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Evaluation of the efficacy of magnesium sulphate in reducing blood loss during functional endoscopic sinus surgeries

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ABSTRACT

Background & Aims: Functional Endoscopic Sinus Surgery (FESS) requires optimal surgical field visibility, but intraoperative bleeding can compromise outcomes. Controlled hypotension and attenuation of stress responses are key anaesthetic goals. Magnesium sulphate, due to its vasodilatory and sympatholytic properties, may improve surgical conditions. This study aimed to evaluate the efficacy of intravenous magnesium sulphate in reducing blood loss, improving surgical field quality, and maintaining hemodynamic stability during FESS.
Material & Methods: This prospective randomized double-blinded study included 60 patients undergoing elective FESS, allocated into two groups. Group M received magnesium sulphate (50 mg/kg bolus followed by 15 mg/kg/hr infusion), while Group C received normal saline. Hemodynamic parameters were recorded perioperatively. Blood loss was assessed using pre- and postoperative haemoglobin and packed cell volume (PCV). Surgical field quality was graded using the Boezaart and Van der Merwe scale. Statistical analysis was performed using independent t-test, Chi-square test, and Mann–Whitney U test, with $p<0.05$ considered significant.
Results: Postoperative haemoglobin (13.51 ± 1.85 vs. 12.27 ± 2.14 g/dL; p=0.019) and PCV (40.03 ± 6.70% vs. 35.70 ± 8.15%; p=0.028) were significantly higher in Group M. Mean Boezaart score was significantly lower in Group M (2.17 ± 0.38 vs. 3.13 ± 0.68; p<0.001), indicating improved surgical field quality. Hemodynamic responses to laryngoscopy were significantly attenuated, with better intraoperative stability in Group M.
Conclusion: Intravenous magnesium sulphate effectively reduces blood loss, improves surgical field quality, and provides stable hemodynamics during FESS, supporting its use as a safe anaesthetic adjunct.

Keywords: Magnesium Sulphate; Endoscopic Sinus Surgery; Controlled Hypotension; Intraoperative Blood Loss; Hemodynamics.

INTRODUCTION

Functional Endoscopic Sinus Surgery (FESS) has become the cornerstone in the surgical management of a wide range of sinonasal disorders, including chronic rhinosinusitis with or without nasal polyposis, fungal sinusitis, mucoceles, and selected skull base pathologies. (1).

Intraoperative bleeding remains one of the most significant challenges during FESS. Bleeding compromises surgical field visibility and necessitates frequent suctioning, which disrupts surgical flow. (2). Consequently, strategies aimed at minimizing blood loss and improving the quality of the surgical field are of paramount importance.
Controlled hypotension under GA is a well-established technique to reduce intraoperative bleeding during FESS. Several pharmacological agents have been employed for this purpose, including vasodilators such as nitroglycerin and sodium

nitroprusside, beta-adrenergic blockers like esmolol, alpha-2 adrenergic agonists such as clonidine and dexmedetomidine, and high concentrations of volatile anaesthetic agents(3). While these agents are effective, each has inherent limitations, including reflex tachycardia, delayed recovery, excessive sedation, or the risk of organ hypoperfusion, particularly in susceptible patients (4).

Magnesium sulphate has gained increasing attention as a potential adjunct in controlled hypotensive anaesthesia. It acts as a non-competitive antagonist at N-methyl-D-aspartate (NMDA) receptors and inhibits calcium influx through voltage-gated calcium channels. These actions result in attenuation of catecholamine release from adrenergic nerve terminals and the adrenal medulla, leading to reduced sympathetic tone, vasodilation, and stabilization of hemodynamic responses to surgical stress (5).

In the perioperative setting, magnesium sulphate has demonstrated multiple beneficial effects, including attenuation of the pressor response to laryngoscopy and intubation, reduction in anaesthetic and opioid requirements, and improved postoperative analgesia(6). Its vasodilatory properties, mediated by both endothelial-dependent and independent mechanisms, contribute to reduced arterial pressure and decreased capillary bleeding. Additionally, magnesium enhances prostacyclin synthesis and inhibits angiotensin-converting enzyme activity, further supporting its hypotensive effects (7).Several clinical studies have evaluated the role of magnesium sulphate in reducing intraoperative blood loss and improving surgical field conditions. Elsharnouby and Elsharnouby demonstrated that perioperative administration of intravenous magnesium sulphate significantly reduced arterial pressure, heart rate, intraoperative blood loss, and duration of surgery compared with placebo in patients undergoing surgery under hypotensive anaesthesia (8). These findings laid the foundation for subsequent research into magnesium's role in endoscopic surgeries.

More recently, randomized controlled trials on FESS have reported favourable outcomes with magnesium sulphate. Improved surgical field quality, assessed using validated grading systems such as the Fromme-Boezaart scale, and reduced estimated blood loss have been observed in patients receiving magnesium compared (9). A systematic review and meta-analysis of randomized controlled trials further supported these findings. (10).

There is considerable variation in the dosing strategies employed across studies, with bolus doses ranging from 40 to 60 mg/kg and infusion rates between 10 and 30 mg/kg/h. Safety considerations also warrant attention, as magnesium potentiates neuromuscular blockade and may cause hypotension or bradycardia if not carefully titrated and monitored(11) . Given these considerations, there remains a need for well-designed, randomized, double-blinded controlled studies employing standardized dosing protocols and objective outcome measures to better define the role of magnesium sulphate in functional endoscopic sinus surgery. Evaluating its efficacy in reducing blood loss, improving surgical field quality, and maintaining hemodynamic stability while monitoring for adverse effects is essential before recommending its routine use. The present study was therefore undertaken to evaluate the efficacy of intravenous magnesium sulphate administered as a bolus followed by continuous infusion in reducing intraoperative blood loss during functional endoscopic sinus surgery. By employing a randomized double-blinded controlled design, this study aims to contribute robust evidence regarding the utility and safety of magnesium sulphate as an adjunct in anaesthesia for functional endoscopic sinus surgery.

MATERIALS AND METHODS:

Ethical Considerations

Ethical approval for the study was obtained from the Institutional Ethics Committee, prior to the commencement of the study vide number IEC/199/23-24.

Study Design

The present study was designed as a prospective randomized comparative study.

Trial Registration

The study was carried out over a period of one year starting on 28/10/2024 after obtaining approval from the Institutional Ethics Committee.

Patient Population

The study population consisted of adult patients scheduled to undergo elective FESS under GA.

Consent

Written informed consent was obtained from all participants after explaining the purpose, procedure, benefits, and potential risks of the study. Confidentiality of patient data was maintained throughout the study period

Inclusion Criteria

Patients fulfilling the following criteria were included in the study:

- Adult patients aged between 18 and 60 years
- Patients scheduled for elective functional endoscopic sinus surgery

- Patients belonging to American Society of Anaesthesiologists (ASA) physical status I or II
- Patients who provided informed written consent to participate in the study

Exclusion Criteria

Patients were excluded from the study if they had any of the following conditions:

- Known hypersensitivity or contraindication to magnesium sulphate
- Significant cardiovascular disease
- Renal impairment
- Hepatic dysfunction
- Coagulation disorders
- Patients on calcium channel blockers or magnesium therapy
- Pregnant or lactating women
- Patients refusing consent for participation in the study

Sampling Method

Eligible patients were selected using simple random sampling. Randomization into the two study groups of 30 each was performed using a computer-generated randomization sequence.

Conduct of study

After informed consent, patients were randomized into two groups. Group M received intravenous magnesium sulphate (bolus of 50mg/kg followed by infusion of 15mg/kg/hr), while Group C received an equal volume of normal saline. The study was double-blinded, with both the anaesthesiologist and surgeon unaware of group allocation.

Standard monitoring (ECG, SpO_2, NIBP, capnography) was applied. Baseline hemodynamic parameters were recorded. General anaesthesia was induced and maintained as per institutional protocol, with endotracheal intubation after adequate muscle relaxation.

Hemodynamic parameters (HR, SBP, DBP, and MAP) were recorded at baseline, peri-induction, post-laryngoscopy, and at regular intraoperative intervals until the end of surgery.

Outcome Measures

Blood loss was assessed indirectly using pre- and postoperative haemoglobin(Hb) and packed cell volume(PCV). Surgical field quality was graded using the Boezaart and Van der Merwe scale.

Grade 1	Cadaveric conditions with minimal suction required
Grade 2	Minimal bleeding with infrequent suction required
Grade 3	Brisk bleeding with frequent suction required
Grade 4	Bleeding covers surgical field after removal of suction before surgical instruments can perform maneuver.
Grade 5	Uncontrolled bleeding; bleeding out of nostril on removal of suction.

Table 1: Boezaart and Van der Merwe scale

Sample Size calculation

Sample size was calculated using published data of a previous study based on the anticipated difference in the blood loss between the $MgSO_4$ and control groups. The blood loss with use of $MgSO_4$ was (mean ± standard deviation) 361.78 ± 194.11. Assuming Type I error of 5% and Type II error of 20% (power of 80%), an increase in the blood loss by 54% was considered clinically significant. This resulted in a sample size of 15 patients for each group calculated by using the formula.

$$k = \frac{n_2}{n_1} = 1$$

$$n_1 = \frac{(\sigma_1^2 + \sigma_2^2/K)(z_{1-\alpha/2} + z_{1-\beta})^2}{\Delta^2}$$

$$n_1 = \frac{(194.11^2 + 194.11^2/1)(1.96 + 0.84)^2}{195.361^2}$$

$$n_1 = 15$$

$$n_2 = K * n_1 = 15$$

$\Delta = |\mu_2 - \mu_1|$ = absolute difference between two means
σ_1, σ_2 = variance of mean #1 and #2
n_1 = sample size for group #1
n_2 = sample size for group #2
α = probability of type I error (usually 0.05)
β = probability of type II error (usually 0.2)
z = critical Z value for a given α or β
k = ratio of sample size for group #2 to group #1

Figure 1: Sample size calculation formula

Statistical Analysis
All collected data were entered into Microsoft Excel and analysed using appropriate statistical software. Continuous variables such as age, weight, Hb and PCV levels were expressed as mean with standard deviation. Comparison between the two groups was performed using the independent sample t-test for continuous variables and Chi-square test for categorical variables. For non-parametric data such as surgical field grading, the Mann-Whitney U test was applied. A p-value less than 0.05 was considered statistically significant.

RESULTS
Sixty patients were randomized into two groups: Group M received magnesium sulphate (bolus plus infusion) and Group C received normal saline. The study was double-blinded, and all patients completed the protocol without dropouts or exclusions.

Preoperative haemoglobin and PCV were comparable between groups (p>0.05). Postoperative haemoglobin showed 13.51 ± 1.85 vs. 12.27 ± 2.14 g/dL; p=0.019(figure-2) and PCV showed 40.03 ± 6.70% vs. 35.70 ± 8.15%; p=0.028 (figure-3) were significantly higher in Group M compared to Group C. The mean Boezaart score was significantly lower in Group M showing 2.17 ± 0.38 vs. 3.13 ± 0.68; p<0.001(figure-4), indicating improved surgical field quality. The data showed a statistically significant (p<0.05) difference in postoperative haemoglobin, PCV and surgical field grading between the two groups (table -2)

Variable	Group M (Mean ± SD)	Group C (Mean ± SD)	P value
Age	35.06 ± 13.00	42.13 ± 13.5	0.59
Weight (kg)	64.92 ± 11.05	65.87 ± 9.89	0.68
Preoperative Hb (g/dL)	13.67 ± 1.97	13.37 ± 2.17	0.575
Postoperative Hb (g/dL)	13.51 ± 1.85	12.27 ± 2.14	0.019*
Preoperative PCV (%)	41.40 ± 6.49	39.83 ± 7.22	0.380
Postoperative PCV (%)	40.03 ± 6.70	35.70 ± 8.15	0.028 *
Boezaart grade	2.17 ± 0.38	3.13 ± 0.68	<0.001*

Table 2: Results; Values are mean ± standard deviation (SD) or number of patients; *p-value is statistically significant

These findings demonstrate reduced intraoperative blood loss and better visualization in the magnesium sulphate group, supporting its efficacy in optimizing surgical conditions during FESS.

DISCUSSION
Manandhar et al. highlighted that FESS has become the cornerstone for managing chronic rhinosinusitis, particularly in low- and middle-income countries where advanced disease often presents with extensive mucosal inflammation and hypervascularity (1). Excessive intraoperative bleeding remains a major challenge in FESS, compromising visualization, prolonging surgery, and increasing complication risk. This study was designed to evaluate whether intravenous magnesium sulphate reduces blood loss while maintaining hemodynamic stability and patient safety.

Sieśkiewicz et al. demonstrated that bleeding during endoscopic sinus surgery is closely related to the microvascular density of the nasal mucosa, making even modest elevations in blood pressure clinically relevant (2). This pathophysiological basis supports controlled hypotension to improve surgical field quality. The present study evaluates magnesium sulphate, with vasodilatory and sympatholytic properties, as an adjunct to general anaesthesia in FESS.

Baseline demographic and clinical characteristics were comparable between Group M and Group C. There were no significant differences in age, gender distribution, or anthropometric parameters (weight, height, BMI), minimizing confounding effects on vascular reactivity, drug pharmacodynamics, and cardiovascular responses.

Although Group M had a slightly higher proportion of ASA II patients, this would typically favour the control group; nevertheless, Group M demonstrated better intraoperative outcomes, supporting a true effect of magnesium sulphate rather than differences in baseline health status.

Mallampati scores were similar in both groups, indicating comparable airway difficulty. This ensures that differences in hemodynamic responses were pharmacological rather than related to variations in intubation stress.
Kennedy et al. emphasized that successful FESS relies heavily on optimal visualization of the surgical field, which in turn depends on minimizing bleeding and maintaining stable hemodynamics (28, 33). The baseline comparability achieved in the present study provides a robust foundation for attributing differences in blood loss, surgical field quality, and hemodynamic stability directly to the intervention under investigation.

Srivastava et al. demonstrated that controlled hypotension plays a pivotal role in reducing intraoperative blood loss during FESS by lowering arterial and capillary pressures within the highly vascular nasal mucosa (3). Intravenous magnesium sulphate significantly reduced intraoperative blood loss, as assessed by perioperative haemoglobin and packed cell volume (PCV). Preoperative values were comparable between groups, confirming similar baseline status. Postoperatively, Group M maintained significantly higher haemoglobin and PCV levels than the control group, indicating less blood loss. The smaller decline in these parameters reflects better preservation of red cell mass, consistent with reduced surgical bleeding, likely due to controlled hypotension and decreased mucosal oozing during FESS

Elsharnouby et al. reported that magnesium sulphate can be effectively used as a hypotensive anaesthetic agent due to its ability to inhibit catecholamine release, block calcium influx into vascular smooth muscle, and reduce systemic vascular resistance (8). The present study corroborates these findings by demonstrating significant differences in postoperative haematological parameters favouring the magnesium group. Similar results were observed by Preethi et al., who showed that magnesium sulphate significantly reduced blood loss and improved surgical field quality in patients undergoing FESS (41). The consistency of findings across studies strengthens the evidence supporting magnesium sulphate as a useful adjunct in sinonasal surgeries.

Sieśkiewicz et al. emphasized that even small reductions in bleeding can substantially improve endoscopic visibility, as the nasal mucosa has a dense microvascular network (2). Surgical field quality, assessed by the Boezaart and Van der Merwe scale, was significantly better in Group M, with lower scores indicating less bleeding and improved visualization. This enhances anatomical clarity, reduces operative difficulty, and may lower the risk of orbital and skull base injuries during FESS

Liu et al., in their meta-analysis of randomized controlled trials, concluded that magnesium sulphate significantly improves the surgical field during endoscopic sinus surgery when compared to placebo or standard anaesthetic techniques (9, 49). The results of the present study are in strong agreement with this conclusion. The highly significant difference in Boezaart grading observed between the two groups supports the primary objective of the study and confirms that magnesium sulphate effectively enhances surgical field conditions by reducing intraoperative bleeding.

The intraoperative infusion phase further highlighted the role of magnesium sulphate in maintaining controlled hypotension. From 45 minutes onward, Group M consistently exhibited significantly lower MAP values compared to Group C, with highly significant differences observed at 60 minutes and at the end of surgery. Estrada de la P et al. demonstrated that magnesium sulphate produces a gradual and sustained hypotensive effect, making it suitable for prolonged procedures requiring stable surgical conditions (44). The sustained reduction in MAP observed in the present study provides a physiological explanation for the improved surgical field quality and reduced blood loss in the magnesium group.

Lang et al., in their meta-analysis comparing dexmedetomidine and magnesium sulphate, concluded that magnesium sulphate is equally effective in providing controlled hypotension with a favourable safety profile (10). The present study supports this observation, as no episodes of excessive hypotension, bradycardia, or hemodynamic instability were noted in the magnesium group. MAP values remained within acceptable ranges, ensuring adequate tissue perfusion throughout surgery.

The findings of the present study are consistent with a growing body of literature supporting the use of magnesium sulphate for controlled hypotension and stress response attenuation in ENT surgeries (18, 20, 21, 26-28). Compared to agents such as nitroglycerin, esmolol, or dexmedetomidine, magnesium sulphate offers the advantage of multimodal action with minimal adverse effects. Its affordability and availability further enhance its suitability, particularly in low- and middle-income settings as highlighted by Manandhar et al. (1).

The study is limited by a relatively small sample size and indirect assessment of blood loss using haemoglobin, PCV, and surgical field grading. Larger studies with direct blood loss measurement are needed.
Intravenous magnesium sulphate is an effective and safe adjunct in FESS, reducing blood loss, improving surgical field quality, and maintaining hemodynamic stability, supporting its use in anaesthetic protocols.

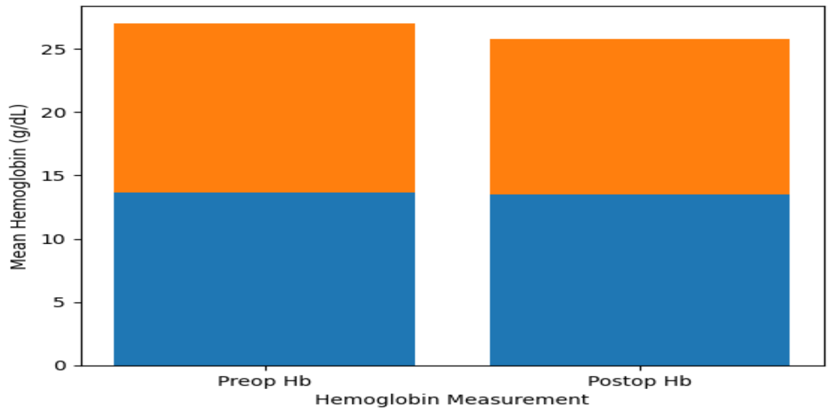

Figure 2: Bar diagram showing comparison of preoperative and postoperative haemoglobin levels between Group M and Group C

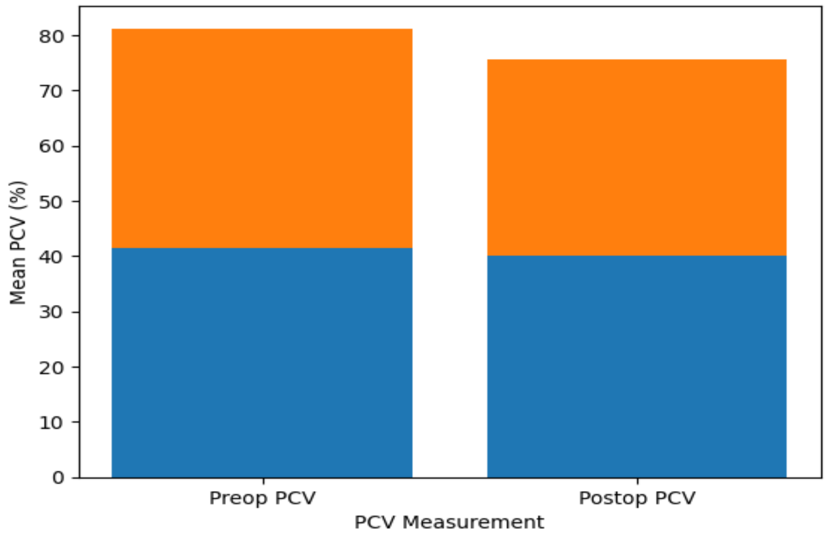

Figure 3 : Bar diagram showing comparison of preoperative and postoperative PCV between Group M and Group C

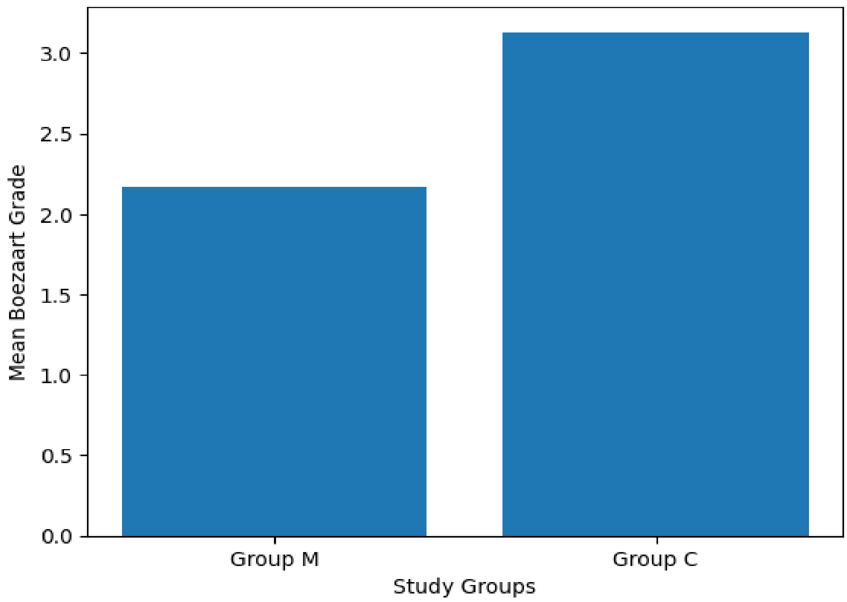

Figure 4: Bar diagram showing comparison of Boezaart and Van der Merwe surgical field grades between Group M and Group C

Conflict of Interest Statement:
The author declares that there are no conflicts of interest related to this study. This research was conducted solely for academic purposes as part of a postgraduate dissertation in the Department of Anaesthesiology at Basaveshwara Medical College and Hospital, Chitradurga. No financial support, sponsorship, or funding was received from any pharmaceutical company, commercial organization, or external agency for the conduct of this study. The study drug used was administered as part of routine clinical practice, and no personal or financial relationships existed that could have influenced the design, conduct, analysis, or reporting of the study findings. All results presented in this dissertation are based on unbiased scientific observations and were interpreted objectively.

Data Availability: The data that support the findings of this study are available from the corresponding author, [K.S], upon reasonable request.

Dr Krithika S
Signature and Name of the corresponding Author

REFERENCES

1. Manandhar S, Khan SA, Pokharel A, Shah D. Revolutionizing chronic rhinosinusitis treatment with functional endoscopic sinus surgery: Insights from a low–middle income country. Medicine (Baltimore). 2025 May 2;104(18):e42382. doi:10.1097/MD.0000000000042382 PubMed PMID: 40324223; PubMed Central PMCID: PMC12055043.
2. Sieśkiewicz A, Reszeć J, Piszczatowski B, Olszewska E, Klimiuk PA, Chyczewski L, et al. Intraoperative bleeding during endoscopic sinus surgery and microvascular density of the nasal mucosa. Adv Med Sci. 2014 Mar;59(1):132–5. doi:10.1016/j.advms.2013.10.001 PubMed PMID: 24797989.
3. Srivastava U, Dupargude AB, Kumar D, Joshi K, Gupta A. Controlled Hypotension for Functional Endoscopic Sinus Surgery: Comparison of Esmolol and Nitroglycerine. Indian J Otolaryngol Head Neck Surg. 2013 Aug;65(Suppl 2):440–4. doi:10.1007/s12070-013-0655-5 PubMed PMID: 24427694; PubMed Central PMCID: PMC3738799.
4. Sandroni C, Cronberg T, Sekhon M. Brain injury after cardiac arrest: pathophysiology, treatment, and prognosis. Intensive Care Med. 2021;47(12):1393–414. doi:10.1007/s00134-021-06548-2 PubMed PMID: 34705079; PubMed Central PMCID: PMC8548866.
5. Do SH. Magnesium: a versatile drug for anaesthesiologists. Korean J Anaesthesiol. 2013 Jul;65(1):4–8. doi:10.4097/kjae.2013.65.1.4 PubMed PMID: 23904932; PubMed Central PMCID: PMC3726845.
6. Dahake JS, Verma N, Bawiskar D. Magnesium Sulphate and Its Versatility in Anaesthesia: A Comprehensive Review. Cureus. 16(3):e56348. doi:10.7759/cureus.56348 PubMed PMID: 38633961; PubMed Central PMCID: PMC11021848.
7. Drożdż D, Drożdż M, Wójcik M. Endothelial dysfunction as a factor leading to arterial hypertension. Pediatr Nephrol. 2023;38(9):2973–85. doi:10.1007/s00467-022-05802-z PubMed PMID: 36409370; PubMed Central PMCID: PMC10432334.
8. Elsharnouby NM, Elsharnouby MM. Magnesium sulphate as a technique of hypotensive anaesthesia. British Journal of Anaesthesia. 2006 Jun 1;96(6):727–31. doi:10.1093/bja/ael085
9. Liu W, Jiang H, Pu H, Hu D, Zhang Y. The effect of magnesium sulphate on surgical field during endoscopic sinus surgery: A meta-analysis of randomized controlled trials. Medicine (Baltimore). 2019 Jul;98(28):e16115. doi:10.1097/MD.0000000000016115 PubMed PMID: 31305395; PubMed Central PMCID: PMC6641709.
10. Lang B, Zhang L, Lin Y, Zhang W, Li F shan, Chen S. Comparison of effects and safety in providing controlled hypotension during surgery between dexmedetomidine and magnesium sulphate: A meta-analysis of randomized controlled trials. PLOS ONE. 2020 Jan 8;15(1):e0227410. doi:10.1371/journal.pone.0227410
11. Simonato D, Borchert RJ, Labeyrie MA, Fuschi M, Thibault L, Henkes H, et al. Glycoprotein IIb/IIIa inhibitors for the neurointerventionalist. Interv Neuroradiol. 2022 Feb;28(1):84–91. doi:10.1177/15910199211015038 PubMed PMID: 33947250; PubMed Central PMCID: PMC8905078.
12. Hicks MA, Tyagi A. Magnesium Sulphate. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 [cited 2026 Mar 11]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK554553/ PubMed PMID: 32119440.
13. Genuis SJ. What's out there making us sick? J Environ Public Health. 2012;2012:605137. doi:10.1155/2012/605137 PubMed PMID: 22262979; PubMed Central PMCID: PMC3202108.
14. Lu JF, Nightingale CH. Magnesium sulphate in eclampsia and pre-eclampsia: pharmacokinetic principles. Clin Pharmacokinet. 2000 Apr;38(4):305–14. doi:10.2165/00003088-200038040-00002 PubMed PMID: 10803454.
15. Hypertension in pregnancy. Report of the American College of Obstetricians and Gynecologists' Task Force on Hypertension in Pregnancy. Obstet Gynecol. 2013 Nov;122(5):1122–31. doi:10.1097/01.AOG.0000437382.03963.88 PubMed PMID: 24150027.

16. Schwalfenberg GK, Genuis SJ. The Importance of Magnesium in Clinical Healthcare. Scientifica (Cairo). 2017;2017:4179326. doi:10.1155/2017/4179326 PubMed PMID: 29093983; PubMed Central PMCID: PMC5637834.
17. Kleinman ME, Brennan EE, Goldberger ZD, Swor RA, Terry M, Bobrow BJ, et al. Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2015 Nov 3;132(18 Suppl 2):S414-435. doi:10.1161/CIR.0000000000000259 PubMed PMID: 26472993.
18. Horton R. The neglected epidemic of chronic disease. Lancet. 2005 Nov 29;366(9496):1514. doi:10.1016/S0140-6736(05)67454-5 PubMed PMID: 16257331.
19. Urbano FL. Review of the NAEPP 2007 Expert Panel Report (EPR-3) on Asthma Diagnosis and Treatment Guidelines. J Manag Care Pharm. 2008;14(1):41–9. doi:10.18553/jmcp.2008.14.1.41 PubMed PMID: 18240881; PubMed Central PMCID: PMC10437625.
20. Genuis SJ. Nutritional transition: a determinant of global health. J Epidemiol Community Health. 2005 Aug;59(8):615–7. doi:10.1136/jech.2004.028985 PubMed PMID: 16020633; PubMed Central PMCID: PMC1733113.
21. Link MS, Berkow LC, Kudenchuk PJ, Halperin HR, Hess EP, Moitra VK, et al. Part 7: Adult Advanced Cardiovascular Life Support: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2015 Nov 3;132(18 Suppl 2):S444-464. doi:10.1161/CIR.0000000000000261 PubMed PMID: 26472995.
22. Callaway CW, Soar J, Aibiki M, Böttiger BW, Brooks SC, Deakin CD, et al. Part 4: Advanced Life Support: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. Circulation. 2015 Oct 20;132(16 Suppl 1):S84-145. doi:10.1161/CIR.0000000000000273 PubMed PMID: 26472860.
23. Wyckoff MH, Aziz K, Escobedo MB, Kapadia VS, Kattwinkel J, Perlman JM, et al. Part 13: Neonatal Resuscitation: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2015 Nov 3;132(18 Suppl 2):S543-560. doi:10.1161/CIR.0000000000000267 PubMed PMID: 26473001.
24. Schwalfenberg G. Not enough vitamin D: health consequences for Canadians. Can Fam Physician. 2007 May;53(5):841–54. PubMed PMID: 17872747; PubMed Central PMCID: PMC1949171.
25. Lo C. Integrating nutrition as a theme throughout the medical school curriculum. Am J Clin Nutr. 2000 Sep;72(3 Suppl):882S-9S. doi:10.1093/ajcn/72.3.882s PubMed PMID: 10966917.
26. 26. Whang R, Hampton EM, Whang DD. Magnesium homeostasis and clinical disorders of magnesium deficiency. Ann Pharmacother. 1994 Feb;28(2):220–6. doi:10.1177/106002809402800213 PubMed PMID: 8173141.
27. McCabe D, Lisy K, Lockwood C, Colbeck M. The impact of essential fatty acid, B vitamins, vitamin C, magnesium and zinc supplementation on stress levels in women: a systematic review. JBI Database System Rev Implement Rep. 2017 Feb;15(2):402–53. doi:10.11124/JBISRIR-2016-002965 PubMed PMID: 28178022.
28. Kennedy DW. Technical innovations and the evolution of endoscopic sinus surgery. Ann Otol Rhinol Laryngol Suppl. 2006 Sep;196:3–12. doi:10.1177/00034894061150s902 PubMed PMID: 17040012.
29. Illum P, Jeppesen F. Sinoscopy: endoscopy of the maxillary sinus. Technique, common and rare findings. Acta Otolaryngol. 1972 Jun;73(6):506–12. doi:10.3109/00016487209138972 PubMed PMID: 5047113.
30. Messerklinger W. Endoscopy of the nose [Internet]. Urban & Schwarzenberg; 1978 [cited 2026 Jan 10]. Available from: https://cir.nii.ac.jp/crid/1970867909798667663
31. Kennedy DW. Functional Endoscopic Sinus Surgery: Technique. Arch Otolaryngol. 1985 Oct 1;111(10):643–9. doi:10.1001/archotol.1985.00800120037003
32. Palmer O, Moche JA, Matthews S. Endoscopic surgery of the nose and paranasal sinus. Oral Maxillofac Surg Clin North Am. 2012 May;24(2):275–83, ix. doi:10.1016/j.coms.2012.01.006 PubMed PMID: 22381998.
33. Kennedy DW, Zinreich SJ, Rosenbaum AE, Johns ME. Functional Endoscopic Sinus Surgery: Theory and Diagnostic Evaluation. Arch Otolaryngol. 1985 Sep 1;111(9):576–82. doi:10.1001/archotol.1985.00800110054002
34. Bhattacharyya N. Incremental health care utilization and expenditures for chronic rhinosinusitis in the United States. Ann Otol Rhinol Laryngol. 2011 Jul;120(7):423–7. doi:10.1177/000348941112000701 PubMed PMID: 21859049.
35. Prasanna LC, Mamatha H. The location of maxillary sinus ostium and its clinical application. Indian J Otolaryngol Head Neck Surg. 2010 Oct;62(4):335–7. doi:10.1007/s12070-010-0047-z PubMed PMID: 22319687; PubMed Central PMCID: PMC3266099.
36. Soler ZM, Smith TL. Quality of life outcomes after functional endoscopic sinus surgery. Otolaryngol Clin North Am. 2010 Jun;43(3):605–12, x. doi:10.1016/j.otc.2010.03.001 PubMed PMID: 20525514; PubMed Central PMCID: PMC2882381.
37. Rosenfeld RM, Piccirillo JF, Chandrasekhar SS, Brook I, Ashok Kumar K, Kramper M, et al. Clinical practice guideline (update): adult sinusitis. Otolaryngol Head Neck Surg. 2015 Apr;152(2 Suppl):S1–39. doi:10.1177/0194599815572097 PubMed PMID: 25832968.

38. Wormald PJ, Hoseman W, Callejas C, Weber RK, Kennedy DW, Citardi MJ, et al. The International Frontal Sinus Anatomy Classification (IFAC) and Classification of the Extent of Endoscopic Frontal Sinus Surgery (EFSS). Int Forum Allergy Rhinol. 2016 Jul;6(7):677–96. doi:10.1002/alr.21738 PubMed PMID: 26991922.
39. ResearchGate [Internet]. [cited 2026 Mar 11]. Fig. 4 Topography and variants of the ethmoidal cells. Horizontal... Available from: https://www.researchgate.net/figure/Topography-and-variants-of-the-ethmoidal-cells-Horizontal-section-through-the-ethmoidal_fig4_374569962
40. Endoscopic anatomy of the right ostiomeatal complex, highlighting the... | Download Scientific Diagram [Internet]. [cited 2026 Mar 11]. Available from: https://www.researchgate.net/figure/Endoscopic-anatomy-of-the-right-ostiomeatal-complex-highlighting-the-uncinate-process_fig5_374569962
41. reethi A, Venkatraman R, Karthika U, Rangapriya A, Preethi A, Venkatraman R, et al. Evaluation of the Efficacy of Magnesium Sulphate in Reducing Blood Loss in Functional Endoscopic Sinus Surgery: A Randomized Double-Blinded Controlled Trial. Cureus. 2023 May 6;15. doi:10.7759/cureus.38636
42. Jangra K, Malhotra SK, Gupta A, Arora S. Comparison of quality of the surgical field after controlled hypotension using esmolol and magnesium sulphate during endoscopic sinus surgery. Journal of Anaesthesiology Clinical Pharmacology. 2016 Sep;32(3):325. doi:10.4103/0970-9185.173400
43. A Comparative Study of Magnesium Sulphate, Lignocaine, and Propofol for Attenuating Hemodynamic Response During Functional Endoscopic Sinus Surgery Under General Anaesthesia: A Prospective Randomized Trial. - Abstract - Europe PMC [Internet]. [cited 2025 Dec 10]. Available from: https://europepmc.org/article/med/39478344
44. Estrada C de la P. Controlled Hypotension During Endoscopic Sinus Surgery: A Comparison of Propofol and Magnesium Sulphate. ASOAJ. 2020 Oct 22;2(3):1–8.
45. (PDF) INTRA-OPERATIVE MAGNESIUM SULPHATE INFUSION DECREASES AGITATION AND PAIN IN PATIENTS UNDERGOING FUNCTIONAL ENDOSCOPIC SINUS SURGERY-A PROSPECTIVE, RANDOMIZED, CONTROLLED AND DOUBLE-BLINDED CLINICAL TRIAL. ResearchGate. 2025 Aug 7. doi:10.22159/ijcpr.2023v15i6.3087
46. Sawant U, Sen J, Sawant U, Sen J. A Comprehensive Review of Magnesium Sulphate Infusion: Unveiling the Impact on Hemodynamic Stability During Laryngoscopy and Tracheal Intubation in Ear, Nose, and Throat Surgeries. Cureus. 2024 Mar 26;16. doi:10.7759/cureus.57002
47. Jangra K, Malhotra SK, Gupta A, Arora S. Comparison of quality of the surgical field after controlled hypotension using esmolol and magnesium sulphate during endoscopic sinus surgery. J Anaesthesiol Clin Pharmacol. 2016;32(3):325–8. doi:10.4103/0970-9185.173400 PubMed PMID: 27625479; PubMed Central PMCID: PMC5009837.
48. Sanad HA, Mohamed AZ, Abd-elraouf AA. Comparative study between three Different Doses of Magnesium Sulphate as a Technique of Hypotensive Anaesthesia during Functional Endoscopic Sinus Surgery. The Egyptian Journal of Hospital Medicine. 2019 Jan 1;74(8):1759–68. doi:10.21608/ejhm.2019.28676
49. Liu W, Jiang H, Pu H, Hu D, Zhang Y. The effect of magnesium sulphate on surgical field during endoscopic sinus surgery: A meta-analysis of randomized controlled trials. Medicine. 2019 Jul;98(28):e16115. doi:10.1097/MD.0000000000016115
50. Vamshidhar M, Pakhare V, Gooty S, Nanda A, Gopinath R, Kumar KD, et al. A Comparative Study of Magnesium Sulphate, Lignocaine, and Propofol for Attenuating Hemodynamic Response During Functional Endoscopic Sinus Surgery Under General Anaesthesia: A Prospective Randomized Trial. Turkish Journal of Anaesthesiology and Reanimation. 2024 Oct 30. doi:10.4274/TJAR.2024.241573