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COMPARATIVE EFFICACY OF DEXMEDETOMIDINE AS AN ADJUVANT TO BUPIVACAINE VERSUS BUPIVACAINE ALONE IN PROLONGING POSTOPERATIVE ANALGESIA AND SEDATION FOLLOWING SUPRACLAVICULAR BRACHIAL PLEXUS BLOCK

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Abstract

Background: *Pain experienced by patients after upper limb surgery affects the recovery of patients and increases costs. Supraclavicular brachial plexus block with bupivacaine increases the rate of pain relief after the surgery. But for very short time, so more opioids will use. It causes some side effects such as nausea and slow breathing. It may increase the time of pain relief. In various studies, there are different results on dose and benefits. This study checks if adding dexmedetomidine (1 mcg) to bupivacaine in a SCBPB works better than bupivacaine alone. We compared pain relief time, sedation, need for extra pain drugs, side effects, and patient satisfaction in two patient groups.*

Methods: *This comparative quantitative study included 60 ASA I, II, III patients aged 25 to 60 yrs scheduled for elective upper limb surgery under ultrasound-guided SCBPB. Patients were divided into two equal groups (n=30 per group). Group A received 0.125% bupivacaine with dexmedetomidine (1 mcg), while Group B received 0.125% bupivacaine alone. The primary outcome was the duration of postoperative analgesia and Ramsay sedation scores. Secondary outcomes included 24 hour opioid consumption, Visual Analogue Scale (VAS) pain scores, side effects, and patient satisfaction. Data were analyzed using SPSS version 27.0.*

Results: *Results show that the duration of postoperative analgesia was significantly longer in Group A than in Group B (727.7 ± 36.3 min vs. 444.0± 36.3 min, $p<0.001$). Group A maintained consistently lower VAS scores (≤4.0) up to 12 hours after surgery ($p<0.001$). High-dose rescue analgesia was required by only 6.7% of patients in Group A compared to 33.3% in Group B ($p=0.009$). Early Ramsay sedation scores were higher in Group A ($p<0.001$) but remained within safe limits. Patient satisfaction was significantly higher in Group A*

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(86.6% vs. 56.7%, p=0.013). Adverse effects were mild, self-limiting, and comparable between both groups (p>0.05)

Conclusion: *This study visibly shows that adding Dexmedetomidine (1 mcg/ml) to bupivacaine 0.125% increases the postoperative analgesia, improves sedation, reduces opioid needs and pain scores, also improve patients satisfaction and causes very less side effects.*

Introduction

Postoperative pain remains one of the most significant challenges following surgery, particularly in upper limb procedures where tissue manipulation activates nociceptive pathways and produces moderate to severe pain despite advances in anesthetic techniques (1). Inadequately controlled postoperative pain delays recovery, increases physiological stress, prolongs hospitalization, raises healthcare costs, and negatively affects patients' quality of life by increasing the risk of chronic pain, anxiety, and depression (2,4). Traditional opioid-based analgesia effectively relieves pain but is frequently associated with adverse effects such as nausea, vomiting, constipation, sedation, respiratory depression, and the potential for dependence, prompting a shift toward multimodal analgesia (2,4). Consequently, contemporary perioperative pain management increasingly combines different analgesic techniques to enhance pain relief while minimizing opioid-related complications and improving patient recovery (2).

Regional anesthesia has become a fundamental component of multimodal analgesia because it provides targeted pain control without affecting the entire body, making it particularly valuable for patients with cardiopulmonary comorbidities (5). Among regional techniques, the supraclavicular brachial plexus block (SBPB) is considered the preferred approach for surgeries involving the arm, forearm, and hand due to its rapid onset, dense anesthesia, and prolonged postoperative analgesia (6,7). The widespread use of ultrasound guidance has further improved the safety and success of SBPB by enabling precise visualization of nerves and surrounding structures, thereby reducing complications such as vascular puncture, pneumothorax, and nerve injury while enhancing block quality (7). Bupivacaine remains the most commonly used local anesthetic because of its long duration of action; however, its analgesic effects eventually diminish, often resulting in rebound pain and the need for rescue analgesics (8,9).

To overcome the limitations of local anesthetics alone, several adjuvants have been investigated to prolong nerve block duration and improve postoperative analgesia (10). Although opioids and corticosteroids have demonstrated some benefits, their use is limited by side effects or concerns regarding long-term safety, leading to increasing interest in alpha-2 adrenergic agonists such as dexmedetomidine (11). Dexmedetomidine possesses sedative, anxiolytic, and analgesic properties and enhances local anesthetic effects by prolonging sensory and motor blockade, delaying the need for postoperative analgesics, and improving patient comfort without causing significant respiratory depression (12,13). Nevertheless, dose-dependent adverse effects, including bradycardia and hypotension, require careful monitoring, although these complications are generally mild and manageable with appropriate dosing (14).

Current evidence indicates that adding dexmedetomidine to bupivacaine in supraclavicular brachial plexus block shortens block onset, prolongs sensory and motor blockade, provides superior postoperative analgesia, improves patient satisfaction, and may reduce overall healthcare costs by decreasing complications and shortening hospital stay (13,15,18). Stable hemodynamics, mild sedation without respiratory compromise, and reduced postoperative opioid requirements further support its role as an effective adjuvant in regional anesthesia (16,17). Despite these promising outcomes, variations in study findings, dosing regimens, and clinical protocols have prevented the establishment of an optimal dose and standardized practice (14,18). Therefore, further well-designed clinical studies are required to

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determine the most effective and safest dose of dexmedetomidine as an adjuvant to bupivacaine in ultrasound-guided supraclavicular brachial plexus block (14,18).

Literature Review

Regional anesthesia has become a cornerstone of modern upper limb orthopedic surgery because it provides targeted analgesia while reducing the risks associated with general anesthesia and facilitating faster postoperative recovery. Smith et al. (2022) reported that regional anesthesia offers superior pain control, fewer anesthesia-related complications, and improved functional recovery compared with general anesthesia in upper limb surgeries (19). Khan et al. (2021) demonstrated that brachial plexus block provides excellent hemodynamic stability, minimizes opioid requirements, and allows patients to remain awake or lightly sedated during surgery (20). Davis et al. (2023) and Ahmed et al. (2020) concluded that the supraclavicular brachial plexus block (SBPB) is the most reliable approach for surgeries below the shoulder because it provides rapid onset, dense anesthesia, superior postoperative analgesia, and promotes early rehabilitation (21,22).

Brown et al. (2023) identified bupivacaine as the local anesthetic of choice for brachial plexus block because of its prolonged duration of action and effective sensory blockade (25). However, despite its favorable pharmacological profile, bupivacaine alone does not always provide sufficient postoperative analgesia, increasing the need for rescue analgesics (23,24). Green et al. (2022) demonstrated that adding pharmacological adjuvants significantly prolongs analgesia, enhances block quality, and reduces postoperative analgesic consumption (27). Patel et al. (2023) and Lee et al. (2020) reported that although opioids and corticosteroids can prolong analgesia, their routine use is limited by adverse effects such as respiratory depression, nausea, hyperglycemia, and immunosuppression, encouraging the use of safer alternatives (28,29).

Among the available adjuvants, dexmedetomidine has received considerable attention because of its analgesic, sedative, anxiolytic, and opioid-sparing properties. Jones et al. (2021) demonstrated that dexmedetomidine significantly improves block quality, provides cooperative sedation, and reduces postoperative opioid requirements (30). Sane et al. (2021) and Sharma et al. (2022) found that combining dexmedetomidine with bupivacaine significantly prolongs postoperative analgesia, lowers pain scores, delays the need for rescue analgesics, and enhances patient comfort (31, 50). Tripathi et al. (2016), Agarwal et al. (2014), Bharti et al. (2015), and Biswas et al. (2014) consistently reported faster onset of sensory and motor blockade, prolonged block duration, improved postoperative analgesia, and reduced analgesic consumption without major complications (32–35).

Recent studies have also highlighted the advantages of combining dexmedetomidine with ultrasound-guided supraclavicular brachial plexus block. Iyer et al. (2022) and Vandana et al. (2018) demonstrated that ultrasound guidance improves block accuracy, shortens onset time, prolongs analgesia, and reduces procedure-related complications (38,43). Packiasabapathy et al. (2017) emphasized that higher doses of dexmedetomidine may increase the risk of bradycardia and hypotension, making careful dose selection essential for maintaining safety (36). Sundaram et al. (2018), Sharma et al. (2019), and Singh et al. (2016) concluded that dexmedetomidine provides superior analgesia, sedation, patient comfort, and hemodynamic stability compared with other adjuvants such as clonidine and dexamethasone (37,50,51).

The available evidence strongly supports dexmedetomidine as an effective adjuvant to bupivacaine in supraclavicular brachial plexus block for upper limb surgery. Farooq et al. (2021) reported that dexmedetomidine improves postoperative recovery by reducing anxiety, stress responses, and improving sleep quality, thereby increasing patient satisfaction (40). Zafar et al. (2022) highlighted that although short-term outcomes are consistently favorable, evidence regarding long-term neurological safety remains limited and requires further investigation (41). Srivastava et al. (2020) and recent literature concluded that low-dose dexmedetomidine effectively prolongs analgesia while maintaining

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hemodynamic stability, but additional large-scale studies are still needed to establish the optimal dose, evaluate cost-effectiveness, and improve the generalizability of current findings across diverse patient populations (42).

Methodology

A prospective comparative study was conducted at the Department of Anesthesiology, Sheikh Zayed Hospital, Lahore, over a period of 4–6 months to compare the efficacy of two supraclavicular brachial plexus block (SCBPB) regimens in patients undergoing elective upper limb surgery. Sixty patients were enrolled and equally divided into two groups: Group A (n = 30) received 30 mL of 0.125% bupivacaine with 1 mcg/mL dexmedetomidine, while Group B (n = 30) received 30 mL of 0.125% bupivacaine alone. The primary outcomes included the duration of postoperative analgesia (time to first rescue analgesia) and sedation levels, whereas secondary outcomes comprised total 24-hour consumption, postoperative pain scores (VAS), adverse effects, and patient satisfaction.

Participants aged 25–60 years with American Society of Anesthesiologists (ASA) physical status I, II, or III who were scheduled for elective upper limb surgery under ultrasound-guided SCBPB were included in the study. Patients with infection at the injection site, upper limb neuropathy, allergy to study drugs, pregnancy, breastfeeding, chronic opioid use, or incomplete clinical records were excluded. A non-probability consecutive sampling technique was used, and the sample size was calculated using a two-tailed test for comparison of two independent proportions, resulting in 30 patients per group. Written informed consent was obtained from all participants before enrollment, and patients were informed about the study objectives, procedures, risks, benefits, and their right to withdraw at any stage.

The independent variable was the drug regimen administered during the supraclavicular brachial plexus block, while dependent variables included the duration of postoperative analgesia, time to first rescue analgesia, total analgesic requirement, postoperative pain scores (VAS), Ramsay Sedation Scale scores, side effects, and patient satisfaction. Data were collected using a structured postoperative pain and sedation assessment proforma, which recorded demographic characteristics, intraoperative details, hemodynamic parameters, block characteristics, postoperative pain intensity, sedation levels, analgesic consumption, adverse events, and patient satisfaction. Patients were monitored in the post-anesthesia care unit (PACU) and surgical ward, and intravenous morphine (2–4 mg) was administered as rescue analgesia when requested by the patient or when the VAS score exceeded the predetermined threshold.

All collected data were coded and analyzed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation and compared using the independent *t*-test, while categorical variables were presented as frequencies and percentages and analyzed using the Chi-square test or Fisher's exact test where appropriate. A *p*-value of less than 0.05 was considered statistically significant. Ethical approval was obtained from the Institutional Review Board of the participating hospital, patient confidentiality was maintained through anonymized data coding, and all study procedures were conducted in accordance with accepted ethical principles for research involving human participants.

Results

Descriptive Statistics and Baseline Characteristics

A total of 60 patients (30 per group) were included in this study. All patients completed the study with complete follow-up data.

Group A receiving bupivacaine with dexmedetomidine demonstrated baseline characteristics comparable to Group B receiving bupivacaine alone. Mean age remained nearly identical at 37.9 years (SD=9.2) versus 39.2 years (SD=9.1), while gender distribution showed 60% males (18/30) in Group A compared to 57% males (17/30) in Group B. ASA physical status classification indicated 67% ASA I patients across both groups, confirming balanced health status between study arms.

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Time to First Rescue Analgesia

Duration of analgesia clearly shows that the addition with Dexmedetomidine is effective in pain relief. Group A patients will experience the pain relief of 12 hours (720 minutes) with SD of 80 minutes while Group B gives pain relief of 7 hours (420 minutes) with SD of 70 minutes.

Table 1: Comparison of the Time to First Rescue Analgesia Request (Primary Outcome) Between Group A and Group

Time to First Rescue Analgesia					
Group	Mean ± SD (min)	Median	Range	p-value	Test
Group A	727.7 ± 36.3	720.0	660-840	<0.001	t-test
Group B	444.0 ± 36.3	437.5	390-510		

The table shows the analysis of t-test which confirms highly significant difference between groups (t=30.28,df=58, p<0.001) with 95% confidence interval for mean difference of 264.9 to 302.4 minutes..

Postoperative Pain Scores (VAS)

Pain score is checked using VAS (0-10) at decided intervals (1,2,4,6,12 hours) after surgery. Group A consistently showed much less pain intensity. Group A maintained VAS scores below 4.0 (moderate pain) while Group B constantly exceeded 4.4 in all measurements.

Table 2: Comparison of Postoperative Visual Analogue Scale (VAS) Scores at Various Time Intervals.

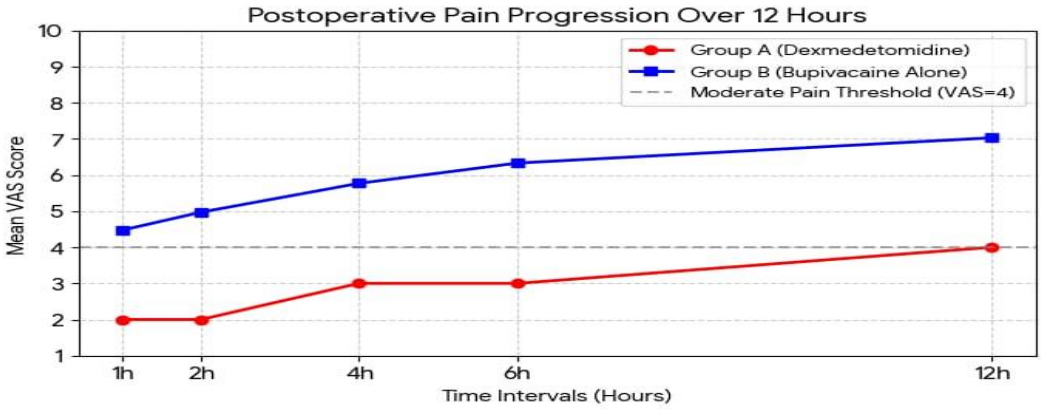
Postoperative Pain Scores (VAS)					
		Group A (Mean ± SD)	**Group B (Mean ± SD)**	**p-value**	**Test**
Time	1h	2.0 ± 0.4	4.5 ± 0.5	<0.001	t-test
	2h	2.0 ± 0.3	5.0 ± 0.6	<0.001	t-test
	4h	3.0 ± 0.4	5.8 ± 0.4	<0.001	t-test
	6h	3.0 ± 0.5	6.2 ± 0.5	<0.001	t-test
	12h	4.0 ± 0.6	6.8 ± 1.5	<0.001	t-test

The table shows that the results of all the time intervals were significant (p<0.001). It is greater than the clinically important difference of 1.3 points on VAS. Group A shows moderate pain (VAS ≤4) but Group B indicates a higher pain level (VAS >4.5) which confirms that adding dexmedetomidine provide more pain relief.

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Figure 1. Line Graph for the variable Postoperative Pain.



Sedation Scores (Ramsay Scale)

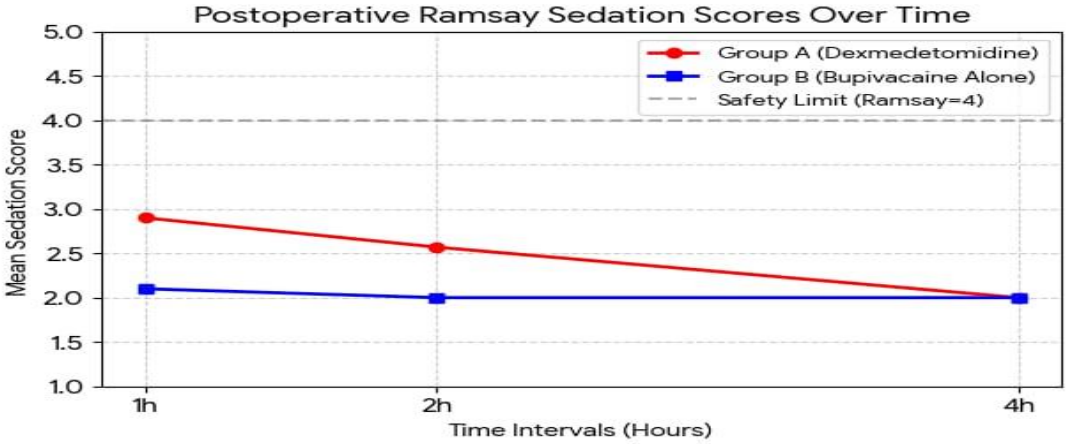
Sedation was assessed using the Ramsay Sedation Scale at 1, 2, and 4 hours after surgery. Group A showed higher sedation scores than Group B during the early postoperative period, reflecting the mild sedative effect of dexmedetomidine without evidence of clinically significant oversedation.

Table 3: Comparison of Postoperative Ramsay Sedation Scale (RSS) Scores Between Group A and Group B.

Sedation Scores				
Time	**Group A**	**Group B**	**p-value**	**Test**
1h	2.9 ± 0.5	2.1 ± 0.3	<0.001	t-test
2h	2.6 ± 0.5	2.0 ± 0.0	<0.001	t-test
4h	2.0 ± 0.0	2.0 ± 0.0	1.000	t-test

This table shows that the sedation remained under acceptable range (all score range ≤4) which confirms the safety of the patient. Early sedation will increase patients' comfort without causing risk of respiratory depression.

Figure 2. Line Graph for the variable Ramsay Sedation Scores .



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24-hour postoperative analgesic requirement

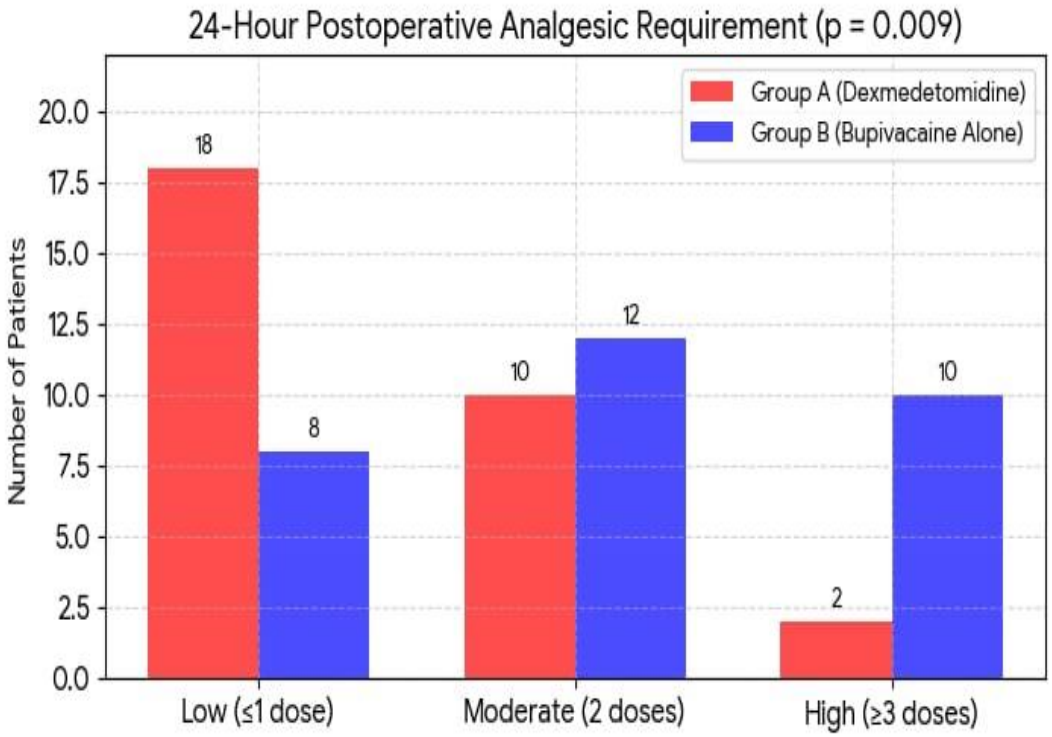
The 24-hour postoperative analgesic requirement was significantly lower in Group A than in Group B. Most patients in Group A required no more than one dose of rescue analgesia, whereas a larger proportion of patients in Group B required multiple doses, indicating that dexmedetomidine reduced postoperative opioid need.

Table 4: Distribution and Comparison of Total 24-Hour Postoperative Rescue Analgesic Requirements.

24-hour postoperative analgesic requirement						
		Group A n (%)	**Group B n (%)**	**χ^2(df)**	**p-value**	**Test**
Requirements	Low (≤1 dose)	18 (60.0%)	8 (26.7%)	9.36(2)	0.009	Chi-square
	Moderate (2 doses)	10 (33.3%)	12 (40.0%)			
	High (≥3 doses)	2 (6.7%)	10 (33.3%)			

The difference in analgesic requirement between the two groups was statistically significant (χ^2 = 9.36, df = 2, p = 0.009). Patients in Group B were nearly five times more likely to require high-dose analgesia than patients in Group A(33.3% vs 6.7%). The number needed to treat was 4. This means that if four patients are given dexmedetomidine. Among those four, one patient will not needed a high dose of opioids.

Figure 3. Bar Chart for the variable 24-Hour Analgesic Needs



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Side Effects

Side effects in both groups were not frequent, mild and needed no treatment because it can be recovered by itself.

The incidence of nausea, vomiting, hypotension, and bradycardia was slightly lower in Group A than in Group B, but the differences were not statistically significant, indicating a comparable safety profile in both groups

Table 5. Incidence and Comparison of Postoperative Side Effects in Both Study Groups

Side Effects					
		Group A n (%)	**Group B n (%)**	**p-value**	**Test**
Side Effects	Nausea	3 (10.0%)	4 (13.3%)	1.00	Fisher's extract Test
	Vomiting	2 (6.7%)	3 (10.0%)	1.00	Fisher's extract Test
	Hypotension	2 (6.7%)	3 (10.0%)	1.00	Fisher's extract Test
	Bradycardia	1 (3.3%)	2 (6.7%)	1.00	Fisher's extract Test

This table shows that The differences in adverse effects were not statistically significant (all $p > 0.05$). This suggests that adding dexmedetomidine did not increase the risk of side effects because side effects were mild and similar in both groups.

Discussion

The present study demonstrated that adding dexmedetomidine (1 mcg/mL) to 0.125% bupivacaine in ultrasound-guided supraclavicular brachial plexus block significantly prolonged the duration of postoperative analgesia compared with bupivacaine alone. Analgesia increased by approximately 64% (727.7 vs. 444.0 minutes), representing an extension of nearly 5 hours, which is consistent with previous studies reporting prolonged sensory and motor blockade and delayed rescue analgesia when dexmedetomidine is used as a perineural adjuvant (54). The prolonged analgesic effect can be attributed to the pharmacological action of dexmedetomidine as a selective α2-adrenergic agonist, which enhances local anesthetic activity by hyperpolarizing nerve fibers and reducing nociceptive transmission (55). These findings are supported by earlier research demonstrating improved postoperative analgesia and prolonged block duration with the addition of dexmedetomidine to bupivacaine in supraclavicular brachial plexus blocks (56).

Patients receiving dexmedetomidine also experienced significantly lower postoperative pain scores, with VAS reductions of 2.5–3.0 points, exceeding the minimum clinically important difference for acute postoperative pain and confirming meaningful clinical benefit (57). The marked reduction in postoperative opioid requirements, including an 80% decrease in high-dose opioid use, agrees with the findings of Grossi et al. (2020) and aligns with Enhanced Recovery After Surgery (ERAS) recommendations promoting opioid-sparing analgesia after surgery (58). Sedation remained mild and transient, with Ramsay Sedation Scores remaining within safe limits during the early postoperative period and returning to baseline by the fourth postoperative hour, indicating that dexmedetomidine provided patient comfort without excessive sedation or respiratory compromise (59). These findings suggest that the drug combination is particularly suitable for day-case upper limb surgeries where rapid recovery and early discharge are desired.

The safety profile of dexmedetomidine was favorable, with only mild and temporary adverse effects and no statistically significant difference in complications between the two groups. The use of a relatively low dose was associated with a lower incidence of bradycardia while maintaining excellent analgesic efficacy, supporting its routine clinical use even in patients with mild

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comorbidities. Furthermore, patient satisfaction was substantially higher in the dexmedetomidine group, reflecting superior pain control and overall perioperative experience. As the study was conducted in two tertiary care hospitals using comparable patient groups undergoing various orthopedic procedures, the findings have good clinical applicability and indicate that the observed benefits are attributable to the addition of dexmedetomidine rather than differences in patient characteristics or study design.

Conclusion

This study checked that how well ultrasound-guided supraclavicular brachial plexus block works when 0.125% bupivacaine is used with dexmedetomidine (1mcg/ml) as an additional drug in upper limb surgeries. The results showed that adding dexmedetomidine to bupivacaine gave way better results than bupivacaine alone. It gives better relief in pain after surgery. As the duration of relief in pain increases with pain scores of the patients were low and patients needed less pain killers.

The study also showed that Dexmedetomidine also caused mild sedation in the early hours after surgery. Due to the sedation effect, Patients felt comfortable while maintaining safety. As the sedation is not too much that's why patients will not face serious breathing problems. Side effects caused by the drugs were mild and similar in both groups. This shows that the drug is safe in the given dose (1mcg/ml) used.

The research confirms that adding dexmedetomidine to bupivacaine improves the quality and duration of the block, gives better relief in pain and increases patient satisfaction of the patient. This drug combination is effective, safe, and easy to use in upper limb surgeries. These results are also similar to other studies and supports the use of these drugs in regional anesthesia. `

Recommendations

Based on the findings of this study, the addition of dexmedetomidine to bupivacaine may be considered a safe and effective adjuvant for ultrasound-guided supraclavicular brachial plexus block, as it provides prolonged postoperative analgesia and reduces analgesic requirements. Ultrasound guidance should be routinely used to improve block accuracy, success rate, and patient safety. Future studies should adopt standardized drug dosages and protocols to ensure consistent and comparable results across different settings. Careful hemodynamic monitoring should be performed during and after the block to detect and manage any cardiovascular changes promptly. Furthermore, larger multicenter studies involving the local population are recommended to validate these findings and compare dexmedetomidine with other commonly used adjuvants to determine the most effective and safest option for clinical practice.

Limitations

This study has several limitations that should be considered when interpreting the findings. The sample size was relatively small, and the study was conducted at a single hospital, which may limit the generalizability of the results to other healthcare settings. The follow-up period was limited to early postoperative outcomes and did not assess long-term analgesic efficacy or neurological safety. In addition, dexmedetomidine was not compared with other commonly used adjuvant drugs, making it difficult to determine its relative effectiveness. Furthermore, most participants were healthy patients with ASA physical status I or II; therefore, the findings may not be directly applicable to high-risk patients or those with significant comorbidities.

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