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A Comparative Study between Injection Nalbuphine and Fentanyl as an Adjuvant to Bupivacaine in Supraclavicular Brachial Plexus Block in Surgeries for Upper Extremity

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ABSTRACT

Background: The efficacy of Nalbuphine and Fentanyl as adjuvants to Bupivacaine in supraclavicular brachial plexus blocks remains a significant point of study in anesthesia, particularly for upper extremity surgeries.

Methods: This randomized study compared Nalbuphine and Fentanyl added to Bupivacaine in 60 patients undergoing upper extremity surgeries. The onset and duration of sensory and motor blocks, as well as hemodynamic parameters, were evaluated.

Results: Nalbuphine demonstrated a significantly faster onset of sensory (5.03 ± 0.88 minutes) and motor blocks (7.1 ± 0.84 minutes) compared to Fentanyl (sensory: 7.5 ± 0.5 minutes, motor: 8.9 ± 0.831 minutes), with $p < 0.001$. The duration of sensory and motor blocks was also significantly prolonged in the Nalbuphine group (sensory: 360.87 ± 8.64 minutes, motor: 348.17 ± 12.54 minutes) compared to the Fentanyl group (sensory: 344.9 ± 12.24 minutes, motor: 324.1 ± 14.04 minutes), $p < 0.001$. Hemodynamic parameters were stable and comparable between the groups.

Conclusion: Nalbuphine, as an adjuvant to Bupivacaine, offers a faster onset and longer duration of both sensory and motor blocks in supraclavicular brachial plexus blocks compared to Fentanyl, with maintained hemodynamic stability.

Key Words: *Nalbuphine, Fentanyl, Bupivacaine, Supraclavicular Brachial Plexus Block, Upper Extremity Surgeries, Sensory Block, Motor Block, Hemodynamic Stability.*

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INTRODUCTION

Regional anesthesia has significantly evolved, providing enhanced pain control, reducing the need for systemic analgesics, and potentially decreasing the duration of hospital stay for surgical patients [1]. Among various regional anesthesia techniques, the supraclavicular brachial plexus block has gained popularity, especially for upper extremity surgeries, due to its reliable sensory and motor blockade [2]. Traditionally, local anesthetics like bupivacaine are used; however, the quest for optimizing analgesic quality while minimizing side effects has led to the exploration of various adjuvants.

Nalbuphine, a semi-synthetic opioid, and fentanyl, a synthetic opioid, are two such adjuvants, each with distinct pharmacological properties. Nalbuphine is a kappa opioid receptor agonist and a partial mu-opioid receptor antagonist, offering analgesia with a ceiling effect for respiratory depression, a significant safety feature [3]. Fentanyl, on the other hand, is a potent mu-opioid receptor agonist, known for its rapid onset and short duration of action [4]. The comparative

efficacy of these adjuvants when combined with bupivacaine in supraclavicular brachial plexus block is an area of active research, which holds potential implications for postoperative pain management.

The rationale behind using adjuvants like nalbuphine and fentanyl lies in their ability to enhance the quality of the block, prolong the duration of analgesia, and reduce the requirement for supplemental analgesics [5]. Bupivacaine, a long-acting local anesthetic, is favored for its prolonged duration of action, but its analgesic efficacy can be significantly enhanced when combined with these adjuvants [6]. The addition of opioids to local anesthetics in peripheral nerve blocks is known to prolong the duration of analgesia postoperatively, a crucial factor in patient recovery and satisfaction [7].

The comparison between nalbuphine and fentanyl as adjuvants to bupivacaine is not only relevant in terms of analgesic efficacy but also in the context of side effects. Opioids, despite their excellent analgesic properties, are associated with nausea, vomiting, pruritus, and respiratory depression [8]. The distinct pharmacological profiles of nalbuphine and fentanyl necessitate a thorough examination of their side effect profiles when used as adjuvants, particularly in terms of respiratory safety and the risk of opioid-induced hyperalgesia [9].

In clinical practice, the selection of an adjuvant for regional anesthesia is influenced by factors such as the onset of action, duration of analgesia, side effect profile, and individual patient characteristics. Nalbuphine's unique receptor activity offers an appealing choice, particularly in patients where respiratory depression poses a significant risk. However, fentanyl's potent analgesic properties and rapid onset cannot be understated [10]. The balance between efficacy and safety in the use of these adjuvants is a crucial consideration in their clinical application.

Moreover, the impact of these adjuvants on patient outcomes extends beyond the immediate postoperative period. Effective postoperative analgesia is linked to reduced incidence of chronic pain, early mobilization, and shorter hospital stays [11]. Therefore, the choice of adjuvant has implications not only for patient comfort but also for overall recovery and healthcare resource utilization.

Finally, the role of patient-specific factors cannot be overlooked. Variabilities in patient response to opioids, due to genetic factors, opioid tolerance, and individual pain thresholds, necessitate a personalized approach to choosing an adjuvant [12]. This further complicates the comparison between nalbuphine and fentanyl, as the optimal choice may vary significantly between individuals.

This comparative study between injection nalbuphine and fentanyl as an adjuvant to bupivacaine in supraclavicular brachial plexus block for upper extremity surgeries represents an important investigation into optimizing regional anesthesia techniques. Such a study not only addresses the efficacy and safety of these adjuvants but also holds implications for patient-centric care in anesthesia, balancing analgesic quality with minimal side effects, and improving overall surgical outcomes.

AIM AND OBJECTIVES

The aim of the study was to evaluate and compare the analgesic efficacy and potency, onset, duration, and density of block of Nalbuphine and fentanyl when added to bupivacaine in a supraclavicular brachial plexus block for upper extremity surgeries. The study was designed with specific objectives in mind. These objectives included studying the onset of action of the anesthetic block, observing the onset of motor and sensory block, determining the duration of sensory and motor blocks, examining any adverse effects, and assessing the overall duration of anesthesia.

MATERIALS AND METHODS

The study was conceived as a prospective single-blinded randomized control study and was conducted in the Department of Anaesthesia at a Tertiary Care Hospital over a period of one and a half years. Approximately 60 patients were estimated to be included in the study based on the selection criteria.

Patients aged 18 to 60 years, of both sexes, and classified as ASA grade I and II were included. The surgeries were required to last between 2 to 5 hours, and only patients willing to participate in the study were considered. Exclusion criteria encompassed unwillingness to participate, pregnancy, age below 18 or above 60, ASA grade III and IV, anatomical abnormalities, known hypersensitivity to local anesthetic drugs, contraindications to regional blocks, coagulation abnormalities, failure of block, and cases converted to general anesthesia.

Ethical considerations were rigorously followed, with the study receiving approval from the Institutional Ethics Committee and the Department of Anaesthesia in the tertiary center.

The study procedure and data collection involved a pre-anaesthetic check-up, including a detailed history, examination, and appropriate investigations. Patients were admitted the day before surgery and fasted for at least 6 hours prior. In the operating theatre, intravenous access was established, and Ringers Lactate was administered.

Patients were randomly allocated into two groups of 30 each, to receive either Nalbuphine [group N] or fentanyl [group F] as an adjuvant to bupivacaine. Monitors such as pulse oximeter, non-invasive blood pressure monitor, and three-lead ECG were connected, and baseline parameters like pulse rate, blood pressure, and SpO2 were recorded.

Pre-medication involved the administration of ondansetron intravenously. Group N received Nalbuphine 10mg with 2mg/kg Bupivacaine 0.25%, and group F received fentanyl 50mcg with 2mg/kg Bupivacaine 0.25%. The drugs for each group were prepared in 30ml syringes, combining the respective adjuvant with bupivacaine.

The supraclavicular brachial plexus nerve block was performed under ultrasound guidance. The patient was positioned supine with a pillow behind the shoulder and the head tilted away from the block side. The transducer was placed transversely proximal to the clavicle's midway point. After ensuring no major blood vessels were in the needle's path using Color Doppler, local anesthetic was injected into the skin, and the needle inserted into the brachial plexus sheath. A total of 20-25 mL of local anesthetic was administered, with negative aspiration checked periodically.

Assessment of the sensory and motor blocks was conducted using specific scales. The duration of sensory and motor blockade was calculated from the onset of action to the return of sensation or movement, respectively. The duration of anesthesia was noted from the completion of the local anesthetic injection to the onset of pain postoperatively, assessed using the Visual Analogue Scale (VAS).

Intraoperative and postoperative monitoring of hemodynamic parameters, blood loss, and side effects like nausea, vomiting, and local anesthetic toxicity were meticulously recorded. Complications including vascular puncture, Horner's syndrome, pneumothorax, and phrenic nerve palsy were noted. Postoperative pain management involved injection Diclofenac and Ondansetron for nausea and vomiting as required.

Overall, the study was conducted with a comprehensive approach, focusing on the effectiveness and safety of Nalbuphine and fentanyl as adjuvants to bupivacaine in supraclavicular brachial plexus blocks for upper extremity surgeries. The methodology was designed to capture a broad spectrum of data, from the onset and duration of the block to the potential adverse effects, thereby providing a detailed comparison of the two adjuvants.

RESULTS

The results of this comparative study on Nalbuphine and Fentanyl as adjuvants to Bupivacaine in supraclavicular brachial plexus blocks for upper extremity surgeries are presented in detail below, focusing on each variable and associated statistical values.

Demographic Data and Surgery Duration

In terms of demographic data and surgery duration (Table 1), there was no significant difference in mean age between Group F (31.80 ± 4.89 years) and Group N (32.70 ± 3.91 years), with a p-value of 0.442. Gender distribution was similarly balanced between the two groups (males: 53.3% in Group F, 46.7% in Group N; females: 46.7% in Group F, 53.3% in Group N), showing no statistical significance ($p = 0.797$). The duration of surgery was comparable between the groups, with means of 167.83 ± 66.94 minutes in Group F and 160.97 ± 65.59 minutes in Group N ($p = 0.69$).

Characteristics of Sensory and Motor Blockade

The characteristics of sensory and motor blockade (Table 2) revealed significant differences between the groups. The onset of sensory block was faster in Group N (5.03 ± 0.88 minutes) than in Group F (7.5 ± 0.5 minutes), with a highly significant p-value of <0.001. Achieving complete sensory block was quicker in Group N (9.03 ± 0.84 minutes) compared to Group F (14.73 ± 0.44 minutes), again showing a highly significant difference ($p < 0.001$). The total duration of sensory block was significantly longer in Group N (360.87 ± 8.64 minutes) than in Group F (344.9 ± 12.24 minutes), $p < 0.001$.

For motor blockade, Group N showed a quicker onset (7.1 ± 0.84 minutes) compared to Group F (8.9 ± 0.831 minutes), with a significant p-value of <0.001. Group N also achieved complete motor block faster (10.93 ± 0.73 minutes) than Group F (17.13 ± 0.76 minutes), $p < 0.001$. The total duration of motor block was longer in Group N (348.17 ± 12.54 minutes) compared to Group F (324.1 ± 14.04 minutes), with a p-value of <0.001.

Duration of Anaesthesia and Intra-op Heart Rate

Regarding the duration of anesthesia and intra-operative heart rate (Table 3), Group N experienced a significantly longer duration of anesthesia (370.47 ± 16.40 minutes) compared to Group F (330.59 ± 19.49 minutes), $p < 0.001$. The baseline heart rate, heart rate at the time of study drug injection, and heart rate at the completion of surgery were similar between the groups, with p-values of 0.765, 0.791, and 0.655, respectively.

Intraoperative and Postoperative Systolic Blood Pressure

Intraoperative and postoperative systolic blood pressure (SBP) readings (Table 4) showed no significant differences between Group F and Group N at all measured time points. Baseline SBP was 115.13 ± 3.12 mmHg in Group F and 115.00 ± 3.25 mmHg in Group N (p = 0.874). Postoperatively at 1 hour, SBP was 114.40 ± 3.27 mmHg in Group F and 115.17 ± 3.17 mmHg in Group N (p = 0.37). At 6 hours postoperatively, SBP values were 112.40 ± 3.33 mmHg for Group F and 113.27 ± 3.32 mmHg for Group N (p = 0.32).

Intraoperative and Postoperative Diastolic Blood Pressure

For diastolic blood pressure (DBP) (Table 5), both intraoperative and postoperative readings showed no significant difference between the groups. Baseline DBP was 74.17 ± 3.47 mmHg in Group F and 73.97 ± 3.78 mmHg in Group N (p = 0.835). Postoperative DBP readings at 1 hour were 75.67 ± 2.37 mmHg in Group F and 75.50 ± 2.32 mmHg in Group N (p = 0.79), and at 6 hours, they were 73.97 ± 2.90 mmHg and 73.40 ± 2.50 mmHg, respectively (p = 0.43).

Intraoperative and Postoperative Mean Arterial Pressure

Mean arterial pressure (MAP) data (Table 6) also revealed no significant differences between the two groups at any time point. Baseline MAP was nearly identical between Group F (73.57 ± 3.54 mmHg) and Group N (73.63 ± 4.00 mmHg), with a p-value of 0.947. This similarity persisted at study drug injection (p = 0.948), at the completion of surgery (p = 0.393), and postoperatively at 1 hour (p = 0.83) and 6 hours (p = 0.72).

Intraoperative and Postoperative Mean Respiratory Rate

The mean respiratory rate (MRR) (Table 7) showed no significant difference between Group F and Group N at all the measured time points, including baseline, at study drug injection, at the completion of surgery, and postoperatively at 1 hour and 6 hours. Baseline MRR was 18.27 ± 1.79 bpm in Group F and 18.50 ± 2.09 bpm in Group N (p = 0.650), and the similarity continued postoperatively with p-values of 0.93 at 1 hour and 0.77 at 6 hours.

In conclusion, the study revealed significant differences in the onset and duration of sensory and motor blocks between Nalbuphine and Fentanyl as adjuvants to Bupivacaine, while hemodynamic parameters including heart rate, blood pressure, and respiratory rate remained stable and comparable between the groups.

Table 1: Demographic Data and Surgery Duration

Variable	Group F	Group N	p value
Age (in years)			
Mean age	31.80 ± 4.89	32.70 ± 3.91	0.442 (NS)
Gender			
Male	16 (53.3%)	14 (46.7%)	0.797 (NS)
Female	14 (46.7%)	16 (53.3%)	
Duration of Surgery (min)			
Mean	167.83 ± 66.94	160.97 ± 65.59	0.69

Table 2: Characteristics of Sensory and Motor Blockade

Variable	Group F (Mean ± SD)	Group N (Mean ± SD)	p value
Onset of Sensory Block (min)	7.5 ± 0.5	5.03 ± 0.88	<0.001
Complete Sensory Block (min)	14.73 ± 0.44	9.03 ± 0.84	<0.001
Total Duration of Sensory Block (min)	344.9 ± 12.24	360.87 ± 8.64	<0.001
Onset of Motor Block (min)	8.9 ± 0.831	7.1 ± 0.84	<0.001
Complete Motor Block (min)	17.13 ± 0.76	10.93 ± 0.73	<0.001
Total Duration of Motor Block (min)	324.1 ± 14.04	348.17 ± 12.54	<0.001

Table 3: Duration of Anaesthesia and Intra-op Heart Rate

Variable	Group F (Mean ± SD)	Group N (Mean ± SD)	p value
Duration of Anaesthesia (min)	330.59 ± 19.49	370.47 ± 16.40	<0.001
Baseline Heart Rate (per min)	79.47 ± 4.24	79.80 ± 4.20	0.765
Heart Rate at Study Drug Injection	79.10 ± 4.28	79.40 ± 4.30	0.791

Variable	Group F (Mean ± SD)	Group N (Mean ± SD)	p value
Heart Rate at Completion of Surgery	73.17 ± 4.99	73.73 ± 4.63	0.655

Table 4: Intra-op and Post-op SBP

Time Point	SBP Group F (Mean ± SD)	SBP Group N (Mean ± SD)	p value
Baseline	115.13 ± 3.12	115.00 ± 3.25	0.874
At Study Drug Injection	114.50 ± 3.00	114.57 ± 3.32	0.936
At Completion of Surgery	108.67 ± 3.74	109.03 ± 3.77	0.711
Post-op 1hr	114.40 ± 3.27	115.17 ± 3.17	0.37
Post-op 6hrs	112.40 ± 3.33	113.27 ± 3.32	0.32

Table 5: Intra-op and Post-op DBP

Time Point	DBP Group F (Mean ± SD)	DBP Group N (Mean ± SD)	p value
Baseline	74.17 ± 3.47	73.97 ± 3.78	0.835
At Study Drug Injection	73.63 ± 3.66	73.50 ± 3.86	0.893
At Completion of Surgery	67.77 ± 4.18	67.93 ± 3.94	0.876
Post-op 1hr	75.67 ± 2.37	75.50 ± 2.32	0.79
Post-op 6hrs	73.97 ± 2.90	73.40 ± 2.50	0.43

Table 6: Intra-op and Post-op MAP

Time Point	MAP Group F (Mean ± SD)	MAP Group N (Mean ± SD)	p value
Baseline	73.57 ± 3.54	73.63 ± 4.00	0.947
At Study Drug Injection	73.13 ± 3.64	73.20 ± 4.09	0.948
At Completion of Surgery	67.03 ± 4.04	67.93 ± 3.92	0.393
Post-op 1hr	76.50 ± 2.31	76.63 ± 2.43	0.83
Post-op 6hrs	74.47 ± 2.31	74.70 ± 2.69	0.72

Table 7: Intra-op and Post-op MRR

Time Point	MRR Group F (Mean ± SD)	MRR Group N (Mean ± SD)	p value
Baseline	18.27 ± 1.79	18.50 ± 2.09	0.650
At Study Drug Injection	17.77 ± 1.80	18.03 ± 2.07	0.603
At Completion of Surgery	12.50 ± 2.31	13.17 ± 3.05	0.351
Post-op 1hr	20.03 ± 1.11	20.07 ± 1.55	0.93
Post-op 6hrs	17.97 ± 1.52	17.83 ± 1.90	0.77

DISCUSSION

The results of this study offer insightful perspectives into the efficacy of Nalbuphine and Fentanyl as adjuvants to Bupivacaine in supraclavicular brachial plexus blocks for upper extremity surgeries. The significant differences observed in the onset and duration of sensory and motor blocks between the two groups highlight the distinctive pharmacological profiles of these adjuvants.

The faster onset of sensory and motor blockade in the Nalbuphine group aligns with previous research. A study by Yaddanapudi et al. [13] indicated that Nalbuphine, as an adjuvant, enhances the onset of sensory and motor blockade. The kappa-opioid receptor agonism of Nalbuphine is postulated to contribute to this rapid onset [14]. In contrast, Fentanyl primarily acts on the mu-opioid receptors, which may explain the slightly delayed onset in our Fentanyl group, a finding that echoes the work of Gupta et al. [15].

The prolonged duration of both sensory and motor blocks in the Nalbuphine group is particularly noteworthy. This finding is consistent with the study by Bhatia et al. [16], which showed a prolonged duration of analgesia with Nalbuphine as an adjuvant. The kappa-opioid receptor-mediated analgesic effect of Nalbuphine, with a relatively lesser risk of respiratory depression, could be the underlying mechanism [17]. In comparison, Fentanyl's shorter duration of

action, as observed in our study, correlates with its pharmacokinetics and is in line with findings by El Bahnasawe et al. [18], who reported a shorter duration of sensory blockade with Fentanyl.

Hemodynamic stability, as indicated by the non-significant differences in heart rate, blood pressure, and respiratory rate between the two groups, is a crucial aspect of patient safety during regional anesthesia. Our findings are corroborated by a study by Joshi et al. [19], which reported hemodynamic stability with the use of Nalbuphine. Similarly, Fentanyl's minimal hemodynamic impact, as observed in our study, is supported by the research of Singh et al. [20].

The use of Nalbuphine as an adjuvant has been praised for its minimal side effects, particularly in terms of respiratory safety. This is consistent with the findings of Sadeghi et al. [21], where lower incidences of nausea and pruritus were reported. Although not a primary focus of our study, these are important considerations for patient comfort and recovery.

Fentanyl, despite its effective analgesic properties, has been associated with a higher incidence of nausea and vomiting, as reported in a study by Honarmand et al. [22]. This potentially stems from its potent mu-opioid receptor agonism. However, in our study, both adjuvants maintained a similar profile regarding safety and tolerability, which could be attributed to the doses used.

This study's findings reinforce the concept that the choice of adjuvant in regional anesthesia is not just about efficacy but also safety and patient comfort. While both Nalbuphine and Fentanyl effectively enhance the analgesic profile of Bupivacaine in supraclavicular brachial plexus blocks, Nalbuphine's advantages in terms of faster onset and longer duration of sensory and motor blocks make it a compelling option. However, the choice must be tailored to individual patient needs, considering the safety profile and potential side effects.

CONCLUSION

This study distinctly demonstrates that both Nalbuphine and Fentanyl, when used as adjuvants to Bupivacaine in supraclavicular brachial plexus blocks, effectively enhance the block's quality. Nalbuphine, however, exhibits a faster onset of sensory (5.03 ± 0.88 minutes) and motor blocks (7.1 ± 0.84 minutes), as well as a prolonged duration of both sensory (360.87 ± 8.64 minutes) and motor blockade (348.17 ± 12.54 minutes) compared to Fentanyl. These findings, with significant p-values of <0.001 in these parameters, highlight Nalbuphine's superior efficacy in this context.

Moreover, the study observes hemodynamic stability in both groups, with no significant differences in heart rate, blood pressure, and respiratory rate, ensuring the safety of both adjuvants. The choice between Nalbuphine and Fentanyl should therefore consider individual patient profiles, surgical requirements, and the need for prolonged analgesia post-surgery.

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