

Does magnesium sulfate affect the incidence of respiratory complications in children undergoing esophageal dilatation? An observational pilot study

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ABSTRACT

Background. In this pilot observational study, we aimed to investigate the effect of preoperative magnesium infusion on laryngospasm frequency and other respiratory complications in children with respiratory findings undergoing esophageal dilatation after the ingestion of caustic substances.

Methods. Sixty children between the ages of 2 and 12 scheduled for esophageal dilatation were divided into two groups: the magnesium group (Group M), which consisted of children with respiratory symptoms and who received IV 30 mg/kg magnesium sulfate preoperatively, and the control group (Group C), who received the same volume of saline. Anesthesia was induced with fentanyl, propofol, and mivacurium and maintained using a 60% N₂O and 2-3% sevoflurane mixture in oxygen. Demographic and hemodynamic data, as well as the incidence of respiratory complications (laryngospasm, bronchospasm, apnea, cough, and desaturation) during the perioperative period were recorded until the time of discharge from the recovery room.

Results. Demographic data and hemodynamics were similar in the two groups. The laryngospasm, bronchospasm, apnea, and cough incidences were also similar

between the groups, although the desaturation incidence was lower in Group M than in Group C ($p=0.013$). The number of complications in total was lower in Group M as well ($p=0.008$), although the number of children who experienced complications in each group was similar.

Conclusion. Prophylactic administration of 30 mg/kg of magnesium to children with respiratory symptoms may decrease the frequency of postoperative respiratory complications in children undergoing esophageal dilatation.

Key words: *corrosive stricture, magnesium sulfate, general anesthesia, complication, respiratory tract*

INTRODUCTION

Esophageal injury caused by caustic substances in children generally occurs after children accidentally drink cleaning agents. Although patient mortality is rare in these cases, morbidity is quite high. (1,2) The burns that occur after ingestion of caustic substances may lead to strictures in the esophagus in the weeks following ingestion. Treatment includes esophageal dilatation under general anesthesia. (3,4) In children with a stricture, aspiration because of dysphagia may cause chronic cough, productive cough, and frequent

pulmonary infections. Furthermore, laryngoscopy (used to place bougies) and tracheal stimulation from endotracheal tube movement during dilatation, as well as the esophageal dilatation itself, may cause respiratory complications during the perioperative period. (5)

According to the routine approach practiced in our clinic, (4) children who are treated at the hospital after ingesting caustic substances are examined to assess the injury severity and the presence of perforation. If no edema hindering oral intake is detected in the oropharyngeal structures, the children are sent home, and a barium swallow is performed three weeks later. When esophageal strictures are detected, these strictures are dilated in three-week intervals.

Magnesium is used to treat hyperreactive airway and asthma because it relaxes the smooth muscles of the bronchi. (6) Although magnesium has been shown to decrease the frequency of laryngospasm in children undergoing tonsillectomy, (7) its effect in other surgeries has not been studied. When one considers that respiratory complications are more frequent in children with respiratory tract problems, magnesium may be beneficial. In this pilot observational study we aimed to investigate the effect of preoperative magnesium infusion on the frequency of laryngospasm

and other respiratory complications in children with pathological auscultation findings undergoing esophageal dilatation after the ingestion of caustic substances.

METHODS

In our clinic, children who are scheduled for esophageal dilatation are administered a 1 mg/kg intravenous (IV) dose of methylprednisolone with 2 ml/kg/hour 5% dextrose in a 0.2% NaCl infusion. If respiratory symptoms are revealed in the preoperative anesthesia examination (e.g., prolonged expiration, coarse or moist rales, cough, and productive cough), then according to our departmental protocol, we administer magnesium infusion under monitored conditions in the premedication room, unless there are any contraindications, such as neuromuscular junction diseases, kidney failure, cardiac conduction defects, and hypotension.

After approval had been obtained from the Clinical Research Ethics Committee (Nr: 2009/1921; Prof. Dr. Güher Saruhan Direskeneli), this prospective observational study enrolled 60 children between the ages of 2 and 12 years of age who were scheduled for elective esophageal dilatation with bougies. Informed consent was obtained from the children's parents. Children with bronchial asthma, acute pulmonary infection, or a contraindication for magnesium and/or bronchodilator treatment were excluded from this study. The same researcher (MSK) screened the children and prescribed the magnesium therapy. The patients were divided into two groups: the magnesium (Group M) and control groups (Group C). Children in Group C had no respiratory symptoms. The anesthesia, follow-up, and outcome assessments were performed by another researcher (HBO, TÖS), who were blinded to the preoperative medication that was used.

After being transferred from the hospital ward to the premedication room, the patients were monitored with a pulse oximeter (SpO₂) and administered an IV dose of 0.1-0.15 mg/kg midazolam and 0.1 mg/kg atropine. Group M received IV doses of 30 mg/kg magnesium sulfate diluted with 0.9% NaCl (total=25 ml in 15 minutes), with electrocardiography and non-invasive blood pressure monitoring. Group C

received the same volume of saline. The patients were then transferred to the operating room, and anesthesia was routinely induced with 1 µg/kg fentanyl, 2-3 mg/kg propofol, and 0.25 mg/kg mivacurium. Following intubation, mechanical ventilation was started with 6-8 ml/kg tidal volume. The inspiration to expiration ratio was 1:2. The positive end expiratory pressure (PEEP) was 4 cm H₂O, and the respiratory rate was set to maintain end-tidal carbon dioxide (EtCO₂) levels between 30 and 35 mmHg. Anesthesia was maintained using 60% N₂O and 2-3% sevoflurane in oxygen. The anesthesia was discontinued at the end of surgery, and the oral and tracheal secretions were cleared. After determining that an adequate ventilation rate and EtCO₂ were maintained with spontaneous respiration within normal limits, the patients who were awake and had adequate muscle strength without bronchospasms received maximal inspiratory volume at the end of inspiration in the lateral decubitus position; then they were extubated. These children were monitored for three minutes while they were given high flow oxygen with a face mask. The children who did not have nasal flaring or desaturation (SpO₂>92%) were transferred to the recovery room. During the recovery room follow-ups, the children who did not require treatment for respiratory complications, with SpO₂≥96% on room air and modified Aldrete recovery scores 9 points, were sent to the ward.

During anesthesia maintenance, the airway peak pressure was monitored in five-minute intervals, and the highest value was recorded. The following periods were defined and recorded: the extubation period (the time anesthesia was discontinued until extubation), the extubation-recovery period (the time from extubation until the patient was transferred to the recovery room), and the duration that the patient remained in the recovery room (the time from entry to the recovery room until the patient fulfilled the recovery room discharge criteria). Laryngospasm, bronchospasm, apnea, cough, and desaturation during the perioperative period were recorded as respiratory complications. Laryngospasm was diagnosed by wheezing, stridor, increased respiration effort, decreased breath sounds, tracheal retraction, paradoxical movement of abdomen and thorax, difficulty in ventilation, and desaturation. Re-intubation was planned

with IV administration of 1 mg/kg succinylcholine if saturation persisted below 92% and did not increase after applying positive pressure ventilation therapy with 100% O₂. The presence of bilateral expiratory wheezing, prolonged expiration, increased airway pressures, decreased breath sounds, shark fin appearance on the EtCO₂ trace, and desaturation was diagnosed as bronchospasm. If bronchospasm was encountered in the perioperative period, the following treatment was planned: 100% O₂ with manual bag ventilation, increased depth of anesthesia, and four to eight puffs of salbutamol with an metered-dose inhaler (MDI) (100 µg) spacer through an endotracheal tube at 20- to 30-minute intervals. The planned treatment for bronchospasm that developed following extubation was 100% O₂ (using a face mask), and 2.5-5 mg of salbutamol was administered with 20- to 30-minute-breaks using a nebulizer. If the symptoms (refractory bronchospasm) continued, the IV administration of 1-10 µg/kg epinephrine was planned. Cessation of respiration for more than 30 seconds was described as apnea. A coughing episode was recorded if a patient experienced more than five coughs in a row. Desaturation was defined as SpO₂<92%. The number of patients with complications and the total number of patients who experienced any of the five respiratory complications mentioned above were recorded for each group. Heart rate (HR) and systolic blood pressure (SBP) were recorded before infusion, at the end of infusion, after anesthesia induction, following intubation, ten minutes after intubation, after extubation, and ten minutes after recovery room entry. Hypotension was defined as a >30% decrease in the normal (by age) SBP value and was to be treated with an IV bolus of 2 ml/kg in 0.9% NaCl. If hypotension persisted at the next measurement, the therapy was to be repeated. If hypotension occurred during anesthesia, the volatile anesthetic concentration was to be decreased by 0.5%, and fluid infusion was planned. If the HR fell below the normal value for the patient's age group, it was defined as bradycardia, and an administration of 0.2 mg/kg atropine was planned for these patients. If the SpO₂ level was >92% during bradycardia, ventilation with 100% O₂ was planned; if it was sustained, then atropine was considered.

STATISTICAL EVALUATION

To the best of our knowledge, no data have been recorded regarding the incidence of respiratory complications in children undergoing esophageal dilatation. A study of the effect of magnesium infusion on the incidence of laryngospasm in tonsillectomy cases reported that laryngospasm occurred in 25% of the control group patients and in 0% of the magnesium group patients. (7) A two-way sample size calculation ($\alpha=0.05$ and $\beta=0.2$) with 25% incidence in the control group indicated that 30 people were needed in each group. The values are shown as median [minimum-maximum] and numbers (frequency %). The Mann-Whitney-U test was used to compare each patient's age, weight, peak pressure, extubation duration, recovery duration, and total number of complications. The presence of complications was compared using the χ^2 test. Blood pressure and heart rate data were compared within the groups with repeated measures ANOVA and between the groups using Student's t test. $P<0.05$ was determined to be statistically significant.

RESULTS

All enrolled participants, with 30 patients in each group, completed the study and were included in the statistical analysis. The groups were similar in terms of the patients' ages, weights, and extubation durations, but the highest peak pressure and recovery room duration were significantly lower in Group M than in Group C (table 1). The laryngospasm, bronchospasm, apnea, and coughing incidences were also similar between the groups, although the desaturation incidence of Group M was lower than that of Group C. The total number of complications was lower in Group M, although the number of children who experienced complications in each group was similar (table 2).

Thirteen patients who developed laryngospasm following extubation were treated with positive pressured ventilation with 100% O₂. In Group C, two laryngospasm patients who were resistant to therapy were treated with IV 1 mg/kg succinylcholine. None of the patients required intubation. Two Group C patients who developed bronchospasm perioperatively were given 100% O₂ and six puffs of salbutamol with an MDI spacer; symptom improvement

was observed after the first application. Seventeen children in Group C and ten children in Group M with SpO₂<96% were given nebulized O₂ in the recovery room.

No significant between-group or within-group differences were detected in the hemodynamic data at the recorded time points (figures 1, 2). One patient in each group developed bradycardia in addition to laryngospasm; the bradycardia improved after the laryngospasm was treated. None of the patients experienced any hemodynamic problems that required treatment.

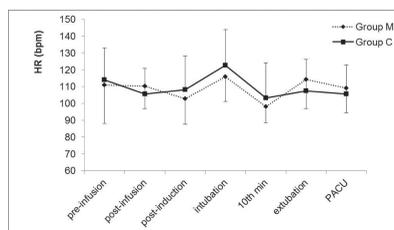


Figure 1. The heart rate (HR) pattern recorded at the measurement times. PACU, Post Anesthesia Care Unit.

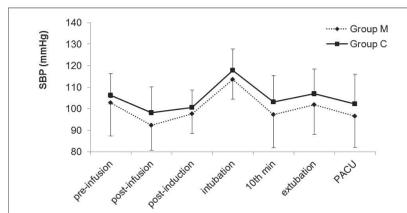


Figure 2. The systolic blood pressure (SBP) values recorded at the measurement times. PACU, Post Anesthesia Care Unit.

DISCUSSION

In this study, we observed an increase in the frequency of respiratory complications in children with esophageal dilatation caused by stricture development following caustic substance ingestion. The preoperative IV administration of 30 mg/kg magnesium sulfate to patients with respiratory symptoms did not change the frequency of laryngospasm but did decrease the frequency of perioperative desaturation and the total number of respiratory complications as well as reduce the peak airway pressures during mechanical ventilation.

Although chronic aspiration caused by

esophageal atresia and gastroesophageal reflux is well known to trigger pneumonia, chronic cough, and hyper-reactive airway, (8,9) there are no data concerning the perioperative respiratory complications of caustic ingestion. Caustic ingestion may cause esophageal strictures and inhibit peristaltic contractions; therefore, swallowing problems can occur. Food and secretion aspirations and chronic micro-aspiration caused by reflux may be observed in these children. Respiratory complications during anesthesia, the most common of which are laryngospasm and bronchospasm, (10) are also well known to occur more frequently in children with airway problems. (11)

The frequency of laryngospasm caused by general anesthesia is increased in the pediatric population compared with adults. (12) Particularly when there is a risk of inadequate depth of anesthesia (i.e., the induction and emergence period), foreign bodies, such as secretions, laryngoscope, tube, and catheters, can irritate the vocal cords and cause laryngospasm. The incidence of laryngospasm may vary because of patient-related factors (e.g., upper respiratory infection, passive smoking, obesity, and reflux) or the type of operation being performed. (13) Laryngospasm and upper respiratory tract complications caused by distal afferent esophageal nerve stimulation are observed more frequently in endoscopic procedures involving the esophagus. (14,15) Thus, children who undergo esophageal dilatation have both patient-related and operation-related risks of laryngospasm. In the literature, the incidence of laryngospasm in general pediatric cases is 0.04-14% and as high as 21-27% in tonsillectomy patients. (5) To the best of our knowledge, there are no available data on the incidence of laryngospasm in children undergoing esophageal dilatation. In our study, although the difference was not statistically significant, the laryngospasm incidence was lower in Group M than in Group C. If magnesium was ineffective, one would expect a higher incidence of laryngospasm in Group M because of the preoperative respiratory system findings. This result can be explained by the preventive effect of the preoperative magnesium infusion. Although lidocaine and other agents reportedly prevent laryngospasm, (5) the Gulhas et al. study is the only one that used magnesium to prevent laryngospasm in children. (7) Forty children undergoing adenoidectomy and tonsillectomy were given

1 mg/kg lidocaine before intubation and 15 mg/kg magnesium after intubation, and they were extubated under deep anesthesia. The Gulhas et al. study did not report airway pressures or complication (other than laryngospasm). Our study differs from the study by Gulhas et al. because of the lack of preventive lidocaine and higher magnesium doses. The laryngospasm incidence observed in Group C was greater than that in the control group in the Gulhas et al. study; this discrepancy may be attributed to the operation type and the fact that their patients were extubated under deep anesthesia. However, extubation under deep anesthesia in patients with a high risk of aspiration because of esophageal trauma would be unsafe.

Magnesium relaxes the smooth muscles by decreasing the intracellular Ca²⁺ level via Na⁺-Ca²⁺ pump activation. In children with moderate to severe asthma, 25-75 mg/kg magnesium as an adjuvant leads to bronchodilatation, prevents inflammation development by mast-cell stabilization, (16) and decreases the peak pressures in treatment-resistant cases. (17) This bronchodilator effect of magnesium is likely also responsible for the lower peak airway pressures observed in Group M in our study. Furthermore, magnesium potentiates opioids and muscle relaxants, which may affect the depth of anesthesia, (18) contributing to the decrease in peak airway pressures.

Although the incidences of apnea, cough, and bronchospasm were not significantly different between the groups, there was a trend of a greater number of complications in Group C. A significantly increased frequency of desaturation in the control group is also likely associated with the higher total number of complications in this group.

Similar extubation durations in both groups suggest that the depth of anesthesia was similar in both groups. Although the complication rate was greater in the control group, no significant between-group difference was observed for the extubation recovery period. The recovery room stay was significantly shorter in Group M. However, this five-minute difference may be the result of the decreased total number of complications in Group M and is not clinically significant.

Regarding the hemodynamic findings, we did not observe any between-group differences. High doses of magnesium may be associated with hypotension, (19) and the lack of serum magnesium measurements can be criticized in our study. However, magnesium doses up to 75 mg/kg have been used in pediatric populations without any adverse events, similar to our study. (20)

The main limitation of this study is its lack of a randomized controlled design.

We hypothesized that there would be an increased number of respiratory complications in the children with pathologic auscultation findings. However, the decreased number of complications in Group M compared with the children without auscultation findings confirms the assumption that magnesium might prevent the respiratory complications that are associated with this surgery.

Our study limitations also include the lack of monitoring of the anesthesia depth and neuromuscular activity. Magnesium sulfate administered in 30-60 mg/kg doses during the induction of pregnant women with preeclampsia was shown to increase the duration of action of 0.15 mg/kg mivacurium by 25 minutes. (21) We did not observe a delay in the extubation duration in Group M, likely because of the timing of the magnesium administration (20 minutes before induction).

To conclude, the administration of prophylactic 30 mg/kg magnesium may decrease the frequency of postoperative respiratory complications in children with respiratory problems who are undergoing esophageal dilatation because of corrosive esophagitis. Further studies are required to design an ideal regimen in terms of the medication dose and administration protocol.

Table 1. Patient demographics in each group, the highest airway peak pressure values recorded during surgery, and the distribution of the durations that were compared between the groups.

| | Group M (n=30) | Group K (n=30) | P |
|---|----------------|----------------|-------|
| Age | 6 [2-12] | 6.5 [2-12] | 0.284 |
| Weight (kg) | 15.5 [8-31] | 16.5 [9-32] | 0.588 |
| Peak airway pressure (cm H ₂ O) | 20.5 [15-28] | 24 [13-36] | 0.041 |
| Anesthesia duration | 40 [35-60] | 37.5 [30-67] | 0.313 |
| Extubation period (min) | 6 [5-15] | 8 [5-20] | 0.086 |
| Extubation-recovery period (min) | 6.5 [4-20] | 7 [4-32] | 0.277 |
| Duration that the patient remained in the recovery room (min) | 30 [25-50] | 35 [25-80] | 0.02 |

The values are shown as the median [minimum-maximum] and were compared with the Mann-Whitney U-test.

Table 2. The distribution of complications between groups, the number of patients with complications, and the total number of complications.

| | Group M (n=30) | Group C (n=30) | P |
|------------------|----------------|----------------|-------|
| Laryngospasm (#) | 3 (10%) | 10 (33.3%) | 0.057 |
| Bronchospasm (#) | 0 (0%) | 2 (6.7%) | 0.492 |

| | | | |
|---|------------|------------|-------|
| Apnea (#) | 7 (23.3%) | 13 (43.3%) | 0,1 |
| Cough (#) | 12 (40%) | 18 (60%) | 0,121 |
| Desaturation (#) | 6 (20%) | 15 (50%) | 0,013 |
| Number of patients with complications (n) (#) | 16 (53.3%) | 24 (80%) | 0.054 |
| Total number of complications () | 1[0-3] | 2 [0-5] | 0.008 |

Values are given as the number (% frequency) or median [minimum- maximum]. #: the data were compared with the χ^2 test. : the data were compared with the Mann-Whitney U-test.

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