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Original Article

Anaesthesia Section

Comparison of Intravenous Dexamethasone versus Perineural Dexamethasone as an Adjuvant to Local Anaesthesia in Supraclavicular Brachial Plexus Block for Upper Limb Surgeries: A Randomised Clinical Study

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ABSTRACT

Introduction: Dexamethasone is a potent adjuvant for prolonging analgesia in supraclavicular brachial plexus blocks. However, the optimal route of administration—perineural or intravenous—remains a subject of debate.

Aim: To compare the effectiveness and safety of intravenous versus perineural dexamethasone as an adjuvant to local anaesthetics in supraclavicular brachial plexus blocks for upper limb surgeries.

Materials and Methods: In this randomised clinical study, conducted in the Department of Anaesthesiology, Smt. Bhikhiben Kanjibhai Shah Medical Institute and Research Centre, Piparia, Vadodara, Gujarat, India included 80 American Society of Anaesthesiologists (ASA) I and II patients undergoing elective upper limb surgeries were divided into two groups: Group I received intravenous dexamethasone, while Group P received perineural dexamethasone, along with a local anaesthetic mixture. The onset and duration of sensory and motor block, duration of analgesia, haemodynamic changes and complications were assessed. Statistical analysis was performed using the t-test and Chi-square test.

Results: Group P exhibited a faster onset of sensory and motor block compared to Group I (p-value <0.05). The duration of sensory block, motor block and postoperative analgesia were significantly longer in Group P (p-value <0.05). Haemodynamic parameters showed significant differences at various time points, but no consistent trend favoured either group. No significant complications were observed.

Conclusion: Perineural dexamethasone prolonged the duration of analgesia and sensory and motor block compared to intravenous dexamethasone, without significant side-effects.

Keywords: Administration routes, Brachial plexus block, Bupivacaine, Lignocaine

INTRODUCTION

Effective pain management is crucial for patient recovery and satisfaction in surgical care, particularly in orthopaedic procedures involving the upper limb [1]. Regional anaesthesia, specifically the supraclavicular approach to brachial plexus block, is highly regarded for its efficacy in providing dense and rapid anaesthesia for arm and forearm surgeries [2]. While local anaesthetics are inherently effective in brachial plexus blocks, their duration of action is limited. Various adjuvant drugs have been explored to enhance and prolong the analgesic effects [3]. Among these, dexamethasone has gained prominence due to its anti-inflammatory properties and ability to extend the duration of analgesia when used in conjunction with local anaesthetics [4-6]. The mechanism by which dexamethasone enhances analgesia is multifaceted, involving the suppression of inflammation and modulation of pain transmission at the nociceptive level. Studies have shown that dexamethasone can prolong nerve block duration by inhibiting the synthesis of inflammatory mediators responsible for pain and swelling postsurgery [7].

However, the optimal route of dexamethasone administration as an adjuvant to local anaesthetics presents a clinical dilemma. Perineural administration directly at the nerve block site may potentiate the local anaesthetic effects more distinctly than intravenous administration, which offers systemic anti-inflammatory benefits. Existing literature reports conflicting results on the efficacy and safety of these administration routes [8-10]. Thus, the study aimed to address this critical knowledge gap by comparing the effectiveness and safety of perineural versus intravenous administration of dexamethasone in supraclavicular brachial plexus blocks and also to compare the duration of analgesia, onset of sensory and motor blocks and the incidence of adverse effects associated with both routes of administration.

The findings of this research paper are expected to contribute significantly to the field of anaesthesiology by clarifying the role of the route of administration of dexamethasone in optimising surgical outcomes. The results could potentially influence future clinical protocols to enhance patient outcomes, reduce opioid consumption, and streamline anaesthesia practices in upper extremity surgeries.

MATERIALS AND METHODS

This randomised clinical study was conducted in the Department of Anaesthesiology at Smt. Bhikhiben Kanjibhai Shah Medical Institute and Research Centre (SBKS MIRC), Piparia, Vadodara, Gujarat, India after obtaining Institutional Ethical Committee (IEC) approval (approval NO. SVIC/ON/MEDI/BNPG21/NOV/22198). The study was conducted over a period of 18 months, from October 2023 to April 2024, involving patients undergoing upper limb orthopaedic surgeries after obtaining written informed consent.

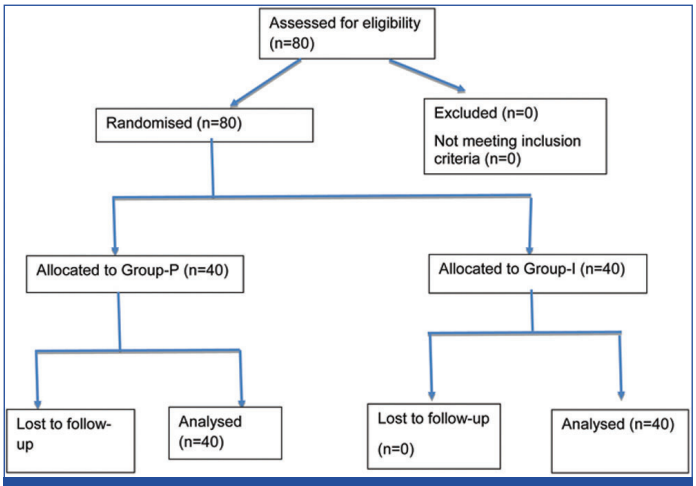
Inclusion criteria: Patients of ASA I and II of either gender, aged 18-65 years, posted for elective upper limb surgeries, were included in the study.

Exclusion criteria: Patients with contraindications to the block, like local infection at the site of the block, known allergy to local anaesthetic drugs and adjuvants, coagulation disorders, or those on anticoagulant therapy. Additionally, patients who refused to participate, as well as those with systemic diseases such as heart disease, respiratory disease, liver disease, kidney disease, anaemia, shock, septicaemia, uncontrolled hypertension, neurological disorders, psychiatric disorders, neuromuscular disorders, or pregnant patients, were excluded from the study.

Sample size calculation: The sample size was calculated using the Process Automation Software System (PASS) 15 {National Vital Statistics System (NVSS)}. The reference study used for the calculation of sample size was Zorrilla-Vaca A and Li J which indicated that perineural dexamethasone significantly prolonged the duration of analgesia by 0.48 hours with a 95% Confidence Interval (CI) [10]. Therefore, a total of 76 patients will be required to achieve a result with 80% power and a 5% probability of a type I error for two-sided testing. To minimise the effect of data loss due to dropouts (patient refusal or surgery cancellation for any reason), 80 patients (40 patients in each group) were recruited. Patients who met the inclusion criteria were divided into two groups based on a randomised computer-generated sequence. Both the assessor and the patients were blinded to the group allocation using the opaque sealed envelope method.

Patients undergoing elective upper limb surgeries with successful supraclavicular brachial plexus block using a local anaesthetic mixture were allocated into two groups based on a randomised computer-generated sequence:

- Group I: Received intravenous dexamethasone (2 mL, 8 mg)+ perineural normal saline (NS, 2 mL) added to the local anaesthetic mixture (30 mL).
- Group P: Received intravenous NS (2 mL as placebo)+perineural dexamethasone (2 mL, 8 mg) added to the local anaesthetic mixture (30 mL) [Table/Fig-1].



[Table/Fig-1]: CONSORT flow diagram.

A total of 32 mL of local anaesthetic solution was administered perineurally. The dose of dexamethasone was determined according to the study conducted by Rahangdale R et al., [11]. The local anaesthetic mixture consisted of Inj. Lignocaine with adrenaline (0.2%) 12 cc, Inj. Bupivacaine (0.5%) 13 cc and Inj. Normal Saline 5 cc to make a total volume of 30 cc.

All patients were kept nil by mouth for eight hours the night before surgery. After obtaining written informed consent on the day of surgery, the patient was transferred to the operating room. In the operating room, an 18-gauge intravenous line was secured on the non operating limb and Ringer's lactate was initiated. The patients were connected to a multiparameter monitor and their Heart Rate (HR), Systolic and Diastolic Blood Pressure (SBP, DBP), Electrocardiogram (ECG), and Oxygen Saturation (SpO_2) were recorded. Patients were premedicated with Inj. Glycopyrrolate 0.004 mg/kg, Inj. Ondansetron 0.1 mg/kg, and Inj. Midazolam 1 mg intravenously. The patient was positioned supine with a bolster under the shoulder and the neck turned to the opposite side, with the arm to be anaesthetised adducted. Following all antiseptic and aseptic precautions, the block was administered lateral to the subclavian artery and 1 to 1.5 cm above the midpoint of the clavicle, using a 24G×1.5 cm hypodermic needle with a nerve stimulator technique.

The Peripheral Nerve Stimulation (PNS) was started with an intensity of 3.0 mA at a frequency of 1 Hz to obtain a defined response (muscle twitch) in order to locate the peripheral nerve. The current was gradually reduced to a target of 0.2 mA when the response stopped. After negative aspiration, a total volume of 32 mL of drug solution was administered. A brief massage for one minute was performed to facilitate even drug distribution.

Patients were monitored intraoperatively for any complications and haemodynamic changes at 0, 3, 5, 10, 15 minutes, and then every 15 minutes for the initial two hours. The onset and duration of sensory and motor block, as well as the duration of analgesia, were assessed using standard techniques [12-14].

Sensory block was evaluated using the pinprick test on a 3-point scale (0=normal sensation, 1=decreased sensation, 2=no sensation) [15]. The motor block was graded as follows: Grade 0- Complete flexion and extension of the elbow, wrist and fingers; Grade 1- Reduced motor power, limited to moving the wrist and/or fingers; and Grade 2- Total motor block, resulting in finger immobility [15].

The duration of analgesia was calculated from the time of block administration until the patient reported a Visual Analogue Scale (VAS) score ≥4, indicating the need for rescue analgesia. The time in minutes when Inj. Diclofenac sodium 1.5 mg/kg had to be administered intravenously for analgesia was noted as the time for rescue analgesia.

STATISTICAL ANALYSIS

The data were analysed using Microsoft (MS) Excel version 16.89.1. Numerical variables were represented by mean and standard deviation (SD). Statistical analysis was performed using t-tests for continuous variables and Chi-square tests for categorical variables. A p-value <0.05 was considered statistically significant. The sample size was determined based on a power analysis to detect a clinically significant difference in the duration of analgesia between the two groups.

RESULTS

There were no significant differences in demographic characteristics between the two groups, including weight, gender and ASA grade [Table/Fig-2] (p-value >0.05). HR, SBP and DBP showed significant differences between the two groups at various time points (p-value <0.05). However, there was no consistent trend favoring either

Parameters	Group I	Group P	p-value
Weight (Kg) (Mean±SD)	59.725±11.605	64.025±8.245	0.06
Gender n (%)			
Male	22 (55)	20 (50)	0.8228
Female	18 (45)	20 (50)	
ASA grade n (%)			
I	21 (52.5)	21 (52.5)	0.1
II	19 (47.5)	19 (47.5)	

[Table/Fig-2]: Demographic parameters comparison between Group-I and Group-P. Chi-square test; Used for categorical variables {Gender and American Society of Anaesthesiologist (ASA) Grade}; Student's t-test: Used for a continuous variable (weight). Statistical *p>0.05 (NS) Not significant

group. SpO_2 levels remained stable and comparable between the groups throughout the study period [Table/Fig-3].

Time frame	Vital parameter	Group P Mean±SD	Group I Mean±SD	T-statistic	p-value
0 min	HR	78.20±6.07	74.02±8.25	-2.577	0.012
	SBP	112.10±6.76	119.85±10.81	3.845	0.000276
	DBP	70.30±6.57	76.90±9.34	3.656	0.000492
	SpO_2	99.45±0.68	99.20±0.52	-1.856	0.067477
3 mins	HR	76.98±7.65	73.80±7.88	-1.828	0.071
	SBP	116.40±8.27	115.65±7.82	-0.417	0.677899
	DBP	77.55±6.02	80.10±6.24	1.86	0.066633
	SpO_2	99.20±0.69	98.98±0.66	-1.494	0.139175
5 mins	HR	76.85±6.08	77.93±7.75	0.691	0.492
	SBP	110.85±6.45	114.55±6.78	2.501	0.014495
	DBP	72.75±6.25	77.00±7.46	2.762	0.007205
	SpO_2	99	99	6.245	<0.00001
10 mins	HR	76.78±7.53	76.03±7.72	-0.44	0.661
	SBP	106.80±5.00	112.55±7.73	3.952	0.00019
	DBP	67.30±4.47	75.65±5.75	7.253	<0.000001
	SpO_2	99	99.35±0.53	4.149	0.000175
15 mins	HR	72.83±5.11	78.63±5.39	4.939	<0.00001
	SBP	108.28±4.51	111.05±5.64	2.43	0.017496
	DBP	71.30±6.33	72.80±7.14	0.994	0.323496
	SpO_2	99.45±0.50	99	-5.649	<0.00001
30 mins	HR	71.78±6.75	77.30±4.85	4.203	<0.0001
	SBP	120.75±9.82	110.60±8.23	-5.012	<0.00001
	DBP	79.10±5.96	78.05±7.05	-0.719	0.474121
	SpO_2	98.95±0.55	99.43±0.50	4.03	<0.0001
45 mins	HR	77.20±4.55	80.50±5.12	3.048	0.003
	SBP	113.60±5.23	112.35±5.99	-0.994	0.323127
	DBP	74.30±7.18	78.50±5.16	3.004	0.003687
	SpO_2	99.38±0.54	99.55±0.55	1.433	0.155941
60 mins	HR	78.75±3.78	79.75±4.30	1.104	0.273
	SBP	110.75±3.81	119.65±9.91	5.301	<0.00001
	DBP	76.45±4.11	77.50±6.94	0.823	0.413471
	SpO_2	98.90±0.67	99	0.941	0.35226
90 mins	HR	76.10±5.99	77.05±4.08	0.829	0.41
	SBP	117.95±7.73	113.55±7.24	-2.627	0.01037
	DBP	74.60±6.78	75.30±5.74	0.498	0.619685
	SpO_2	99	99.50±0.51	6.245	<0.00001
120 mins	HR	79.45±6.14	78.85±6.13	-0.437	0.663
	SBP	117.45±7.86	114.75±6.07	-1.72	0.089703
	DBP	75.45±7.50	75.10±5.94	-0.231	0.817607
	SpO_2	99	99.38±0.49	4.837	<0.0001

[Table/Fig-3]: Comparison of vital parameters between Group P and Group I. Student's t-test was used for a continuous variable where p>0.05 (NS) Not significant

The onset of sensory and motor block was significantly faster in Group P (11.41±2.5 minutes) compared to Group I (13.00±2.5 minutes) (p-value=0.006). Similarly, the onset of motor block was faster in Group P (14.88±1.20 minutes) than in Group I (15.70±1.00 minutes) (p-value=0.0017). Although the duration of sensory block was longer in Group P (958.00±95 minutes) compared to Group I (510.25±105 minutes), the difference was statistically significant (p-value <0.0001). The duration of motor block was also slightly longer in Group P (910.60±150 minutes) than in Group I (470.25±160 minutes); however, the difference was again significant (p-value <0.0001). The duration of postoperative analgesia was significantly longer in Group P (995.00±130 minutes) compared to Group I (700.25±140 minutes) (p-value <0.0001) [Table/Fig-4].

The t-test shows a statistically significant difference between the two groups, with Group I reaching a VAS score greater than 4 significantly earlier than Group P (p-value ≤0.05) [Table/Fig-5]. No significant complications or side-effects related to the anaesthetic procedure were observed in either group.

Outcome parameter	Group	Total (Mean±SD)	p-value
Onset of sensory block (minutes)	Group P	11.41±2.5	0.006
	Group I	13.00±2.5	
Onset of motor block (minutes)	Group P	14.88±1.2	0.0017
	Group I	15.70±1.00	
Duration of sensory block (minutes)	Group P	958.00±95	<0.0001
	Group I	510.25±105	
Duration of motor block (minutes)	Group P	910.60±150	<0.0001
	Group I	470.25±160	
Duration of postoperative analgesia (minutes)	Group P	995.00±130	<0.0001
	Group I	700.25±140	

[Table/Fig-4]: The table summarises various outcome parameters related to the effectiveness and duration of anaesthesia between two groups, Group-P and Group-I.

Parameter	Group I M±SD	Group P M±SD	T-statistic	p-value
Time of VAS >4 (min) (Time of rescue analgesia)	1009.5±99.79	1116.75±93.96	-4.949	0.000004

[Table/Fig-5]: Comparison of the time to VAS score greater than 4 between Group-I and Group-P, including mean, standard deviation, T-statistic, and p-value.

DISCUSSION

The results of the present study demonstrated that perineural dexamethasone significantly reduced the onset time of sensory and motor block while prolonging the duration of postoperative analgesia compared to intravenous dexamethasone. These findings are consistent with several previous investigations [8,10,11,16] that have examined the efficacy of perineural dexamethasone as an adjuvant in brachial plexus blocks.

In the present study, the onset of sensory and motor block was found to be (11.41±2.5 minutes) and (14.88±1.2 minutes) in Group P, respectively, which was faster compared to (13.00±2.5 minutes) and (15.70±1.0 minutes), respectively, in Group I. The results of this study are similar to those of Mathew R et al., where the time for onset of sensory block in Group DP (10.20±1.443 minutes) was significantly faster than that in Group DI (11.60±1.443 minutes) with a p-value of 0.001. The time to onset of motor block in Group DP (13.92±1.754 minutes) was also significantly earlier than that in Group DI (14.96±1.274 minutes) with a p-value of 0.02 [16]. In contrast, Veena G et al., found contradictory results; in her study, Group A (intravenous dexamethasone) had a faster onset of sensory (22.2±4.6 minutes) and motor blockade (30.2±6.0 minutes) compared to Group B (perineural dexamethasone), where the onset of sensory block was (30.2±6.0 minutes) and motor block was (33.0±8.1 minutes), but the difference was not significant (p-value=0.12) [17].

The duration of sensory and motor block in the current study for Group P was (958±95 minutes) and (910.60±150 minutes), respectively, while for Group I, it was (510.25±105 minutes) and (470.25±160 minutes), respectively. Therefore, it was observed that the duration was prolonged in Group P compared to Group I, and the difference was statistically significant with p-value <0.0001. These results were similar to the meta-analysis conducted by Zorrilla-Vaca A and Li J which included 13 randomised controlled trials comprising a total of 937 patients (intravenous: 464 patients; perineural: 473 patients). Perineural dexamethasone significantly prolonged the duration of analgesia (Standardised Mean Difference [SMD],

0.48 h; 95% CI, 0.18-0.79) [10]. Persec J et al., also found that the duration of sensory (1,260 minutes in Group 1 vs. 600 minutes in Group 2) and motor (1,200 minutes in Group 1 vs. 700 minutes in Group 2) blockade was significantly longer in Group 1 (p-value <0.05), where 25 mL of 0.5% levobupivacaine plus four milligrams of dexamethasone was given in Group 1 and 25 mL of 0.5% levobupivacaine plus one millilitre saline was given in Group 2 [18].

However, contrary to the findings in the present study, McHardy PG et al., found no significant difference in the duration of analgesia, as the duration was 18.5 hours with perineural dexamethasone and 20.3 hours with intravenous dexamethasone (p-value=0.99), indicating that the difference was statistically insignificant [19]. In the present study, the time at which VAS exceeded 4 in Group P was 1116.75 minutes, while in Group I it was 1009.5 minutes; this difference was statistically significant. Similar results were concluded by the study performed by Veena G et al., where the VAS scores of <3 and ≥3 were 63% and 37% in Group A, respectively. In contrast, in Group B, these scores were 91% and 9%, respectively, which was statistically significant (p-value=0.008) [17]. However, contradictory to the current study, the study conducted by Samar P et al., reported that the average time for VAS >4 in Group I was 1320±276 minutes and in Group P was 1158±264 minutes, but the difference was insignificant [20].

These discrepancies could be due to differences in the type of nerve block, local anaesthetic agents used, the dose of dexamethasone, and the patient population.

The haemodynamic changes observed in this study, although statistically significant at certain time points, did not follow a consistent pattern favouring either group, suggesting that both routes of dexamethasone administration are well-tolerated and do not cause significant haemodynamic instability. Studies conducted by Mathew R et al., and McHardy PG et al., also concluded that there were no significant changes in haemodynamics in either group [16,19]. The absence of complications in both groups further supports the safety of using dexamethasone as an adjuvant in brachial plexus blocks.

Limitation(s)

The limitations of this study include the need for future randomised controlled trials with larger patient populations to validate these findings and assess the long-term safety of perineural dexamethasone. Long-term follow-up of patients administered perineural dexamethasone was also not possible for monitoring any delayed neurological complications.

CONCLUSION(S)

This study demonstrated that perineural dexamethasone is more effective than intravenous dexamethasone in reducing the onset time of sensory and motor block and prolonging postoperative analgesia in supraclavicular brachial plexus blocks. By providing a faster onset and prolonged analgesia, perineural dexamethasone reduces pain intensity and the need for rescue analgesia in the postoperative period compared with intravenous dexamethasone.

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