

Effect of dexamethasone in low volume supraclavicular brachial plexus block: A double-blinded randomized clinical study

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Abstract

Background and Aims: With the use of ultrasound, a minimal effective volume of 20 ml has been described for supraclavicular brachial plexus block. However achieving a long duration of analgesia with this minimal volume remains a challenge. We aimed to determine the effect of dexamethasone on onset and duration of analgesia in low volume supraclavicular brachial plexus block.

Material and Methods: Sixty patients were randomly divided into two groups of 30 each. Group C received saline (2 ml) + 20 ml of 0.5% bupivacaine and Group D received dexamethasone (8 mg) + 20 ml of 0.5% bupivacaine in supraclavicular brachial plexus block. Hemodynamic variables and visual analog scale (VAS) score were noted at regular intervals until 450 min. The onset and duration of sensory and motor block were measured. The incidence of “Halo” around brachial plexus was observed. Student’s *t*-test and Chi-square test were used for statistical analysis.

Results: The onset of sensory and motor block was significantly earlier in dexamethasone group (10.36 ± 1.99 and 12 ± 1.64) minutes compared to control group (12.9 ± 2.23 and 18.03 ± 2.41) minutes. The duration of sensory and motor block was significantly prolonged in dexamethasone group (366 ± 28.11 and 337.33 ± 28.75) minutes compared to control group (242.66 ± 26.38 and 213 ± 26.80) minutes. The VAS score was significantly lower in dexamethasone group after 210 min. “Halo” was present around the brachial plexus in all patients in both the groups.

Conclusion: Dexamethasone addition significantly increases the duration of analgesia in patients receiving low volume supraclavicular brachial plexus block. No significant side-effects were seen in patients receiving dexamethasone as an adjunct.

Key words: Analgesia, brachial plexus block, dexamethasone

Introduction

Ultrasound has become the cornerstone of peripheral nerve blocks in upper limb surgeries. The supraclavicular approach provides an easiest and consistent method of anesthesia for below shoulder joint surgeries compared to axillary and infraclavicular approaches.^[1-3]

Moreover, huge volume (30-40 ml) of local anesthetics used in conventional blocks, is associated with Horner’s syndrome, phrenic nerve palsy, and systemic toxicity.^[4,5] The majority of these complications can be overcome using ultrasound-guided technique. However, providing longer duration of analgesia with a minimal volume of local anesthetic agent remains a challenge.

Adjuvants such as tramadol, neostigmine, clonidine, etc., were added to 25-40 ml of local anesthetics to prolong the

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duration of the block. However, studies quote that tramadol and neostigmine had no effect on the duration of the block.^[6,7] Even though, clonidine proved to prolong the duration of analgesia, it was associated with mild sedation.^[8]

Dexamethasone, a long-acting glucocorticoid ($t_{1/2} > 36$ h) has potent anti-inflammatory and analgesic effects.^[9] It was proved to be beneficial in peripheral nerve blocks.^[10] The effect of dexamethasone as an adjuvant has been explored by previous studies, but its role in the context of a lower volume of a local anesthetic agent under ultrasound guided blocks is still unclear. Hence, the present study was aimed to evaluate the effect of dexamethasone on the onset and duration of anesthesia in low volume supraclavicular brachial plexus block.

Material and Methods

This study was conducted between October 2010 and May 2011 after obtaining approval from Institute Ethics Committee (human studies) (Ref:Ser:4/oct/2010).

Sixty patients of American Society of Anesthesiologists I or II between the age of 20-69 years, scheduled for elective upper limb surgeries with expected duration of 60-120 min were included in the study after obtaining written informed consent. Patients with communication difficulty, hypersensitivity to local anesthetics and dexamethasone, those on sedative medications and perioperative intravenous (IV) steroids were excluded from the study. Upper limb orthopedic surgeries for fractures around the elbow, forearm, and hand with expected length of surgical incision between 2 and 5cm were included in this study. Patients were allowed to fast for 6 h prior to surgery and were premedicated with oral diazepam 0.15 mg/kg body weight the night before surgery and in the morning of surgery.

Randomization was done by a computer-generated table of random numbers. Patients were randomly divided into two groups of 30 each, in which Group C received 20 ml of 0.5% bupivacaine with 2 ml of normal saline and Group D received 20 ml of 0.5% bupivacaine with 2 ml of dexamethasone 8 mg. The study drug was prepared by an anesthesiologist not involved in the study and the anesthesiologist performing the block was blinded about the study drug.

After entering the operating theater, all the vital monitors such as pulse oximetry, noninvasive blood pressure, electrocardiography, etc., were connected. An 18G IV cannula was secured in the nonoperating upper limb. Patients were kept in supine position with operating limb in adducted position and head turned 30° toward contralateral side. The skin surface of supraclavicular fossa was prepared with alcoholic chlorhexidine solution. A 6-13 MHz linear ultrasound probe

(S-ICU™; Sonosite, Bothell, WA, USA) was used to obtain the image of the brachial plexus and subclavian artery at supraclavicular level. 20 ml of bupivacaine 0.5% and 2 ml of study drug (22 ml) was loaded in a 50 ml syringe and connected to a 22G regional block needle (BD, NJ, USA) via connection tubing (protect-A-line (832), Vygon, France). Once the brachial plexus was identified, 20 ml of study drug was injected to create a “Halo” around the brachial plexus and remaining 2 ml was used for intercostobrachial nerve block.

“Halo” around the brachial plexus was kept as an endpoint for minimal effective volume in this study. If “Halo” was not achieved with 20 ml of the local anesthetic mixture, it was noted, and the incidence of inadequate Halo or absent Halo was observed.

After the block procedure, the onset of sensory block of each nerve was assessed by spirit soaked cotton on each dermatome using verbal analog scale from 100 (normal sensation) to 0 (no sensation) and the motor block of each nerve was evaluated by thumb abduction (radial nerve), thumb adduction (ulnar nerve), thumb opposition (median nerve), pronation of forearm and flexion of elbow in supination (musculocutaneous nerve) and quantified by modification of Lovett rating scale.^[11] The onset of the block and the time of injection was noted. Once the onset of the block was ensured, surgery was allowed to proceed. The duration of analgesia was assessed postoperatively at hourly intervals until visual analog scale (VAS) score 30. Rescue analgesia with injection diclofenac sodium 1.5 mg/kg was given for VAS >30 and then the study was terminated.

VAS^[12] score was assessed by residents in postanesthetic care unit. All blocks were performed by different anesthesiologists posted in orthopedics operation theater. Similarly, hemodynamic variables such as pulse rate, systolic blood pressure, diastolic blood pressure, and respiratory rate were measured at 0, 5, 10, 15, 20, 30, 60 and 90 min and then hourly up to 450 min.

The onset of sensory and motor blockade was defined by the time interval between injection of study drug to complete loss of cold perception and complete paralysis (grade 0), respectively in all nerve distributions. The duration of sensory blockade was defined by the time interval between complete loss of cold perception and appearance of pain requiring analgesia. The duration of motor blockade was defined as the time interval between complete motor paralysis (grade 0) to the complete return of motor power (grade 6).

Patients were observed for any complications such as nausea, vomiting, bradycardia, hypotension, convulsions, hematoma, etc.

Sample size was estimated based on a pilot study of 10 patients. Dexamethasone added to bupivacaine prolonged the duration of the supraclavicular brachial plexus sensory block from 450 ± 220 min to 720 ± 340 min compared with placebo. It was estimated that a minimum of 24 patients in each group would be required to have a 90% power of detecting a 270-min difference at a significance level of 0.05% and 95% confidence interval. Statistical analysis^[13] was performed with SPSS for Windows (SPSS Inc., Chicago, IL, USA) version 16. The observations recorded in both groups were tabulated and statistical analysis of demographic data and comparison of groups was carried out using Student's *t*-test (paired for intragroup and unpaired for intergroup comparison) and Chi-square test.

$P < 0.05$ was taken to be statistically significant.

Results

The demographic variables such as age, weight, gender, and surgical characteristics [Table 1] were comparable in both the groups. In this study, the mean onset time of sensory block was significantly faster in Group D (10.36 ± 1.99 min) as compared to Group C (12.9 ± 2.23 min).

The duration of sensory block in Group C and D were 242.66 ± 26.38 min and 366 ± 28.11 min respectively. The difference of analgesia in both groups was found to be statistically significant ($P < 0.05$).

Mean onset of motor block in Group D (12 ± 1.64 min) was faster as compared to Group C (18.03 ± 2.41 min). The duration of motor block was prolonged significantly in Group D (333.37 ± 28.75 min) as compared to Group C (213 ± 26.80 min) ($P < 0.05$).

VAS score in the postoperative period was higher ($P < 0.05$) in Group C after 210 min as compared to Group D [Table 2].

Table 1: Patient and surgical characteristics

Parameters	Group C (n = 30)	Group D (n = 30)	P
Age (years)	36.56 ± 13.56	36.83 ± 12.19	0.93
Weight (kg)	57.7 ± 11.04	57.66 ± 7.65	0.98
Gender (%)			
Male	24 (80)	22 (73.33)	0.54
Female	6 (20)	8 (26.66)	
Duration of surgery (min)	85 ± 8.81	88 ± 9.5	0.20
Length of surgical incision (cm)	3.8 ± 1.8	4.2 ± 1.9	0.40

No statistically and clinically significant changes were observed in hemodynamic and respiratory parameters in either group. The duration of surgery was similar in both the groups and 20 ml of the local anesthetic agent was sufficient to produce "Halo" in both the groups. Apart from nausea observed among 2 patients in Group C and 1 patient in Group D, there were no complications during this study.

Discussion

Huge volume (30-40 ml) of local anesthetics used in most brachial plexus blocks usually spreads outside the nerve sheath producing complications such as Horner's syndrome and phrenic nerve palsy.^[4,5] Ultrasound-guided nerve blocks obviate majority of these complications. Various studies^[14,15] using ultrasound showed that just 5 ml of local anesthetic solution was sufficient to produce phrenic nerve sparing in interscalene block. Vandepitte *et al.*^[16] concluded in their step-up technique of ultrasound-guided brachial plexus block that only 7 ml of the local anesthetic agent was sufficient to produce block lasting 8.9 h. O'Donnell and Iohom^[17] reported that 1 ml of 2% lidocaine per nerve was adequate enough to produce a successful block of the brachial plexus at axillary level.

However, the low volume of local anesthetic agents compromised the duration of analgesia in ultrasound guided blocks.^[17,18] The effect of dose, volume and concentration of local anesthetics have been studied in laboratories on isolated nerves by measuring compound action potentials and on single nerves using voltage clamp techniques.^[19,20] Many of these studies showed that multilayered ensheathments in peripheral nerves impede the diffusion of the drug in ion channels, and there is significant variability in the nerve/connective tissue ratio in different locations in the same nerve.^[21]

Hence, the exact volume of local anesthetic agent remains controversial. There are no studies to prove the minimal effective volume of local anesthetics needed in supraclavicular approach.

Table 2: Comparison between VAS scores of both the groups

Time from induction (min)	Mean \pm SD		P
	Group C	Group D	
90	0 ± 0	0 ± 0	—
150	0 ± 0	0 ± 0	—
210	0.35 ± 0.82	0 ± 0	0.02
270	2.5 ± 1.28	0.26 ± 0.71	0.00
330	4.68 ± 0.97	2.36 ± 0.96	0.00
390	6.46 ± 0.86	4.1 ± 0.93	0.00
450	7.98 ± 0.49	6.5 ± 0.98	0.00

SD = Standard deviation, VAS = Visual analog scale

Hence, we considered to keep the appearance of “Halo” around the brachial plexus as the end point of minimal effective volume in our study, and 20 ml volume of the local anesthetic agent was sufficient to produce “Halo” around the brachial plexus in all the patients in both the groups.

Kothari^[22] also found in his lateral approach technique that only 20 ml of local anesthetics mixture (10 ml 2% lidocaine, 6 ml 0.5% bupivacaine, 4 ml normal saline) was needed to produce adequate brachial plexus block lasting 180-200 min without any adjuvants.

Various adjuvants such as tramadol, neostigmine, clonidine, dexamethasone, etc., were tried to enhance the duration of analgesia in supraclavicular brachial plexus block.^[6-8,10] Among them, dexamethasone seemed to have a better profile without any side-effects.

The systematic review and meta-analysis done by Choi *et al.*^[23] on the effect of dexamethasone (4-10 mg) on a long acting and intermediate acting local anesthetics proved that the prolongation of analgesia was from 730 to 1306 min for long-acting local anesthetics and was 168-343 min with intermediate-acting local anesthetics. Motor block was also prolonged from 664 to 1102 min. However, their trials were conducted with 30-40 ml of a local anesthetic agent that may also have a confounding effect on its duration.

The mean onset of sensory and motor blockade was significantly earlier in Group D compared to Group C. This could be due to the synergistic action of local anesthetics and dexamethasone. Vieira *et al.*^[24] performed ultrasound-guided interscalene brachial plexus block in 88 patients scheduled for shoulder arthroscopy using 20 ml of the local anesthetic mixture with dexamethasone adjuvant. There was no significant reduction in onset of sensory and motor blockade in dexamethasone group compared to control group. This discrepancy could be due to the difference in the local anesthetic volume and technique of block.

The mean duration of sensory and motor blockade was significantly longer in Group D compared to Group C. Vieira *et al.* also reported significant prolongation in the duration of sensory and motor block (1457 min and 1374 min) with dexamethasone group compared to control group (833 min and 827 min).

Trabelsi *et al.*^[25] conducted ultrasound-guided supraclavicular brachial plexus block in 60 patients undergoing upper extremity surgery using 15 ml of 2% lidocaine plus 2 ml of adjuvant (8 mg dexamethasone, 100 mg tramadol, 2 ml saline). They too found a significant prolongation of duration of analgesia

with dexamethasone group (1110 min) compared to tramadol group (240 min).

Dexamethasone produces analgesia by blocking pain signal transmission in nociceptive c-fibers, suppressing ectopic neural discharge and by inhibiting the action of phospholipase A₂.^[26]

The block prolonging effect of peripherally applied dexamethasone could be due to alteration in the function of potassium channels in the excitable cells by dexamethasone via glucocorticoid receptors present in the brachial plexus.^[27-30] It may also be due to the local vasoconstrictive effect of dexamethasone via glucocorticoid receptors.^[31]

Controversies exist over the route of administration of dexamethasone. Parveen *et al.*^[32] found that IV dexamethasone significantly prolonged the duration of analgesia (934 ± 68 min) compared to control group (342 ± 48.7 min) in supraclavicular brachial plexus block with long-acting local anesthetic agent. After IV injection, intracellular uptake of glucocorticoids activates cytoplasmic glucocorticoid receptors that in turn binds to glucocorticoid response elements in DNA. This leads to both decreased production of inflammatory proteins (Ox-2, inducible nitric oxide synthase, cytoplasmic phospholipase A₂, interleukins [ILs] inflammatory chemokines, etc.) and increased production of anti-inflammatory proteins (lipocortin-1 [IL-1]) receptor antagonist. Desmet *et al.*^[33] showed that both IV and perineural administration of dexamethasone to supraclavicular brachial plexus block equivalently prolonged the duration of analgesia.

The safety of dexamethasone use in a nerve sheath may raise some concerns. In animal experiments, small doses of betamethasone and triamcilonon acetate given intrathecally did not induce spinal neurotoxicity. In one study, 2000 intrathecal injections of dexamethasone (8 mg) were given to 200 patients for the treatment of posttraumatic visual disturbance.^[34-36] No neurological complications were observed. Nerve injury is a rare complication of dexamethasone injection^[37] and it usually occurs in the context of needle trauma. It was not seen in our study also.

Studies using dexamethasone microspheres are still in experimental stage. In one study in a sheep model,^[38] dexamethasone added to bupivacaine microspheres seemed to prolong the duration of analgesia from 700 ± 485 to 5160 ± 2136 min. However, there was a delay in onset of motor block, and appropriate drug delivery system is still unavailable to follow in human studies.

Continuous infusion pump for brachial plexus block seems to be an alternative for increasing the duration of analgesia. Ilfeld *et al.*^[39] showed that local anesthetic infusion through portable infusion pump for perineural brachial plexus block decreased pain (VAS 0 vs. 4.8), opioid requirement and sleep disturbances in postoperative day 1 and was maintained for 2-4 days. However, risks of catheter site infection^[40] and catheter migration^[41] has to be weighed against the prolonged analgesia.

There are certain limitations in this study also. First, this study didn't exclude the systemic action of steroid following absorption from the injection site. Second, if the volume of local anesthetic agent is the deciding factor for duration of action of dexamethasone, then various imaging studies and calculations are needed to calculate the volume of brachial plexus sheath. Third, follow-up for nerve injury was not done beyond 7 h. Fourth, prolongation of motor block was an unwanted effect that prevents the early recognition of iatrogenic nerve injury and early ambulation.

Conclusion

Addition of dexamethasone to supraclavicular brachial plexus block produces early onset and prolonged duration of analgesia with lesser volume of local anesthetic agent. The duration of analgesia with this volume of the local anesthetic agent does not exceed 7 h.

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Conflicts of interest

There are no conflicts of interest.

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