



A PROSPECTIVE COMPARATIVE STUDY ON EFFECT OF FENTANYL AND DEXMEDETOMIDINE AS ADDITIVES TO ROPIVACAINE IN ULTRASOUND-GUIDED SUPRACLAVICULAR BRACHIAL PLEXUS BLOCK FOR ELECTIVE UPPER LIMB SURGERIES

*Dr. Mehak Shabir¹, Dr. Anjum Shamim², *Dr. Sabeeha Gul³

¹Postgraduate Scholar, Department of Anaesthesiology and Critical Care, Government Medical College Anantnag. India.drmehakshabir@gmail.com

²Associate Professor and Head, Department of Anesthesiology and Critical Care, Government Medical College Anantnag, India. Anj.khan786@gmail.com

³Assistant professor, Department of Radiology, Government Medical College Srinagar, India. geminigul@gmail.com

***Corresponding Author: *Dr. Sabeeha Gul**

Assistant professor, Department of Radiology, Government Medical College Srinagar, India.
Mail id: geminigul@gmail.com

Abstract

Background: Ultrasound-guided supraclavicular brachial plexus block (SCBPB) is a widely accepted regional anesthetic technique for upper limb surgeries. Ropivacaine is commonly used because of its favorable safety profile; however, its duration of analgesia may be limited when used alone. Adjuvants such as fentanyl and dexmedetomidine are therefore added to improve block characteristics and postoperative analgesia.

Objectives: To compare fentanyl and dexmedetomidine as additives to 0.5% ropivacaine in ultrasound-guided supraclavicular brachial plexus block with respect to onset and duration of sensory and motor block, postoperative analgesia, hemodynamic parameters, and adverse effects.

Methods: This prospective comparative study was conducted on 68 patients aged 18–60 years, classified as ASA physical status I or II, undergoing elective upper limb surgeries. Patients were randomized into two groups: Group F (n = 34) received 30 mL of 0.5% ropivacaine with fentanyl (1 µg/kg), and Group D (n = 34) received 30 mL of 0.5% ropivacaine with dexmedetomidine (1 µg/kg). The onset and duration of sensory and motor block, duration of postoperative analgesia, Visual Analogue Scale (VAS) scores, rescue analgesic requirement, intraoperative hemodynamic parameters, and adverse events were recorded and analyzed.

Results: The onset of sensory block was significantly faster in Group D compared to Group F (1.8 ± 0.3 vs 2.5 ± 0.7 minutes; $p < 0.001$), as was the onset of motor block (3.4 ± 0.8 vs 5.5 ± 1.1 minutes; $p < 0.001$). The duration of sensory block (785.3 ± 107.7 vs 674.1 ± 75.7 minutes), motor block (754.6 ± 117.1 vs 637.1 ± 84.8 minutes), and postoperative analgesia (1121.5 ± 190.6 vs 915.5 ± 164.1 minutes) was significantly longer in Group D ($p < 0.001$). Postoperative pain scores were consistently lower and the total rescue analgesic requirement was significantly reduced in the dexmedetomidine group (53.9 ± 22.8 mg vs 68.5 ± 26.8 mg; $p < 0.001$). Dexmedetomidine was associated with lower heart rate and blood pressure during the early intraoperative period, while

oxygen saturation remained stable and comparable between both groups. The incidence of adverse effects was similar in the two groups.

Conclusion: Dexmedetomidine is a superior adjuvant to fentanyl when added to 0.5% ropivacaine for ultrasound-guided supraclavicular brachial plexus block, providing faster onset, prolonged block duration, improved postoperative analgesia, and stable hemodynamic profile without an increase in adverse effects.

Keywords: Supraclavicular brachial plexus block; Dexmedetomidine; Fentanyl; Ropivacaine; Ultrasound guidance; Postoperative analgesia

INTRODUCTION

The use of regional anesthesia for upper limb surgeries has become increasingly popular in recent years [1]. This type of anesthesia provides a more targeted approach to pain management, allowing for quicker recovery times and reduced risk of systemic side effects compared to general anesthesia [2]. One of the most commonly used techniques for upper limb surgery is the brachial plexus block (BPB). In the brachial plexus block, a local anesthetic is injected into the brachial plexus to provide nerve block coverage of the arm and hand [3]. Of the four commonly utilized approaches to brachial plexus blocks, viz. interscalene, supraclavicular, infraclavicular, or axillary, the supraclavicular brachial plexus block approach is one of the most commonly performed in day-to-day anesthesiology practice [4]. Supraclavicular approach for brachial plexus block achieves anesthesia of the entire upper extremity just distal to the shoulder [3]. In the recent years, this block is performed under ultrasonography guidance. Ultrasound use in regional anesthesia in general and supraclavicular brachial plexus block in particular has been observed to offer many benefits to both the anesthesiologist as well as the patients. These benefits including a higher success rate, shorter time to onset of blocks, possibly better quality of sensory block, and reduction of the incidence of pneumothorax and systemic toxicity [5].

Ropivacaine is a commonly used local anesthetic for BPB [6]. It is a long-acting local anesthetic of the amide group, and works by reversibly blocking the entry of sodium into the nerve cell membranes, leading to decreased membrane permeability to sodium and raised threshold for nerve excitability. This in turn slows nerve conduction and reduces rate of rise of action potential. Ropivacaine is the preferred anesthetic drug for BPB due to its relatively long duration of action and low toxicity profile. However, the use of ropivacaine alone may not provide adequate pain control, especially in the postoperative period. Therefore, adjuvants, such as opioids and alpha-2 agonists, are often times added to ropivacaine to enhance their pain-relieving properties. [7]

Fentanyl is a potent synthetic opioid that is frequently used as an adjuvant to local anesthetics. Fentanyl is a tertiary amine and phenylpiperidine derivative. More than 1000 times more potent than meperidine and around 100 times more potent than morphine, fentanyl is one of the most widely used analgesic in anesthesiology. It has a rapid onset of action and provides effective pain relief. [8] However, the use of fentanyl is associated with certain side effects, such as respiratory depression, nausea and vomiting, and increased risk of opioid-related adverse events. [9]

Dexmedetomidine is a highly selective alpha-2 agonist that is increasingly being used as an adjuvant to local anesthetics for regional anesthesia. [10] Dexmedetomidine is a stereoisomer of medetomidine, having a greater selectivity for alpha-2 receptors than other agents of its class (α_2 : α_1 ratio of 1620:1 vs. 220:1). As central alpha-1 adrenoceptor activation counteracts the sedative alpha-2 effects, dexmedetomidine has a high sedative potency. Furthermore, an added benefit of dexmedetomidine based intraoperative sedation is that the patients remain easily arousable. [11] This particular characteristic added with its anxiolytic features and little to no respiratory depression makes it a very viable and widely used intraoperative sedative in surgeries. [12] It has been shown to

provide effective pain relief and improve the quality of anesthesia. Unlike opioids, dexmedetomidine does not have any respiratory depressant effects, and it has a low risk of causing nausea and vomiting. Additionally, dexmedetomidine has been shown to reduce the need for supplemental analgesia and improve postoperative outcomes.[6]

Since intraoperative and postoperative pain management is a crucial responsibility of any anesthesiologist, there is always an ongoing search for the best agent to manage such pain during different procedures. While research has been done on the topic of BPB, the search for the ideal additive to ropivacaine in ultrasound-guided supraclavicular brachial plexus block has proven to be elusive. This is because of the fact that some studies have shown benefits of using one drug over the other, while others showing no significant differences.[13,14] Furthermore, research of such nature have been few and far between in India, especially in socioeconomically disadvantaged and hard-to-reach areas of the country, such as the mountainous union territory of Jammu and Kashmir. In this context the present study will be conducted in order to evaluate the effect of dexmedetomidine and fentanyl as additives to 0.5% ropivacaine during ultrasound guided brachial plexus block in elective upper limb surgeries with respect to the postoperative pain and recovery among the patients in a secondary care institution of Anantnag, Jammu and Kashmir, India.

Materials and Methods

Study Design and Setting

This prospective comparative study was conducted in the Department of Anaesthesiology and Critical Care at a tertiary care teaching hospital after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrollment.

Study Population

The study included **68 patients** of either sex, aged **18–60 years**, classified as **American Society of Anesthesiologists (ASA) physical status I or II**, scheduled for elective upper limb surgeries under ultrasound-guided supraclavicular brachial plexus block.

Inclusion Criteria

- Age between 18 and 60 years
- ASA physical status I or II
- Patients scheduled for elective upper limb surgeries
- Willingness to provide informed consent

Exclusion Criteria

- Patient refusal
- ASA physical status III or IV
- Known hypersensitivity to ropivacaine, fentanyl, or dexmedetomidine
- Patients on sedatives or hypnotic drugs
- History of uncontrolled hypertension, cardiovascular disease, psychiatric illness, severe diabetes, autonomic neuropathy, or hyperthyroidism
- Infection at the site of block
- History of alcohol or drug abuse

Sample Size

The sample size was calculated based on previous literature considering the difference in onset of motor block between dexmedetomidine and fentanyl groups, with a significance level of 10% and power of 80%. The calculated sample size was **34 patients per group**, making a total of **68 patients**.

Randomization and Group Allocation

Patients were allocated into two groups using the **Sequentially Numbered Opaque Sealed Envelope (SNOSE)** method to ensure randomization and allocation concealment.

- **Group F (n = 34):** Received 30 mL of 0.5% ropivacaine with fentanyl 1 µg/kg
- **Group D (n = 34):** Received 30 mL of 0.5% ropivacaine with dexmedetomidine 1 µg/kg

Preoperative Preparation

All patients underwent a detailed pre-anesthetic evaluation, including history, general and systemic examination, airway assessment, and routine investigations. Patients were kept fasting for at least 8 hours prior to surgery. Oral alprazolam 0.5 mg was administered the night before surgery.

On arrival in the operating room, baseline vital parameters including heart rate, blood pressure, respiratory rate, and oxygen saturation were recorded. An intravenous line was secured using an 18-gauge cannula, and lactated Ringer's solution was initiated. Premedication included intravenous ondansetron 4 mg, ranitidine 50 mg, and midazolam 0.03 mg/kg.

Block Technique

Ultrasound-guided supraclavicular brachial plexus block was performed under strict aseptic precautions using a high-frequency linear ultrasound probe. The brachial plexus was identified lateral to the subclavian artery using the in-plane technique. After negative aspiration, the study drug solution as per group allocation was injected incrementally to achieve circumferential spread around the plexus.

Assessment of Block Characteristics

- **Onset of sensory block** was assessed using the pin-prick method and defined as the time from completion of drug injection to loss of sensation.
- **Onset of motor block** was assessed using the modified Bromage scale and defined as the time to achieve complete motor blockade.

Patients were assessed at **5, 10, 15, 20, and 30 minutes** after block administration. Patients with inadequate block after 30 minutes were excluded from the study.

Duration of Block and Analgesia

- **Duration of sensory block** was defined as the time from onset of complete sensory block to the first complaint of pain requiring rescue analgesia.
- **Duration of motor block** was defined as the time from onset of motor block to complete recovery of motor function.
- **Duration of analgesia** was defined as the time from block administration to the first request for rescue analgesia.

Hemodynamic Monitoring

Heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, respiratory rate, and oxygen saturation were recorded at baseline, every 5 minutes for the first 30 minutes, and thereafter at 40 and 60 minutes intraoperatively.

Postoperative Pain Assessment

Postoperative pain was assessed using the **Visual Analogue Scale (VAS)** at regular intervals up to 24 hours postoperatively. Rescue analgesia was administered when $VAS \geq 4$ using intravenous diclofenac 1 mg/kg. If pain persisted, intravenous tramadol 0.5 mg/kg and paracetamol 1 g were administered. The total rescue analgesic requirement over 24 hours was recorded.

Adverse Events

Patients were monitored for adverse effects such as bradycardia, hypotension, nausea, vomiting, and any other complications during the intraoperative and postoperative periods.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using **Statistical Package for Social Sciences (SPSS) version 22**. Continuous variables were expressed as mean $\pm$ standard deviation, and categorical variables as frequencies and percentages. Intergroup comparisons were performed using the independent t-test for continuous variables and chi-square test for categorical variables. A **p-value** < 0.05 was considered statistically significant.

RESULTS

A total of **68 patients** scheduled for elective upper limb surgeries under ultrasound-guided supraclavicular brachial plexus block were included in the study. Patients were equally divided into two groups: **Group F (Fentanyl, n = 34)** and **Group D (Dexmedetomidine, n = 34)**. The results are presented as follows.

Baseline Demographic and Surgical Characteristics

To ensure comparability between the two study groups, baseline demographic variables and surgical characteristics were analyzed.

Table 1. Baseline demographic and surgical profile of study participants (n = 68)

Parameter	Fentanyl (n=34)	Dexmedetomidine (n=34)	p-value
Age <40 years	9 (26.5%)	7 (20.6%)	0.724
Age 40–49 years	11 (32.4%)	14 (41.2%)	
Age $\geq$ 50 years	14 (41.2%)	13 (38.2%)	
Male	21 (61.8%)	17 (50.0%)	0.329
Female	13 (38.2%)	17 (50.0%)	
Rural residence	17 (50.0%)	19 (55.9%)	0.627
Urban residence	17 (50.0%)	15 (44.1%)	
Duration of surgery (min, Mean $\pm$ SD)	125.6 $\pm$ 12.7	120.5 $\pm$ 12.9	0.109

There were no statistically significant differences between the two groups with respect to age distribution, sex, residence, or duration of surgery, indicating that both groups were comparable at baseline.

Table 2. Onset of sensory and motor block (minutes)

Parameter	Fentanyl (Mean $\pm$ SD)	Dexmedetomidine (Mean $\pm$ SD)	p-value
Onset of sensory block	2.5 $\pm$ 0.7	1.8 $\pm$ 0.3	$<0.001^*$
Onset of motor block	5.5 $\pm$ 1.1	3.4 $\pm$ 0.8	$<0.001^*$

The onset of both sensory and motor block was significantly faster in the dexmedetomidine group compared to the fentanyl group.

Table 3. Duration of sensory block, motor block, and analgesia (minutes)

Parameter	Fentanyl (Mean $\pm$ SD)	Dexmedetomidine (Mean $\pm$ SD)	p-value
Duration of sensory block	674.1 $\pm$ 75.7	785.3 $\pm$ 107.7	$<0.001^*$
Duration of motor block	637.1 $\pm$ 84.8	754.6 $\pm$ 117.1	$<0.001^*$
Duration of analgesia	915.5 $\pm$ 164.1	1121.5 $\pm$ 190.6	$<0.001^*$

Dexmedetomidine significantly prolonged sensory block, motor block, and postoperative analgesia compared to fentanyl.

Table 4. Postoperative VAS scores over 24 hours

Time (hours)	Fentanyl (Mean $\pm$ SD)	Dexmedetomidine (Mean $\pm$ SD)	p-value
2	3.2 $\pm$ 0.6	2.1 $\pm$ 0.7	<0.001*
4	3.8 $\pm$ 0.5	1.1 $\pm$ 0.6	<0.001*
6	3.2 $\pm$ 0.8	2.2 $\pm$ 0.5	0.025*
8	3.2 $\pm$ 0.9	0.0 $\pm$ 0.0	<0.001*
16	4.1 $\pm$ 0.8	1.3 $\pm$ 0.3	<0.001*

Postoperative VAS scores were consistently lower in the dexmedetomidine group at most time points, indicating superior postoperative analgesia.

Table 5. Total rescue analgesic dose (mg)

Group	Mean $\pm$ SD	p-value
Fentanyl	68.5 $\pm$ 26.8	<0.001*
Dexmedetomidine	53.9 $\pm$ 22.8	

Patients receiving dexmedetomidine required significantly lower doses of rescue analgesics.

Table 6. Incidence of adverse events

Adverse event	Fentanyl n (%)	Dexmedetomidine n (%)	p-value
Bradycardia	3 (8.8)	3 (8.8)	0.757
Hypotension	2 (5.9)	2 (5.9)	
Nausea	6 (17.6)	3 (8.8)	
None	23 (67.6)	26 (76.5)	

The incidence of adverse events was comparable between the two groups, with no statistically significant difference.

All intraoperative hemodynamic parameters were combined into a single consolidated table for clarity.

Figure 1 Comparison of hemodynamic parameters between groups (Mean $\pm$ SD)

Figure 1a; Heart rate and SBP

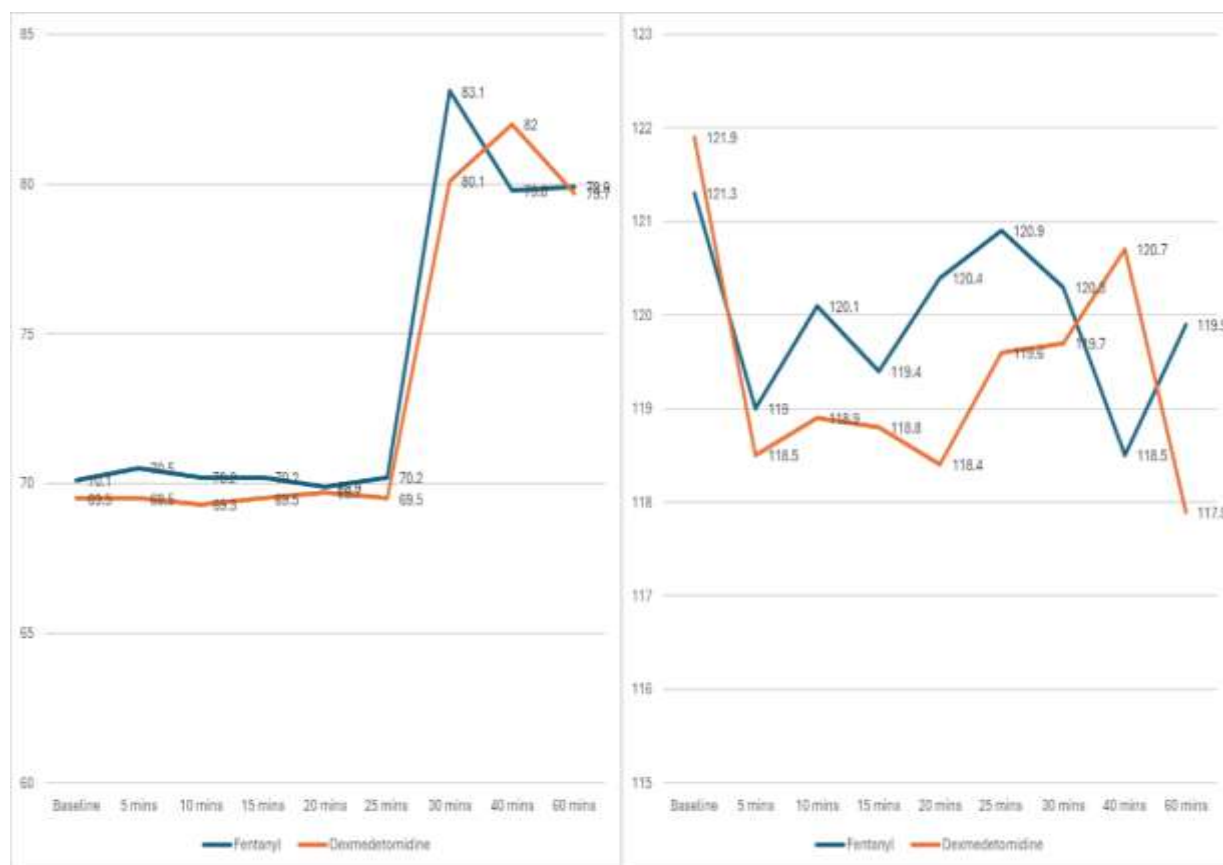


Figure 1b: DBP AND MAP

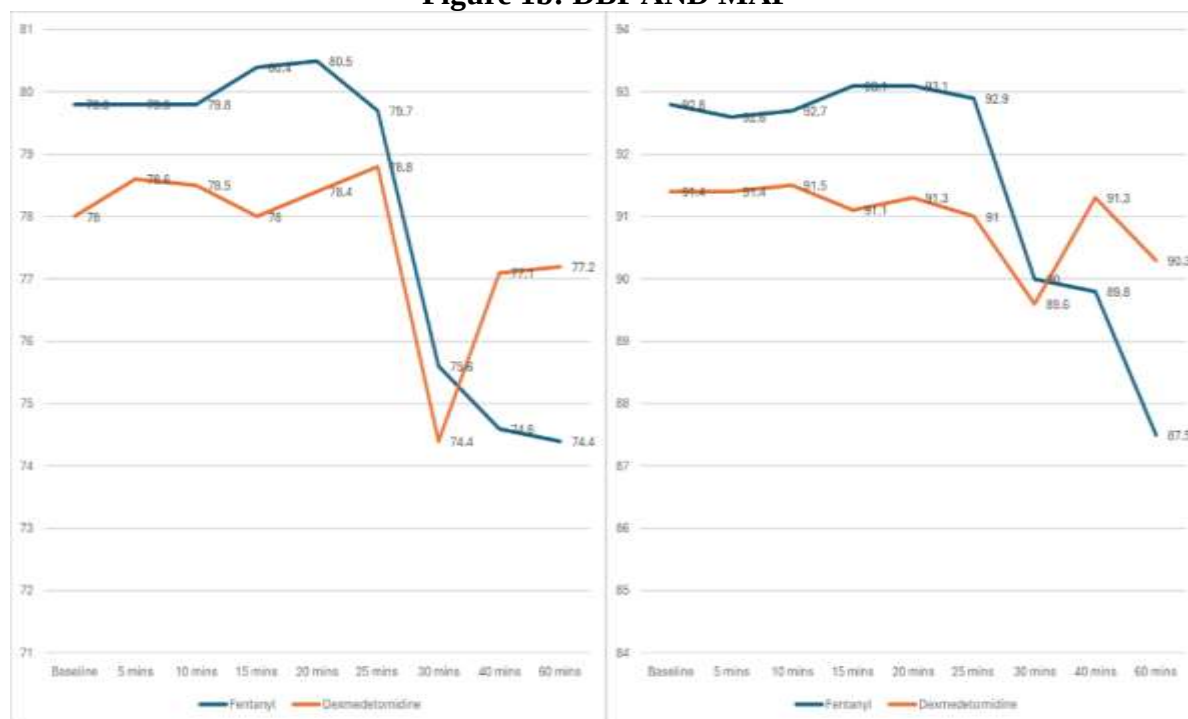
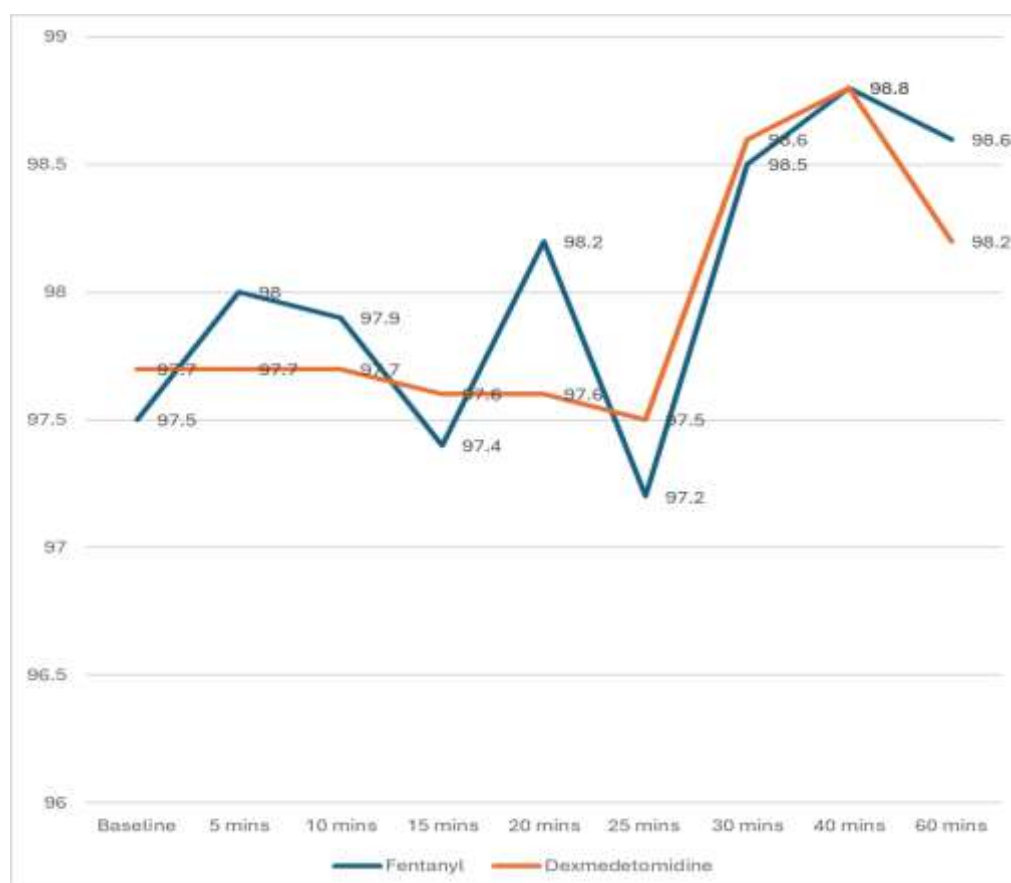
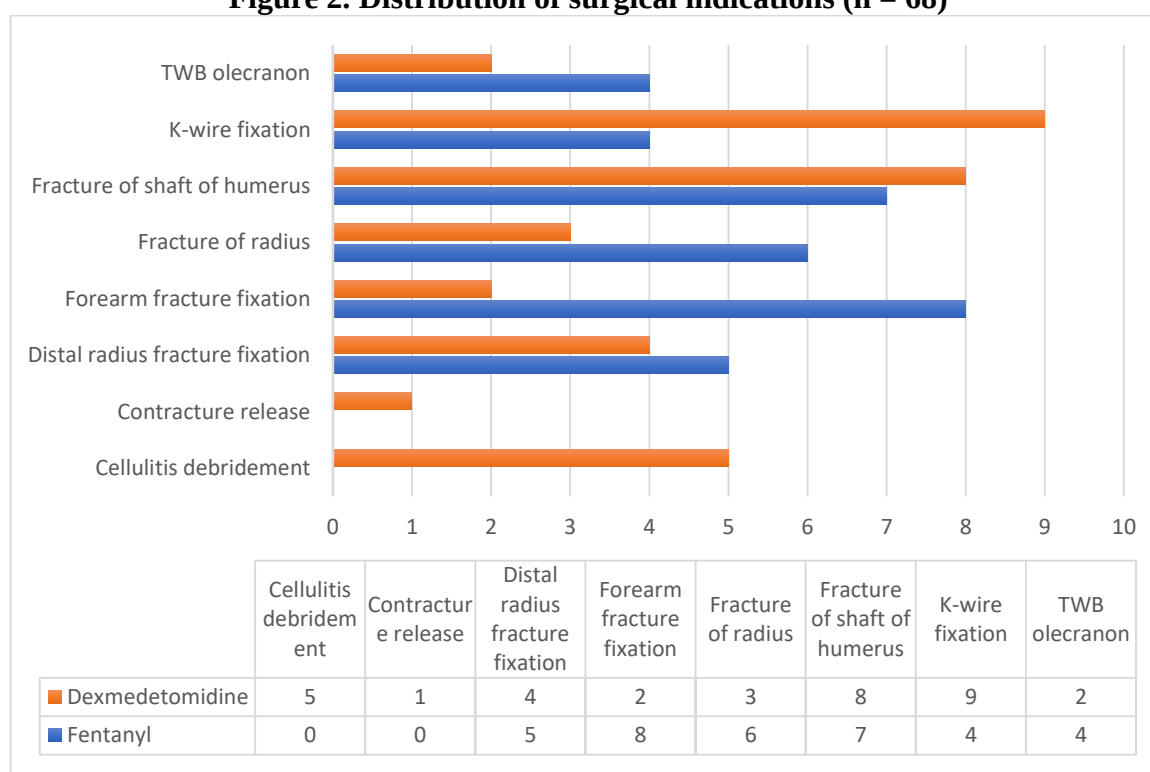


Figure 1c: Spo2



Dexmedetomidine was associated with a statistically significant reduction in heart rate and blood pressure during the early intraoperative period; however, oxygen saturation remained stable and comparable in both groups throughout surgery.

Figure 2. Distribution of surgical indications (n = 68)



The distribution of surgical indications was comparable between the two groups, with no statistically significant difference.

Discussion

The present prospective comparative study evaluated the effects of dexmedetomidine and fentanyl as adjuvants to 0.5% ropivacaine in ultrasound-guided supraclavicular brachial plexus block for elective upper limb surgeries. The findings of this study demonstrated significant advantages of dexmedetomidine over fentanyl with respect to onset of block, duration of sensory and motor blockade, postoperative analgesia, rescue analgesic requirement, and hemodynamic stability.

The demographic profile of the study population was comparable between the two groups, with no statistically significant difference in age distribution, sex, or residential background. This indicates adequate randomization and minimizes the influence of confounding variables. Similar demographic characteristics have been reported in previous studies evaluating supraclavicular brachial plexus block by **Hamed et al.(15)** and **Sahi et al.(16)**, supporting the external validity of the present findings. The range of surgical indications observed in the study further highlights the versatility of supraclavicular brachial plexus block for upper limb procedures, a finding consistent with earlier reports by **Cham et al.(17)** and **Dharmarao et al.(18)**.

The onset of sensory and motor blockade is a critical determinant of the clinical efficacy of regional anesthesia. In the present study, dexmedetomidine produced a significantly faster onset of both sensory and motor block compared to fentanyl. This finding can be attributed to dexmedetomidine's pharmacological action as a highly selective α -2 adrenergic receptor agonist, which reduces norepinephrine release and causes hyperpolarization of neuronal membranes, thereby enhancing the effect of local anesthetics. Similar observations have been reported by **Umamaheshwar et al.(19)** and **Tyagi et al.(20)**, who demonstrated significantly shorter onset times with dexmedetomidine when used as an adjuvant in supraclavicular brachial plexus blocks.

Fentanyl, although an effective opioid analgesic, primarily acts by binding to μ -opioid receptors and modulating pain perception rather than directly influencing nerve conduction. This mechanism likely explains the relatively slower onset of blockade observed with fentanyl. Comparable findings have been reported by **Swaroet al.(21)** and **Kaur et al.(16)**, where dexmedetomidine consistently outperformed fentanyl in terms of block onset. The faster onset associated with dexmedetomidine is clinically advantageous, particularly in high-volume operating rooms, as it reduces waiting time and improves workflow efficiency.

The duration of sensory and motor blockade was significantly prolonged in the dexmedetomidine group compared to the fentanyl group. Dexmedetomidine extended both sensory and motor block durations, underscoring its superior ability to sustain neural blockade. These findings are consistent with those reported by **Farooq et al.(22)**, **Sahi et al.(23)**, and **Dharmarao et al.(18)**, all of whom observed longer block durations with dexmedetomidine compared to fentanyl. The prolonged blockade produced by dexmedetomidine is mediated through both peripheral and central mechanisms, including increased nerve membrane hyperpolarization and suppression of sympathetic outflow.

In contrast, fentanyl prolongs analgesia primarily through opioid-mediated modulation of pain pathways without significantly affecting nerve conduction. Studies by **Lee et al.(24)** and **Yadav et al.(25)** have similarly demonstrated that while fentanyl enhances block duration compared to local anesthetic alone, it is inferior to dexmedetomidine in sustaining sensory and motor blockade.

Postoperative analgesia was significantly superior in the dexmedetomidine group, as evidenced by a longer duration of analgesia, lower postoperative VAS scores over 24 hours, and reduced rescue analgesic requirement. Dexmedetomidine exerts its analgesic effects by acting on α -2 adrenergic receptors in the dorsal horn of the spinal cord, inhibiting the release of nociceptive neurotransmitters and suppressing pain transmission. These findings are in agreement with those reported by **Hashim et al.(26)** and **Patra et al.(27)**, who demonstrated prolonged postoperative analgesia and reduced analgesic consumption with dexmedetomidine compared to fentanyl.

Hemodynamic stability is an important consideration in regional anesthesia. In the present study, dexmedetomidine was associated with lower heart rate and mean arterial pressure during the intraoperative period while maintaining values within clinically acceptable limits. This reflects its sympatholytic action mediated through central α -2 adrenergic receptor activation. Similar hemodynamic profiles have been reported by **Lotfy et al.(28)** and **Dharmarao et al.(18)**. In contrast, fentanyl lacks a direct sympatholytic effect and primarily reduces cardiovascular responses indirectly by alleviating pain, which may explain the greater hemodynamic variability observed in the fentanyl group, as also noted by **Tyagi et al.(20)** and **Hamed et al.(15)**.

The requirement for rescue analgesics was significantly lower in the dexmedetomidine group, further supporting its superior analgesic efficacy. Reduced postoperative analgesic consumption has been similarly reported by **Lotfy et al.(28)** and **El-Raouf et al.(29)**. Lower rescue analgesic requirements not only enhance patient comfort but also reduce drug-related adverse effects and overall healthcare costs. Studies by **Ghasemi et al.(30)** and **Hamed et al.(15)** have reported higher postoperative analgesic requirements with fentanyl, reinforcing the findings of the present study.

Conclusion

In conclusion, dexmedetomidine offers distinct clinical advantages over fentanyl as an additive to ropivacaine for supraclavicular brachial plexus block and can be safely recommended for routine use in elective upper limb surgeries, particularly in settings where prolonged postoperative analgesia and hemodynamic stability are desired.

Conflict of interest: Nil

Funding: Nil

References

1. Mannion S. Regional anaesthesia for upper limb trauma: a review. *Anestezia Regională pentru Traumatismele Membrului Superior*. 2013;20(1):49–59.
2. Griffin J, Nicholls B. Ultrasound in regional anaesthesia. *Anaesthesia*. 2010;65(Suppl 1):1–2.
3. Vermeylen K, Engelen S, Sermeus L, Soetens F, Van de Velde M. Supraclavicular brachial plexus blocks: review and current practice. *Acta Anaesthesiol Belg*. 2012;63(1):15–21.
4. Bruce BG, Green A, Blaine TA, Wesner LV. Brachial plexus blocks for upper extremity orthopaedic surgery. *J Am Acad Orthop Surg*. 2012;20(1):38–47.
5. Li JW, Songthamwat B, Samy W, Sala-Blanch X, Karmakar MK. Ultrasound-guided costoclavicular brachial plexus block: sonoanatomy, technique, and block dynamics. *Reg Anesth Pain Med*. 2017;42(2):233–40.
6. Kathuria S, Gupta S, Dhawan I. Dexmedetomidine as an adjuvant to ropivacaine in supraclavicular brachial plexus block. *Saudi J Anaesth*. 2015;9(2):148.
7. Das A, Majumdar S, Halder S, Chattopadhyay S, Pal S, Kundu R, et al. Effect of dexmedetomidine as adjuvant in ropivacaine-induced supraclavicular brachial plexus block: a prospective, double-blinded, randomized controlled study. *Saudi J Anaesth*. 2014;8(Suppl 1):S72.
8. Kaur M, Kaur R, Kaur S, Baghla N, Bansal A, Kalia A, et al. A study to compare the analgesic efficacy of dexmedetomidine and fentanyl as adjuvants to levobupivacaine in ultrasound-guided supraclavicular brachial plexus block. *Anesth Essays Res*. 2018;12(3):669–75.
9. Cham SC, Sangawar MA, Ramtani UL, Chavan BS, Cham C. Comparison of the effects of fentanyl and dexmedetomidine in supraclavicular brachial plexus block achieved with ropivacaine. *J Evol Med Dent Sci*. 2015;4(54):9427–37.
10. Kaur S, Attri JP, Kaur G, Singh TP. Comparative evaluation of ropivacaine versus dexmedetomidine with ropivacaine in epidural anesthesia for lower limb orthopedic surgeries. *Saudi J Anaesth*. 2014;8(4):463–69.

11. Ishii H, Kohno T, Yamakura T, Ikoma M, Baba H. Action of dexmedetomidine on substantia gelatinosa neurons of the rat spinal cord. *Eur J Neurosci*. 2008;27(12):3182–90.
12. Weerink MAS, Struys MMRF, Hannivoort LN, Barends CRM, Absalom AR, Colin P. Clinical pharmacokinetics and pharmacodynamics of dexmedetomidine. *Clin Pharmacokinet*. 2017;56(8):893–913.
13. Farooq N, Singh RB, Sarkar A, Rasheed MA, Choubey S. Evaluation of fentanyl and dexmedetomidine as adjuvants to ropivacaine in brachial plexus block: a double-blind, prospective, randomized study. *Anesth Essays Res*. 2017;11(3):730–36.
14. Lotfy ME, Doha NM, Elbakry AE, Mohamed SS. Comparative study between dexmedetomidine and fentanyl added to bupivacaine for ultrasound-guided brachial plexus block. *Res Opin Anesth Intensive Care*. 2020;7(1):25–31.
15. Hamed MA, Talaat SM, Abdallah NM. Comparative study between fentanyl and dexmedetomidine as adjuvants to ropivacaine in supraclavicular brachial plexus block. *Egypt J Anaesth*. 2018;34(1):17–23.
16. Sahi S, Verma AK, Jindal P, Singh B, Bansal S. Comparison of dexmedetomidine and fentanyl as adjuvants to ropivacaine in supraclavicular brachial plexus block. *Anesth Essays Res*. 2018;12(2):420–425.
17. Cham SC, Sangawar MA, Ramtani UL, Chavan BS, Cham C. Comparison of the effects of fentanyl and dexmedetomidine in supraclavicular brachial plexus block achieved with ropivacaine. *J Evol Med Dent Sci*. 2015;4(54):9427–9437.
18. Dharmarao PS, Sindhura KS, Raghunath G, Praveen K. Comparison of dexmedetomidine and fentanyl as adjuvants to ropivacaine in supraclavicular brachial plexus block. *J Evid Based Med Healthc*. 2018;5(38):2692–2697.
19. . Umamaheshwar L, Ramesh S, Kumar A. Comparison of dexmedetomidine and fentanyl as adjuvants to ropivacaine in ultrasound-guided supraclavicular brachial plexus block. *Indian J Clin Anaesth*. 2022;9(1):45–50.
20. . Tyagi N, Jain A, Verma S. Comparative evaluation of dexmedetomidine and fentanyl as adjuvants to ropivacaine in supraclavicular brachial plexus block. *Cureus*. 2023;15(3):e36421.
21. . Swaro S, Swaro B, Ramaswamy AH. Comparison of fentanyl and dexmedetomidine as adjuvants to ropivacaine in supraclavicular brachial plexus block. *Int J Sci Stud*. 2016;4(6):123–127.
22. . Farooq N, Singh RB, Sarkar A, Rasheed MA, Choubey S. To evaluate the efficacy of fentanyl and dexmedetomidine as adjuvants to ropivacaine in brachial plexus block: a double-blind, prospective, randomized study. *Anesth Essays Res*. 2017;11(3):730–736.
23. Sahi S, Kaur M, Singh A. Dexmedetomidine versus fentanyl as adjuvants to local anesthetics in supraclavicular brachial plexus block: a comparative study. *Int J Res Med Sci*. 2018;6(5):1625–1630.
24. Lee AR, Yi HW, Chung IS, Ko JS, Ahn HJ, Gwak MS, et al. Dexmedetomidine as an adjuvant to ropivacaine in supraclavicular brachial plexus block. *Korean J Anesthesiol*. 2016;69(1):68–73.
25. Yadav RK, Sah BP, Kumar P, Singh SN. A comparative study of fentanyl and dexmedetomidine as adjuvants to ropivacaine in supraclavicular brachial plexus block. *J Clin Diagn Res*. 2016;10(6):UC01–UC04.
26. Hashim NM, El-Shahawy MA, Abdallah NM. Dexmedetomidine versus fentanyl as adjuvants to ropivacaine in ultrasound-guided supraclavicular brachial plexus block. *Ain-Shams J Anaesthesiol*. 2019;11:12.
27. . Patra P, Das S, Banerjee A. Dexmedetomidine versus fentanyl as adjuvants to ropivacaine in supraclavicular brachial plexus block: a randomized study. *J Anaesthesiol Clin Pharmacol*. 2022;38(2):215–221.

28. Lotfy ME, Doha NM, Elbakry AE, Mohamed SS. Comparative study between dexmedetomidine and fentanyl added to bupivacaine for ultrasound-guided brachial plexus block. *Res OpinAnesth Intensive Care*. 2020;7(1):25–31.
29. El-Raouf AM, Ahmed HM, Mohamed SA. Dexmedetomidine versus fentanyl as adjuvants in peripheral nerve blocks: a comparative study. *Egypt J Hosp Med*. 2020;78(1):154–160.
30. Ghasemi M, Pouraghaei M, Soleimanpour H. Comparison of fentanyl and dexmedetomidine as adjuvants to local anesthetics in regional anesthesia. *Anesth Pain Med*. 2021;11(2):e113412.