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Original Article

Anaesthesia Section

Effect of Magnesium Sulphate on Anaesthetic Agent Requirements Under BIS-targeted Anaesthesia and Postoperative Analgesia: A Prospective Randomised Controlled Study

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ABSTRACT

Introduction: Administration of an appropriate dose of anaesthetic drug and simultaneously achieving adequate depth of anaesthesia with minimal side effects is a challenge. Magnesium Sulphate ($MgSO_4$) significantly reduces the requirements of anaesthetic agents.

Aim: This study aimed to evaluate the impact of $MgSO_4$ on requirements of propofol, vecuronium, and sevoflurane under Bispectral Index (BIS) guidance, along with associated changes in haemodynamic parameters and postoperative analgesia.

Materials and Methods: The present prospective randomised double-blinded controlled study was conducted at Medical College and SSG Hospital, Vadodara, Gujarat, India, from November 2019 to October 2020. It was carried out among 100 patients undergoing elective tympanomastoidectomy under GA. Group M received $MgSO_4$ 40 mg/kg, and Group N received normal saline. Both groups received fentanyl 2 µg/kg as premedication. Induction was carried out using propofol infusion at 30 mg/kg/hr and was stopped at a BIS index of 40-50. Following intubation with succinylcholine, maintenance of anaesthesia was achieved using O_2 + N_2O, sevoflurane and vecuronium, targeting a BIS index between 40 and 60. The primary parameters assessed included total propofol requirement for induction, intraoperative requirement of vecuronium and sevoflurane, haemodynamic variables {Heart Rate (HR), Mean Arterial Pressure (MAP)} and postoperative analgesic requirement. Haemodynamic variables were recorded at baseline (preinduction), during induction, immediately after intubation, every five minutes for the first 15 minutes, and then every 15 minutes until the end of surgery. Postoperative analgesia was assessed using Visual Analog Scale (VAS) scores at 0, 1, 2, 4, 6, and 12 hours, postoperatively. Statistical analysis was performed using the student's t-test for normally distributed data and the Mann-Whitney U or Kolmogorov-Smirnov test for non-normally distributed data, with a p-value of <0.05 considered statistically significant.

Results: The requirement of propofol was 101.6±21.21 mg in Group M while it was 141.6±14.14 mg in Group N ($p<0.0001$). Vecuronium requirement in Group M was 5.48±0.707 mg and in Group N it was 6.7±1.414 mg ($p<0.0001$). Sevoflurane consumption was 37.16±9.03 mg in Group M and 46.25±8.84 mg in Group N ($p<0.001$). The average duration of analgesia was 10.72±3.85 hours in Group M and 7±2.36 hours in Group N ($p<0.0001$). The number of rescue analgesia were less i.e., 1.44±0.54 in Group M than Group N which was 2.02±0.58 ($p<0.0001$).

Conclusion: Magnesium Sulphate in GA significantly reduces the requirement of propofol, vecuronium and sevoflurane while maintaining BIS value of 40 to 60 with satisfactory postoperative analgesia.

Keywords: Bispectral index, Propofol, Sevoflurane, Vecuronium

INTRODUCTION

The concept of safe and evidence-based practice in Anaesthesiology has evolved very well over years. The standardised practice is based on per kilogram dosage, but variation in requirement between individuals of the same body weight is frequently observed. Also, the larger the dose of a particular drug greater will be its side effect. These can be overcome by reducing the requirement of one drug by adding another as an adjuvant [1]. Magnesium sulphate ($MgSO_4$), an NMDA receptor antagonist because of its multi-beneficial actions as an analgesic, sedative, cerebral vasodilator, antiepileptic, anti-arrhythmic, bronchodilator and antinociceptive, has gained wider popularity as an add-on drug in anaesthesia. It also attenuates sympathetic response to laryngoscopy and intubation and reduces overall anaesthetic requirements [2,3].

Walia C et al., observed that $MgSO_4$ as an adjuvant in GA has shown a significant reduction in perioperative requirement of propofol, opioids and muscle relaxants [4]. But the probability of awareness under anaesthesia following dose reduction is the main concern. The use of BIS, a brain-function monitor based on the processed Electro-encephalogram (EEG) provides objective evidence for adequate depth of anaesthesia [4,5]. The BIS monitor analyses brain activity to generate a 0-100 index of consciousness. Values between 40-60 indicate adequate anaesthesia. In this study, BIS was used to evaluate the impact of $MgSO_4$ on anaesthetic requirements, enhancing safety and drug optimisation [5]. The rationale of this study is to assess whether $MgSO_4$, known for its sedative, analgesic and sympatholytic properties, can effectively reduce the requirement of anaesthetic agents when used as an adjuvant during GA. By minimising anaesthetic drug doses, $MgSO_4$ may help reduce associated side effects while maintaining adequate depth of anaesthesia.

The novelty of this study lies in its integration of $MgSO_4$ administration with BIS-guided anaesthesia. While BIS monitoring is commonly used to assess and maintain optimal anaesthetic depth, its application in evaluating the drug-sparing effects of $MgSO_4$ has not been extensively studied. This unique combination allows for a more objective, real-time assessment of $MgSO_4$'s impact on anaesthetic requirements, aiming to enhance safety, precision and overall quality of anaesthesia care. Therefore, this study aimed to evaluate the impact of $MgSO_4$ on the requirements of propofol, vecuronium,

and sevoflurane, along with associated changes in haemodynamic parameters and postoperative analgesia.

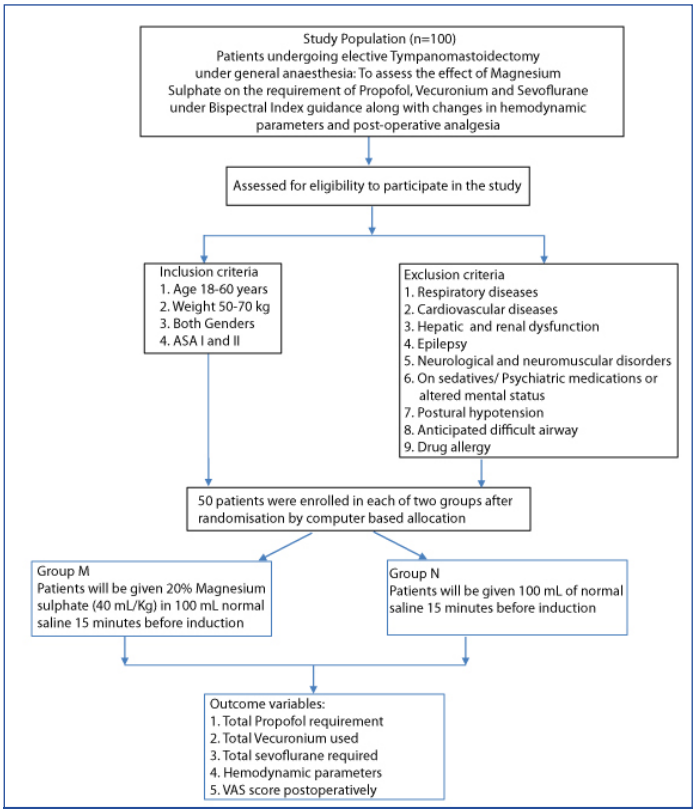
MATERIALS AND METHODS

The present prospective randomised controlled double-blinded study was primarily conducted at Medical College and SSG Hospital, Vadodara, Gujarat, India, from November 2019 to October 2020. Ethical clearance was obtained from IECHR-PGR/107-19. The study was registered under the Clinical Trial Registry of India (CTRI/2019/11/021951). Informed written consent was obtained from the patients who underwent elective Tympanomastoidectomy.

Inclusion criteria: All patients who underwent a preanaesthetic check-up with details regarding present complaints, past medical history, personal history, general physical and systemic examination. Patients aged 18-60 years, weighing 50-70 kg of either gender, American Society of Anaesthesiologists (ASA) physical status I and II undergoing elective tympanomastoidectomy under General Anaesthesia (GA) requiring endotracheal intubation and who were willing to participate in the study were included.

Exclusion criteria: Patients with respiratory, cardiovascular, hepatic, renal dysfunction, epilepsy, neurological and neuromuscular disorders, anticipated difficult airway, postural hypotension, on sedatives or psychiatric medications or with altered mental status and drug allergy were excluded from the study.

Sample size calculation: Sample size estimation was based on the parameter "Mean propofol induction dose" from the reference study by Walia C et al., taking an Alpha error of 0.05, Power of the study (beta error of 0.05) [4]. As the initial sample size was very small, a time-bound study was adopted, enrolling a larger number with a total of 100 patients. The CONSORT study flowchart is given in [Table/Fig-1].



[Table/Fig-1]: CONSORT Study Flowchart.

Study Procedure

All patients were randomised into two groups of 50 each in a 1:1 ratio, known as group M and group N, using computer-based software. Their allocation was concealed with sealed opaque envelopes. This study was conducted in a double-blinded manner, meaning that both the patients and the senior Anaesthesiology Professor administering the anaesthesia were unaware of the group allocation. The adjuvant solutions ($MgSO_4$ or placebo) were prepared by an independent anaesthesiologist who was not involved in patient care or data collection. In group M, 20% $MgSO_4$ 40 mg/kg [6] in 100 mL normal saline and group N, normal saline 100 mL over 15 minutes were given. Infusions were given 15 minutes before induction. Injection propofol (20 mL) was loaded in a 50 mL syringe undiluted and attached with a venous extension and infusion pump (Infusa-101-P). BIS (BIS monitor- Covidien) sensor was attached to the monitor for pre-use check and accuracy. Fresh EEG leads were attached over the forehead of the patient at respective sites after cleaning the local area with spirit and then connected to the BIS sensor [5]. Baseline parameters like HR, MAP, SpO_2 and BIS index were noted. Depth of anaesthesia was monitored using BIS values along with Signal Quality Index (SQI) and Electromyographic (EMG) activity. BIS values were targeted between 40 and 60 [4]. When BIS exceeded 60, sevoflurane concentration was increased to deepen anaesthesia. Conversely, if BIS fell below 40, sevoflurane concentration was reduced to avoid excessive anaesthetic depth. Data were considered valid only if the SQI was ≥50 and EMG activity remained <50 dB [5].

All the above said vital parameters and BIS index were noted just before starting and five minutes after infusion of adjuvant in both the groups. Patients were given injection glycopyrrolate 5 µg/kg i.v., fentanyl 2 µg/kg i.v., ondansetron 0.1 mg/kg i.v. five minutes before induction as premedication. Preoxygenated for three minutes with 100% O_2 using close circuit. Injection propofol was given in titrated doses @ 30 mg/kg/h [7], infusion of which was stopped when a BIS index of 40-50 for 10 seconds has been achieved. Laryngoscopy and intubation were then facilitated with injection succinylcholine 2 mg/kg. Further, muscle relaxation was achieved using bolus dose of vecuronium at 0.08mg/kg. Anaesthesia was maintained using O_2+N_2O (50:50) plus sevoflurane 2-3% [8]. BIS index was targeted between 40 and 60. The concentration of sevoflurane was adjusted according to increase or decrease in HR and MAP of 20% from baseline values. Maintenance of muscle relaxation was done with vecuronium 0.01mg/kg. Inhalational anaesthetics were stopped at the end of surgery. Residual neuromuscular blockade was antagonised with injection neostigmine 50µg/kg i.v. and glycopyrrolate 10µg/kg i.v.. Tracheal extubation then proceeded following fulfilment of the clinical criteria for extubation.

Primary observation was to assess the requirement of anaesthetic agents- required dose of propofol, total dose of vecuronium (loading + maintenance), intraoperative sevoflurane requirement which was calculated using Dion's formula [9].

Haemodynamic parameters like HR, MAP, SpO_2 and BIS index were observed at specified time intervals like after adjuvant infusion, after induction, following intubation, 3 minutes, 5 minutes, 7 minutes, 10 minute, every 15 minutes, before reversal, before extubation and 10 minutes after extubation. Postoperative analgesia was assessed using VAS score by noting the duration of analgesia and number of rescue analgesia in the first 24 postoperative hours at intervals of 2, 4, 6, 8, 12, 18 and 24 hours.

Duration of postoperative analgesia was defined as the time from completion of surgery to either a VAS score >4 or on demand, consistent with prior studies [10,11]. Rescue analgesia was given in the form of injection diclofenac 75 mg intramuscularly when VAS >4 or on demand.

STATISTICAL ANALYSIS

Data was collected, tabulated, and analysed using Microsoft Excel 2021. Statistical analysis was done using MedCalc version 12.5.0. Normality of continuous data was tested by D'Agostino-Pearson test. Continuous variables were represented as means and standard deviation and nominal variables were presented as counts and percentages. A p-value of <0.05 was considered statistically

significant. Data following a normal distribution were analysed using the Student's t-test. For data not following a normal distribution, the Mann-Whitney U test or the Kolmogorov-Smirnov test was used. A p-value of <0.05 was considered statistically significant.

RESULTS

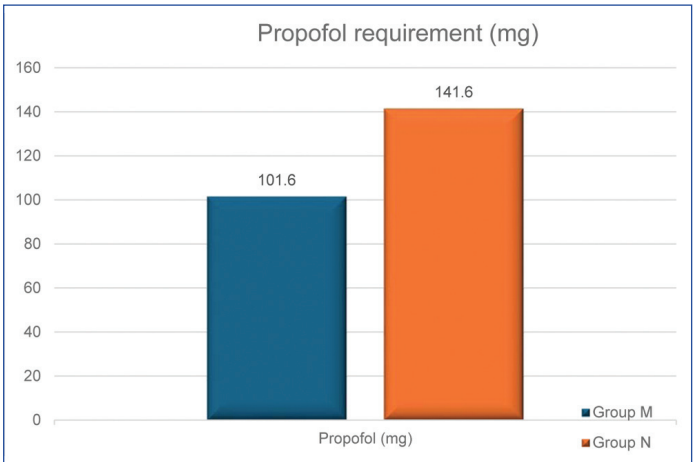
The demographic and baseline clinical characteristics of the patients in group M (Magnesium Sulphate) and group N (Normal Saline). is presented in [Table/Fig-2].

Parameters	Group M Mean±SD	Group N Mean±SD	p-value
Age (years)	32.8±15.39	34.58±8.48	0.4755
Sex			
Male	26 (52%)	17 (34%)	0.106
Female	24 (48%)	33 (66%)	0.106
Weight (kg)	61±3.54	60.78±3.38	0.7513
ASAPS*			
I	27 (54%)	26 (52%)	1.0
II	23 (46%)	24 (48%)	1.0
Duration of surgery (minutes)	129.2±25.46	136±20.80	0.1468

[Table/Fig-2]: Demographic and baseline characteristics of study groups.
*Independent sample t-test for continuous variables, **Chi-square test categorical variables, p-value >0.05; ASA PS: American Society of Anaesthesiologists Physical Status classification.

The mean age was comparable between the groups (32.8±15.39 years in group M vs. 34.58±8.48 years in group N; p=0.4755). The distribution of sex, body weight, and ASA physical status classification was also similar, with p-values >0.05 for all comparisons. Additionally, the mean duration of surgery did not differ significantly between the two groups (129.2±25.46 minutes in group M vs. 136±20.80 minutes in group N; p=0.1468). These findings confirm that the two study groups were demographically and clinically comparable at baseline [Table/Fig-2].

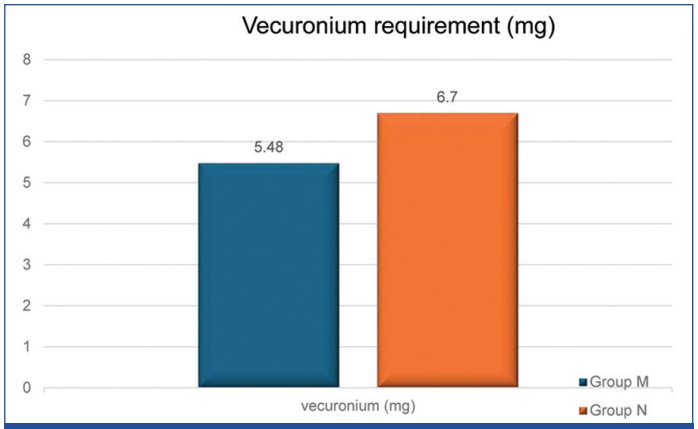
The mean induction dose of propofol in group M was 101.6±21.21 mg as compared to 141.6±14.14 mg in group N, which was statistically significant (p<0.0001). This accounted for a 28% reduction in the requirement of propofol in group M when compared with group N. The percentage reduction was calculated using the formula: {(Mean in group N - Mean in group M)/Mean in group N}×100 [Table/Fig-3].



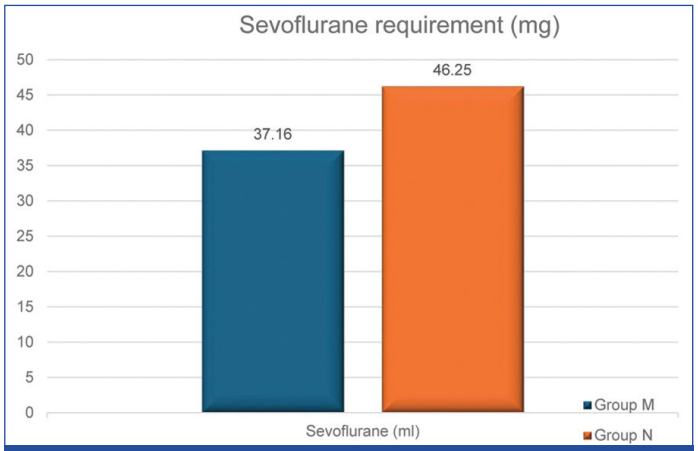
[Table/Fig-3]: Column diagram showing propofol requirement among two groups (p<0.0001).
unpaired t-test

The total requirement of vecuronium in group M was 5.48±0.707 mg compared to 6.7±1.414 mg in group N, reflecting an 18% reduction in group M. This difference was statistically highly significant (p<0.0001) [Table/Fig-4].

The total consumption of sevoflurane in group M was 37.16±9.03 mL compared to 46.25±8.84 mL in group N, representing a 20% reduction in group M and this difference was statistically significant (p<0.001) [Table/Fig-5].



[Table/Fig-4]: Column diagram showing vecuronium requirement among two groups (p<0.0001)
unpaired t-test



[Table/Fig-5]: Column diagram showing sevoflurane consumption among two groups (p<0.001).

Intraoperative monitoring of HR revealed that both groups had comparable baseline values. However, group M exhibited a significant reduction in HR following the administration of the adjuvant, which persisted through induction, intubation and up to 45 minutes of surgery (p<0.05). Beyond this point, HR differences between the groups were not statistically significant [Table/Fig-6].

Time	Group M Mean±SD	Group N Mean±SD	p-value
Baseline	91.44±8.99	90.52±10.90	0.6462
After adjuvant infusion	85.68±7.28	89.86±10.04	0.0191
After induction	84.94±7.42	88.54±9.28	0.0346
Following intubation-3 min	87.04±8.01	92.22±8.60	0.0024
5 min	86.48±7.20	92.3±7.76	0.0002
7 min	86.92±6.61	90.9±7.50	0.0059
10 min	87.04±6.13	89.98±6.45	0.0215
15 min	86.44±6.08	89.14±5.83	0.0256
30 min	86.92±6.06	89.86±6.15	0.0179
45 min	85.76±6.06	88.66±5.43	0.0133
60 min	86.2±4.54	87.14±5.17	0.3364
75 min	84.72±4.49	85.32±4.50	0.5061
90 min	85.84±4.62	87.06±5.05	0.2105
105 min	86.04±4.58	87.20±4.85	0.2218
120 min	85.54±3.75	86.92±3.71	0.0674
135 min	85.58±3.59	86.69±3.89	0.1413

150 min	82.75±2.91	83.62±4.92	0.2845
165 min	85.25±2.60	84.57±2.22	0.1628
180 min	85.33±1.15	85.5±0.71	0.3759
Before reversal	86.04±4.58	87.22±4.84	0.2135
After extubation	87.04±3.92	88.06±3.51	0.1736
10 min after extubation	84.96±4.24	86.3±4.25	0.1177

[Table/Fig-6]: Mean Heart Rate (HR) (beats per minute) at various time intervals. Independent sample t-test. A p-value <0.05

Similarly, Mean Arterial Pressure (MAP) was also comparable at baseline. Following adjuvant infusion, group M showed a significant decline in MAP compared to group N, and this reduction remained significant up to approximately 30-40 minutes of the intraoperative period [Table/Fig-7].

Time	Group M Mean±SD	Group N Mean±SD	p-value
Baseline	96.33±7.34	95.76±7.29	0.6977
After adjuvant infusion	92.65±5.75	95.13±6.47	0.0455
After induction	90.51±5.47	93.35±4.48	0.0055
Following intubation-3 min	89.67±5.75	93.08±4.30	0.0011
5 min	89.57±5.36	92.09±4.15	0.0100
7 min	85.33±4.51	87.21±4.82	0.0468
10 min	83.95±3.62	86.85±3.33	0.0001
15 min	83.19±2.38	85.35±3.38	0.0004
30 min	83.15±2.34	84.43±2.75	0.0138
45 min	83.17±2.44	83.84±2.37	0.1668
60 min	82.99±1.82	83.51±2.06	0.1841
75 min	83.04±1.86	83.66±2.23	0.1343
90 min	82.65±2.01	83.63±2.22	0.0228
105 min	82.52±1.67	82.98±1.50	0.1505
120 min	82.76±1.65	82.91±1.56	0.6415
135 min	83.18±1.87	84.04±1.62	0.0157
150 min	84.79±3.15	85.22±2.08	0.4225
165 min	85.21±2.01	85.90±2.54	0.1352
180 min	85.11±2.52	85.67±3.29	0.3417
Before reversal	83.16±2.17	83.61±2.26	0.3123
After extubation	82.97±2.05	83.58±2.16	0.1507
10 min after extubation	82.68±1.98	83.4±2.41	0.1058

[Table/Fig-7]: Mean Arterial Pressure (mmHg) at various time intervals.

Oxygen saturation remained stable and comparable between both groups throughout the intraoperative and postoperative periods. The depth of anaesthesia was effectively maintained using BIS monitoring with values consistently targeted between 40 and 60. The mean BIS values and SQI were comparable between the two groups and within the valid range throughout the procedure.

The mean duration of postoperative analgesia was significantly longer in group M (10.72±3.85 hours) compared to group N (7±2.36 hours), and the number of rescue analgesics required within the first 24 hours postoperatively was significantly lower in group M (1.44±0.54) than in group N (2.02±0.58), with both differences reaching statistical significance (p<0.0001; [Table/Fig-8]).

Parameters	Group M Mean±SD	Group N Mean±SD	p-value
Duration of analgesia (hours)	10.72±3.85	7±2.36	<0.0001
Number of rescue analgesia	1.44±0.54	2.02±0.58	<0.0001

[Table/Fig-8]: Postoperative analgesia between Group M (Magnesium Sulphate group) and group N (Normal Saline group). Independent sample t-test; A p-value < 0.05 was considered statistically significant

As far as the complications are concerned, only hypotension was observed among 3 (6%) patients in group M and 1 (2%) patient in group N.

DISCUSSION

The present study findings suggested that $MgSO_4$ significantly reduced the requirements of anaesthetic agents, namely propofol, vecuronium and sevoflurane while maintaining depth of anaesthesia as evidenced by BIS. It also provides effective analgesia in postoperative period. Magnesium Sulphate is an N-methyl D-aspartate receptor antagonist that depresses CNS and blocks peripheral neuromuscular transmission. It deserves a specific mention because of its multi beneficiary actions like analgesic, sedative, cerebral vasodilator, antiepileptic, anti-arrhythmic, bronchodilator, antinociceptive, attenuation of sympathetic response to laryngoscopy and intubation, reduces overall anaesthetic requirements etc. Thereby has gained wider popularity as an add-on drug for anaesthesia [4]. Given the well-established benefits of $MgSO_4$, the present study aimed to evaluate its effect on reducing the requirements of propofol, vecuronium, and sevoflurane as well as its role as an analgesic.

However, caution was exercised regarding the probability of an avoidable complication, awareness under anaesthesia. The BIS monitor, approved by the Food and Drug Administration, is most widely used to assess the depth of anaesthesia [12,13]. So, the BIS monitor, a non-invasive device that reliably measures the depth of anaesthesia by providing a continuous display of the BIS index, was utilised. The BIS monitor analyses brain activity to produce a numerical index (0-100) reflecting consciousness, with 40-60 indicating adequate anaesthesia [5]. It helps minimise awareness risk and guides drug titration. This study used BIS monitoring to evaluate $MgSO_4$'s effect on anaesthetic requirements, enhancing safety and optimising dosing. Routinely, the End Tidal Anaesthetic Gas Concentration (ETAC) - which provides accurate identification and quantification of the exhaled gases - is monitored to assess the depth of anaesthesia. ETAC-guided anaesthesia is comparable to BIS-guided anaesthesia and can be used as an alternative method to monitor depth of anaesthesia [14].

In considering the dose of $MgSO_4$, Walia C et al., in their study used 30mg/kg of $MgSO_4$ and found smooth and gradual decrease of HR and MAP [4]. In other studies, boluses of $MgSO_4$ at 40 mg/kg followed by infusions at different rates were used and found more episodes of hypotension with loading followed by infusion but not with loading dose alone [6,15]. So, in this study, a loading dose of 40 mg/kg [6] of 20% $MgSO_4$ was administered 15 minutes prior to induction, without subsequent infusion. This dose falls within the range used in previous studies, such as those by Seyhan TO et al., and Elsharnouby NM and Elsharnouby MM and has been observed to be safe and noticeably far lesser than that used in management of eclampsia [6,15].

As mentioned earlier although induction agents were administered in per kg doses, the exact requirement might vary among persons. Also, the peak plasma concentration of propofol obtained after a bolus dose are substantially higher than with a continuous infusion. The vasodilatory and myocardial depressant actions of propofol are concentration dependent and hence the decrease in blood pressure during an infusion phase of propofol is much less than that with a bolus dose [16]. For these reasons, induction with propofol was done at a constant rate of 30 mg/kg/h [7] simultaneously assessing the depth using BIS monitoring. Infusion was stopped at BIS index of 40-50. Inhalational agents were avoided during induction to exclude its additive effect in reaching the required anaesthetic depth.

A 28% reduction in propofol requirement was observed in Magnesium group which can be explained by its NMDA receptor antagonism. This result is similar to that obtained by Walia C et

al., in which the mean induction dose of propofol following $MgSO_4$ infusion at 30mg/kg was 114±15.5 mg [4] and is also supported by various other studies [17,18]. However, similar observation was not found in a TIVA study carried out by Ryu JH et al., and they have postulated that this outcome might have been the result of using target-controlled infusion of propofol which was supported by reports stating that huge variations between target and serum concentrations of propofol and remifentanil occur during TIVA [19].

When muscle relaxation is taken into consideration, laryngoscopy and intubation was done with succinylcholine and maintenance of procedure was done with vecuronium. An 18% reduction in vecuronium was observed in magnesium group. This can be attributed to the fact that $MgSO_4$ blocks peripheral neuromuscular transmission by reducing acetylcholine release at the myoneural junction. Walia C et al., found nearly similar result with mean vecuronium requirement of 5.4±0.8 mg following $MgSO_4$ infusion at 30 mg/kg [4]. Similar observation was seen in studies done using Atracurium and Rocuronium [19,20]. In short promising results on reduction of muscle relaxants was observed in almost every study where effect of $MgSO_4$ on muscle relaxants was an observing parameter.

$MgSO_4$ has been implicated to influence the Minimum Alveolar Concentration (MAC) of various volatile anaesthetics. Although not many studies were carried out to know its effect on inhalational agents, the present study aimed in knowing the relation of $MgSO_4$ with sevoflurane. Calculation of consumption of a liquid agent turning into vapour is practically not so easy but Dion's formula that uses Dial setting of an agent for a set period simplified the task [9]. A 20% reduction of sevoflurane was observed in magnesium group. Of the few studies conducted, the one by Oguzhan N et al, where $MgSO_4$ was used at 30mg/kg over 10 minutes before induction followed by infusion at 10mg/kg/h, significant reduction in sevoflurane consumption was not seen and is not in consonance with the present study [21]. This may be because their loading dose was lesser. Decreased requirement of Desflurane following $MgSO_4$ administration was seen by Olgun B et al., [18]. But contradictory results were observed by Riaz M et al., that MAC of Desflurane being unaffected by $MgSO_4$ [3]. So, further studies are still needed to understand better on this regard.

The haemodynamic parameters were stable throughout the intraoperative period in both the groups with very few incidences of hypotension in group M. However, the mean HR in $MgSO_4$ group was significantly lesser than in control group during initial 40 minutes of surgery which is supported by the study conducted by Ryu JH et al., [19]. Also, statistically significant lesser MAP was seen in $MgSO_4$ group than in control group during initial 30 minutes of surgery. This fall in blood pressure following $MgSO_4$ infusion was also observed by Ryu JH et al., and Oguzhan N et al., [19,21]. This trend towards lower MAP and HR might be explained by the vasodilation due to calcium channel blockade or by its analgesic effect and the consequent inhibition of catecholamine release [19] $MgSO_4$ has been observed to produce low tidal volume and respiratory rate in paediatric age group by Amer MM et al., [16]. But no significant changes were observed on oxygen saturation which is in consonance with our study. Stable haemodynamic parameters were observed in all patients in their postoperative period too.

As discussed previously the main purpose behind the analysis on recent dates with $MgSO_4$ is to reduce overuse of opioids, its dependence and opioid related deaths especially in the perioperative period. $MgSO_4$ has been proposed to be a very good analgesic in both acute and chronic settings. Mechanism being its NMDA receptor antagonism preventing calcium release thereby attenuating nociceptive central sensitisation which emphasises the concept of pre-emptive analgesia.

Group M experienced a longer duration of postoperative analgesia and needed fewer doses of rescue analgesia compared to group N, with the differences showing high statistical significance ($p<0.0001$). Most of the referenced studies that investigated the impact of magnesium sulfate reported consistently favourable outcomes in terms of analgesic efficacy [10,11]. However, the findings by Lysakowski C et al., presented a contrasting perspective, as they did not observe a similarly compelling benefit [22].

Hypotension was the only observed complication in both the groups among 0.03% patients in group M and 0.01% patient in group N which was similar to that observed by Walia C et al., [4]. Hypotension that occurred was statistically significant but clinically did not require any treatment.

Limitation(s)

One of the limitations of this study was the absence of preoperative serum magnesium measurements and the lack of correlation between clinical observations- such as intraoperative anaesthetic agent requirement, haemodynamic responses to surgical stimuli, recovery profile including time to eye opening and extubation, postoperative analgesia scores and serum magnesium concentrations. Although $MgSO_4$ was administered within a safe dosage range significantly lower than that used in the management of eclampsia, monitoring for potential magnesium toxicity should have been in place particularly under GA. As magnesium can potentiate NDMR administration of muscle relaxants should ideally have been guided by neuromuscular monitoring. Additionally, combining a loading dose with a continuous infusion of $MgSO_4$ may have yielded more pronounced effects. However, due to the absence of neuromuscular blockade monitoring only a loading dose was used in this study.

CONCLUSION(S)

The pretreatment with $MgSO_4$ in GA significantly reduces the induction dose of propofol, overall dose of vecuronium and sevoflurane by maintaining a constant BIS value of 40-60. It also contributes to better haemodynamic stability and improved postoperative analgesia. So, magnesium sulphate, when used as an adjuvant in BIS-guided GA, enhances anaesthetic efficiency, reduces drug consumption and improves patient comfort without compromising safety.

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