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Original Research Article

A Comparative Study of Dexmedetomidine and Fentanyl as an Adjuvant for Epidural Analgesia for Lower Limb Orthopaedic Surgeries

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Conflict of interest: Nil

Abstract:

Background: Epidural anesthesia is integral to modern anesthesia, offering flexibility in vertebral-level selection for anesthesia and pain relief. It complements general anesthesia by reducing the required depth of anesthesia and maintaining hemodynamic stability during surgery. Particularly beneficial for lower abdominal and limb surgeries, epidural anesthesia addresses challenges associated with general anesthesia, such as airway manipulation and exposure to multiple medications. It also minimizes postoperative complications like nausea and vomiting, enhancing patient comfort and recovery.

Methods: This study randomly assigned 80 patients into two groups of 40 each. Group A received 15 ml of 0.75% Ropivacaine plus 1µg/kg of Fentanyl epidurally, while Group B received the same dose with Dexmedetomidine. Patients underwent preoperative assessment and fasting, receiving premedication with Alprazolam 0.5 mg and Ranitidine 150 mg. In the operation theatre, standard monitoring was performed, and basal vital parameters were recorded.

Results: Group B exhibited a significantly longer duration of sensory blockade (317 min) compared to Group A (259.8 min), with a significant difference in motor blockade duration as well. The proportion of patients with motor blockade at T7 was significantly higher in Group A than in Group B.

Conclusion: Dexmedetomidine enhances Ropivacaine epidural anesthesia more effectively than Fentanyl, accelerating sensory and motor block onset and prolonging recovery. Dexmedetomidine offers superior postoperative analgesia and patient satisfaction, despite Fentanyl's cardiovascular stability advantage. Dexmedetomidine's sedation benefits make it preferable for infra-umbilical surgeries under epidural anesthesia.

Keywords: Dexmedetomidine, Fentanyl, Ropivacaine, Epidural anesthesia.

Introduction

Epidural anesthesia holds a crucial role in modern anesthesia practice, offering flexibility in vertebral-level placement for anesthesia and analgesia. It complements general anesthesia, reducing the need for deep anesthesia levels and ensuring hemodynamic stability during surgery. Particularly for lower abdominal and limb surgeries, epidural anesthesia circumvents the drawbacks associated with general anesthesia, such as airway manipulation and polypharmacy, while minimizing postoperative complications like nausea and vomiting. [1] Rapid postoperative mobilization and minimal discomfort are key goals in contemporary surgery, making epidural anesthesia highly desirable. [2] It not only facilitates perioperative surgical anesthesia but also provides postoperative analgesia, ideal for lower abdominal and limb surgeries of longer duration. [3, 4] Graded epidural anesthesia or drug supplementation during surgery is achievable with this technique. [5] Commonly employed local anesthetics include lignocaine, bupivacaine, and, more recently, ropivacaine. [6] While lignocaine has an intermediate duration of action and bupivacaine exhibits prolonged action, the latter is associated with a heightened risk of severe cardiac toxicity. [7] Ropivacaine, a newer long-acting amino amide local anesthetic, offers similar benefits to bupivacaine for epidural anesthesia while posing a lower risk of cardiac toxicity due to its faster reversal of sodium channel

blockade and reduced negative inotropic potency. [8]

Fentanyl, a highly lipophilic opioid, has gained popularity as an additive, albeit with side effects like pruritus, nausea, and vomiting. Dexmedetomidine, a highly selective α-2 agonist, represents a recent advancement with sedative, analgesic, and hemodynamic stabilizing effects, reducing the need for other anesthetic drugs. [9] Given the scarcity of comparative studies between fentanyl and dexmedetomidine as adjuvants to ropivacaine for epidural anesthesia, our study aims to compare these agents in elective infra-umbilical surgeries. We will assess epidural administration of 15 ml ropivacaine 0.75% plus fentanyl 1 µg/kg versus ropivacaine plus dexmedetomidine 1 µg/kg for orthopedic lower limb surgeries, examining parameters such as onset and duration of sensory and motor blockade, duration of analgesia and motor blockade, highest level of sensory block achieved, number of blocked dermatomes, regression time to T12 level, and associated complications.

Material and Methods

This observational study was done in the Department of Anesthesiology, Kakatiya Medical College and MGM Hospital, Warangal from January 2021 to July 2022. After obtaining approval from the hospital's scientific and ethics committee, and written informed consent, 80 patients were enrolled in this study. The study population included patients of either sex, ASA grade 1 and 2, ages between 20-60 years; all patients posted for elective orthopedic lower limb surgeries who underwent epidural procedures were included in this study.

Inclusion Criteria:

1. Age between 20 - 60 years
2. ASA Grade 1 & 2
3. Elective orthopaedic lower limb surgeries

Exclusion Criteria:

1. Patient refusal
2. ASA grades 3 & 4
3. Any bleeding disorders and patients on anti-coagulants
4. Local infection at the site of injection
5. H/o allergy to local anesthetics
6. Raised intracranial pressure
7. Bronchial Asthma
8. Severe hypovolemia
9. Uncontrolled hypertension/ diabetes mellitus
10. Neurological disorders, Myopathic diseases, and Deformities of the spine
11. Cardiac disease, Renal disease, Hepatic disease
12. Emergency surgery
13. Hemodynamically unstable patients

Sample Size and Sample Technique:

Where N=sample size, σ=assumed standard deviation of each group (assumed to be equal), Z crit=value according to the table for the desired significance criterion, Zpwr =values that given in the table for the desired statistical power, D=minimum expected difference between two means. The sample size is rounded to the nearest whole number of 80 (40 in each group). 80 patients who came for elective infraumbilical surgeries were randomly selected for the study without any bias based on inclusion and exclusion criteria using a computer-based software programme. Power analysis was carried out before the initiation of the study.

Data Collection Techniques & Tools:

After approval from the institutional ethical committee and proper written informed consent, patients included in this study were randomly divided into 2 Groups of 40 patients each. Randomization was done according to computer-based software 60. (www.graphpad.com). It is also enclosed along with other enclosures.

Group A – Were given 15 ml of 0.75% Ropivacaine plus 1µg/kg of Fentanyl epidurally. *Group B* – Were given 15 ml of 0.75% Ropivacaine plus 1µg/kg of dexmedetomidine epidurally.

A preoperative assessment was done for each patient and written informed consent was taken. Patients were allowed for a period of fasting of 8 hours for solids and 2 hours for clear liquids and were given premedication with Tab. Alprazolam 0.5 mg and tab Ranitidine 150 mg on the night before surgery. On the day of surgery patient was shifted into the operation theatre, an 18G IV cannula was secured and as per ASA standards all monitors (electrocardiogram (ECG), non-invasive blood pressure (NIBP), pulse oximeter (SPO_2), were connected and basal vital parameters were noted.

Parameters Studied

a. *The onset of sensory block:* Sensory blockade was assessed by 24 G Blunt tip needle for pinprick sensation at 1 min and so on in 0.5 min(30 sec) intervals till sensory block attained at T10 level along anterior axillary line. The onset time of sensory block is the time required for loss of pinprick sensation at the T10 dermatome level after giving an epidural injection in minutes.

b. *The maximum level of sensory block attained, and time taken for the same* Maximum dermatomal level of sensory block attained was observed (for loss of pinprick sensation from cephalad to caudal direction taking clavicle as a reference point) in every 5-minute interval

after attaining T10 dermatomal level block. Time taken for the same was noted from the time of epidural injection. Several maximum dermatomes blocked were noted in each group.

c. *Regression time:* It is the time taken for regression of sensory block to T12 dermatomal level from the time of epidural injection.
d. *Onset and duration of motor blockade:* Onset time is the time from injection of a drug to the patient's inability to lift the extended leg straight. The duration of the block was recorded from onset time to time when the patient was able to lift the extended leg. The degree of motor blockade is assessed by the Bromage scale.

Any Complications: Heart Rate <60 bpm was considered as bradycardia and treated with inj—atropine 0.6 mg IV. Systolic Blood Pressure <90mm of Hg was considered as hypotension and treated with Injection Mephentermine 6 mg intravenous boluses. Nausea and vomiting were treated with an injection of Ondansetron 4 mg I.V. Shivering was treated with an injection of Pethidine I.V 25mg.

Data Analysis: Statistical analysis was performed using Microsoft Office Excel 2007. Data were analyzed with demographic data & for comparison of two groups, Chi-Square & student's 'T' to test analyses were performed. Demographic variables like age, gender, weight, and height were compared with the statistical tool student t-test, to know whether there is any significant difference between the two groups. Qualitative variables like ASA GRADE and Degree of Motor block, were compared with Chi-square test to check whether there is any association between these variables and the groups. The z-proportion test was performed to check the significant difference in the proportions between the two groups for the variables such as complications, maximum level of sensory blockade, and sedation score. Student t-test was performed for the quantitative variables like onset sensory, onset motor, time to achieve highest sensory level, duration of sensory block, and duration of motor block.

Results

Of the 40 patients assigned to both groups, there were 51 females (63.75%), of which 27 were in group A and 24 were in group B. Similarly, 29 males (36.25%) were included in the study, of which there were 13(32.5%) and 16(40.0%) patients in Groups A and B, respectively. Since the p-value (0.485) of the Chi-square test is greater than 0.05, it concludes that the Group and gender are independent of each other i.e., the proportion of male patients and female patients between the two groups are similar at a 5% level of significance.

Patients aged between 21 and 55 years were included in this study. The P-value (0.620) of the student t-test (-0.498) is greater than 0.05, the level of significance, which concludes that the mean age of Group A (42.7 years) and Group B (43.6 years) was not statistically significant, that is, there was no significant difference between the groups. The mean weight of group A (66.15 kg) was not significantly different from that of group B (67.70 kg) at the 5% level of significance. Thus, there was no significant difference in the mean weight between the two groups of patients. There was no significant difference in the mean height (in cm) of the patients between the two groups at the 5% level of significance, as per the insignificant p-value (0.237) depicted in Table 1.

Table 1: Demographic profile of the cases included in the study

Group	N	Mean	SD	T value	P value
Age in years					
Group A	40	42.77	6.95		
Group B	40	43.60	7.82	-0.498	0.620
Weight in Kgs					
Group A	40	66.15	7.22	-0.85	0.40
Group B	40	67.70	9.04		
Height in centimeters					
Group A	40	157.27	6.05	-1.192	0.237
Group B	40	159.07	7.39		

* Significant

Among patients with ASA grades 3 and 4 who were not included in this study, the proportion of patients with Group-A ASA grade I was 67.5% and ASA grade II was 32.5%. Similarly, group B was ASA grade I and 65% of cases were ASA grade II were 35%. The distribution of ASA-grade patients was similar in both groups; the p-values were (>0.05) hence, they were not significant. The Average time of Onset of Sensory blockade at T10for for Group A (8.0625 min) was significantly greater than that of Group B (6.6125 min), as per the significant p-value (0.002). The Average time of onset of motor blockade in group A (12.965 min) was significantly greater than that in group B (10.43

min), as per the significant p-value of Student's t-test (3.522). The mean duration of the sensory blockade in group B (317 min) was significantly greater than that in group A (259.8 min), as per the significant p-value of the student's t-test. The mean duration of motor blockade for group B (253.75 Min) is significantly higher than group A (209.625 Min) as per the significant p-value depicted in Table 2.

Table 2: Showing the duration of sensory and motor blockade in two groups

Group	N	Mean	SD	T value	P value
Onset time of sensory blockade in minutes					
Group A	40	8.062	2.00	3.21	0.002*
Group B	40	6.612	2.04		
Time to achieve the highest level of sensory blockade in min					
Group A	40	12.65	3.02		
Group B	40	11.32	2.70	2.07	0.042*
Total duration of Sensory blockade					
Group A	40	259.87	42.64	-5.94	0.0001*
Group B	40	317.00	43.35		
Duration of motor blockade in minutes					
Group A	40	209.62	33.82	-5.29	0.001*
Group B	40	253.75	40.49		

* Significant

Comparison of both groups with respect to the Duration of Motor Blockade(min). Table 3 explains that except for the T7 level, the remaining levels the proportion of the group-A and group-B patients are similar, whereas at the T7 level, the proportion of group A was statistically significant compared to group B, as per the significant p-values.

Table 3: Comparison of both groups with respect to the Duration of Sensory Blockade(in Mins)

Level	Group-A	Group-B	Total	P value
T4	0(0.00)	3(7.50)	3(3.75)	0.072
T5	6(15.00)	12(30.00)	18(22.50)	0.102
T6	19(47.50)	23(57.50)	42(52.50)	0.368
T7	13(32.50)	1(2.50)	14(17.50)	0.000*
T8	2(5.00)	1(2.50)	3(3.75)	0.555

* Significant

The Degree of Motor Blockade concerning the Bromage scale in groups A and B, where most of the patients had grade III motor blockade. In group A, 2.5% had grade II motor blockades and 97.5% had grade III motor blockade. Similarly, in group B, all 100% of the patients had grade III motor blockade. When the Sedation scores were compared in both groups of patients (Table 4), the proportion of group A patients with a sedation score of 1 was significantly greater than that of group B, while the proportion of group B patients with a sedation score of 3 was significantly greater than that of group A. For a sedation score of 2, the proportions of both groups were similar.

Table 4: Comparison of Sedation score between the two groups

Sedation score	Group-A	Group-B	Total	P value
1	9(22.50)	2(5.00)	11(13.75)	0.019
2	28(70.00)	24(60.00)	52(65.00)	0.346
3	3(7.50)	14(35.00)	17(21.25)	0.001*
4	0	0	0	-
5	0	0	0	-

* Significant

Table 5 shows that except for the complication of "Bradycardia (B)," there is no significant difference between group A and group B at a 5% level of significance with respect to all the remaining complications, i.e. there is no significant difference in percentages with regard to the different types of complications. However, the proportion of group B patients had significantly more complications in bradycardia (B) than group A, as per the significant p-values.

Table 5: Frequency of complications recorded in two groups

Complications	Group-A	Group-B	Total	P Value
Bradycardia(B)	1(2.5)	6(15)	7(8.75)	0.042*
Hypotension(H)	4(10)	8(20)	12(15)	0.206
Shivering	4(10)	2(5)	6(7.5)	0.394
Nausea	3(7.5)	1(2.5)	4(5)	0.302
Vomiting	4(10)	1(2.5)	5(6.25)	0.161
Dry Mouth	1(2.5)	3(7.5)	4(5)	0.302
No Complications	23(57.5)	19(47.5)	42(52.5)	0.368

* Significant

Discussion

A total of 80 patients classified as ASA class I and II, scheduled for various lower limb orthopedic surgeries, were randomly assigned to either Group A (Ropivacaine with Fentanyl) or Group B (Ropivacaine with Dexmedetomidine) using computerized randomization. Patients in Group A received 15 ml of 0.75% Ropivacaine plus Fentanyl 1µg/kg epidurally, while patients in Group B received 15 ml of 0.75% Ropivacaine plus Dexmedetomidine 1µg/kg epidurally, all administered under strict aseptic conditions in a sitting position at the L2 – L3 interspace. Sensory and motor blockade parameters were monitored, and any complications occurring in both groups were observed. In this study, we chose Ropivacaine, Dexmedetomidine, and Fentanyl for epidural anesthesia. Ropivacaine is a common choice for epidural anesthesia in our hospital for abdominal and lower limb orthopedic surgeries. Although Ropivacaine shares structural similarities with Bupivacaine, it lacks the cardiotoxic effects associated with Bupivacaine and has only recently been introduced to the Indian market. Several researchers have studied Dexmedetomidine as an adjuvant to epidural local anesthetics [10 – 12]. Fentanyl is also commonly used as an intravenous, intrathecal, and epidural opioid for postoperative pain and cancer pain, and it is known for its cardiac stability, particularly when administered through the epidural route [13]. Several studies have examined the efficacy of epidural anesthesia using Ropivacaine and Dexmedetomidine 1mcg/kg, as well as with the addition of fentanyl 1mcg/kg. However, many of these studies utilized 15ml of 0.75% Ropivacaine alongside an adjuvant, often requiring supplementary doses of Ropivacaine for rescue analgesia. In light of this, we conducted a study administering a single shot of 20ml of 0.75% Ropivacaine for epidural anesthesia, combined with an adjuvant, to compare the effectiveness of Ropivacaine with Fentanyl 1mcg/kg versus Ropivacaine with Dexmedetomidine 1mcg/kg. In our investigation, the meantime for the onset of sensory analgesia at T10 in Group A (8.0625) was notably longer than in Group B (6.6125), as indicated by the significant p-value (0.002). This finding aligns with the observations made by Bajwa et al. [14] who reported an onset of sensory analgesia at T10 of 7.12 ± 2.44 minutes in the Ropivacaine + Dexmedetomidine group compared to 9.14 ± 2.94 minutes in the Ropivacaine + Fentanyl group. Additionally, our results are consistent with those of Chittra et al. [15] who found a significantly shorter onset of sensory block in the Dexmedetomidine-Ropivacaine group (7.93 ± 0.98 minutes) compared to the Fentanyl-Ropivacaine group (9.76 ± 1.69 minutes). Moreover, the studies conducted by Bajwa et al. [14] demonstrated a similar trend, with an onset of sensory analgesia at T10 of 8.52 ± 2.36 minutes in the Ropivacaine + Dexmedetomidine group compared to 9.72 ± 3.44 minutes in the Ropivacaine + Clonidine group, supporting our findings. In our investigation, we found that the maximum level of sensory block in Group B was T4 (n=3), while in Group A it was T5 (n=6). The range of block was extensive in both groups, spanning from T12 to T4, with Group B exhibiting a higher block level in the majority of patients compared to Group A. Significantly more subjects in Group B (95%) achieved a sensory level of T6 or above compared to Group A (62.5%) ($p<0.001$). Chittra et al. [15] reported a median value of the highest sensory dermatomal level achieved in Group DR as T3, achieved by 40% of patients, while none in Group FR reached T3, with the highest sensory level achieved being T4. These findings are consistent with our study. Similarly, Bajwa et al. [14] demonstrated that the maximum level of sensory block in Group RD was at the T4-6 level compared to T5-T7 in Group RF, aligning with our results. Additionally, the study by Bajwa et al. [14] showed that the maximum level of sensory block in Group RD was at the T5-6 level compared to T6-T7 in Group RC, supporting our findings. In our research, we observed that the duration of sensory block was significantly longer in Group B compared to Group A, with a mean duration of approximately 317 ± 43.3 minutes for Group B versus 259.8 ± 42.6 minutes for Group A ($p<0.001$). This finding is consistent with the study by Bajwa et al. [16] which reported a mean duration of analgesia of 366.62 ± 24.42 minutes in Group RD compared to 242.16 ± 23.86 minutes in Group RF, demonstrating high significance. Similar results were noted in the study by Chittra et

al. [15], where the duration of analgesia was significantly longer in Group DR compared to Group FR, with durations of 413.33 ± 66.71 and 354.66 ± 66.88 minutes, respectively. Regarding motor blockade, the onset of motor blockade was significantly earlier in Group B (10.43 ± 2.83 minutes) compared to Group A (12.6 ± 3.54 minutes), a statistically significant difference. This aligns with the findings of Bajwa et al. [16], which observed an earlier onset of motor blockade in patients administered Group RD (18.16 ± 4.52 minutes) compared to Group RF (22.98 ± 4.78 minutes). In our study, motor blockade was evaluated using the modified Bromage scale, with onset recorded once patients achieved complete motor blockade. Chittra et al. [15] also found a statistically significant difference in the onset of motor blockade, with times of 21.33 ± 2.65 and 16.13 ± 2.77 minutes in Groups FR and DR, respectively, supporting our findings. Additionally, Saikia et al. [17] observed a significant disparity in motor blockade between Group RD (20.5 ± 1.187) and Group RF (24.2 ± 1.113), further confirming our observations. In the study by Chittra et al. [15], patients in the DR group exhibited significantly higher sedation scores throughout the intraoperative period compared to those in the FR group. Patients in the DR group were less responsive to verbal commands, reaching grade 3 sedation as early as 30 minutes after epidural injection. This difference is statistically significant and aligns with our study findings. Similarly, in the study conducted by Bajwa et al. [16], the authors found that the mean sedation score was notably higher in the Dexmedetomidine group (RD) compared to the clonidine group (RC). Specifically, 36% of patients in the RD group achieved a sedation score of 3, in contrast to 16% in the RC group ($P<0.0001$). Moreover, only 16% of patients in the RD group had sedation scores of 1, while 32% of patients in the RC group remained alert and awake, demonstrating a highly significant statistical difference ($P<0.0001$). These results closely mirror our study's outcomes. In Group B, six patients experienced bradycardia, which was managed with Inj. Atropine 0.6mg, while hypotension occurred in eight patients in the RD group and four patients in the RF group, requiring treatment with intravenous fluids and Inj. Mephentermine 6 mcg. Nausea and vomiting were reported in two patients in the RD group and seven patients in the RF group, necessitating IV ondansetron 4mg. Dry mouth was observed in three patients in the RD group and one patient in the RF group, with reassurance provided to the patients. Shivering was noted in two patients in the RD group and four patients in the RF group, managed with injection iv pethidine 25 mg. Bradycardia emerged as the only statistically significant side effect. Similar complications and side effects were documented in the study conducted by Bajwa et al. [16] In a study by Ravikumar. M et al. [18] dry mouth, bradycardia, and hypotension were more prevalent in the Ropivacaine with Dexmedetomidine group, while nausea and vomiting were more common in the Ropivacaine with Fentanyl group, aligning with our findings. Vasupalli R et al. [19] observed bradycardia and dry mouth exclusively in the RD group, with no occurrences in the RF group. Hypotension, nausea, vomiting, and tremors were observed in both groups but were statistically insignificant. In the study by Chittra et al. [15] although complications such as bradycardia and hypotension were present in the DR group and nausea, vomiting, and shivering were noted in the FR group, none of these complications were statistically significant.

Conclusion

Dexmedetomidine, a selective α2A adrenergic agonist, exhibits notable advantages when combined with Ropivacaine epidurally compared to Fentanyl, an intermediate-acting μ receptor agonist. The addition of Dexmedetomidine significantly accelerates the onset and prolongs the recovery of both sensory and motor block. While both drugs synergize effectively with Ropivacaine, Dexmedetomidine offers superior benefits in terms of postoperative analgesia duration and patient satisfaction. Despite Fentanyl's advantage in cardiovascular stability, Dexmedetomidine's sedative properties prove beneficial, enhancing patient satisfaction during procedures conducted under regional anesthesia. Thus, Dexmedetomidine emerges as a more favorable adjunct than Fentanyl for patients undergoing infra-umbilical surgeries solely under epidural anesthesia.

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