Laryngospasm in Pediatric Anesthesia with Intravenous versus Inhalation Anesthetic Induction

Lucas Alessi[1], Jacob Linomaz, MHA[1], Ally E. Spohn[1], Megan Dekok, MSc[1], Nicholas Rodriguez[1], Neha Lamsal, DO[1], Richard Alessi, MD[2]

1. Rocky Vista University, College of Osteopathic Medicine, Englewood, CO
2. Northern Colorado Anesthesia Professionals, Fort Collins, CO

Keywords/phrases:
Pediatric Anesthesia, Laryngospasm, Intravenous Induction, Inhalation Induction

Abstract

This review explores the occurrence of laryngospasm following intravenous (IV) administration of propofol versus inhalation induction with sevoflurane in pediatric anesthesia. A structured literature search was conducted using PubMed, MEDLINE, PsycINFO, and CINAHL to identify relevant studies. A total of 14 articles were selected based on predefined inclusion criteria. This review seeks to elucidate the optimal induction method to reduce perioperative respiratory complications, particularly laryngospasm, and improve pediatric patient outcomes. Evidence suggests that IV anesthesia with propofol is associated with a lower incidence of laryngospasm compared to inhalation anesthesia with sevoflurane, especially in patients predisposed to respiratory complications, such as those with upper respiratory infections. Additionally, reduced perioperative complications may lead to cost-effective healthcare outcomes, including decreased hospital admissions. However, in certain clinical scenarios such as patients with difficult IV access or significant needle phobia, inhalation induction may still be preferable. This review highlights the need for further research to better understand the benefits and limitations of IV induction in pediatric anesthesia, while also considering patient-specific factors that influence induction choice.

Introduction

The administration of anesthesia in pediatric patients presents unique challenges due to anatomical and physiological differences that require careful consideration for both efficacy and safety. Factors such as smaller airway size, variable compliance, and difficulty with vascular access make pediatric anesthesia more complex than in adults.[1] Among the primary induction methods, intravenous (IV) induction with propofol and inhalation induction with sevoflurane are commonly used. The choice between these methods significantly influences perioperative outcomes, especially airway stability and the risk of respiratory complications including laryngospasm.[2]

This review focuses on how different anesthesia techniques impact the occurrence of laryngospasm, an involuntary closure of the vocal cords that can lead to partial or complete airway obstruction.[3] Laryngospasm is a critical, adverse respiratory event characterized by arterial oxygen desaturation and is associated with severe coughing, airway obstruction, and postoperative stridor.[4] The incidence of laryngospasm varies with the induction method, patient risk factors, and perioperative management strategies. This respiratory complication not only

increases the risk of postoperative morbidity but also impacts hospital costs and the emotional well-being of patients and families.[5,6]

In pediatric anesthesia, the decision between IV and inhalation induction is influenced by a variety of factors, including patient anatomy, vascular access, and airway reactivity.[1] IV induction, primarily using propofol, provides rapid sedation by modulating gamma-aminobutyric acid (GABA-A) receptors in the central nervous system, which is considered the primary target of propofol. However, propofol also interacts with other molecular targets, including glycine receptors, NMDA receptors, and voltage-gated ion channels, contributing to its clinical effects and providing quick sedation with minimal respiratory irritation.[7] While propofol's favorable recovery profile and rapid onset make it a preferred choice for many pediatric procedures, its use requires careful monitoring for potential side effects, such as hypotension or allergic reactions.[8,9]

On the other hand, sevoflurane is the agent of choice for inhalation induction in pediatric anesthesia, acting primarily on GABA-A receptors and NMDA receptors to suppress central nervous system activity. Sevoflurane also targets other channels, such as voltage-gated ion channels, which contribute to its overall anesthetic effect, though the full molecular mechanism is still not entirely understood.[7] Its advantages include ease of administration, a pleasant odor, and a generally favorable safety profile for pediatric use. While sevoflurane has a relatively fast onset among inhaled anesthetics, it is slower than intravenous agents such as propofol. This difference may be clinically significant in situations requiring rapid induction, such as emergencies, where propofol is typically preferred. Although sevoflurane remains widely used in pediatric anesthesia due to its ease of administration, pleasant odor, and favorable safety profile, it carries rare but serious risks, including malignant hyperthermia and heightened airway reactivity.[10]

This review synthesizes existing literature comparing the incidence of laryngospasm between IV and inhalation induction techniques in pediatric patients. By critically examining the safety profiles, complication rates, and the risk of laryngospasm, this review aims to provide a foundation for selecting the most appropriate induction method, balancing efficacy with safety to optimize outcomes for pediatric patients.

Methods

This narrative review was conducted to compare the incidence of laryngospasm in a pediatric patient population undergoing anesthesia with either IV induction using propofol or inhalation induction with sevoflurane. A structured literature search was performed to identify relevant studies from multiple electronic databases, ensuring a comprehensive evaluation of the topic. Propofol and sevoflurane were chosen for comparison as they are two of the most used agents for pediatric anesthesia induction, each with distinct pharmacologic profiles and airway reactivity implications. Understanding their association with laryngospasm risk is clinically significant for optimizing patient safety and selecting the most appropriate induction strategy in children.

Literature Search Strategy

A structured search was performed in January 2024 across PubMed, MEDLINE, PsycINFO, and CINAHL to identify studies published from 2005 to 2023 that explored pediatric anesthesia induction methods and associated respiratory complications. The search included the following terms in all databases: *anesthetic induction; intravenous anesthesia OR IV propofol; inhalation anesthesia OR sevoflurane; child OR pediatric; and respiratory complications OR laryngospasm OR airway events.* Both MeSH terms and free-text keywords were used where applicable, and Boolean operators (AND/OR) refined the search strategy across databases to ensure comprehensive coverage.

Eligibility Criteria

Studies were eligible for inclusion if they: (1) were published in peer-reviewed journals between 2005 and 2023; (2) focused on pediatric populations aged 0–18 years undergoing anesthesia; (3) directly compared IV propofol induction with sevoflurane inhalation induction; and (4) reported outcomes related to laryngospasm or other respiratory complications. The 2005 cutoff was selected to capture studies relevant to current anesthesia practices and advancements in airway management, pharmacology, and clinical guidelines. Studies were excluded if they: (1) were not in English; (2) focused exclusively on adult populations; (3) or did not distinguish between induction and maintenance anesthesia.

Study Selection Process

After duplicates were removed, the abstracts of all retrieved records were screened for relevance. Full-text articles were then reviewed according to the eligibility criteria, with any disagreements resolved by consensus among all authors. The primary review was conducted by LA, JL, AS, and MD, while secondary review and validation were carried out by NL, NR, and RA. A total of 14 studies were included in the final review.

Rationale for Narrative Review Approach

A narrative review approach was selected to provide a comprehensive synthesis of the existing literature, offering broader insights into the topic. While a systematic review or meta-analysis could have been considered, the included studies varied in methodology, patient populations, and outcome measures, which would have made direct comparisons challenging. Therefore, this review sought to critically evaluate and contextualize the findings, identifying patterns and gaps in the literature that may guide future research.

Study Selection and Characteristics

An initial search across PubMed, MEDLINE, PsycINFO, and CINAHL retrieved 6,867 records. After applying the inclusion and exclusion criteria, 6,845 records were excluded, leaving 24 full-text articles for review. Ten articles were excluded due to factors such as settings unrelated to the operative or perioperative period (e.g., studies outside the context of anesthesia delivery), findings unrelated to patient outcomes or medical management, or a focus on adult populations.

Additionally, two sources were identified through reference list reviews, including a core anesthesia textbook used to support mechanistic and pharmacologic context. This brought the total number of studies included in the final analysis to 14. The study selection process is depicted in Figure 1, and Table 1 provides a detailed overview of these studies, including their methodology and key findings related to perioperative respiratory events and anesthesia induction techniques in pediatric patients.

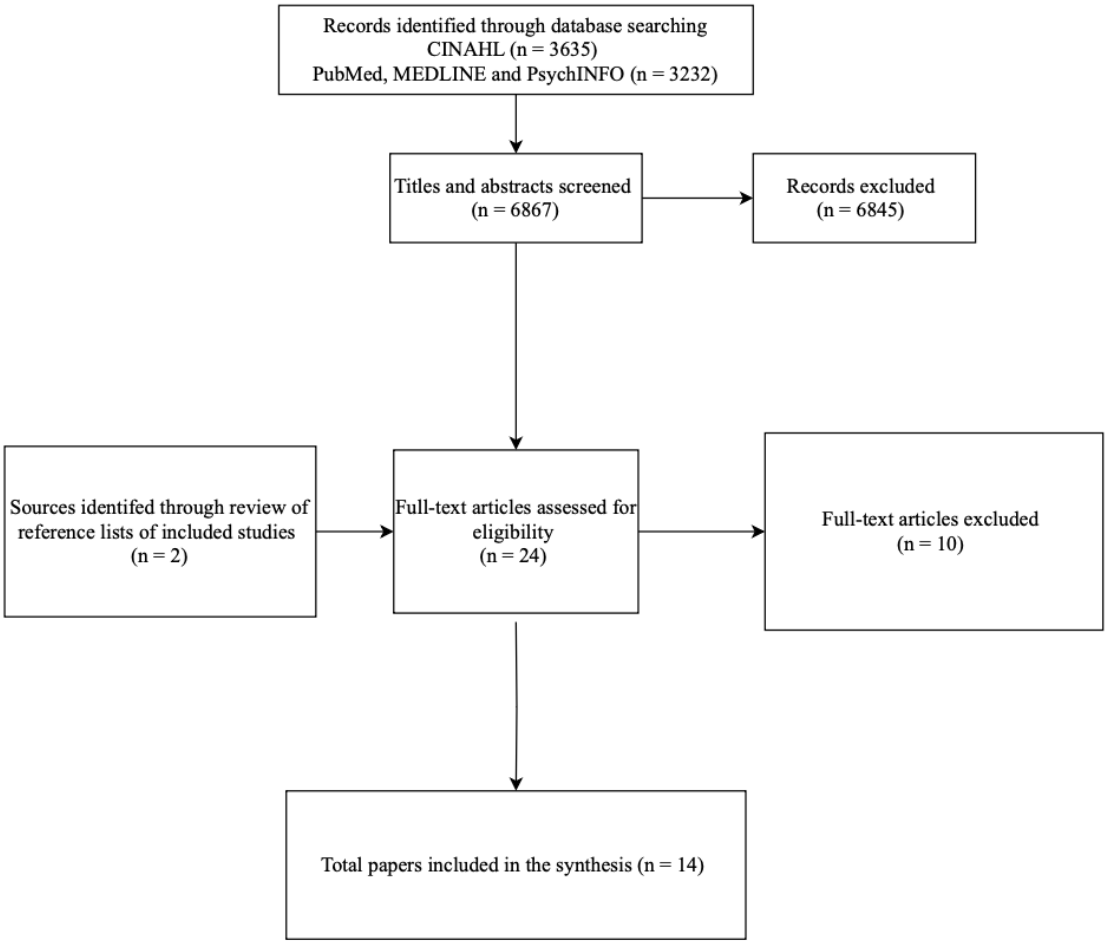

Figure 1*: Literature Review Methodology*

This figure illustrates the study selection process from the initial retrieval of 6,867 records through screening, full-text review, and final inclusion of 14 studies for synthesis.

Table 1: *Literature Review Summary.* This table provides an overview of studies included in the literature review, detailing their methodology and key findings regarding perioperative respiratory events and anesthesia induction techniques in pediatric patients.

Author(s)	Year	Title	Demographics	Study Design	Key Findings
Roodneshin F, Fakhar B, Poor Zamany Nejat Kermany M[1]	2023	Comparing the effects of TIVA vs Sevoflurane in children	Pediatric < 7 n = 60 All participants had upper respiratory tract infections and undergoing emergent surgery	Prospective randomized study	TIVA with propofol reduced respiratory events (e.g., stridor, laryngospasm, bronchospasm). Differences were noted during LMA implantation, removal, and PACU recovery.
Davidson AJ[2]	2018	Induction of Anesthesia for Children: Should We Recommend the Needle or the Mask?	Pediatric	Editorial	IV induction offers airway stability; inhalation may be preferable in patients with needle phobia.
Al-alami AA, Zestos MM, Baraka AS[3]	2009	Pediatric laryngospasm: prevention and treatment	Pediatric	Literature review	IV anesthesia lowers laryngospasm risk vs. inhalation. Incidence of laryngospasm ranges from 0.04 to 14%. Muscle relaxants reduce risk during tracheal intubation; deep LMA removal reduces risk with sevoflurane or isoflurane.
Oberer C, von Ungern-Sternberg BS, Frei FJ, Erb TO[4]	2005	Respiratory Reflex Responses of the Larynx Differ between Sevoflurane and Propofol in Pediatric Patients	Pediatric 2-6 years n = 60	Randomized Controlled Trial	Sevoflurane caused more apnea with laryngospasm and coughing than propofol. Propofol had fewer reflex responses.

Flick RP, Wilder RT, Pieper SF, Koeverden KV, Ellison KM, Marienau MES, Hanson AC, Schroeder DR, Sprung J[5]	2008	Risk factors for laryngospasm in children during general anesthesia	Pediatric n = 130	Case-Control Study	Laryngeal mask airway use, recent upper respiratory infection, and airway anomalies increased laryngospasm risk.
Oofuvong M, Geater AF, Chongsuvivatwong V, Chanchayanon T, Sriyanaluk B, Saefung B, Nuanujn K[6]	2015	Excess Costs and Length of Hospital Stay Attributable to Perioperative Respiratory Events in Children	Pediatric < 15 years n = 430 (215 matched pairs)	Prospective matched cohort study	PREs led to longer hospital stays, 30% higher hospital costs, and 58% higher indirect costs.
Pardo M, Soni N, eds. Miller's Basics of Anesthesia. 8th ed. Elsevier; 2023:chapters 7, 8[7]	2023	Miller's Basics of Anesthesia, 8th ed.: Chapter 7 – Inhaled Anesthetics; Chapter 8 – Intravenous Anesthetics	NA	Textbook chapters synthesizing pharmacologic and mechanisms clinical application	Sevoflurane: Inhaled agent preferred in pediatrics for smooth induction; acts on GABA-A, NMDA, and potassium channels. Rare risk of malignant hyperthermia. Propofol: Rapid IV induction via GABA-A modulation; also affects glycine and NMDA receptors. Quick onset, antiemetic, but may cause hypotension.
Porter LL, Blaauwendraad SM, Pieters BM[8]	2020	Respiratory and hemodynamic perioperative adverse events in pediatric anesthesia	Pediatric 4 studies	Systematic review/meta-analysis	IV and inhalation had similar overall adverse event rates, but inhalation caused more events in high-risk children.

Lauder GR[9]	2015	Total intravenous anesthesia will supersede inhalational anesthesia in pediatric anesthetic practice	Pediatric	Prospective study	TIVA expected to surpass inhalation due to more advantages with newer agents.
Lerman J, Jöhr M[10]	2009	Inhalational anesthesia vs total intravenous anesthesia (TIVA) for pediatric anesthesia	Pediatric	Debate	Advocates for inhalation due to ease of use, reliability, and faster induction without IV access.
Karam C, Zeeni C, Yazbeck-Karam V, Shebbo FM, Khalili A, Abi Raad SG, Beresian J, Aouad MT, Kaddoum R[11]	2023	Respiratory Adverse Events After LMA® Mask Removal in Children: A Randomized Trial Comparing Propofol to Sevoflurane	Pediatric 6 months to 7 years n = 134	Prospective, randomized, double-blind clinical trial	Children receiving TIVA with propofol had significantly lower respiratory adverse events (10.8%) compared to sevoflurane (36.2%). Propofol reduced the severity of respiratory complications. Emergence agitation was more common in sevoflurane-treated patients.
Trachsel D, Svendsen J, Erb TO, von Ungern-Sternberg BS[12]	2016	Effects of anaesthesia on paediatric lung function	Pediatric	Review	Anesthesia negatively impacts respiratory drive, ventilation-perfusion matching, and tidal breathing, increasing hypoxemia risk. Highlights the importance of understanding pediatric respiratory physiology to prevent complications.

Ramgolam A, Hall GL, Zhang G, Hegarty M, von Ungern-Sternberg BS[13]	2018	Inhalational versus Intravenous Induction of Anesthesia in Children with a High Risk of Perioperative Respiratory Adverse Events	Pediatric (0-8 years) n = 300 Children with at least two risk factors (anatomical abnormalities, infections, etc.) for PREs	Randomized Controlled Trial	IV propofol significantly reduced perioperative respiratory events (10.7%) compared to inhalational sevoflurane (26%), particularly in high-risk children.
Birlie Chekol W, Yaregal Melesse D[14]	2020	Incidence and Associated Factors of Laryngospasm among Pediatric Patients Undergoing Surgery	Pediatric birth - 12 years n = 310	Cross-sectional study	Laryngospasm occurred in 18.4% of cases, linked to URTI, airway anomalies, and LMA use.

Legend

TIVA = Total Intravenous Anesthesia **PACU** = Post Anesthesia Care Unit

PRE = Perioperative Respiratory Events **URTI** = Upper Respiratory Tract Infection

LMA = Laryngeal Mask Airway **IV** = Intravenous

BP = Blood Pressure **Pediatric =** Ages 0 – 18 years old

Results

Analysis revealed that IV induction with propofol consistently reduced respiratory complications compared to inhalation induction with sevoflurane. Roodneshin et al. (2023) found that, in children under seven years old with upper respiratory tract infections, IV induction with propofol significantly decreased adverse respiratory events, including stridor, laryngospasm, and bronchospasm.[1] In a randomized controlled trial, Karam et al. (2023) demonstrated that total intravenous anesthesia (TIVA) with propofol resulted in significantly fewer respiratory complications (10.8%) compared to sevoflurane (36.2%) during laryngeal mask airway (LMA) insertion and post-anesthesia recovery.[11] These findings align with the physiological analysis presented by Trachsel et al. (2016), who emphasized that volatile anesthetics like sevoflurane are associated with decreased functional residual capacity (FRC) and frequent atelectasis formation,

both of which can impair airway clearance and increase the risk of perioperative respiratory complications. Sevoflurane may also exaggerate airway reflexes in some pediatric patients, contributing to events such as laryngospasm and bronchospasm. In contrast, propofol provides smoother airway conditions due to its bronchodilatory properties and reduced tendency to trigger airway irritation.[12] Collectively, these findings emphasize the potential of mitigating respiratory complications with IV induction, particularly in pediatric patients with risk factors for airway reactivity.

In contrast, inhalation induction with sevoflurane was linked to a higher incidence of bronchospasm, laryngospasm, and minor adverse drug reactions, particularly in patients with complex vascular conditions. Despite these complications, inhalation induction remained the preferred technique when IV access was difficult to obtain or when patients experienced significant needle phobia. Risk factors for perioperative respiratory complications identified in the studies included recent upper respiratory infections, frequent wheezing, nocturnal cough, a history of atopic dermatitis, exposure to passive smoke, and a family history of atopic conditions. These risk factors significantly increased the likelihood of respiratory complications during anethesia.[13,14] Al-alami et al. (2009) further demonstrated that intravenous anesthesia was associated with lower rates of respiratory complications, such as laryngospasm, compared to inhalational anesthesia.[3]

The findings suggest an opportunity to implement these results into standard anesthesia management practices to optimize patient outcomes and resource utilization. Properly managed anesthesia reduces the incidence of complications, leading to shorter hospital stays and a reduced need for resources, such as supplies, medications, and personnel. Patients who experience perioperative respiratory events are at a higher risk for longer hospitalizations (up to twice as long) as well as increased excess hospital costs (30% higher) and indirect costs among outpatient procedures (58% higher), underscoring the importance of minimizing these complications for both clinical and economic reasons.[6]

Discussion

This review highlights the advantages of IV induction with propofol over inhalation induction with sevoflurane, particularly in pediatric populations at risk for respiratory complications. Propofol has consistently been associated with a lower incidence of laryngospasm, bronchospasm, and stridor, which are common concerns during anesthesia induction, especially in children with upper respiratory infections or atopic conditions.[1,7] Moreover, TIVA using propofol has demonstrated superior outcomes during laryngeal mask airway insertion, reducing perioperative respiratory complications and improving postoperative recovery.[11,12] These findings underscore that intravenous induction with propofol should be strongly considered in pediatric patients with airway reactivity, as it consistently demonstrates a lower incidence of adverse respiratory events compared to sevoflurane. Oberer et al. (2005) found that laryngospasm occurred significantly more frequently with sevoflurane anesthesia, even at deeper levels of hypnosis, reinforcing concerns about its airway irritability.[4] This supports the general preference for IV induction in children with respiratory risk factors, including those with upper respiratory infections or atopic conditions. IV induction has shown fewer instances of laryngospasm, bronchospasm, and abnormal cardiac rhythms, making it a safer option for many.

Nonetheless, inhalation induction remains a valid technique when IV access is difficult or when patients have significant needle phobia, where mask induction may be the preferred alternative.

While IV induction offers well-documented safety advantages, inhalation with sevoflurane remains a practical option in specific clinical contexts—especially when IV access is difficult or needle phobia is significant. In these cases, the benefits of avoiding needle-related discomfort may outweigh the risks associated with inhalation induction, which is linked to a higher incidence of bronchospasm, laryngospasm, and other adverse reactions. These considerations contribute to need for individualized anesthesia planning based on patient-specific factors, such as medical history, psychological profile, and procedural context. However, in children with known airway reactivity or recent respiratory illness—where safety is paramount—IV induction with propofol should be strongly favored when clinically feasible. Consistent evidence supports propofol's superior safety in these populations, reinforcing its role as the preferred agent when clinically appropriate.

A key aspect of optimizing anesthesia management lies in identifying risk factors for perioperative respiratory complications and understanding how these may influence the choice among available agents. Children with recent upper respiratory infections, asthma, frequent wheezing, or exposure to passive smoke are particularly susceptible to respiratory complications due to heightened airway sensitivity or inflammation during anesthesia induction.[12-14] Anatomical factors, such as craniofacial anomalies or smaller airway calibers, and conditions like allergic rhinitis or atopic dermatitis, further contribute to airway reactivity.[1] These findings emphasize the importance of a personalized, multifactorial approach that incorporates anatomical, clinical, and environmental considerations.

Emerging evidence suggests that IV induction with propofol may be particularly beneficial for children with these respiratory risk factors. However, other agents, such as isoflurane and ketamine, may also have roles in managing pediatric patients with respiratory vulnerabilities. Isoflurane is recognized for its hemodynamic stability and its ability to maintain respiratory function in patients with airway sensitivity or reactivity.[15] Whereas, ketamine's ability to preserve respiratory drive and provide a protective effect against laryngospasm makes it a useful option, especially in children prone to airway complications.[16] Despite the advantages of these agents, further studies are needed to explore their comparative efficacy, particularly in relation to IV induction and inhalation agents like propofol and sevoflurane.

Laryngospasm remains a particularly persistent and serious complication in pediatric anesthesia, often affecting children with recent infections, atopy, or chronic respiratory conditions.[3] Prevention depends heavily on strategic anesthetic planning—including early consideration of IV access—and individualized risk assessment. Thorough evaluation of a child's medical history, airway anatomy, and environmental exposures is vital in minimizing the risk of laryngospasm and ensuring safe induction and emergence from anesthesia.

Limitations

Despite strong support for IV induction with propofol, the interpretation of these findings must be balanced against several important limitations. Variability in study design, patient

populations, and outcome measures hinder generalizability and complicates comparisons across settings. Additionally, the narrow focus on propofol and sevoflurane limits the applicability of findings to other anesthetic agents commonly used in clinical practice. While evidence supports IV induction as a safer option in many cases, the most significant real-world limitation is often patient cooperation. In young children, anxiety, needle phobia, and difficulty establishing IV access may necessitate inhalation induction, even when IV induction would be clinically preferable. Expert commentary from Davidson (2018) further reinforces that anesthetic decisions should be individualized, considering not only safety data but also patient preferences, prior experiences, and institutional norms.[2]

In addition to these clinical limitations, such as needle phobia and difficulty obtaining IV access, social and institutional factors—such as parental anxiety, institutional protocols, and operating room efficiency—can significantly influence anesthesia decisions in pediatric care.[12] These non-clinical elements often drive induction strategies regardless of clinical evidence, limiting the translation of research findings into routine practice. While inhalation induction remains appropriate in select cases, IV induction is generally safer and more effective, particularly for patients with airway vulnerabilities or comorbidities.[1, 11]

Future Research

Advancements in airway management and IV access techniques—such as ultrasound guidance, topical anesthetics, and behavioral distraction strategies—remain critical to reducing complications like laryngospasm.[14] Future research should aim to address gaps in clinical diversity by evaluating a broader range of anesthetic agents, incorporating social and demographic variables, and accounting for regional differences in practice. In addition to technique, pharmacological adjuncts such as lidocaine, atropine, and magnesium also merit further investigation for their potential role in minimizing airway reactivity during both induction and emergence.[17]

Gavel et al. (2014) noted that, although both topical and intravenous lidocaine may help dampen laryngeal reflexes, study outcomes remain inconsistent. Comparatively, through their systematic review and meta-analysis, Mihara et al. (2014) concluded that both forms of lidocaine are effective in preventing laryngospasm in children, supporting its consideration as an adjunct in high risk cases.[18] Atropine, widely used for its antisialagogue, sedative, amnestic, and heart rate increasing properties, is often used before induction to reduce secretion and prevent bradycardia.[7,19] Yet, as Gavel et al. (2014) also highlighted, atropine's direct ability to prevent laryngospasm is unproven and requires further target evaluation.[17]

Magnesium is another agent of growing interest, with promising results from studies like that of Gulhas et al. (2003), in which intravenous administration significantly reduced laryngospasm during tonsillectomy and adenoidectomy.[20] These findings suggest a potential protective mechanism worth further study. Future investigations should clarify optimal dosing, identify pediatric populations most likely to benefit, and compare these adjuncts head-to-head. Additionally, agents like fentanyl or dexmedetomidine may warrant study for their possible benefit in smoothing emergence and reducing airway complications, particularly in vulnerable pediatric groups.

Conclusion

The selection of an appropriate anesthetic induction method is a critical component of pediatric anesthesia, particularly for minimizing respiratory complications like laryngospasm. This narrative review highlights the advantages of IV induction with propofol over inhalation induction with sevoflurane, particularly in patients with a history of respiratory sensitivity or airway reactivity. Across multiple studies, IV induction is consistently favored for its lower incidence of laryngospasm, making it the preferred method—particularly in children with a history of respiratory sensitivity or airway reactivity. While inhalation remains a useful technique in needle-averse or IV-inaccessible cases, our findings support a preference toward IV induction as the first-line approach in high-risk pediatric populations. However, further research is needed to better define patient subgroups that would most benefit from either IV or inhalation induction. Exploring multimodal approaches could also help reduce airway complications. A personalized, evidence-based approach to anesthesia induction, considering individual patient risk factors and procedural contexts, will be essential in ensuring safe anesthetic induction and optimizing outcomes in pediatric surgical care.

Acknowledgments

The authors sincerely thank Dr. Nicole Michels, PhD for her insightful feedback and editorial suggestions, which greatly contributed to this manuscript.

Conflict of Interest

All authors declare they have no conflicts of interest.

References

1. Roodneshin F, Fakhar B, Poor Zamany Nejat kermany M. Comparing the effects of Total intravenous anesthesia and sevoflurane on respiratory adverse events in under-7 children with upper respiratory tract infection. *Int J Pediatr*. 2023;11(8). doi:10.22038/ijp.2023.73291.5308
2. Davidson AJ. Induction of anesthesia for children: should we recommend the needle or the mask? *Anesthesiology*. 2018;128(6):1051-1052. doi:10.1097/ALN.0000000000002207
3. Al-alami AA, Zestos MM, Baraka AS. Pediatric laryngospasm: prevention and treatment. *Curr Opin Anaesthesiol*. 2009;22(3):388-395. doi:10.1097/ACO.0b013e32832972f3
4. Oberer C, Von Ungern-Sternberg BS, Frei FJ, Erb TO. Respiratory reflex responses of the larynx differ between sevoflurane and propofol in pediatric patients. *Anesthesiology*. 2005;103(6):1142-1148. doi:10.1097/00000542-200512000-00007
5. Flick RP, Wilder RT, Pieper SF, et al. Risk factors for laryngospasm in children during general anesthesia. *Pediatr Anesth*. 2008;18(4):289-296. doi:10.1111/j.1460-9592.2008.02447.x
6. Oofuvong M, Geater AF, Chongsuvivatwong V, et al. Excess costs and length of hospital stay attributable to perioperative respiratory events in children. *Anesth Analg*. 2015;120(2):411-419. doi:10.1213/ANE.0000000000000557
7. Pardo M, Soni N, eds. Miller's Basics of Anesthesia. 8th ed. Elsevier; 2023:chapters 7, 8.

8. Porter LL, Blaauwendraad SM, Pieters BM. Respiratory and hemodynamic perioperative adverse events in intravenous versus inhalational induction in pediatric anesthesia: A systematic review and meta-analysis. *Pediatr Anesth*. 2020;30(8):859-866. doi:10.1111/pan.13904
9. Lauder GR. Total intravenous anesthesia will supercede inhalational anesthesia in pediatric anesthetic practice. *Pediatr Anesth*. 2015;25(1):52-64. doi:10.1111/pan.12553
10. Lerman J, Jöhr M. Inhalational anesthesia vs total intravenous anesthesia (TIVA) for pediatric anesthesia. *Pediatr Anesth*. 2009;19(5):521-534. doi:10.1111/j.1460-9592.2009.02962.x
11. Karam C, Zeeni C, Yazbeck-Karam V, et al. Respiratory adverse events after LMA® mask removal in children: A randomized trial comparing propofol to sevoflurane. *Anesth Analg*. 2023;136(1):25-33. doi:10.1213/ANE.0000000000005945
12. Trachsel D, Svendsen J, Erb TO, Von Ungern-Sternberg BS. Effects of anaesthesia on paediatric lung function. *Br J Anaesth*. 2016;117(2):151-163. doi:10.1093/bja/aew173
13. Ramgolam A, Hall GL, Zhang G, Hegarty M, Von Ungern-Sternberg BS. Inhalational versus intravenous induction of anesthesia in children with a high risk of perioperative respiratory adverse events: A randomized controlled trial. *Anesthesiology*. 2018;128(6):1065-1074. doi:10.1097/ALN.0000000000002152
14. Birlie Chekol W, Yaregal Melesse D. Incidence and Associated Factors of Laryngospasm among pediatric patients who underwent surgery under general anesthesia, in University of Gondar Compressive Specialized Hospital, Northwest Ethiopia, 2019: A Cross-Sectional Study. *Anesthesiol Res Pract*. 2020;2020:1-6. doi:10.1155/2020/3706106
15. Sahu D, Kaul V, Parampill R. Comparison of isoflurane and sevoflurane in anaesthesia for day care surgeries using classical laryngeal mask airway. *Indian J Anaesth*. 2011;55(4):364. doi:10.4103/0019-5049.84857
16. Simonini A, Brogi E, Cascella M, Vittori A. Advantages of ketamine in pediatric anesthesia. *Open Med Wars Pol*. 2022;17(1):1134-1147. doi:10.1515/med-2022-0509
17. Gavel G, Walker RWM. Laryngospasm in anaesthesia. Contin Educ Anaesth Crit Care Pain. 2014;14(2):47-51. doi:10.1093/bjaceaccp/mkt031.
18. Mihara, T., Uchimoto, K., Morita, S. and Goto, T. (2014), The efficacy of lidocaine to prevent laryngospasm in children: a systematic review and meta-analysis†. *Anaesthesia*, 69: 1388-1396. https://doi.org/10.1111/anae.12788
19. Rajabi F, Shafa A, Shirani M. Effect of atropine administration before induction of anesthesia on the incidence of delirium and other complications in a post-anesthesia care unit (PACU) among children undergoing surgery: a randomized, placebo-controlled clinical trial. Iran J Pediatr. 2023;33(3):e126575. doi:10.5812/ijp-126575.
20. Gulhas N, Durmus M, Demirbilek S, Togal T, Ozturk E, Ersoy MO. The use of magnesium to prevent laryngospasm after tonsillectomy and adenoidectomy: a preliminary study. Pediatr Anesth. 2003;13(1):43-47. doi:10.1046/j.1460-9592.2003.00927.x.