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Original Research Article

A Comparative Study of Efficacy of Dexmedetomidine Versus Clonidine as Adjuvant to Ropivacaine in PNS Guided Supraclavicular Brachial Plexus Block

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Conflict of interest: Nil

Abstract:

Background: Regional anesthesia, particularly the supraclavicular brachial plexus block, is widely used for upper limb surgeries due to its rapid onset, dense blockade, and superior postoperative analgesia. The addition of α2-adrenergic agonists as adjuvants to local anesthetics can enhance block characteristics.

Aim: To compare the efficacy of dexmedetomidine and clonidine as adjuvants to ropivacaine in PNS-guided supraclavicular brachial plexus block.

Methodology: This prospective comparative observational study was conducted on 80 ASA I–II patients undergoing elective upper limb surgeries. Patients were randomly assigned to two groups: RC (ropivacaine with clonidine 1 μg/kg) and RD (ropivacaine with dexmedetomidine 1 μg/kg). Onset and duration of sensory and motor blocks, duration of analgesia, and hemodynamic parameters were assessed and analyzed using SPSS v24, with $p \leq 0.05$ considered significant.

Results: The RD group showed a significantly faster onset of sensory (5.1 ± 0.9 vs. 10.65 ± 1.14 min) and motor block (10.23 ± 1.12 vs. 14.8 ± 1.29 min) and prolonged sensory (752.5 ± 5.9 vs. 470.25 ± 29.39 min), motor (513.75 ± 20.34 vs. 274.75 ± 28.19 min), and analgesia duration (765.82 ± 104.48 vs. 464.27 ± 66.2 min) than RC ($p < 0.001$). Hemodynamics remained stable in both groups.

Conclusion: Dexmedetomidine is a superior adjuvant to ropivacaine compared to clonidine, providing faster onset, longer block duration, and extended analgesia without significant adverse effects.

Keywords: Dexmedetomidine, Clonidine, Ropivacaine, Supraclavicular brachial plexus block, regional anesthesia.

Introduction

In contemporary anesthetic practice, regional anesthesia is an increasingly popular technique due to its capacity to offer sensory and motor blockade that is localized, better postoperative analgesia, and less systemic side effects than general anesthesia [1]. The brachial plexus block is one of the commonest approaches to regional anesthesia in upper limb surgeries, as it entails effective pain relief and anesthesia of upper extremity operations, including arm, forearm, and hand. Supraclavicular methods of sterilizing the brachial plexus block are very popular since it has rapid onset, high density and predictable anesthetic coverage of the upper extremity distal of shoulder [2]. Using nerve localization methods as Peripheral Nerve Stimulator (PNS) guidance, anesthesiologists can accomplish precise deposition of local anesthetics around the plexus, which guarantees the maximum success of blockage and lessens the chances of complications pneumothorax, intravascular injection or incomplete blockage.

Local anesthetic agent and appropriate adjuvants are necessary to identify the onset, duration and quality of the nerve block [3] of anesthetic. As an amide type long act local anesthetic, Ropivacaine is an agent with good pharmacological effects, such as reduced cardiotoxicity and neurotoxicity relative to bupivacaine. The use of ropivacaine offers superior sensory and motor block properties that last a long

time, which is why it is a perfect agent when it comes to peripheral nerve blocks [4]. But the biggest drawback of local anesthetics such as ropivacaine is that they have a limited duration of effect which makes it necessary to supplement them or to add some postoperative analgesic methods. Therefore, several adjuvants have been investigated to increase the time of analgesia and enhance the quality of the block in general.

The use of the alpha- 2 adrenergic receptor agonist, e.g. clonidine and dexmedetomidine, as an adjuvant to local anesthetic has come into the limelight of regional anesthesia [5]. These agents operate via central and peripheral actions (inhibition of the release of norepinephrine, hyperpolarization of the nerve cells and conditioning neurons to become less excitable). It has also been demonstrated that the addition of alpha 2 agonists improves both sensory and motor block properties, increases postoperative analgesia, and decreases systemic analgesic requirements [6]. In addition, they have sedative, anxiolytic and sympatholytic effects, which increase patient comfort and hemodynamic stability during surgery.

One of the earliest representatives of this group of agents was clonidine, an adjuvant in peripheral nerve blocks, a partial alpha2 -agonist [7]. It has been proved capable of increasing the duration of action of local anesthetics and reducing the control of postoperative pain without any serious adverse effects on its use in proper dosage. These mechanisms are suggested to be vasoconstriction in the injection site, direct inhibition of C- fiber transmission and aiding in potassium ion conductance within the excitable cells [8]. Nevertheless, clonidine has certain adverse effects that include its sedative and hypotensive properties, which are advantageous in certain surgical scenarios but may be used, at times, to restrict its clinical use especially in patients with cardiovascular instability.

Dexmedetomidine on the other hand is a newer, much more selective 2-adrenergic receptor agonist and its selectivity to the 2 receptors is about eight times higher than that of clonidine [9]. The greater receptor selectivity of it is translated into greater sedative and analgesic effects with lesser cardiovascular side effects when used at controlled doses. Compared with local anesthetics alone, adjuvant dexmedetomidine was proven to reduce the onset time of sensory and motor blocks, increase the length of the anesthesia and analgesia duration, and give a better postoperative pain relief. Enhancement of the quality of anesthesia is another benefit of the drug, which causes cooperative sedation without respiratory depression and is especially beneficial in the regional anesthesia.

A number of clinical researches have compared effectiveness of dexmedetomidine and clonidine as adjuvants in different regional anesthesia methods such as epidural, spinal, and peripheral nerve blocks. Most of these studies have implied that dexmedetomidine has a prolonged period of sensory and motor blockage and better analgesic effect than clonidine, although both medications are coupled with minimal side effects when administered prudently. Nevertheless, the comparative benefits of dexmedetomidine to clonidine in combination with ropivacaine in PNS-guided supraclavicular brachial plexus block are still a subject to research divergence in view of the differing study design, patient demographics, and anesthetic regimens that yielded divergent results.

Surgical procedures on the hand, wrist, and forearm, have better suited the supraclavicular brachial plexus block because it offers rapid and dense anesthesia of the upper extremity, and it is close to the nerve trunks. As a supplement to ropivacaine use, the dexmedetomidine or clonidine might increase the quality of the anesthesia, extend the postoperative analgesia time and patient satisfaction with the use of the painkiller, and decreasing the use of supplemental analgesics. Moreover, the sedative and anxiolytic effects of these agents may enhance the comfort and hemodynamic stability during the surgical events, which brings about positive results of the surgical procedures.

Methodology

Study Design: The present study was a prospective comparative observational study conducted to evaluate and compare the efficacy of dexmedetomidine and clonidine as adjuvants to ropivacaine in peripheral nerve stimulator (PNS) guided supraclavicular brachial plexus block for upper limb surgeries.

Study Area: The study was carried out in the Department of Anaesthesiology, Burdwan Medical College, Burdwan, West Bengal, India.

Study Duration: The study was conducted over a period of one and a half years, from July 2023 to December 2024.

Sample size: Study was conducted on 80 patients. Sample size calculation was done in accordance with the study by Krishnappa et al71 using the following formula:

$$N = \frac{2(Z_{\alpha/2} + Z_{\beta})^2 \sigma^2}{d^2}$$

Where N is the sample size in each group; Zα/2 = 1.96 corresponds to the two-tailed critical value at a 5% significance level (confidence level 95%); Zβ = 1.28 corresponds to the desired power of 90% (β error = 10%); d is the mean difference of clinical significance (3.0) and σ is the assumed standard deviation (4.15); therefore, the sample size was calculated using these parameters (α = 5%, β = 10%, power = 90%).

Putting the values, we got:

$$N = \frac{2(Z_{\alpha/2} + Z_{\beta})^2 \sigma^2}{d^2} = \frac{2(1.96 + 1.28)^2 (4.15)^2}{(3.0)^2} = 40$$

The total sample size required for this study was = (40x 2) = 80

Sample design: Subjects were serially taken until desired number (N=80) of patients were collected and divided into 2 groups of equal number of patients (n=40 per group).

Inclusion criteria:

- Age group-21-60years
- Gender-both male and female
- ASA physical status-Grade 1 or Grade 2
- Patients undergoing supraclavicular brachial plexus block for upper limb elective surgeries

Exclusion criteria:

- Patients not consenting for regional anaesthesia.
- Patients on any sedative or antipsychotics
- Patients with history of any cardiac/respiratory/hepatic/renal disorders.
- Pregnancy and lactation
- Patients allergic to drugs
- Patients with clotting disorder or local infection
- Non cooperative patients
- History of seizure or convulsion
- Any untreated comorbidities
- Need for blood transfusion during surgery
- History of alcohol or substance abuse
- Major intra-operative complications

Study variables:

- Onset of sensory block
- Onset of motor block
- Duration of sensory block
- Duration of motor block
- Duration of analgesia
- Respiratory rate
- Heart rate
- Blood pressure-SBP and DBP

Study tools:

- **Sensory block was assessed by pin prick test.**
    - Grade 0- no sensation felt
    - Grade 1- Dull sensation felt
    - Grade 2- Sharp pain felt
- **Motor block was assessed by modified BROMAGE scale.**
    - Grade 0- no movement
    - Grade 1- finger movement
    - Grade 2- flexion of wrist against gravity
    - Grade 3- extension of elbow against gravity
- **VAS score:**
    - 0-2 no pain
    - 3-5 mild pain
    - 6-7 moderate pain
    - 8-9 severe pain
    - 10 worst pain possible
- **Laboratory investigations:**
    - Hb%, TC, DC, ESR, platelets
    - ECG
    - Urea and creatinine levels of blood
    - PT / INR
    - Sodium and potassium levels in blood
- **Drugs:**

Patients receive 30 ml of ropivacaine 0.5% with 1ml (1µg/kg) clonidine (group RC) or will receive 30 of ropivacaine 0.5% with 1ml (1µg/kg) dexmedetomidine (group RD).

Study Procedure: The study was initiated by recruitment of the patients after permission was obtained by the Institutional Ethics Committee and the written informed consent was received by 80 counselled patients. Serial enrolment was conducted following the inclusion and exclusion criteria and the eligible participants were randomly split into two groups according to the adjuvant used with ropivacaine when performing the supraclavicular block of the brachial plexus, which included Group RC, which was to use ropivacaine with clonidine and Group RD, which was to use ropivacaine with dexmedetomidine. A comprehensive pre-anaesthetic check-up such as proper history taking, clinical examination and routine laboratory investigations were being done on all patients prior to the procedure. Intravenous access was achieved in the operation theatre and non-invasive blood pressure (NIBP), electrocardiography (ECG), and pulse oximetry were spectacle monitors, which were connected to capture baseline parameters. After administration of supraclavicular brachial plexus block using the adjuvants respectively, the onset and duration of the sensory and motor blocks, and duration of analgesia were observed. The beginning of sensory block was considered as the duration of time between the injection of the local anaesthetic and the loss of response to pinprick in the distribution of all three nerves, whereas the beginning of the motor block was considered as the time during which the complete motor paralysis was observed (Grade 0 of the Modified Bromage Scale). The sensory block period was determined as the period between total sensory block and early pain sensation felt during the postoperative period and motor block period was considered as the period between full paralysis and the period of full recovery of the motor activity. Analgesic period was considered as the period between the beginning of sensory block and the beginning of postoperative pain signaled by a Visual Analogue

Scale (VAS) score = 4, above which analgesic rescue was performed.

Statistical Analysis: Assuming p value <0.05 was significant and considering effect was two sided, we got Zα/2=1.96; assuming power of study to be 90% we got Zβ=1.28; considering Mean difference of 3.0 and standard deviation of 4.15 was statistically significant. We got n=40. Hence minimum 40 patients were taken in each group.

Statistical Methods: The data are tabulated in Microsoft excel and analysed with SPSS V.24 software. The continuous variables are presented with mean and standard deviation. The categorical variables are presented with frequency and percentage. Chi square test, independent t test is used for the statistical analysis. The p value ≤0.05 is considered statistically significant.

Ethical Considerations: The study was conducted only after obtaining due ethical clearance from the institutional ethical committee. Informed and written consent was taken from all participants before enrolment in the study. After receiving the approval of synopsis by WBUHS the research work was started Informed and written consent from each participant selected in the study population was taken.

Result

Table 1 gives the comparison of the onset of sensory block in the two groups. The average time of onset was much less in the RD group (5.1 ± 0.9 minutes) than in the RC group (10.65 ± 1.14 minutes), and the p-value of the difference was highly significant (0.001). This shows that the dexmedetomidine versus clonidine addition created an effect of an earlier onset of sensory block as the dexmedetomidine versus clonidine showed better results in earlier onset of sensory block as an adjuvant.

Table 1: Comparison of Onset of sensory block

Parameter	Group	Mean	SD	P value
Onset of sensory block (min)	RD	5.1	0.9	<0.001
	RC	10.65	1.14	

Table 2 shows the comparison of the onset of motor block of the two study groups. The overall motor block onset duration of RD group (Ropivacaine with Dexmedetomidine) was 10.23 ± 1.12minutes and RC group (Ropivacaine with Clonidine) was 14.8 ± 1.29 minutes. The effect between the two groups was observed to be very significant (p < 0.001) and this implies that dexmedetomidine when added to ropivacaine caused onset on motor block faster than clonidine. This result indicates that dexmedetomidine would be a better adjuvant agent compared to clonidine in ensuring an earlier motor block onset with supraclavicular brachial plexus block.

Table 2: Comparison of Onset of Motor Block

Parameter	Group	Mean	SD	P value
Onset of motor block (min)	RD	10.23	1.12	<0.001
	RC	14.8	1.29	

The comparison of the duration of sensory block in the two groups of the study is expressed in Table 3. The average sensory block time was also longer in the RD group (752.5 ± 5.9 minutes) than in the RC group (470.25 ± 29.39 minutes). The result of the comparison between the two groups was found to be significantly high (p < 0.001), which showed that the addition of dexmedetomidine (RD group) as an adjuvant to ropivacaine significantly extended the duration of the sensory block as compared to clonidine (RC group). This finding indicates that, dexmedetomidine offers a longer term sensory analgesic response, which improves the quality and the period of anesthesia.

Table 3: Comparison of Duration of Sensory Block

Parameter	Group	Mean	SD	P value
Duration of sensory block (min)	RC	470.25	29.39	<0.001
	RD	752.5	5.9	

Table 4 gives the comparison of the duration of motor block in the two study groups. The average motor block in the RC was 274.75 ± 28.19 minutes and in the RD was much higher 513.75 ± 20.34 minutes. The p-value (less than 0.001) shows that the difference between the two groups is very significant, implying that the use of dexmedetomidine as an adjuvant to ropivacaine (RD group) significantly increased the duration of motor block as opposed to clonidine (RC group).

Table 4: Comparison of Duration of Motor Block				
Parameter	**Group**	**Mean**	**SD**	**P value**
Duration of motor block (min)	RC	274.75	28.19	<0.001
	RD	513.75	20.34	

In Table 5, the duration of analgesia by the two study groups, RC and RD are compared. The average time of analgesia was also significant in the RD group (765.82 ± 104.48 minutes) as opposed to the RC group (464.27 ± 66.2 minutes). The p-value of the difference between the two groups was very significant, and it was below 0.001, which means that the use of dexmedetomidine as an adjuvant to ropivacaine was significantly associated with a longer duration of analgesia than that of clonidine.

Table 5: Comparison of Duration of Analgesia				
Parameters	**Group**	**Mean**	**SD**	**P value**
Duration of analgesia (min)	RC	464.27	66.2	<0.001
	RD	765.82	104.48	

The results on heart rate (HR) of the two groups, RC, and RD, at different times after administration of drugs is compared as shown in Table 6. In the case of baseline, mean heart rates of the RC group were 80.08 ± 5.91 and mean heart rates of the RD group were 80.8 ± 7.14 with no significant difference (p =0.622). At all the later time points (5, 10, 15, 20, 25, 30, 45, 60, 90 minutes), the mean values of the heart rate between the two groups were similar, and none of the differences were statistically significant (all $p > 0.05$). It means that both adjuvants, clonidine (RC) and dexmedetomidine (RD), were able to keep the levels of heart rates constant without any significant hemodynamic change throughout the period of observation.

Table 6: Comparison of Heart Rate (HR per minute)				
Time point	**Group**	**Mean**	**SD**	**P value**
Baseline	RC	80.08	5.91	0.622
	RD	80.8	7.14	
5 minutes	RC	82.25	7.49	0.247
	RD	84.38	8.76	
10 minutes	RC	82.13	9.06	0.345
	RD	83.93	7.85	
15 minutes	RC	81.5	7.14	0.49
	RD	82.7	8.31	
20 minutes	RC	81.53	9.22	0.865
	RD	81.18	9.08	
25 minutes	RC	79	11.88	0.502
	RD	80.68	10.25	
30 minutes	RC	80.35	11.48	0.601
	RD	79.03	11.08	
45 minutes	RC	78.75	12.14	0.968
	RD	78.85	10.11	
60 minutes	RC	80.55	13.69	0.723
	RD	79.5	12.7	
90 minutes	RC	82.95	7.98	0.539
	RD	80.95	7.98	

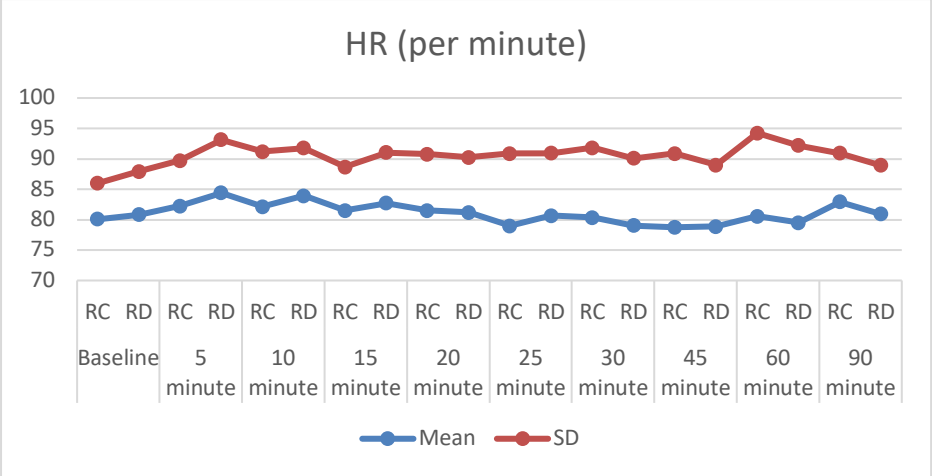

Figure 6: Comparison of Heart Rate (HR per minute)

Discussion

The results of the current research also indicate conclusively that, in PNS-guided supraclavicular brachial plexus block, the dexmedetomidine-ropivacaine adjuvant combination has better block properties than clonidine. Our study showed that the RD group of the study demonstrated a much faster onset of both sensory and motor blocks and a considerably longer anesthesia and postoperative analgesia period without severe hemodynamic instability. Such effects are in line with a number of past research that tested the use of α2-adrenergic agonists as local anesthetic adjuvants. Algesic response, which improves the quality and the period of anesthesia.

The first one in the current study is the mean onset time of sensory block, which was found to be 5.10 ± 0.90 in the RD group and 10.65 ± 1.14 in the RC group ($p < 0.001$). This has an earlier onset that is consistent with the results of Kataria et al. (2017) [10] who have also found a faster onset of sensory and motor block when using dexmedetomidine that included levobupivacaine (mean 6.3 ± 0.9 minutes) in supraclavicular block in comparison with clonidine (8.7 ± 1.1 minutes) with levobupivacaine. The authors explained it by the increased lipophilicity and receptor selectivity of dexmedetomidine that enables it to penetrate neural membranes and enhances the local anesthetic effect. On the same note, Jethani et al. (2020) [11] have found a greater onset of sensory and motor block with dexmedetomidine than with clonidine, which indicates more effective synergistic activity of dexmedetomidine with local anesthetics in peripheral nerve blocks. These findings confirm the outcomes of our study that dexmedetomidine will be an adjuvant acting faster than clonidine.

On the contrary, others had previously investigated the question with no statistically significant difference in early onset of the two adjuvants like Tripathi et al. (2016) [12]. Such discrepancies could be explained by the varying concentration of local anesthetic, volume and the method or route of delivery (ultrasound-guided and PNS-guided). Irrespective of such differences, the trend in the majority of the studies, including our own, is that dexmedetomidine tends to initiate anesthesia faster, a property that could be attributed to its high (1620:1) α2-adrenergic receptors affinity relative to clonidine (200:1), which increases hyperpolarization and results into faster nerve conduction blockade.

Among the most striking results in our study, the longtime sensory and motor block in the dexmedetomidine group was found. It had a mean sensory block duration of 752.50 ± 5.90 minutes in RD group and 470.25 ± 29.39 minutes in the RC group ($p < 0.001$). In the same way, the motor block took 513.75 and 274.75 minutes with a standard deviation of 20.34 and 28.19, respectively. These results are quite consistent with the results of Kanvee et al. (2015) [13] who found a sensory and motor block duration of 540.12 and 580.8 minutes, respectively, with the use of dexmedetomidine, respectively, and 346.6 and 386.4 with clonidine. These findings were also supported by Natarajan et al. [14] who found that using dexmedetomidine in supraclavicular block produced a much longer sensory block duration (602.5 ± 45.2 minutes) than 440.4 ± 51.6 minutes using clonidine mixed with ropivacaine. This increased period with dexmedetomidine could be explained by its presynaptic norepinephrine release and postsynaptic hyperpolarization of membrane that inhibit neuronal activity and prolong anesthetic effects.

Regarding the analgesia, it was found that the mean postoperative analgesic duration in the RD group was 765.82 minutes plus 66.20 minutes whereas in RC group is 464.27 ± 104.48 minutes ($p < 0.001$). This observation is in line with the reports of Swami et al. (2012) [15] who observed that dexmedetomidine (approximately 600 minutes) relative to clonidine (420 minutes) as an adjuvant to bupivacaine produced significantly longer analgesia.

Equally, an investigation by Abhishek and Nagarajan (2024) [16] revealed that patients of dexmedetomidine with ropivacaine in ultrasound-guided supraclavicular block had a mean analgesia duration of 720 minutes, which is better than 480 minutes using clonidine, supporting the evidence of the superior analgesic effect of dexmedetomidine. The prolonged analgesia is believed to be due to the central and peripheral 2-receptor-mediated regulation of nociceptive transmission at the dorsal horn with the resultant decreased substance P release and extended antinociceptive action of dexmedetomidine.

The hemodynamic stability of our research with the absence of substantial changes in heart rate or mean arterial pressure among the groups is consistent with previous researches (Shekhawat et al., 2018) [17]. Though both 2-agonists have sympatholytic effects which may result in bradycardia and hypotension, the effects were small and clinically irrelevant at the administered doses. This is congruent with the research conclusions presented by Muzi et al. (1992) [18] whose research showed that clonidine lowers sympathetic, but does not affect baroreflex, responses in normotensive patients, a similar property shared by dexmedetomidine at the correct doses. Our study results are similar to the hemodynamic effects of both agents, which supports the safety of both agents when administered under controlled doses.

On the other hand, other studies have also indicated a slight yet significant decrease in heart rate and systolic blood pressure in patients that were exposed to dexmedetomidine relative to clonidine, but these changes did not demand clinical intervention. As with the current results, the hemodynamic effects of dexmedetomidine were foreseeable and tolerable, which revealed the safety of the agent in terms of its adjuvant use in regional blocks. The observed sedative effect of dexmedetomidine which is considered mild and easily manageable may be beneficial in the clinical practice since it reduces the anxiety of patients and contributes to their intraoperative comfort without leading to respiratory depression. The risks of both agents were linked to the few side effects, mostly mild sedation and bradycardia, meaning that the application of α2-agonists in the right dosage is still clinically stable and effective.

Conclusion

The present study demonstrated that the addition of dexmedetomidine to ropivacaine in PNS-guided supraclavicular brachial plexus block significantly enhanced the quality of anesthesia compared to clonidine. Dexmedetomidine produced a faster onset of sensory and motor blockade, prolonged the duration of both sensory and motor effects, and extended postoperative analgesia without causing any significant hemodynamic instability or adverse effects. Both adjuvants maintained stable heart rates and blood pressures throughout the procedure, confirming their safety in clinical use. The superior efficacy of dexmedetomidine can be attributed to its higher α2-receptor selectivity, which results in enhanced neural hyperpolarization and longer analgesic action. Therefore, dexmedetomidine appears to be a more effective and reliable adjuvant than clonidine for improving block characteristics and patient comfort in upper limb surgeries.

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