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The Effect of Systemic Magnesium on Postsurgical Pain in Children Undergoing Tonsillectomies: A Double-Blinded, Randomized, Placebo-Controlled Trial

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Disclosures

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Abstract

Introduction—Tonsillectomy is a frequently performed surgical procedure in children; however few multimodal analgesic strategies have been shown to improve postsurgical pain in this patient population. Systemic magnesium infusions have been shown to reliably improve postoperative pain in adults, but its effects in pediatric surgical patients remains to be determined. In the current investigation our main objective was to evaluate the use of systemic magnesium to improve postoperative pain in pediatric patients undergoing tonsillectomy. We hypothesized that children who received systemic magnesium infusions would have less post-tonsillectomy pain than the children who received saline infusions.

Methods—The study was a prospective, randomized, double-blinded, clinical trial. Subjects were randomized using a computer-generated table of random numbers to one of the two intervention groups: systemic magnesium infusion (initial loading dose 30 mg/kg given over 15 minutes followed by a continuous magnesium infusion 10 mg/kg/hr) or the same volume of saline. The primary outcome was pain scores in the postanesthesia care unit (PACU) measured by FLACC pain scores. Pain reduction was measured by the decrement in the area under the pain scale versus 90-minute postoperative time curve using the trapezoidal method. Secondary outcomes included opioid consumption in the PACU, emergence delirium scores (measured by the pediatric anesthesia emergence delirium scale) and parent satisfaction.

Results—Sixty subjects were randomized and 60 completed the study. The area under pain scores (up to 90 minutes) was not different between the study groups, median (IQR) of 30 (0 to 120) score*min and 45 (0 to 135) score*min for the magnesium and control groups, respectively, $P=0.74$. Similarly, there was no clinically significant difference in the morphine consumption in the PACU between the magnesium group, median (IQR) of 2.0 (0 to 4.44) mg IV morphine compared to control, median (IQR) of 2.5 (0 to 4.99) mg IV morphine, $P=0.25$. The serum level of magnesium was significantly lower in the control group compared to the treatment group at the end of the surgery ($P<0.001$).

Discussion—Despite a large number of studies demonstrating the efficacy of systemic magnesium for preventing postsurgical pain in adults, we could not find evidence for a significant clinical benefit of systemic magnesium infusion in children undergoing tonsillectomies. Our findings reiterate the importance of validating multimodal analgesic strategies in children that have been demonstrated to be effective in the adult population.

Introduction

Tonsillectomy is a frequently performed surgical procedure in children, however achieving adequate postoperative pain control remains challenging.¹ Being one of the most painful otorhinolaryngologic procedures, many patients have high postoperative analgesic requirements and poor postsurgical recovery, including functional limitations up to 1 week after surgery.^{2–4} Non-opioid analgesic strategies have been advocated as viable pathways to

improve postsurgical pain and overall recovery in children undergoing tonsillectomies but few interventions have been proven to be reliably useful.^{5–10} Despite having undesirable side effects (e.g., respiratory depression, nausea and vomiting), opioid analgesics remain the mainstay of perioperative pain control for patients undergoing this surgical procedure.^{11,12}

Magnesium alters the perception and duration of pain by serving as an antagonist of N-methyl-D-aspartate glutamate receptors.¹³ Several randomized clinical trials have demonstrated the efficacy of systemic magnesium for reducing postsurgical pain in adult patients. In addition, three recent meta-analyses have concluded that magnesium infusions improve pain control by decreasing opioid consumption and a recent editorial endorsed the use of magnesium as a multimodal analgesia strategy in adult patients.^{14–17} In contrast, no studies have examined the efficacy of magnesium infusions to ameliorate postsurgical pain in pediatric patients.

The main objective of the current investigation was to evaluate the use of systemic magnesium to improve postoperative pain in pediatric patients undergoing tonsillectomy. We hypothesized that children who received systemic magnesium infusions would have lower post-tonsillectomy pain than the children who received saline infusions.

Methods

The study was a prospective, randomized, double-blinded, clinical trial. Approval for the study was received by the IRB of the Ann and Robert H. Lurie Children's Hospital of Chicago. The study was registered before patient enrollment at ClinicalTrials.gov, identifier: NCT02218424, Principal Investigator: Hubert Benzon, registration date: August 12th 2014. Written informed consent was obtained from parents or legal guardians of all participating subjects. Eligible subjects were children aged 4–10 years old, ASA patient classification I–III, and undergoing tonsillectomy by a single surgeon at our institution. Exclusion criteria included any patient with physical or developmental delay, psychiatric illness, current use of sedative or anticonvulsant medication, preexisting renal or cardiovascular disease or regular use of analgesic medication.

Subjects were randomized using a computer-generated table of random numbers to one of the two intervention groups: systemic magnesium infusion (initial loading dose of 30 mg/kg given over 15 minutes followed by a continuous magnesium infusion of 10 mg/kg/hr) or the same volume of saline. The magnesium dose is consistent with prior clinical studies that examined the analgesic effects of the drug in adult patients.^{14–16} The study drug was prepared by the research pharmacy at the Ann & Robert H. Lurie Children's Hospital of Chicago and was identical for both groups. A research associate and research nurse from the clinical research unit blinded to group allocation were responsible for all data collection.

All children enrolled in the study received a standardized anesthetic regimen. Children were given oral midazolam as premedication or a parent was present for induction if deemed clinically necessary. All patients were induced via inhaled induction with nitrous oxide mixed with oxygen and sevoflurane. Peripheral IV access was obtained and patients were started on the study drug. Fentanyl 2 mcg/kg, dexamethasone 0.1 mg/kg, and ondansetron

0.1 mg/kg were given IV prior to the start of surgery. Patients were tracheally intubated under a deep plane of anesthesia without muscle relaxant. Maintenance of anesthesia included nitrous oxide mixed with oxygen at a 1:1 ratio with sevoflurane. The same senior otolaryngology surgeon performed the surgery for all cases using the coblation device with standard settings. After completion of the surgery, a plasma magnesium level was obtained from each patient from an extremity different from the one with the IV *in situ*. The study drug infusion was stopped, and all patients were tracheally extubated “deep” while spontaneously ventilating.

Upon arrival to the recovery room, a research nurse from the clinical research unit at the Ann & Robert H. Lurie Children’s Hospital of Chicago was present as well as a research associate to collect postoperative pain scores and direct the administration of postoperative pain medication. FLACC behavioral pain assessment (Face, Legs, Activity, Cry, Consolability) scores were taken every 5 minutes for the first 30 minutes in recovery, then every 15 minutes until 1.5 hours after surgery. When a pain score of 4 or higher was determined, the patient was treated with a standardized dose of morphine 0.1 mg/kg. The pediatric anesthesia emergence delirium (PAED) scale was also measured every 5 minutes for the first 30 minutes, then every 15 minutes until 1.5 hours after surgery.¹⁸ All patients were monitored for at least 4 hours prior to discharge. A dosing regimen of ibuprofen 10 mg/kg/dose alternating with hydrocodone with acetaminophen 0.15 mg/kg/dose every 3 hours was recommended to all patients at discharge, and when feeling better hydrocodone was switched to acetaminophen 10 mg/kg/dose.

Postoperative phone calls were conducted after 24 hours and families were asked by phone interview using the parents postoperative pain measure scale, a validated 15-question tool, satisfaction with overall anesthetic care (scale 0–10, where 0 means very unsatisfied and 10 means very satisfied), and were also asked about the use frequency of oral pain medication at home.¹⁹

The primary outcome was pain scores in the postanesthesia care unit (PACU) measured by FLACC pain scores. Pain reduction was measured by the decrement in the area under the pain scale versus 90 minute postoperative time curve using the trapezoidal method (Graph Pad Prism version 5.03, Graph Pad Software, Inc., La Jolla, Ca).²⁰ Secondary outcomes included opioid consumption in the PACU, emergence delirium scores (measured by the PAED scale)¹⁸ and parent satisfaction.

Group sample sizes of 28 and 28 achieve 81% power to show a difference in means when there is a difference of 1.0 between the null hypothesis mean difference of 0.0 and the actual mean difference of –1.0 at the 0.050 significance level (alpha) using a two-sided Mann-Whitney-Wilcoxon Test and a 1.3 standard deviation. The standard deviation was obtained from a prior study evaluating postoperative pain in children undergoing tonsillectomies.²¹ These results are based on 2000 Monte Carlo samples from the null distributions.

The Shapiro-Wilk and Anderson-Darling tests were used to test the assumption of normal distribution ($P>0.1$). Normally distributed interval data are reported as mean (SD) and were analyzed using independent student’s t test. Non-normally distributed interval and ordinal

data are reported as median (range or Interquartile range (IQR)) and were analyzed using the Mann-Whitney U test. The Wilcoxon-Mann-Whitney odds and 95% CI for a random pair for pain score (area under the curve) and morphine consumption values from the magnesium and the saline group were determined from the area under the receiver operator characteristic curve from the binary logistic model.^{22,23} Categorical data are presented as counts (n) and were analyzed using Fisher's exact test. Data were analyzed using STATA version 12 (College Station, Texas, USA).

Results

Sixty children undergoing tonsillectomy with or without adenoidectomy surgery were recruited to the study between October 1, 2014 and April 30, 2015. The details of the conduct of the study are presented in Figure 1. There were no differences in baseline characteristics between the study groups (Table 1).

The serum level of magnesium was significantly different between the study groups at the end of the surgery ($P < 0.001$) (Figure 2). The area under pain scores (up to 90 minutes) was not different between the study groups, median (IQR) of 30 (0 to 120) score*min and 45 (0 to 135) score*min for the magnesium and control groups, respectively, $P = 0.74$. The Wilcoxon-Mann-Whitney odds for a random pair of pain score (area under the curve) values from a magnesium subject compared with a non-magnesium subject was 0.89 (95% CI, 0.47–1.63, $P = 0.71$). Similarly, there was no clinically significant difference in morphine consumption in the PACU between the magnesium group, median (IQR) of 2.0 (0 to 4.44) mg IV morphine compared to control, median (IQR) of 2.5 (0 to 4.99) mg IV morphine, $P = 0.25$. The Wilcoxon-Mann-Whitney odds for a random pair of morphine consumption values from a magnesium subject compared with a non-magnesium subject was 0.69 (95% CI, 0.37–1.43, $P = 0.28$). Other secondary outcomes also did not differ between the study groups (Table 2). No adverse events were observed in any of the study subjects.

Discussion

The most important finding of the current study was that a continuous intraoperative infusion of IV magnesium did not cause a clinically important decrease in postoperative pain scores or opioid consumption in children undergoing tonsillectomies. There was no clinically significant difference in postoperative pain scores during the first 90 minutes in the recovery room, and no difference in total morphine consumption in the recovery room. Furthermore, no difference was noted in ibuprofen or hydrocodone with acetaminophen administration for the first 24 hours after surgery. Taken together, our results suggest that systemic magnesium infusion is not an effective strategy to reduce postsurgical pain in children undergoing tonsillectomies.

Our results are clinically important because magnesium infusions have been demonstrated to be an effective strategy to minimize postsurgical pain across multiple studies in adults.^{14–16} The difficulties in conducting randomized clinical trials in children often predispose pediatric practitioners to use multimodal analgesic strategies validated in adults but that lack confirmatory studies in children. The use of ineffective multimodal strategies in children

undergoing tonsillectomies may lead to an increased use of opioids analgesics and the development of undesirable opioid-related side effects such as respiratory depression and vomiting.

Another interesting finding of our current investigation was the lack of a beneficial effect of systemic magnesium on the development of postoperative emergence delirium in children. There was no clinically significant difference in PAED scores between those treated with IV magnesium versus those treated with placebo at wake up, 5 minutes after wake up, and 30 minutes after wake up. These findings are very different than the ones presented by prior investigators. Abdulatif et al., using a similar dosing regimen of magnesium (30 mg/kg bolus followed by a continuous infusion of 10 mg/kg/hr) found a reduced incidence and severity of emergence agitation in pediatric patients undergoing tonsillectomies.²⁴

O'Flaherty et al. evaluated postoperative opioid use of IV ketamine, magnesium sulphate, or both, compared to placebo.²⁵ Neither ketamine, magnesium, or ketamine plus magnesium provided any improvement in patients' postoperative pain scores or analgesic consumption. Our study differed from the study of O'Flaherty et al. since we included both an initial loading dose followed by an IV infusion of magnesium while the O'Flaherty et al. study examined only a small dose of IV magnesium after induction and prior to surgical incision. This difference is important because the use of a single magnesium bolus has not been demonstrated to be effective for reducing postoperative pain in adults.²⁶ To the best of our knowledge, our study is the first to examine the effect of a systemic infusion of magnesium on postoperative pain outcomes in children.

It is important to develop effective multimodal analgesic strategies in order to improve pain control in pediatric patients undergoing surgical procedures. We continue to use opioids as the mainstay treatment, particularly in patients undergoing tonsillectomy, because few other modalities have been proven to be effective. Specifically for pediatric patients undergoing tonsillectomies, the use of postoperative opioids may predispose patients with obstructive sleep apnea to death or severe neurological impairment.²⁷

Our study should only be interpreted within the context of its limitations. We have only examined patients undergoing a single surgical procedure; therefore, we cannot generalize our findings for children undergoing different surgical procedures. Studies that evaluate the analgesic benefit of magnesium in surgical procedures where the drug has been shown to be effective in adults are needed. Another limitation was that the magnesium infusion was only administered intraoperatively. It is possible that an infusion during the postoperative period may increase the analgesic effects of systemic magnesium. Nonetheless, the vast majority of studies that demonstrated the analgesic efficacy of systemic magnesium in adults used only an intraoperative infusion.^{14–16}

It is possible that a higher dose of a magnesium infusion could have improved pain scores. Because we only tested the analgesic efficacy of a single infusion dose, we could not examine a potential dose-response effect of systemic magnesium on analgesic outcomes in children. The infusion rate of 10 mg/kg/hr was extrapolated from the adult literature,

however, to our knowledge there is no literature evaluating the pharmacodynamic profile of systemic magnesium and pain control, so optimal dosing is still unclear at this time.

In summary, despite a large number of studies demonstrating the efficacy of systemic magnesium in preventing postsurgical pain in adults, we could not find evidence for a significant clinical benefit of a systemic magnesium infusion in children undergoing tonsillectomies. Our findings reiterate the importance of validating in children multimodal analgesic strategies that have been demonstrated to be effective in the adult population. Future studies to confirm or refute our current findings in different surgical procedures in children are warranted.

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References

1. Subramanyam R, Varughese A, Willging JP, Sadhasivam S. Future of pediatric tonsillectomy and perioperative outcomes. *Int J Pediatr Otorhinolaryngol.* 2013; 77:194–9. [PubMed: 23159321]
2. Guntinas-Lichius O, Volk GF, Geissler K, Komann M, Meissner W. Pain after pediatric otorhinolaryngologic surgery: a prospective multi-center trial. *Eur Arch Otorhinolaryngol.* 2014; 271:2049–60. [PubMed: 24510234]
3. Vons KM, Bijker JB, Verwijs EW, Majoor MH, de Graaff JC. Postoperative pain during the first week after adenoidectomy and guillotine adenotonsillectomy in children. *Paediatr Anaesth.* 2014; 24:476–82. [PubMed: 24646093]
4. Stewart DW, Ragg PG, Sheppard S, Chalkiadis GA. The severity and duration of postoperative pain and analgesia requirements in children after tonsillectomy, orchidopexy, or inguinal hernia repair. *Paediatr Anaesth.* 2012; 22:136–43. [PubMed: 22023485]
5. Javid MJ, Hajjafari M, Hajipour A, Makarem J, Khazaeipour Z. Evaluation of a low dose ketamine in post tonsillectomy pain relief: a randomized trial comparing intravenous and subcutaneous ketamine in pediatrics. *Anesth Pain Med.* 2012; 2:85–9. [PubMed: 24223344]
6. Rusy LM, Houck CS, Sullivan LJ, Ohlms LA, Jones DT, McGill TJ, Berde CB. A double-blind evaluation of ketorolac tromethamine versus acetaminophen in pediatric tonsillectomy: analgesia and bleeding. *Anesth Analg.* 1995; 80:226. [PubMed: 7818104]
7. Haddadi S, Marzban S, Karami MS, Heidarzadeh A, Parvizi A, Naderi Nabi B. Comparing the duration of the analgesic effects of intravenous and rectal acetaminophen following tonsillectomy in children. *Anesth Pain Med.* 2014; 4:e13175. [PubMed: 24660154]
8. Hermans V, De Pooter F, De Groote F, De Hert S, Van der Linden P. Effect of dexamethasone on nausea, vomiting, and pain in paediatric tonsillectomy. *Br J Anaesth.* 2012; 109:427–31. [PubMed: 22879656]
9. Mathiesen O, Jørgensen DG, Hilsted KL, Trolle W, Stjernholm P, Christiansen H, Hjortsø NC, Dahl JB. Pregabalin and dexamethasone improves post-operative pain treatment after tonsillectomy. *Acta Anaesthesiol Scand.* 2011 Mar; 55(3):297–305. [PubMed: 21288210]
10. Somdas MA, Senturk M, Ketenci I, Erkorkmaz U, Unlu Y. Efficacy of bupivacaine for post-tonsillectomy pain: a study with the intra-individual design. *Int J Pediatr Otorhinolaryngol.* 2004; 68:1391–5. [PubMed: 15488969]
11. Howard D, Davis KF, Phillips E, Ryan E, Scalford D, Flynn-Roth R, Ely E. Pain management for pediatric tonsillectomy: an integrative review through the perioperative and home experience. *J Spec Pediatr Nurs.* 2014; 19:5–16. [PubMed: 24393224]

12. Goldman JL, Baugh RF, Davies L, Skinner ML, Stachler RJ, Brereton J, Eisenberg LD, Roberson DW, Brenner MJ. Mortality and major morbidity after tonsillectomy: etiologic factors and strategies for prevention. *Laryngoscope*. 2013; 123:2544–53. [PubMed: 23595509]
13. Kroin JS, McCarthy RJ, Von Roenn N, Schwab B, Tuman KJ, Ivankovich AD. Magnesium sulfate potentiates morphine antinociception at the spinal level. *Anesth Analg*. 2000; 90:913–7. [PubMed: 10735798]
14. De Oliveira GS Jr, Castro-Alves LJ, Khan JH, McCarthy RJ. Perioperative systemic magnesium to minimize postoperative pain: a meta-analysis of randomized controlled trials. *Anesthesiology*. 2013; 119:178–90. [PubMed: 23669270]
15. Albrecht E, Kirkham KR, Liu SS, Brull R. Peri-operative intravenous administration of magnesium sulphate and postoperative pain: a meta-analysis. *Anaesthesia*. 2013; 68:79–90. [PubMed: 23121612]
16. Murphy JD, Paskaradevan J, Eisler LL, Ouanes JP, Tomas VA, Freck EA, Wu CL. Analgesic efficacy of continuous intravenous magnesium infusion as an adjuvant to morphine for postoperative analgesia: a systematic review and meta-analysis. *Middle East J Anaesthesiol*. 2013; 22:11–20. [PubMed: 23833845]
17. Naidu, Ramana, MD; Flood, Pamela, MD. Magnesium: Is There a Signal in the Noise? *Anesthesiology*. 2013; 119:13–15. [PubMed: 23665913]
18. Beringer RM, Greenwood R, Kilpatrick N. Development and validation of the Pediatric Anesthesia Behavior score--an objective measure of behavior during induction of anesthesia. *Paediatr Anaesth*. 2014; 24(2):196–200. [PubMed: 24103068]
19. Chambers CT, Reid GJ, McGrath PJ, Finley GA. Development and preliminary validation of a postoperative pain measure for parents. *Pain*. 1996; 68(2–3):307–313. [PubMed: 9121819]
20. De Oliveira GS Jr, Fitzgerald P, Streicher LF, Marcus RJ, McCarthy RJ. Systemic lidocaine to improve postoperative quality of recovery after ambulatory laparoscopic surgery. *Anesth Analg*. 2012; 115:262–7. [PubMed: 22584558]
21. Ozkiri M, Kapusuz Z, Saydam L. Comparison of ropivacaine, bupivacaine and lidocaine in the management of post-tonsillectomy pain. *Int J Pediatr Otorhinolaryngol*. 2012; 76:1831–4. [PubMed: 23021528]
22. Divine G, Norton HJ, Hunt R, Dienemann J. Statistical grand rounds: a review of analysis and sample size calculation considerations for Wilcoxon tests. *Anesth Analg*. 2013; 117:699–710. [PubMed: 23456667]
23. Dexter F. Wilcoxon-Mann-Whitney test used for data that are not normally distributed. *Anesth Analg*. 2013; 117:537–8. [PubMed: 23966647]
24. Abdulatif M, Ahmed A, Mukhtar A, Badawy S. The effect of magnesium sulphate infusion on the incidence and severity of emergence agitation in children undergoing adenotonsillectomy using sevoflurane anaesthesia. *Anaesthesia*. 2013; 68:1045–52. [PubMed: 23909742]
25. O'Flaherty JE, Lin CX. Does ketamine or magnesium affect posttonsillectomy pain in children? *Paediatr Anaesth*. 2003; 13:413–21. [PubMed: 12791115]
26. Tramèr MR, Glynn CJ. An evaluation of a single dose of magnesium to supplement analgesia after ambulatory surgery: randomized controlled trial. *Anesth Analg*. 2007; 104:1374–9. [PubMed: 17513629]
27. Coté CJ1, Posner KL, Domino KB. Death or neurologic injury after tonsillectomy in children with a focus on obstructive sleep apnea: houston, we have a problem! *Anesth Analg*. 2014; 118:1276–83. [PubMed: 23842193]

Figure 1.
Study flow chart for subjects

Figure 2.

Box plot of magnesium serum levels at the end of surgery. Median values shown as solid line within box of 25th and 75th percentile values. Whiskers represent 5th and 95th percentile values. The serum magnesium levels were higher in the magnesium group, median (IQR) of 3.1(2.9 to 3.3) mg/dl compared to 1.9 (1.9 to 2) mg/dl in the control group, $P<0.001$. Data were compared using the Mann-Whitney U test.

Table 1

Baseline Demographic and Surgical Characteristics Between Study Groups

	Magnesium (n=30)	Control (n=30)	P value
Age (months)	76.5 (65 to 94)	76.5 (61 to 92)	0.74
Gender			1.0
Male	15	15	
Female	15	15	
Body Mass Index (Kg/m ²)	16.1 (14.3 to 18.2)	16.9 (14.4 to 20.0)	0.54
Obstructive Sleep Apnea			1.0
Yes	7	8	
No	23	22	
Surgical Duration (minutes)	36.5 (32 to 40)	35(33 to 39)	0.78

Data are presented as median (IQR) or counts (n)

Table 2

Postanesthesia Care Unit Data

	Magnesium (n=30)	Control (n=30)	P value
Time to morphine consumption (min)	25.5 (16 to 90)	18.5 (14 to 90)	0.24
PAED scores at wake up	9 (3 to 12)	7 (2 to 12)	0.65
PAED scores at 5 minutes after wake up	5 (3 to 11)	6.5 (0 to 12)	0.80
PAED scores at 30 minutes after wake up	0 (0 to 0)	0 (0 to 0)	0.45
Number of ibuprofen dosages 24 h	4 (3 to 4)	4 (3 to 4)	0.32
Number of acetaminophen-hydrocodone dosages 24 h	0 (0 to 1.5)	0.5 (0 to 2)	0.52
PPPM scale (0–15) at 24 hours	5.5 (4 to 7)	5 (2 to 7)	0.54
Parental satisfaction with anesthetic scale (0–10)	10 (10 to 10)	10 (10 to 10)	0.68

Data are presented as median (IQR). PAED = pediatric anesthesia emergence delirium. PPPM = parents postoperative pain measure scale.