclavicular block with bupivacaine), and subsequent RCTs Mathew R et al., and Godbole MR et al., [4,10,11].

Dexamethasone 8 mg (perineural or i.v.): Multiple RCTs and meta-analyses used 8 mg as the standard dose for prolonging brachial plexus block: Movafegh A et al., and Cummings KC et al., [6,7].

The i.v. Paracetamol 1 g: The dose is standard and supported by Sinatra RS et al., and Macintyre PE et al., guidelines [15,16].

All patients were monitored with Electrocardiogram (ECG), Non-Invasive Blood Pressure (NIBP), and SpO_2 (Peripheral capillary oxygen saturation). Baseline haemodynamic parameters were recorded. Supraclavicular blocks were performed under ultrasound guidance (Hitachi Arietta S70, linear probe). A 22G needle was advanced in-plane after aseptic preparation, with half the volume injected at the corner pocket and the remainder cranially. Sensory block was assessed by pinprick, and motor block by a modified Bromage scale. Postoperative pain was assessed using VAS at baseline, 5, 15, and 30 minutes, and at 1, 2, 6, and 8 hours. Rescue analgesia (i.v. tramadol 1.5 mg/kg + i.v. ondansetron 4 mg) was administered if VAS >4. Two patients required rescue analgesia in Group A, whereas 18 people required rescue analgesia in Group B. Adverse effects, if any, were also noted.

STATISTICAL ANALYSIS

Data were entered in Microsoft Excel and analysed using Statistical Package for Social Sciences (SPSS) version 21. Quantitative variables were expressed as mean±SD and analysed using Student's t-test. Qualitative variables were expressed as frequencies and percentages, analysed with Chi-square test. A p-value <0.05 was considered statistically significant, while p<0.001 was taken as highly significant. Results were represented in tabular and graphical formats.

RESULTS

The comparison of groups according to mean age is shown in [Table/Fig-2]. The study included two groups with nearly identical mean ages: Group A at 43.07 years and Group B at 42.33 years. The p-value 0.79 indicates no statistically significance. It also shows the gender distribution between the two groups, with a p-value of 0.77 indicating no statistically significance and also shows the comparison of groups according to ASA. Group A had 20 patients and Group B had 18 patients in ASA I. While, Group A had 10 patients and Group B had 12 patients in ASA II. The p-value of 0.59 indicated no statistically significance in ASA classifications. Furthermore, it compares the duration of analgesia and time to rescue analgesia between groups. Group A had a longer analgesia duration of 527.9 minutes, while Group B had 447.4 minutes. Additionally, Group A's time to rescue analgesia was 543 minutes compared to 462 minutes for Group B, showing improved pain control. These differences were statistically significant (p<0.001).

Variables	Group A	Group B	p-value
Age (years)	43.07±11.6	42.33±10.42	0.79
ASA (I/II)	20/10	18/12	0.59
Male/Female	23/7	21/9	0.77
Duration of analgesia (minutes)	527.9±30.9	447.4±19	<0.001
Time for rescue analgesia (minutes)	543±32.7	462.2±18.4	<0.001

[Table/Fig-2]: Comparison of groups according to demographics and analgesia. Age, duration and time for rescue analgesia was analysed by students t-test. ASA and gender distribution was analysed by Chi-square test.

Comparison of sensory blockade between groups is shown in [Table/Fig-3]. Group A had a quicker onset at 4.93 minutes and a longer duration of 511.4 minutes, while Group B had an onset of 7.87 minutes and a duration of 432.3 minutes. Both differences were statistically significant (p<0.001). Comparison of groups according to motor blockade characteristics is shown in [Table/Fig-4]. Group A had a faster onset at 9.93 minutes and a longer duration of 401.4 minutes, while Group B's onset was 13.2 minutes with a duration of 366.4 minutes. These differences were statistically significant (p<0.001). Comparison of VAS pain scores is depicted by [Table/Fig-5]. At eight hours, Group A (2.86±0.73) showed markedly sustained analgesia compared to Group B (5.16±0.94, p<0.001), suggesting longer duration of pain relief with perineural dexamethasone.

Sensory blockade (mean±SD)	Group A	Group B	p-value
Time of onset (minutes)	4.93±0.82	7.87±0.97	<0.001
Duration (minutes)	511.4±31.4	432.3±19.5	<0.001

[Table/Fig-3]: Comparison of groups according to sensory blockade. analysed by students t-test.

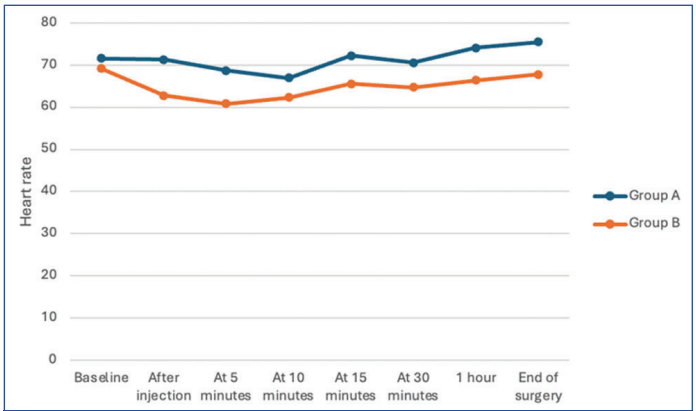
Motor blockade (mean±SD)	Group A	Group B	p-value
Time of onset (minutes)	9.93±0.82	13.2±1.04	<0.001
Duration (minutes)	401.4±30.3	366.4±26.7	<0.001

[Table/Fig-4]: Comparison of groups according to motor blockade. analysed by students t-test.

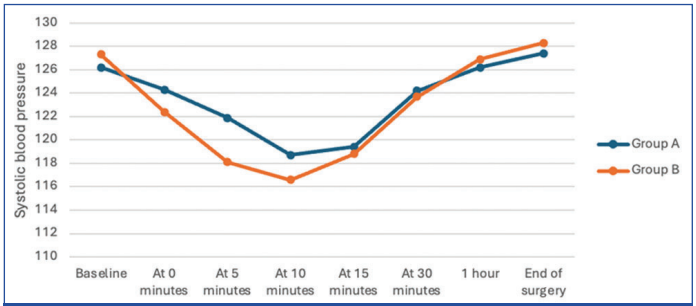
[Table/Fig-6] compares the heart rate in both groups. It shows lower heart rates in Group B as compared to Group A, possibly suggesting a lower stress response. [Table/Fig-7] compares the systolic blood pressure in both groups. However, no significant differences were observed. No statistically significant adverse effects were noted in both groups, as depicted in [Table/Fig-8].

VAS (mean±SD)	Group A	Group B	p-value
Baseline	5.43±1.16	5.53±1.04	0.72
At 5 minutes	2.86±0.73	3.23±0.77	0.06
At 15 minutes	0	0	-
At 30 minutes	0	0	-
At 1 hour	0	0	-
At 2 hours	0	0	-
At 6 hours	1.9±0.74	2.23±0.76	0.09
At 8 hours	2.86±0.73	5.16±0.94	<0.001

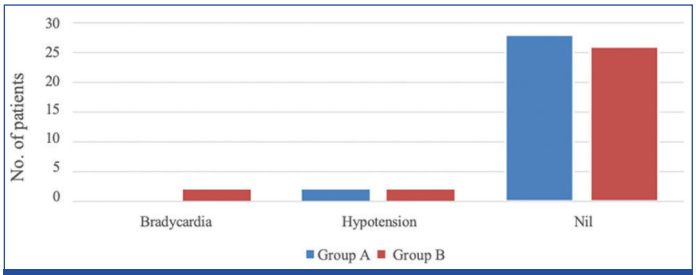
[Table/Fig-5]: Comparison of groups according to Visual Analog Scale (VAS). analysed by students t-test.



[Table/Fig-6]: Comparison of groups according to heart rate.



[Table/Fig-7]: Comparison of groups according to systolic blood pressure.



[Table/Fig-8]: Comparison of groups according to adverse effects.

DISCUSSION

The present randomised control, double-blind study compared the analgesic effects of perineural dexamethasone added to supraclavicular brachial plexus block with those of intravenous dexamethasone combined with paracetamol in patients undergoing forearm surgeries. The findings indicate that the perineural approach significantly extended the duration of both sensory and motor blockade, facilitated a faster onset of action, lowered postoperative pain scores, and delayed the need for rescue analgesics compared with the intravenous method. These results support the enhanced efficacy of regional anesthesia with perineural dexamethasone and contribute additional evidence to the ongoing discussion on the relative benefits of perineural versus systemic administration.

The current study showed that patients receiving perineural dexamethasone experienced a faster onset of both sensory and motor blockade compared with those who received intravenous

administration. This earlier onset is clinically significant as it allows quicker readiness for surgery and reduces intraoperative discomfort. Comparable findings were described by Mathew R et al., who noted a more rapid onset when dexamethasone was administered perineurally with bupivacaine in supraclavicular blocks [10]. Godbole MR et al., also observed superior onset characteristics with perineural administration [11], and Shende et al. reported that adding dexamethasone to local anaesthetic solutions effectively shortened the onset of both sensory and motor block [17]. Collectively, these results indicate that perineural dexamethasone augments the action of local anaesthetics, possibly by modifying perineural pH and enhancing penetration across nerve membranes.

Another observation was the prolonged duration of both sensory and motor block in the perineural group, together with a delayed requirement for rescue analgesics. This result is in line with Movafegh A et al., who demonstrated that perineural dexamethasone significantly extended the duration of axillary brachial plexus blocks with lidocaine [6]. Similarly, Cummings KC et al., found that perineural dexamethasone with ropivacaine or bupivacaine produced longer-lasting interscalene blocks [7]. Kirkham KR et al., in their meta-analysis, further emphasised a dose-dependent effect, with 8 mg perineural dexamethasone providing the greatest prolongation [8]. These consistent findings across multiple trials support the idea that local deposition of the drug has a more pronounced role than systemic absorption in prolonging block duration.

The present study also revealed that patients in the perineural group had a longer pain-free interval and lower postoperative VAS scores. Similar outcomes were reported by Kirkham KR et al., who documented prolongation in pain-free periods [8]. Albrecht E et al., observed that perineural administration increased analgesia duration by nearly two hours compared with intravenous use [14]. In addition, Desai N et al., reported a mean increase of 2.73 hours in analgesia with perineural dexamethasone, which was statistically significant [18]. Conversely, Albrecht E et al., suggested that intravenous dexamethasone could yield analgesic effects comparable to perineural administration, while Rosenfeld DM et al., found no difference between the two routes [12,13]. These contrasting reports reflect ongoing discussion; however, the present findings align with studies favouring perineural administration as the more effective option for postoperative pain relief in upper limb surgeries.

In addition to longer block duration, the perineural group demonstrated reduced analgesic consumption and lower heart rates, indicating better pain control and potentially reduced stress response. Williams BA et al., highlighted that dexamethasone contributes to improved analgesia through both anti-inflammatory and antiemetic mechanisms [9]. The present study also incorporated multimodal analgesia, as patients in the intravenous group received paracetamol. Although paracetamol is a well-established opioid-sparing drug, supported by the findings of Sinatra RS et al., and Macintyre PE et al., its administration did not achieve the same degree of block prolongation as perineural dexamethasone [15,16]. This emphasises that while systemic analgesics have a complementary role, they do not replicate the efficacy of local adjuvants in regional anaesthesia.

Clinically, the outcomes of this study have significant implications for enhanced recovery protocols. Prolonged block duration, better pain control, and reduced opioid use contribute to improved patient satisfaction and smoother postoperative recovery. Yang ZS et al., in their network meta-analysis, confirmed that dexamethasone, regardless of administration route, reduces rebound pain and opioid requirements [19]. Nevertheless, consistent with the findings of Cummings KC et al., and Godbole MR et al., perineural administration appears to provide greater benefits in terms of block prolongation [7,11]. Importantly, available evidence supports the safety of dexamethasone when used within recommended doses, although the intravenous route remains a valid option in patients where perineural use is contraindicated. Overall, perineural dexamethasone is a valuable adjuvant for optimising perioperative outcomes in forearm surgeries.

Limitation(s)

The study was conducted at a single centre, which may have limited external validity. Long-term outcomes such as incidence of chronic pain or functional recovery were not assessed. Moreover, although both perineural and intravenous routes were compared, a control group without dexamethasone could have provided further insight into the effect of the drug.

CONCLUSION(S)

The present study demonstrated that perineural dexamethasone, when used as an adjuvant in supraclavicular block, significantly prolonged sensory and motor block duration, provided faster onset, and ensured superior postoperative analgesia compared with intravenous dexamethasone with paracetamol. Patients in the perineural group required fewer rescue analgesics and reported lower VAS pain scores in the postoperative period. These findings highlight the greater efficacy of the perineural route over the intravenous route for enhancing block characteristics and pain relief in forearm surgeries. Incorporating perineural dexamethasone into clinical practice may improve patient comfort, reduce opioid requirements, and facilitate smoother recovery.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Jul 26, 2025
- Manual Googling: Sep 11, 2025
- iThenticate Software: Sep 13, 2025 (16%)

ETYMOLOGY: Author Origin

EMENDATIONS: 7

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. No

Date of Submission: **Jul 23, 2025**
Date of Peer Review: **Aug 20, 2025**
Date of Acceptance: **Sep 15, 2025**
Date of Publishing: **Dec 01, 2025**