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HEMODYNAMIC COMPARISON OF DEXMEDETOMIDINE, CLONIDINE, AND FENTANYL USED AS ADJUVANTS TO EPIDURAL ANAESTHESIA FOR LOWER LIMB ORTHOPEDIC SURGERY IN A TERTIARY CARE HOSPITAL

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ABSTRACT

Background: Epidural anaesthesia is widely used for lower limb orthopaedic surgeries because of its ability to provide effective intraoperative anaesthesia and prolonged postoperative analgesia. Addition of adjuvants such as dexmedetomidine, clonidine, and fentanyl to epidural local anaesthetics improves block characteristics and haemodynamic stability. This study was conducted to compare the effects of dexmedetomidine, clonidine, and fentanyl on intraoperative haemodynamics when used as adjuvants to epidural ropivacaine.

Methodology: This randomized prospective comparative study was conducted in the Department of Anaesthesiology, Sree Mookambika Institute of Medical Sciences, Kulasekharam, from February 2025 to November 2025. A total of 45 ASA grade I and II patients aged 20–60 years undergoing lower limb orthopaedic surgeries under epidural anaesthesia were randomly divided into three groups of 15 each. Group A received ropivacaine with dexmedetomidine, Group B received ropivacaine with clonidine, and Group C received ropivacaine with fentanyl. Intraoperative haemodynamic parameters, onset and duration of sensory and motor blockade, analgesia, and adverse effects were assessed.

Results: A statistically significant fall in systolic, diastolic, and mean arterial pressure was observed in Groups B and C from 15 to 120 minutes after epidural block ($p<0.05$). Dexmedetomidine demonstrated better haemodynamic stability compared to clonidine and fentanyl groups. All three groups provided effective anaesthesia and satisfactory analgesia with manageable adverse effects.

Conclusion: Dexmedetomidine, clonidine, and fentanyl are effective epidural adjuvants in lower limb orthopaedic surgeries. Dexmedetomidine showed superior haemodynamic stability and prolonged analgesic effect with minimal adverse effects.

Keywords: Epidural Anaesthesia, Dexmedetomidine, Clonidine, Fentanyl, Haemodynamics, Orthopaedic Surgery.

INTRODUCTION

Epidural anaesthesia is one of the most commonly employed regional anaesthetic techniques for lower abdominal, pelvic, perineal, and lower limb surgeries because of its effectiveness in providing excellent intraoperative anaesthesia and prolonged postoperative analgesia.[1] It offers several advantages over general anaesthesia, including reduced stress response to surgery, better postoperative pain control, decreased incidence of thromboembolic events, earlier mobilization, and improved patient satisfaction.

www.ajmrhs.com
eISSN: 2583-7761

Date of Received: 03-06-2026
Date Acceptance: 09-06-2026
Date of Publication: 08-07-2026

In orthopaedic surgeries, especially lower limb procedures, adequate perioperative analgesia is essential for facilitating early postoperative rehabilitation and ambulation with minimal discomfort.[2]

Epidural blockade is considered one of the most versatile and valuable procedures in modern anaesthesiology. The epidural space can be accessed at various vertebral levels, allowing flexibility in the administration of anaesthesia according to the site and duration of surgery.[3] The vertebral column consists of 33 vertebrae including 7 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 4 coccygeal vertebrae. The sacral vertebrae are fused to form the sacrum, while the coccygeal vertebrae fuse to form the coccyx.[4] Knowledge of spinal anatomy is essential for safe and effective epidural blockade. The normal vertebral column exhibits cervical and lumbar lordosis along with thoracic and sacral

kyphosis, giving the spine its characteristic double "C" curvature when viewed laterally.[5]

Local anaesthetic agents used in epidural anaesthesia provide sensory, motor, and sympathetic blockade. However, the duration and quality of analgesia achieved with local anaesthetics alone may sometimes be inadequate for prolonged surgeries and postoperative pain relief. Therefore, various adjuvants are commonly added to epidural local anaesthetics to improve the quality of block, hasten onset of action, prolong duration of sensory and motor blockade, reduce analgesic requirements, and provide haemodynamic stability.[6] Among the various adjuvants available, dexmedetomidine, clonidine, and fentanyl are widely used because of their favourable pharmacological properties.

Dexmedetomidine is a highly selective alpha-2 adrenergic receptor agonist with sedative, anxiolytic, sympatholytic, and analgesic properties.[7] It acts predominantly on post-synaptic alpha-2 receptors in the central nervous system and dorsal horn of the spinal cord, thereby inhibiting nociceptive neurotransmission and enhancing analgesia. Dexmedetomidine produces sedation resembling natural sleep without causing significant respiratory depression, which makes it an attractive adjuvant in regional anaesthesia.[8] Epidural dexmedetomidine has been shown to prolong both sensory and motor blockade while maintaining haemodynamic stability.

Clonidine is another alpha-2 adrenergic agonist commonly used as an epidural adjuvant. It acts mainly by stimulating pre-synaptic alpha-2 receptors, resulting in decreased sympathetic outflow and enhanced analgesia.[9] Clonidine possesses antihypertensive, sedative, anxiolytic, and analgesic properties. When combined with local anaesthetics in epidural anaesthesia, clonidine prolongs the duration of sensory and motor blockade and improves postoperative analgesia in abdominal and orthopaedic surgeries.[10] However, side effects such as hypotension and bradycardia may occur with higher doses.

Fentanyl is a potent synthetic opioid frequently used as an epidural adjuvant because of its rapid onset and strong analgesic effect.[11] It acts primarily on opioid receptors in the substantia gelatinosa of the spinal cord to inhibit pain transmission. Addition of fentanyl to epidural local anaesthetics improves intraoperative analgesia and prolongs postoperative pain relief while reducing the requirement of systemic analgesics.[12]

Although dexmedetomidine, clonidine, and fentanyl are commonly used epidural adjuvants, differences exist regarding their effects on intraoperative haemodynamics, onset and duration of blockade, analgesic quality, and side effect profile. Hence, comparative evaluation of these agents is important to identify the most effective and safe adjuvant for epidural anaesthesia in lower limb orthopaedic surgeries. The present study was undertaken to compare the effects of dexmedetomidine, clonidine, and fentanyl on intraoperative haemodynamic parameters when used as adjuvants in epidural anaesthesia for lower limb orthopaedic surgeries.

Aim

To compare the effects of dexmedetomidine, clonidine, and fentanyl on intraoperative haemodynamic parameters when used as adjuvants to epidural anaesthesia in patients undergoing lower limb orthopaedic surgeries.

Objectives

1. To evaluate and compare the intraoperative haemodynamic parameters such as heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, and oxygen saturation among the three study groups.
2. To compare the onset time of sensory and motor blockade following epidural administration of dexmedetomidine, clonidine, and fentanyl as adjuvants.

MATERIALS AND METHODS

This randomized prospective comparative study was conducted in the Department of Anaesthesiology at Sree Mookambika Institute of Medical Sciences, Kulasekharam, from February 2025 to November 2025. After obtaining approval from the Institutional Ethics Committee and written informed consent from all participants, a total of 45 patients of either sex were enrolled in the study. Patients aged between 20 and 60 years belonging to American Society of Anesthesiologists (ASA) physical status I and II scheduled for elective lower limb orthopaedic surgeries under epidural anaesthesia were included in the study.

Patients who refused participation, those receiving anticoagulant therapy with INR >1.5, patients with congenital abnormalities of the lower spine or meninges, active central nervous system disease, history of allergy to local anaesthetics or alpha-2 adrenergic agonists, uncontrolled systemic illnesses such as diabetes mellitus and hypertension, and patients with uncorrected hypovolemia were excluded from the study.

All patients underwent detailed pre-anaesthetic evaluation including history taking, physical examination, airway assessment, and routine laboratory investigations. Patients were kept nil per oral as per standard fasting guidelines. On arrival to the operating room, intravenous access was secured and patients were preloaded with intravenous crystalloids before initiation of the anaesthetic procedure. Baseline haemodynamic parameters including heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure,

respiratory rate, and oxygen saturation were recorded. Standard monitoring including electrocardiography (ECG), non-invasive blood pressure (NIBP), and pulse oximetry (SpO_2) was instituted in all patients. All emergency drugs and equipment necessary for administration of epidural anaesthesia and resuscitation were checked and kept ready.

The patients were placed in sitting position and the L3–L4 intervertebral space was identified using anatomical landmarks. Under strict aseptic precautions, painting and draping were performed and local infiltration of the skin was done with 2 mL of 2% lignocaine. The patients were randomized into three groups of 15 each using a computer-generated randomization table. Group A received epidural ropivacaine with dexmedetomidine, Group B received epidural ropivacaine with clonidine, and Group C received epidural ropivacaine with fentanyl.

An 16-gauge Tuohy needle was inserted through the L3–L4 interspace and advanced carefully until the epidural space was identified using the loss of resistance technique. A 16-gauge epidural catheter was then threaded through the needle and secured with approximately 3–4 cm of the catheter remaining within the epidural space. A test dose of 3 mL of 2% lignocaine with adrenaline 1:200000 was administered to confirm correct placement of the catheter and exclude intrathecal or intravascular placement.

After confirmation of epidural catheter placement, the study drugs were administered according to group allocation. Intraoperative haemodynamic parameters including heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, respiratory rate, and oxygen saturation were monitored at regular intervals throughout the surgery. The onset and duration of sensory and motor blockade, duration of analgesia, and incidence of adverse effects such as hypotension, bradycardia, nausea, vomiting, respiratory depression, and sedation were also recorded and analysed.

The collected data were entered into Microsoft Excel and analysed using Statistical Package for Social Sciences (SPSS) software version 25.0. Quantitative variables were expressed as mean ± standard deviation, while qualitative variables were expressed as frequency and percentage. One-way analysis of variance (ANOVA) was used for comparison of continuous variables among the three groups, followed by post hoc analysis wherever necessary. Chi-square test or Fisher's exact test was applied for comparison of categorical variables. A p-value of less than 0.05 was considered statistically significant.

RESULT

Table 1. Distribution of Patients According to Gender in Three Groups

Gender	Group A (RD)		Group B (RC)		Group C (RF)		P value
	n	%	N	%	n	%	
Male	08	53.3	10	66.7	09	64	0.83
Female	07	46.7	05	33.3	06	40	
Total	15	100	15	100	15	100	

Majority of patients in present study was males in all the groups. Males constituted 53.3% & 66.7% of population in group A and B respectively whereas 60% patients in group C was males. The gender distribution in present study in the three groups using chi square test was observed to be comparable (p=0.83).

Table 2- Duration of Surgery in Three Different Groups

Duration of surgery (min)	Group A (RD)		Group B (RC)		Group C (RF)		P value
	Mean	SD	Mean	SD	Mean	SD	
	93.90	6.61	96.50	09.43	97.97	12.10	0.15

Above table represents mean duration of surgery amongst the patients of three groups. Mean duration of surgery in group A was 93.90±6.61 minutes whereas the mean duration of surgery in Group B and C was 96.50±09.43 and 97.97±12.10 respectively. Test of significance (ANOVA test) observed no statistically significant difference in duration of surgery among the three groups, (p=0.15).

Table 3- Comparison of Systolic Blood Pressure at Various Time Intervals between the Groups

Systolic Blood	Group A (RD)	Group B (RC)	Group C (RF)	P value

pressure (mmHg)	Mean	SD	Mean	SD	Mean	SD	
Basal	123.80	3.699	122.87	4.167	123.13	4.066	0.65
5 minute	124.27	3.956	124.27	3.352	124.67	3.032	0.88
10 minute	119.00	4.835	118.73	3.982	118.27	4.258	0.81
15 minute	117.53	3.589	112.27	7.478	112.33	7.068	0.002
20 minute	116.53	5.303	110.93	10.748	109.20	9.419	0.005
25 minute	115.47	5.117	109.67	9.728	108.67	9.178	0.004
30 minute	115.00	5.324	108.13	9.909	107.53	9.258	0.001
40 minute	115.00	5.139	108.80	10.823	107.13	9.108	0.002
50 minute	115.20	5.549	109.43	11.398	107.87	9.641	0.007
60 minute	113.80	5.616	109.60	11.993	108.00	9.896	0.05
70 minute	114.73	4.283	108.60	10.702	108.20	8.903	0.005
80 minute	114.73	4.472	109.07	11.064	109.13	9.947	0.02
90 minute	115.33	4.373	109.20	11.075	109.73	10.086	0.02
105 minute	115.73	4.226	108.93	10.031	109.73	9.976	0.005
120 minute	116.00	4.267	109.60	9.733	109.73	9.450	0.004
135 minute	116.27	4.093	114.07	5.860	114.73	6.136	0.28
150 minute	116.87	4.321	115.53	5.770	116.00	5.872	0.62
180 minute	117.27	4.185	114.20	7.902	115.07	8.267	0.23
210 minute	117.80	4.405	115.73	4.571	116.47	4.862	0.22

Mean systolic blood pressure at baseline was 123.80±3.69, 122.87±4.16 and 123.13±4.066 mmHg in group A, B and C respectively. ANOVA test was used to compare three groups. The present study observed a statistically highly significant drop in systolic blood pressure among Group B and C from 15 minutes following the block to 120 minutes of the procedure ($p<0.05$).

Table 4- Comparison of Diastoloc Blood Pressure at Various Time Intervals between the Groups

Diastolic Blood pressure (mmHg)	Group A (RD)		Group B (RC)		Group C (RF)		P value
	Mean	SD	Mean	SD	Mean	SD	
Basal	83.27	3.352	83.07	3.657	83.53	3.104	0.87
5 minute	85.27	3.084	84.93	2.766	84.87	3.181	0.86
10 minute	78.27	3.513	79.13	3.627	79.13	3.589	0.56
15 minute	76.47	3.471	71.47	5.329	71.53	5.399	0.001
20 minute	75.47	3.998	69.47	6.078	69.87	5.704	0.001
25 minute	75.13	4.158	69.67	6.456	69.20	6.206	0.001
30 minute	74.20	4.342	67.53	6.163	68.00	6.560	0.001
40 minute	73.60	4.438	67.87	6.847	67.80	6.692	0.001
50 minute	74.07	4.346	67.93	6.443	68.13	6.927	0.001
60 minute	73.60	4.107	70.40	7.815	68.87	6.426	0.05
70 minute	73.47	4.455	69.27	7.268	68.33	6.370	0.004
80 minute	73.67	4.037	69.47	7.592	68.33	6.082	0.003
90 minute	74.13	4.297	69.47	7.592	69.47	7.682	0.01
105 minute	74.40	4.407	70.40	6.420	70.13	6.323	0.008
120 minute	75.07	4.448	70.60	7.318	70.53	7.276	0.01
135 minute	76.13	4.783	75.00	5.502	75.73	5.502	0.70

150 minute	76.60	4.553	76.33	5.707	76.60	5.876	0.98
180 minute	76.53	4.066	75.00	5.913	76.47	6.230	0.48
210 minute	76.53	4.066	75.87	4.265	77.07	4.510	0.56

The diastolic blood pressure at baseline was comparable among three groups. The mean diastolic blood pressure at baseline in group A, B and C was 83.27±3.352 mmHg, 83.07±3.65 mmHg and 83.53±3.104 mmHg. The present study observed a statistically highly significant drop (using ANOVA) in diastolic blood pressure among patients of Group B and C from 15 minutes following the block to 120 minutes of the procedure ($p<0.05$).

Table 5: Comparison of Heart Rate at Various Time Intervals between the Groups

Pulse rate (per minute)	Group A (RD)		Group B (RC)		Group C (RF)		P value
	Mean	SD	Mean	SD	Mean	SD	
Basal	78.70	4.75	78.90	6.20	78.70	6.19	0.97
5 minute	79.80	5.7	80.10	6.2	80.07	5.75	0.98
10 minute	74.23	5.18	73.43	4.56	73.10	4.17	0.63
15 minute	71.43	5.74	70.03	4.92	70.87	4.88	0.58
20 minute	70.33	6.86	65.43	6.54	65.97	6.18	0.008
25 minute	68.37	6.99	63.83	6.0	64.30	5.82	0.01
30 minute	67.50	7.05	63.63	5.94	64.27	5.47	0.04
40 minute	67.17	6.60	62.73	5.81	63.90	5.60	0.02
50 minute	66.53	6.30	66.40	6.04	66.60	6.39	0.99
60 minute	66.13	6.05	66.20	5.62	66.67	5.64	0.93
70 minute	67.03	5.38	66.57	4.85	68.33	6.06	0.43
80 minute	67.27	5.13	66.77	4.95	67.90	5.64	0.71
90 minute	67.53	4.73	65.77	4.61	67.30	4.55	0.28
105 minute	67.13	5.85	67.30	6.48	69.03	6.22	0.23
120 minute	66.90	5.19	66.47	4.95	67.77	4.38	0.49
135 minute	67.73	4.77	66.97	4.38	68.10	4.59	0.76
150 minute	68.43	4.76	66.87	5.14	68.67	5.94	0.85
180 minute	69.17	3.92	68.17	3.58	69.93	4.06	0.45
210 minute	69.53	4.09	68.23	3.64	69.37	5.03	0.89

Mean basaline heart rate in patients of group A was 78.70±4.75 per minute, 78.90±6.20 per minute in group B and 78.70±6.19 per minute in group C. From 20 minutes following anesthesia, statistically significant difference (using ANOVA) amongst 3 groups was observed with mean heart rate of 70.33±6.86, 65.43±6.54 and 65.97±6.18 per minute in group A, B and C respectively. The present study observed statistically highly significant drop (using ANOVA) in heart rate among Group B and C during 20 to 40 mins ($p<0.05$). There was no significant difference in mean heart rate thereafter, throughout the observation period.

DISCUSSION

Maintenance of stable intraoperative haemodynamics is one of the primary goals of epidural anaesthesia, particularly in lower limb orthopaedic surgeries where prolonged operative duration and sympathetic blockade can significantly influence cardiovascular parameters. In the present study, dexmedetomidine, clonidine, and fentanyl were compared as adjuvants to epidural ropivacaine with regard to their effects on intraoperative haemodynamics and block characteristics.

The present study observed a statistically significant decrease in systolic blood pressure, diastolic blood pressure, and mean arterial pressure in Groups B and C from 15 minutes after epidural administration until 120 minutes of surgery ($p<0.05$). The reduction in blood pressure was effectively managed with intravenous fluids and mephenteramine 6 mg intravenous bolus when required. The haemodynamic changes observed may be attributed to sympathetic blockade produced by epidural anaesthesia along with the pharmacological effects of the adjuvant drugs. Alpha-2 adrenergic agonists such as dexmedetomidine and clonidine decrease

sympathetic outflow and enhance vagal activity, thereby contributing to hypotension and bradycardia.[13]

In the present study, dexmedetomidine demonstrated better haemodynamic stability compared to clonidine and fentanyl groups. Similar findings were reported by Rahimzadeh et al. (2018), who observed a statistically significant reduction in mean arterial pressure during the first 60 minutes after epidural block in patients receiving fentanyl when compared to dexmedetomidine.[14] Dexmedetomidine, due to its highly selective alpha-2 agonistic action, provides stable haemodynamics along with prolonged analgesia and sedation without causing significant respiratory depression. Its sympatholytic effect attenuates stress responses during surgery and contributes to cardiovascular stability.[15]

Singh BR et al. (2015) compared clonidine and fentanyl as epidural adjuvants and reported a statistically significant decrease in mean systolic blood pressure at 15, 30, 60, and 120 minutes following epidural administration in both groups.[16] Their findings correlate well with the present study, where significant reductions in blood pressure were observed in clonidine and fentanyl groups. Clonidine acts by stimulating pre-synaptic alpha-2 adrenergic receptors in the central nervous system, leading to reduced catecholamine release and decreased sympathetic tone. This contributes to prolonged sensory blockade and enhanced analgesia but may also produce hypotension and bradycardia in susceptible patients.[17]

Paul A et al. (2017) observed no statistically significant difference in mean arterial pressure between dexmedetomidine and fentanyl groups during epidural anaesthesia ($p>0.05$).[18] Similarly, Neha et al. (2017) also reported no significant difference in haemodynamic parameters among patients receiving dexmedetomidine and fentanyl as epidural adjuvants.[19] These findings suggest that although transient reductions in blood pressure may occur, all three adjuvants are generally capable of maintaining acceptable intraoperative haemodynamic stability when administered in appropriate doses with adequate monitoring and fluid management.

Apart from haemodynamic effects, dexmedetomidine and clonidine are known to enhance the quality and duration of sensory and motor blockade by acting on alpha-2 receptors in the dorsal horn of the spinal cord.[20] Fentanyl, being a lipophilic opioid, acts synergistically with local anaesthetics by inhibiting nociceptive transmission through opioid receptors in the substantia gelatinosa.[21] Addition of these adjuvants to epidural ropivacaine not only improves intraoperative analgesia but also prolongs postoperative pain relief, thereby reducing the requirement for rescue analgesics.

Overall, the present study demonstrates that dexmedetomidine, clonidine, and fentanyl are effective epidural adjuvants for lower limb orthopaedic surgeries. Among them, dexmedetomidine provided comparatively better haemodynamic stability with effective analgesia and minimal adverse effects. However, all three drugs can be safely used under careful monitoring and appropriate perioperative management.

CONCLUSION

Dexmedetomidine, clonidine, and fentanyl were found to be effective adjuvants to epidural ropivacaine in lower limb orthopaedic surgeries. All three drugs provided satisfactory intraoperative anaesthesia and stable haemodynamic parameters with adequate analgesia. Dexmedetomidine demonstrated comparatively better haemodynamic stability with prolonged sensory and motor blockade and fewer adverse effects when compared to clonidine and fentanyl. Although transient decreases in blood pressure were observed in the clonidine and fentanyl groups, these changes were manageable with appropriate fluid therapy and vasopressor support. Hence, dexmedetomidine may be considered a superior epidural adjuvant for lower limb orthopaedic surgeries due to its favourable haemodynamic profile and enhanced analgesic efficacy.

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How to cite this article: Dr. Sreekala, Dr. Subhasan JV, HEMODYNAMIC COMPARISON OF DEXMEDETOMIDINE, CLONIDINE, AND FENTANYL USED AS ADJUVANTS TO EPIDURAL ANAESTHESIA FOR LOWER LIMB ORTHOPEDIC SURGERY IN A TERTIARY CARE HOSPITAL, Asian J. Med. Res. Health Sci., 2026; 4 (2): 1865-1871.

Source of Support: Nil, Conflicts of Interest: None declared.