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Magnesium Sulfate: A Multi-Modal Adjunct for Post-Operative Analgesia

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Abstract

The goal of multi-modal analgesia is to minimize the use of opioid analgesics intra-operatively and in recovery.[1] Magnesium sulfate(MgSO4), a physiological cation, serves as a multi-modal adjunct in the reduction of opioid use in the peri-operative setting.[2,7] Historically, opioids have been the choice of providers in treating and controlling pain.[2,4] Recent literature supports the use of a multi-modal approach to control pain and reduce the amount of opioid used.[1-6,8] MgSO4, an inexpensive and safe alternative to opioids, has been shown to reduce the amount of opioids used in recovery.[3,6] MgSO4 is an endogenous electrolyte and antagonist at the NMDA receptor blocking the entry of calcium into the cell.[2,3,7] The entry of calcium ignites numerous nociceptive pathways leading to a chronic pain and a hypersensitivity state to noxious stimuli.[7] By antagonizing the NMDA receptor, MgSO4 prevents patients from a heightened reaction to stimuli and reduction in opioid use.[7] Therefore, the use of MgSO4 as part of a multi-modal analgesia approach should be used during anesthesia management to reduce postoperative pain and the consumption of opioids during and after surgery.[1,4,6] The purpose of this case report is to analyze the analgesic effects of MgSO4 in multi-modal pain management.

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Introduction

- A multi-modal approach that includes $MgSO_4$ prevents the development of a hypersensitive pain state and reduces the number of opioids administered.[1,7]
- $MgSO_4$ has been shown to reduce the amounts of opioids used in recovery and reduce patient reported visual analog scale (VAS) pain scores.[1-3,5]
- $MgSO_4$ is an antagonist at the NMDA receptor inhibiting the transmission of pain signals into a hyperalgesia state.[1,2,7,10] (Figure 2)
- Untreated pain has the potential to lead to central sensitization which can cause acute pain to develop into chronic pain.[7]
- The purpose of the case report is to discusses the role $MgSO_4$ plays in preventing central sensitization and reducing post-operative analgesia.

Literature Search

- Database search: Embase, Medline Complete, PubMed
- Keywords used: magnesium sulfate, multi-modal, post-operative, non-opioid, analgesia.
- Total of 26 articles retrieved; 8 articles used for this case report.

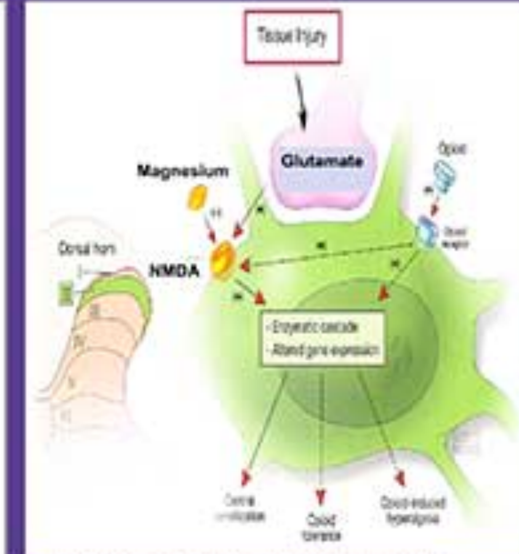

Figure 1. The effects of repeated activation of glutamate at the NMDA receptor leading to central sensitization. MgSO4 acts at the NMDA receptor inhibiting the process of central sensitization.[7]

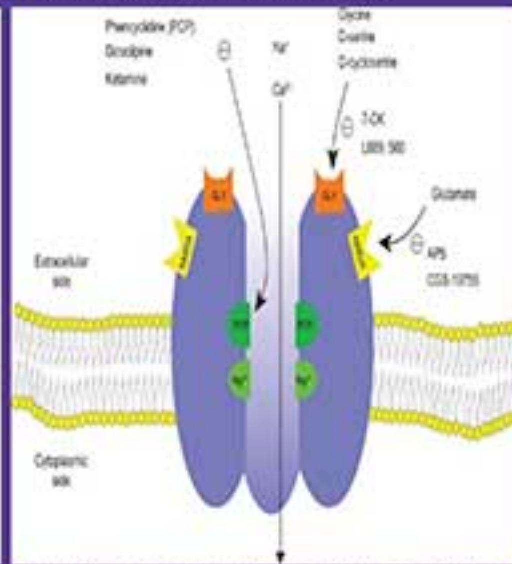

Figure 2. MgSO4 is an NMDA receptor antagonist that prevents the influx of calcium ions which leads to long-term potentiation of chronic pain signals.[10]

Case Description

Preanesthetic evaluation

- A 51-yo, 103 kg, 163 cm, female patient presented for a left total hip arthroplasty due to left hip osteoarthritis.
- Medical history: hypertension, hyperlipidemia, mild asthma, controlled gastroesophageal reflux disease, diabetes mellitus II, hypothyroidism, migraines, chronic back pain, osteoarthritis, depression, anxiety, constipation, and morbid obesity.
- Surgical history: cholecystectomy, hysterectomy, left knee arthroplasty, hernia repair, and lumbar discectomy.

Intraoperative Management

- Preoperative vital signs: HR 68, blood pressure 139/76 mm Hg, SpO_2 98%, RR 16, temperature 35.9 °C
- Standard monitoring, pre-oxygenation via facemask
- Standard induction with lidocaine 100 mg, fentanyl150 mcg, propofol 180 mg, rocuronium 10 mg, and succinylcholine 160 mg intravenously.
- 7.5 ETT secured at 22cm at the lip. Direct laryngoscopy using a Miller #2 blade.
- Ketamine 25 mg IV push, dexmedetomidine 40 mcg IV titrated over 10 minutes, dexamethasone 8 mg IV, ondansetron 4 mg IV, and cefazolin 2 g IV were given prior to surgical incision.
- Maintenance: $MgSO_4$ 3 gms added to 1 L LR fluid bag. Infused at 6 ml/kg/hr. Patient received a total of $MgSO_4$ 3 gms. TIVA – Propofol infusion at 150 mcg/kg/min due to patient's history of sever PONV.
- Intermittent boluses of phenylephrine 50 – 100 mcgs to maintain MAP greater than 70 mm Hg.
- Dexmedetomidine 20 mcg and Ketorolac 30 mg IV prior to surgical closure.

Recovery

- Patient was evaluated in the PACU 30 minutes after arrival. Pain was rated 2 out of 10 on the numeric pain scale. Per PACU nurse, no opioids had been given.

Pathophysiology

- Magnesium is an important electrolyte for human homeostasis and plays a key role in analgesic effects at the NMDA receptor.[1-3,7]
- Magnesium is an antagonist at the NMDA receptor that inhibits the entry of calcium ions thus preventing the intra-cellular cascade responsible for the development of central sensitization.[1-3,7]
- $MgSO_4$ has been found to inhibit the transmission of pain signals at the NMDA receptor to the chronic pain state.[4,9] (Figure 1)
- Low $MgSO_4$ levels were shown to be associated with a hyperalgesia chronic pain state in rats.[7]
- The administration of $MgSO_4$ can reverse low levels of $MgSO_4$ and has been shown to produce an anti-hyperalgesia effect.[7]

Conclusions and Recommendations

- $MgSO_4$ is an important part of the multi-modal approach in reducing the amount of opioid consumption and preventing central sensitization leading to chronic pain syndrome.[2-4]
- Decrease in opioid consumption may lead to decrease in PONV, PACU length of stay, and adverse events in rehabilitation.[1,2,5]
- $MgSO_4$ as part of the multi-modal approach used in conjunction with ketamine, dexmedetomidine, and ketorolac reduced the need for additional opioids intraoperatively and resulted in the patient's reported pain score of 2 out of 10.
- The NMDA receptor site plays a key role in the process of peripheral to central sensitization. $MgSO_4$ is an NMDA antagonist preventing heightened nociceptive pain signals from reaching the brain.[10] (Figure 1)
- Antagonism at the NMDA receptor reduces the pain perceived by the patient and prevents a hyperalgesia state.[6] (Figure 1)

Further research is needed in the following areas:

- Studies utilizing larger sample sizes; the largest sample size in the literature reviewed for this case study was 125 participants.[4]
- A consensus is needed in the amount of $MgSO_4$ to reduce the need of opioids administered and patient reported pain scores.
- The current research shows conflicting results on the impact $MgSO_4$ has on reducing the patient's reported pain and opioid consumption. Since $MgSO_4$ has shown promising results, continuing research is needed to quantify the impact $MgSO_4$ has on the reduction patient reported pain scores and opioid consumption.[3-6,8]
- The current literature cites a variety of routes of administration to include: IV bolus, continuous IV infusion, and IV bolus plus a continuous infusion. All three methods show variability in patients' reported pain scores and opioid consumption.[3-8]
- There is limited research utilizing $MgSO_4$ as the independent factor versus a placebo.

Discussion

- The patient had a significant history of chronic back pain and requested a general anesthetic instead of regional anesthesia. The patient agreed to a multi-modal approach to reduce the total of opioids administered.
- The patient was at risk of increased opioid administration due history of chronic back pain and daily intake of hydrocodone at home.
- Fentanyl 100 mcg was used on induction. The patient did not receive any further opioids intraoperatively.
- The patient reported a pain of 2 out of 10 from the numerical pain scale 30 minutes after PACU arrival.
- After 30 minutes in the PACU, the patient had not requested any opioids or other analgesics for pain.
- A multi-modal approach including $MgSO_4$ was used due to the patient's history of chronic back pain, chronic opioid use, and lack of regional anesthesia. $MgSO_4$ is an antagonist at the NMDA receptor inhibiting the transmission of nociceptive signals into a pathological pain state. $MgSO_4$ has been shown to reduce amounts of opioids used and reduce patient VAS pain scores in recovery.[1-4,8]
- The patient received $MgSO_4$ 3 gms added to 1 L LR fluid bag infused at 6 ml/kg/hr over the length of the procedure. Alternatively, the patient could have received the $MgSO_4$ 3gms before surgical incision.
- The patient was not followed up after 30 minutes in the PACU. VAS pain scores and opioid consumption needs to be documented for the length of the patient's hospital stay. This can give a better perspective of the length of the multi-modal therapy used.
- $MgSO_4$ was given in conjunction with ketamine, ketorolac, fentanyl, and dexmedetomidine. $MgSO_4$ could have been used independently.
- An alternative route of administration could have been used. The current literature shows varying results utilizing an IV bolus, continuous infusion, or continuous infusion plus an IV bolus of $MgSO_4$.[1-6,8]

References

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