



PROSPECTIVE STUDY TO COMPARE EFFECTIVENESS OF ADENOSINE WITH MAGNESIUM SULPHATE AS ADJUVANTS TO ROPIVACAINE IN ULTRASOUND GUIDED TRANSVERSUS ABDOMINIS PLANE BLOCK FOR POSTOPERATIVE ANALGESIA IN PATIENTS UNDERGOING OPEN ABDOMINAL SURGERY

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Abstract

Background: Postoperative pain following abdominal surgeries significantly affects recovery and outcomes. The transversus abdominis plane (TAP) block, a regional anesthesia technique, has gained popularity for its ability to provide effective analgesia and reduce opioid consumption. **Aim:** To determine the comparative effectiveness of adenosine and magnesium sulphate as adjuvants to ropivacaine in TAP block for post-operative analgesia in patients undergoing abdominal surgeries. **Methods:** A prospective comparative study included 100 patients undergoing elective abdominal surgeries. Participants were allocated into two groups: one received ropivacaine with MgSO₄ and the other with adenosine in ultrasound-guided TAP blocks. Demographic data, intraoperative and postoperative hemodynamic parameters, pain scores (VAS), sedation levels (Ramsay Sedation Score), rescue analgesic requirements, and complications were recorded. TAP blocks were performed using ultrasound guidance, ensuring precise placement of the local anesthetic and adjuvant. Postoperative pain was assessed at regular intervals up to 24 hours. Statistical analyses were conducted to compare analgesic efficacy, duration, opioid consumption, and safety profiles between the two groups. **Results:** Demographic characteristics were comparable between groups, with no significant differences. Both groups exhibited stable intraoperative hemodynamic parameters, no intraoperative complications were observed, underscoring the safety of both adjuvants. Postoperative pain scores were initially similar but diverged significantly at 24 hours. The MgSO₄ group reported lower VAS scores (3.5 ± 1.3) compared to the adenosine group (4.1 ± 1.3 , $p = 0.040$). MgSO₄ also demonstrated superior analgesic duration, with a longer time to first rescue analgesia and longer duration of analgesia overall. Patients in the MgSO₄ group required fewer tramadol boluses, with 62% needing only one or two doses compared to 70% in the adenosine group requiring two or three doses ($p < 0.001$). Sedation levels were comparable, though

the MgSO₄ group exhibited slightly lower scores at one hour postoperatively ($p = 0.048$). Magnesium Sulfate (MgSO₄) significantly prolonged the duration of analgesia compared to adenosine, with a mean analgesia duration of 483.4 ± 48.1 minutes versus 415.3 ± 29.8 minutes ($p < 0.001$), and a mean time to first rescue analgesia does also being longer than the adenosine group patients (421.5 ± 30.9 minutes vs 372.8 ± 38.2 minutes, $p < 0.001$). Complications such as nausea and vomiting were minimal and comparable between groups, with no significant differences. **Conclusion:** Both MgSO₄ and adenosine proved to be safe and effective adjuvants in TAP blocks for postoperative pain management. MgSO₄ demonstrated superior analgesic efficacy, prolonged duration, and reduced opioid requirements, making it particularly suitable for surgeries with higher pain profiles or extended recoveries. Adenosine provided adequate short-term analgesia, making it a viable alternative for low-pain or short duration procedures.

Keywords: Transversus abdominis plane (TAP) block, Magnesium Sulfate (MgSO₄), Adenosine, Postoperative pain, a regional anesthesia technique, VAS

Introduction:

Open abdominal surgeries are inevitably accompanied by considerable postoperative pain, which is a significant variable in patient outcomes and post-operative complications.¹ Managing this pain effectively is crucial to improving recovery and reducing the risk of complications. While opioids are widely used for post-operative pain relief, their side effects and potential for addiction limit their application. This has led to the exploration of alternative pain management strategies, such as the Transversus Abdominis Plane (TAP) block.²

The Transversus Abdominis Plane (TAP) is identified as a neurofascial layer situated between the Internal Oblique (IO) and Transversus Abdominis (TA) muscles within the abdominal wall. It serves as a conduit for sensory nerves supplying the skin, muscles, and parietal peritoneum of the anterior abdominal wall.³ The approach of blocking these sensory nerves by administering a local anesthetic within the Transversus Abdominis Plane is referred to as a TAP block. By employing the TAP block technique, which involves blocking the sensory afferent nerves coursing between the abdominal muscles, effective mitigation of postoperative pain can be achieved.⁴

The TAP block has gained popularity due to its potential to reduce opioid consumption and its minimal side effects. This technique provides significant pain relief and can improve patient outcomes by reducing the need for opioid medications, which are associated with a range of adverse effects such as nausea, vomiting, constipation, respiratory depression, and the potential for dependency. As an anesthetist, the exploration of optimal adjuvants to traditional local anesthetics in TAP block becomes crucial for refining postoperative pain management strategies and improving patient outcomes.⁵

Adenosine and magnesium sulphate both hold potential as adjuvants in the TAP block technique, each offering unique mechanisms of action that could enhance the effectiveness of ropivacaine. Adenosine's interaction with A₁ receptors and its ability to inhibit neurotransmitter release could lead to prolonged and improved analgesia, making it a valuable candidate for further study. On the other hand, magnesium sulphate's NMDA receptor antagonism and calcium channel blocking properties offer a different pathway to achieving enhanced pain relief. Comparing adenosine and magnesium sulphate with respect to onset, duration, and quality of analgesia, as well as potential side effects, can contribute valuable evidence for anesthetists seeking to optimize pain management strategies in abdominal surgeries.¹⁴

Material and Methods:

This study was conducted at the operation theatre and in-patient department of the Department of Anaesthesiology and Critical care, at Government Medical College and associated hospital, Anantnag, Jammu and Kashmir, India.

Study design and duration:

An observational analytical study with a prospective design was conducted. The total duration for the present study was 9 months (March 2024 to November 2024).

Study sample and grouping:

All patients undergoing open abdominal surgery like umbilical, paraumbilical, ventral or epigastric hernia repair, appendectomy, appendicular perforation, hysterectomy, genitourinary surgery and exploratory laprotomy under General Anesthesia, receiving transversus abdominis block after induction of GA in the study institution during the period of the study were considered as the study population.

Two groups of patients were considered for the present study. The group 1 patients received transversus abdominis block with Ropivacaine 0.25 % (18ml) + 12 mg adenosine (adenosine group), and patients in the group 2 transversus abdominis block with Ropivacaine 0.25 % (18ml) + 500mg MgSO₄ (Magnesium Sulphate group).

Inclusion criteria:

- ☐ Patients undergoing abdominal surgeries under general anaesthesia and receiving transversus abdominis block for post-operative analgesia.
- ☐ Those who gave informed written consent to be part of study.
- ☐ Age 18-60 years
- ☐ ASA Grades I and II patients.

Exclusion criteria:

- Those patients who refused consent to be part of study.
- Age less than 18 years.
- Patients with uncorrected coagulopathies or thrombocytopenia.
- Morbid obesity (Body Mass Index 35 kg/ m²)
- Local Site infection on abdominal wall.
- Known Allergy to any of the study drugs.

Study procedure

Detailed patient history was obtained, and a thorough clinical examination was conducted. Evaluation for the presence of any co-morbid systemic illness was performed. Laboratory investigations, including hemogram, urine routine and microscopic examination, kidney function test, liver function test, electrocardiograph, and blood sugar level, coagulation profile were reviewed. Patients were shifted to the operating room, and intravenous access was obtained on the forearm with a No.18 G IV cannula. A preload of 500 ml crystalloid was administered before the surgery. Non invasive blood pressure monitoring, pulse oximetry, and ECG monitoring was utilized to monitor all patients. Baseline vitals were recorded. Intravenous premedication with rantidine 50mg and 4 mg of ondansetron was given to prevent aspiration.

All patients were operated under general anesthesia. General anesthesia was carried out with Propofol 1.5mg/kg, Fentanyl 1 micro-g/kg and Atracurium 0.5mg/kg to facilitate tracheal intubation. Isoflurane 1% to maintain Anesthesia. Vital parameters were monitored every 5 minutes during the intraoperative period. Reversal was carried out by using neostigmine (0.05 mg/kg) and glycopyrrolate (0.01mg/kg). After induction the abdomen was draped and the TAP block was performed under all aseptic precautions using suitable approach bilaterally. TAP blocks were performed under ultrasound guidance with the Sonosite. A high-frequency probe (10 MHz) was used to infiltrate the local anesthetic agent into a plane between the internal oblique muscle and transversus abdominis muscle. A 21G spinal needle was used to inject the drug. The first injection of normal saline was given under ultrasound guidance to confirm the correct placement of the needle in the neurovascular plane. Once confirmation is achieved, the respective drug was

injected, depending on the patient's group. In both groups, 1 gm IV paracetamol was administered. The duration of surgery was between 60 to 90 minutes.

Outcomes

The primary outcome for the present study is VAS for postoperative pain scoring on movement at 1, 2, 6, 12, 24, and 48 hours postoperatively. The secondary outcomes include analgesia duration, postoperative analgesia requirement and frequency of nausea, vomiting, somnolence or any other adverse effects. Analgesia duration is defined as the time elapsed from injection of local anesthetic till first need of postoperative rescue analgesic in the form of tramadol 50 mg.

Statistical analysis:

Statistical analysis was performed using SPSS, (Version 20.0). The continuous variable will be expressed as Mean and Standard deviation. Categorical variables were expressed as frequency and percentage. Independent 't'-test will be used to find the significance difference between groups. Chi-square test and Fisher's exact test were used to find out association between the categorical variables. $P < 0.05$ was considered as statistically significant.

Ethical issues:

The Institutional Ethics Committee of the study institute approved the study before its commencement.

Results:

Demographic characteristics were comparable between groups, with no significant differences [Table 1].

Table 1: Demographic profile among the study population

Age (years)	MgSO ₄ group	Adenosine group	p-value
<40	26 (52)	14 (28)	0.068
40-50	19 (38)	22 (44)	
>50	5 (10)	14 (28)	
M/F	29 (58)/21 (42)	36 (72)/14 (28)	0.142

The most common surgical indications included hernia repair (24% in MgSO₄ vs. 20% in Adenosine) and total abdominal hysterectomy (20% in MgSO₄ vs. 22% in Adenosine). Distribution across other indications such as appendectomy and colorectal surgery was similar, with no statistically significant differences noted [Table 2].

Table 4: Distribution of patients according to their indication for surgery

Indication	MgSO ₄ group	Adenosine group	p-value
Appendectomy	7 (14)	8 (16)	0.985
Colorectal surgery	3 (6)	3 (6)	
Exploratory laparotomy	2 (4)	1 (2)	
Hernia repair	12 (24)	10 (20)	
TAH	10 (20)	11 (22)	
Total	50 (100)	50 (100)	

It was seen that the two study groups did not differ significantly with respect to their intraoperative mean arterial blood pressure [Table 3].

Table 3: Distribution of patients according to their intraoperative mean arterial blood pressure changes

MAP (mmHg)	MgSO ₄ group (Mean±SD)	Adenosine (Mean±SD)	group p-value
Baseline	94.9±6.1	95.5±5.1	0.667
After TAP block	96.6±6.2	95.1±6.1	0.275
5 mins	95.8±5.1	95.8±5.4	0.987
15 min	94.3±4.6	94.7±5.5	0.688
30 min	95.5±5.8	96.1±5.2	0.657
45 min	94.1±5.7	94.5±6.1	0.696
60 mins	96.1±6.5	95.7±5.9	0.764
End of surgery	94.9±4.9	96.2±5.7	0.252

Postoperative pain scores were similar between the groups initially. However, at the 24-hour mark, the Adenosine group reported significantly higher pain scores (mean 4.1) compared to the MgSO₄ group (mean 3.5), highlighting better pain control with MgSO₄ [Table 4].

Table 4: Distribution of patients according to their postoperative mean VAS score

VAS	MgSO ₄ group (Mean±SD)	Adenosine (Mean±SD)	group p-value
0 min	0±0	0±0	-
15 min	0±0	0±0	-
45 min	0±0	0±0	-
1 hour	1.1±0.2	1±0	0.314
2 hours	1.2±0.3	1.3±0.4	0.319
4 hours	1.6±0.5	1.6±0.5	0.592
6 hours	1.8±0.8	1.9±0.8	0.476
12 hours	2.8±1.1	2.9±1.1	0.690
24 hours	3.5±1.3	4.1±1.3	0.040*

Sedation levels were comparable between groups, though a statistically significant difference was observed at 1 hour postoperatively, with MgSO₄ demonstrating slightly lower scores, indicating less sedation [Fig 1].

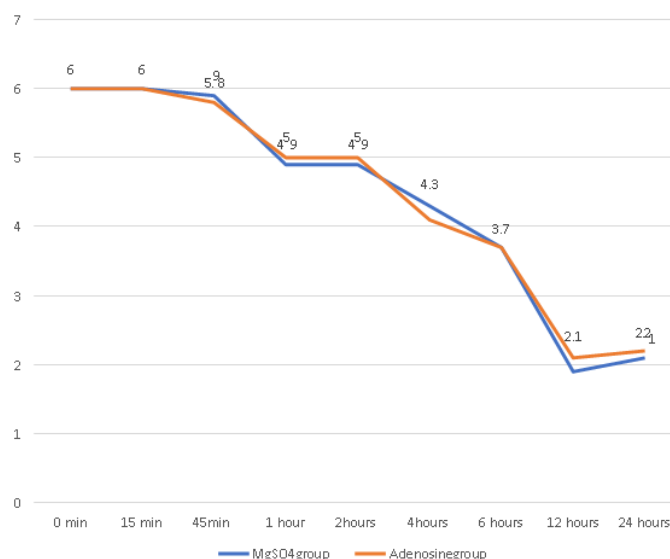


Fig 1.

The MgSO₄ group exhibited significantly longer analgesic duration (483.4 ± 48.1 minutes) compared to the Adenosine group (415.3 ± 29.8 minutes). The time to first rescue analgesia was notably longer in the MgSO₄ group (421.5 ± 30.9 minutes) compared to the Adenosine group (372.8 ± 38.2 minutes, $p < 0.001$) [Fig 2].

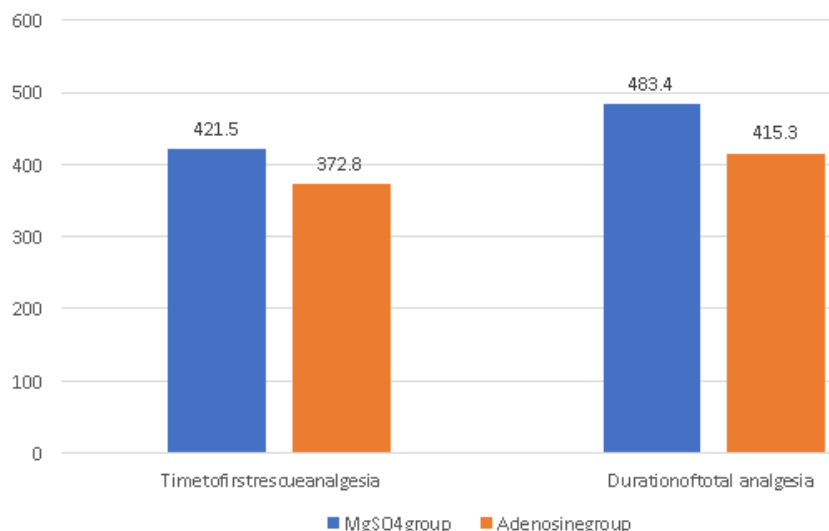


Fig 2.

Patients in the MgSO₄ group required fewer tramadol boluses compared to the Adenosine group, with a statistically significant reduction ($p < 0.001$). This suggests superior analgesic efficacy of MgSO₄ [Fig 3].

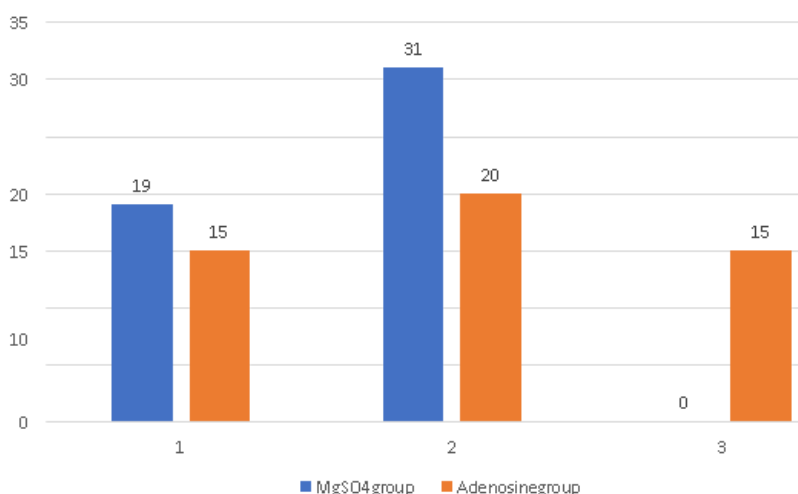


Fig 3.

Minor complications like nausea and vomiting were slightly more frequent in the MgSO₄ group but without statistical significance. Somnolence was absent in both groups [Fig 4].

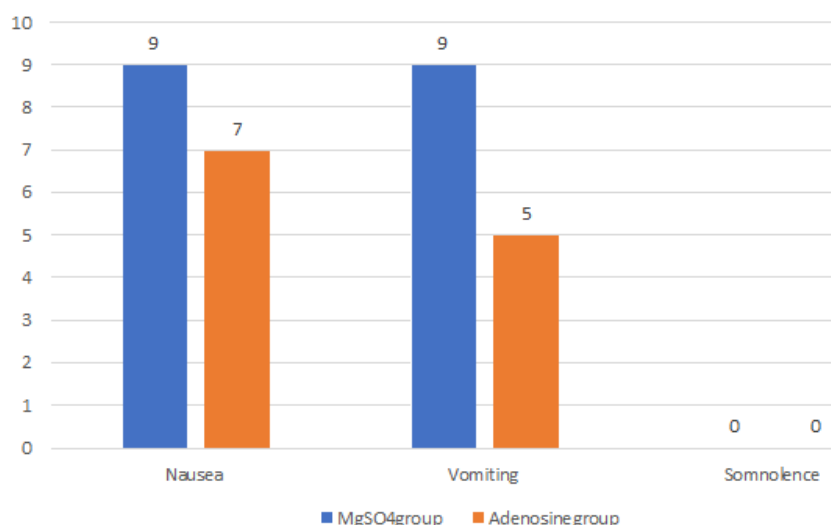


Fig 4.

Discussion:

This study compared the efficacy and safety of adenosine and magnesium sulphate (MgSO₄) as adjuvants to ropivacaine in transversus abdominis plane (TAP) blocks for postoperative analgesia in abdominal surgeries.

The demographic distribution in this study highlighted distinct trends in age and sex between the two groups, though none of these differences were statistically significant. The MgSO₄ group had a greater proportion of younger patients under 40 years (52%), whereas the adenosine group had a higher percentage of patients above

50 years (28%). This demographic difference might reflect variations in surgical indications or baseline health conditions influencing group allocation. Similar trends were reported by Ammar et al. (2017), who observed that age did not significantly impact the efficacy of adjuvants in TAP blocks.²⁷ Furthermore, the slight predominance of male patients in both groups aligns with other studies, such as those

by Ibrahim et al. (2018), where no sex-based disparities were observed in analgesic efficacy.²⁹

The hemodynamic stability observed in this study is likely attributable to the localized effects of TAP blocks, which minimize systemic absorption of the adjuvants. This finding is supported by Aiad et al., who noted that the low systemic bioavailability of MgSO₄ reduces the risk of cardiovascular side effects.²⁶ Additionally, adenosine's receptor-mediated effects are predominantly peripheral, further contributing to its safety profile.

Postoperative pain management is a cornerstone of patient recovery, and this study demonstrated the superior analgesic efficacy of MgSO₄ compared to adenosine in TAP blocks. VAS scores were comparable initially but diverged significantly at the 24-hour mark, with the MgSO₄ group reporting lower pain scores (mean 3.5 ± 1.3) than the adenosine group (mean 4.1 ± 1.3 , $p = 0.040$). This result aligns with Siam et al. (2021) and Bhat et al. (2022), who reported prolonged analgesia with MgSO₄ due to its NMDA receptor antagonism and calcium channel blocking properties.^{30, 34}

The reduced requirement for rescue analgesics in the MgSO₄ group further supports its efficacy. Patients in the MgSO₄ group required significantly fewer tramadol boluses, with 62% needing only one or two doses, compared to 70% in the adenosine group requiring two or three doses ($p < 0.001$). These findings are consistent with Dolma et al., who observed decreased opioid consumption with MgSO₄-enhanced TAP blocks.²⁴ Similarly, Rahimzadeh et al. reported lower supplemental analgesic needs in patients receiving MgSO₄ as an adjuvant.²³

Over the 24-hour postoperative period, sedation levels gradually normalized in both groups, reflecting the localized effects of TAP blocks and the diminishing systemic influence of the

adjuvants. The gradual tapering of sedation is consistent with findings from Moeen et al. (2024), who observed similar trends in patients undergoing laparoscopic cholecystectomy with MgSO₄-enhanced TAP blocks.³⁶ Additionally, Shokeir et al. (2021) reported that the localized nature of TAP blocks minimizes systemic absorption, reducing the risk of prolonged sedation or other central side effects.³¹

It was seen that Magnesium Sulfate (MgSO₄) significantly prolonged the duration of analgesia compared to adenosine, with a mean analgesia duration of 483.4 ± 48.1 minutes versus 415.3 ± 29.8 minutes ($p < 0.001$), and a mean time to first rescue analgesia does also being longer than the adenosine group patients (421.5 ± 30.9 minutes vs 372.8 ± 38.2 minutes, $p < 0.001$). This aligns with studies by Siam et al. and Bhat et al., which demonstrated that MgSO₄ enhances postoperative analgesia via NMDA receptor antagonism and calcium channel blockade, thereby reducing central sensitization and prolonging pain relief.^{30, 34}

This study's limitations include the lack of long-term follow-up to assess chronic pain outcomes and potential adverse effects. Future research could explore the synergistic potential of combining adenosine and MgSO₄ to leverage their distinct mechanisms. Comparative studies involving larger cohorts and diverse surgical populations are warranted to validate these findings further.

Conclusion

Both MgSO₄ and adenosine proved to be safe and effective adjuvants in TAP blocks for postoperative pain management. MgSO₄ demonstrated superior analgesic efficacy, prolonged duration, and reduced opioid requirements, making it particularly suitable for surgeries with higher pain profiles or extended recoveries. Adenosine provided adequate short-term analgesia, making it a viable alternative for low-pain or short duration procedures. The findings support the integration of MgSO₄ in clinical practice for optimizing postoperative pain management. Future research should explore synergistic combinations of adjuvants and their long-term impacts on recovery and chronic pain outcomes.

Conflict of interest: Nil

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