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RESEARCH ARTICLE

COMPARATIVE STUDY OF THE EFFECT OF EPIDURAL FENTANYL VERSUS MAGNESIUM SULFATE AS ADJUVANTS TO 0.75% ROPIVACAINE IN LOWER LIMB SURGERIES

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Abstract

Background: Epidural anesthesia is frequently chosen for lower limb operations, and adding adjuvants can refine block characteristics while reducing local anesthetic requirements. This randomized, double-blind study evaluated fentanyl and magnesium sulfate as adjuncts to ropivacaine.

Methods: Fifty ASA I–II adults were randomly allocated to receive either ropivacaine with fentanyl or ropivacaine with magnesium sulfate. Sensory and motor block onset, regression pattern, analgesic duration, hemodynamic variations, and adverse effects were recorded.

Results: Magnesium sulfate produced a noticeably faster rise in sensory and motor blockade. Fentanyl provided a longer-lasting block with extended analgesia and delayed need for rescue dosing. Hemodynamic trends and side-effect incidence remained comparable.

Conclusion: Magnesium sulfate is preferable when rapid block establishment is essential. Fentanyl is advantageous when prolonged postoperative pain relief is the objective. Both agents can be safely used as epidural adjuvants.

Introduction:-

Pain is a multidimensional experience influenced by physiological, emotional, and social components. In clinical practice, adequate perioperative pain control is essential to prevent adverse stress responses. Epidural anesthesia, which involves depositing a local anesthetic within the epidural space to interrupt nerve conduction, has proven effective for a wide range of major procedures, including lower limb surgeries.Ropivacaine, a long-acting amide anesthetic, blocks sodium channel activity in nerve fibers and provides reliable sensory blockade with relatively reduced motor impairment. Lower limb surgeries—ranging from orthopedic reconstruction to trauma management—often necessitate robust regional anesthesia.Adjuvants are pharmacological agents added to local anesthetics to improve onset, depth, or duration of neural blockade. Magnesium sulfate enhances analgesia primarily through NMDA receptor antagonism and calcium-channel modulation, whereas fentanyl produces potent neuraxial

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analgesia through spinal opioid receptor activation.This study compares the impact of fentanyl and magnesium sulfate when used with ropivacaine in epidural anesthesia for lower limb surgeries.

Methodology:-

This prospective, randomized, double-blind study was conducted from August 2022 to January 2024 after institutional approval. Adults aged 18–60 years, ASA I–II, and scheduled for elective lower limb procedures were included. Exclusion criteria encompassed emergency surgery, pregnancy, systemic disorders, chronic opioid/sedative use, or contraindications to epidural anesthesia.

Participants were randomly divided into:

• Group RF: 0.75% ropivacaine + 50 µg fentanyl
• Group RM: 0.75% ropivacaine + 100 mg magnesium sulfate

A standard epidural technique at L3–L4 was used. Sensory block levels were monitored with pinprick, and motor block was assessed using the Modified Bromage scale. Hemodynamic variables were continuously observed. Time to onset of sensory and motor block, regression characteristics, VAS pain scores, need for rescue top-up, and adverse events were documented.

Results:-

Table 1: Demographic and Baseline Characteristics

Parameter	Group RF (n=25)	Group RM (n=25)	p-value
Age (years)	34.3±7.9	38.5±8.8	>0.05
Gender (M/F)	19/6	20/5	0.733
ASA Status (I/II)	18/7	19/6	>0.05
BMI (kg/m²)	22.6±2.9	24.1±2.8	0.079
Duration of Surgery (min)	122.8±14.9	117.6±16.4	0.246

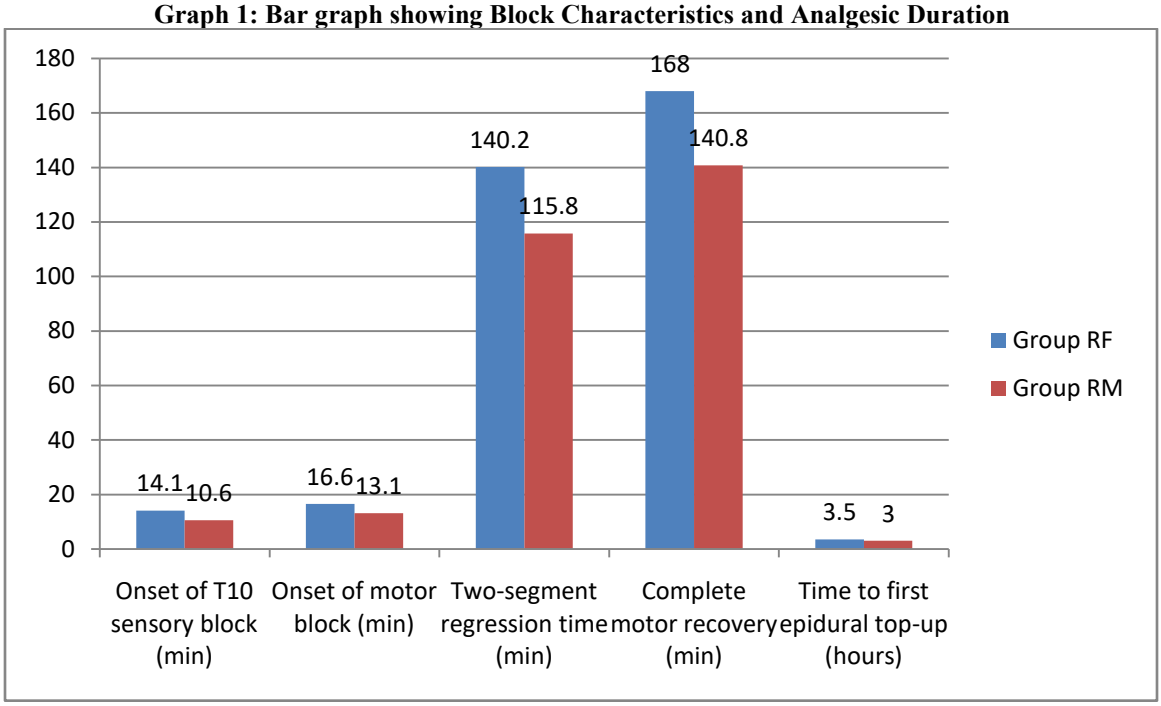
Demographic characteristics were similar across both groups.

Table 2: Block Characteristics and Analgesic Duration

Parameter	Group RF (n=25)	Group RM (n=25)	p-value
Onset of T10 sensory block (min)	14.1±1.4	10.6±1.4	<0.005*
Onset of motor block (min)	16.6±1.2	13.1±1.2	<0.005*
Two-segment regression time (min)	140.2±10.7	115.8±13.9	<0.005*
Complete motor recovery (min)	168±11.3	140.8±11.7	<0.005*
Time to first epidural top-up (hours)	3.5±0.7	3.0±0.6	0.003*

***Statistically significant (p<0.05)**

Graph 1: Bar graph showing Block Characteristics and Analgesic Duration



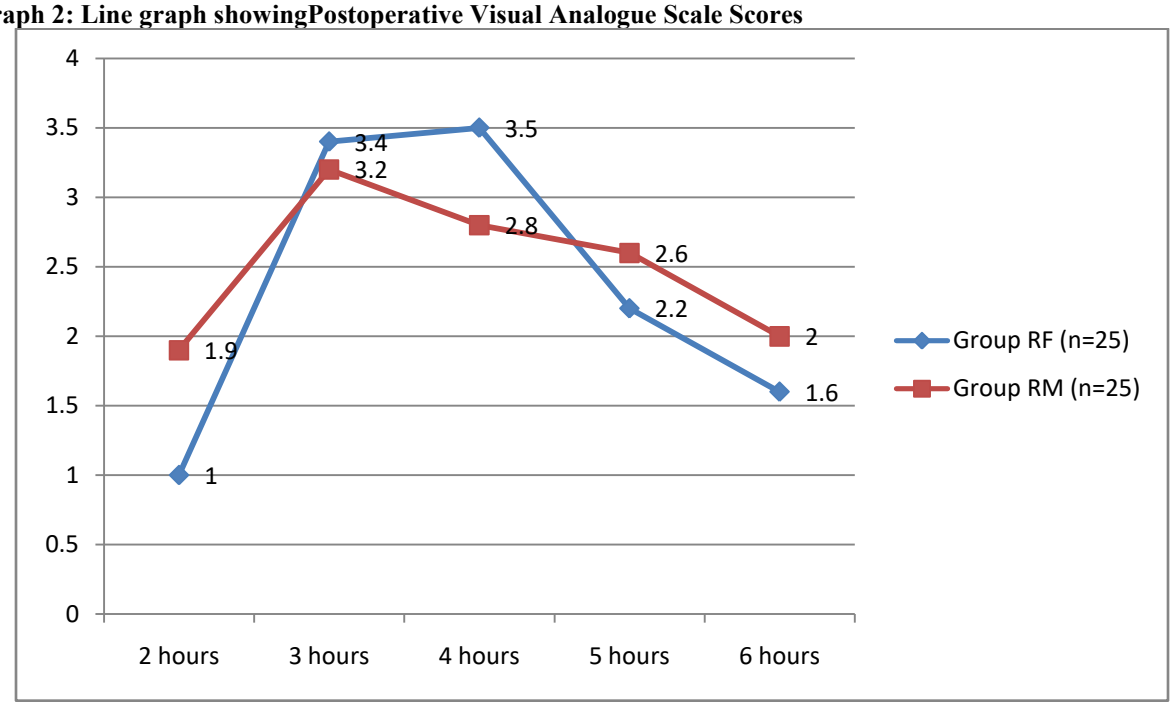
Group RM demonstrated significantly faster onset of both sensory block (Table 2) and motor block compared to Group RF, indicating rapid anesthesia induction with magnesium sulfate. Conversely, Group RF showed significantly prolonged two-segment regression time, delayed complete motor recovery, and longer duration before requiring first epidural top-up, indicating extended analgesic effect with fentanyl.

Table 3: Postoperative Visual Analogue Scale Scores

Time Point	Group RF (n=25)	Group RM (n=25)	p-value
2 hours	1.0±0.8	1.9±1.3	0.004*
3 hours	3.4±2.2	3.2±2.1	0.866
4 hours	3.5±2.5	2.8±2.0	0.625
5 hours	2.2±0.9	2.6±1.6	0.100
6 hours	1.6±0.6	2.0±1.1	0.306

***Statistically significant (p<0.05)**

Graph 2: Line graph showingPostoperative Visual Analogue Scale Scores



Postoperative pain assessment revealed significantly lower VAS scores in Group RF at 2 hours postoperatively (Table 3), indicating superior early postoperative analgesia with fentanyl. However, VAS scores were comparable between groups at subsequent time intervals.

Table 4: Adverse Effects

Adverse Effect	Group RF (n=25)	Group RM (n=25)
Hypotension	5 (20%)	6 (24%)
Nausea/Vomiting	2 (8%)	2 (8%)
Shivering	1 (4%)	1 (4%)
Bradycardia	2 (8%)	2 (8%)

Both groups demonstrated comparable incidence of adverse effects with no statistically significant differences ($p>0.05$), indicating similar safety profiles for both adjuvants (Table 4).Regarding hemodynamic parameters, heart rate showed no statistically significant differences between groups except at 60 minutes and end of surgery. Systolic blood pressure demonstrated statistical significance at all time durations except preoperative values and 5 minutes post-administration. Diastolic blood pressure showed significance only at 15 and 30 minutes. Mean arterial pressure demonstrated statistical significance at all time points except preoperative and 5 minutes, with Group RF showing relatively better hemodynamic stability. Modified Ramsay Sedation Scores were comparable between groups (RF: 1.8 ± 0.7 vs RM: 1.7 ± 0.7, $p=0.694$), indicating similar sedation levels.

Discussion:-

Magnesium sulfate's quicker onset can be attributed to its NMDA receptor antagonism, which enhances the effect of local anesthetics. Fentanyl's capacity to prolong postoperative pain relief corresponds to its rapid diffusion into the spinal cord and strong affinity for opioid receptors.Although the study design minimizes bias, limitations include modest sample size, single-center execution, and short follow-up duration. Sedation scores, although recorded, were not deeply correlated with recovery quality. Surgical types were not subdivided, which may have influenced analgesic requirements. Cost-effectiveness, particularly favoring magnesium sulfate, was not evaluated.Nevertheless, clinical translation is clear: magnesium sulfate is useful when rapid anesthesia onset is needed, while fentanyl is advantageous for sustained postoperative analgesia.

Limitations:-

• Small sample size and single-center design.
• Only short-term postoperative outcomes assessed.
• Sedation score analysis limited.
• Lack of surgical stratification.
• No cost-benefit assessment performed.

Clinical Implications:-

• Magnesium sulfate → rapid onset for quicker surgical readiness.
• Fentanyl → prolonged analgesia with reduced need for early rescue doses.
• Both agents show comparable safety and hemodynamic stability.
• Magnesium sulfate may be more economical for routine use.

Conclusion:-

Both magnesium sulfate and fentanyl significantly improve the characteristics of epidural ropivacaine. Magnesium provides more rapid onset, while fentanyl offers more sustained analgesia. Selection should be based on clinical requirements and desired postoperative pain management goals.

Key Highlights:-

• Magnesium sulfate accelerates sensory and motor block onset.
• Fentanyl prolongs analgesia and delays regression.
• Hemodynamic stability is similar in both groups.
• Early postoperative pain scores favored fentanyl.
• Adverse effects were minimal and comparable.

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