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ACUTE RESPIRATORY COMPLICATIONS IN CHILDREN UNDERGOING EMERGENCY ORTHOPEDIC SURGERY: CLINICAL PREDICTORS AND ANESTHETIC STRATEGIES – A NARRATIVE REVIEW

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Abstract: Background: Acute respiratory complications are among the most frequent perioperative challenges in pediatric anesthesia, particularly during emergency orthopedic procedures where time constraints and clinical instability increase risk. **Objective:** To review the current literature regarding clinical predictors of perioperative respiratory complications in children undergoing emergency orthopedic surgery and to evaluate anesthetic strategies designed to prevent and manage these events. **Methods:** A narrative literature review was conducted using PubMed, Embase, Scopus, and Cochrane databases. Studies published in English up to 2025 were included if they addressed respiratory outcomes, risk factors, or anesthetic approaches in pediatric emergency orthopedic surgery. **Results:** Epidemiological evidence highlights age under one year, recent respiratory infection, obesity, obstructive sleep apnea, high ASA classification, and major trauma as significant predictors of complications. The most common events include laryngospasm, bronchospasm, desaturation, hypoxemia, and the need for reintubation. Preventive strategies rely on careful preoperative assessment, optimal timing of intubation, use of rapid-sequence induction when indicated, short-acting anesthetic agents, protective ventilation strategies, and early postoperative monitoring. Regional anesthesia, when feasible, reduces airway manipulation and may decrease respiratory risk. **Conclusion:** Acute respiratory complications in pediatric emergency orthopedic surgery are strongly associated with identifiable preoperative predictors. Early recognition of risk factors and tailored anesthetic strategies are critical to improving perioperative outcomes. Prospective multicenter studies are

needed to develop standardized protocols and evidence-based guidelines.

Keywords: Pediatric anesthesia; respiratory complications; orthopedic emergency; clinical predictors; anesthetic strategies.

Introduction

Acute respiratory complications remain a major concern in pediatric anesthesia and are a leading cause of perioperative morbidity in children. Their incidence is markedly higher in emergency settings compared with elective procedures, reflecting the interplay between limited preparation time, urgent surgical indications, and suboptimal physiological status at the time of surgery. Emergency orthopedic surgery, frequently performed for trauma or acute infections, poses unique challenges: these patients often present with pain, hypovolemia, or concomitant respiratory illness, all of which compound anesthetic risk.

Children are physiologically more vulnerable to respiratory complications due to smaller airway dimensions, higher oxygen consumption, and lower functional residual capacity compared with adults. These features predispose them to rapid desaturation during apnea or airway obstruction. Several studies have identified specific clinical predictors of increased respiratory risk, including young age (particularly infants), recent or ongoing upper respiratory tract infections, obesity, obstructive sleep apnea, and higher ASA physical status classification. In trauma-related orthopedic emergencies, the presence of polytrauma, reduced consciousness, or aspiration risk further elevates perioperative complexity.

Despite these challenges, advances in pediatric anesthesiology have expanded the arsenal of preventive and therapeutic strategies. Careful preoperative evaluation, selection of anesthetic agents with favorable respiratory profiles, optimization of airway management techniques, and application of protective ventilation strategies have all been proposed to reduce complications. Moreover, regional anesthesia, when applicable, offers the advantage of minimizing airway manipulation and systemic anesthetic exposure.

Given the potential severity of these events and the paucity of large prospective trials, a narrative review of the current evidence is warranted. This article aims to synthesize available data on the epidemiology, clinical predictors, and anesthetic strategies relevant to acute respiratory complications in children undergoing emergency orthopedic surgery, highlighting both established principles and areas requiring further research.

Objectives

The objective of this review is to provide a comprehensive synthesis of the current evidence regarding acute respiratory complications in children undergoing emergency orthopedic surgery. Specifically, this article seeks to describe the epidemiology of these events, to identify and analyze clinical predictors that increase the risk of perioperative respiratory compromise, and to evaluate anesthetic strategies aimed at prevention and management. By integrating data from clinical studies, systematic reviews, and expert recommendations, the review intends to highlight established practices, areas of controversy, and gaps in knowledge, ultimately

offering anesthesiologists and perioperative teams a structured overview to guide clinical decision-making and improve patient safety.

Methods

This study was designed as a narrative review of the literature. A comprehensive search was conducted using PubMed, Embase, Scopus, and the Cochrane Library to identify relevant studies published in English up to March 2025. The search strategy included combinations of keywords and MeSH terms such as *"pediatric anesthesia"*, *"respiratory complications"*, *"airway events"*, *"orthopedic emergency surgery"*, *"clinical predictors"*, and *"anesthetic strategies"*.

Studies were considered eligible if they reported on perioperative respiratory events, clinical risk factors, or anesthetic approaches in pediatric patients undergoing orthopedic procedures, with particular emphasis on emergency contexts. Both original research articles and systematic reviews were included. Exclusion criteria were case reports without broader applicability, studies focusing exclusively on elective surgery without reference to emergency settings, and articles not available in English.

Titles and abstracts were screened for relevance, and full texts were reviewed for inclusion. Data extraction was performed with attention to epidemiology, predictors of respiratory complications, anesthetic techniques, and reported outcomes. Given the heterogeneity of study designs and outcome measures, no formal meta-analysis was performed. Instead, findings were synthesized narratively, with emphasis on clinical applicability and gaps in current evidence.

Review

Respiratory Physiology in Children: Vulnerabilities

Children present unique anatomical and physiological characteristics that predispose them to acute respiratory complications during anesthesia. Compared with adults, they have smaller airways, higher airway resistance, and a proportionally larger tongue, all of which increase the risk of obstruction under anesthesia or sedation[1,3]. In addition, their functional residual capacity is relatively low, while metabolic oxygen consumption is high, leading to rapid desaturation during periods of apnea or hypoventilation[1,7]. The chest wall is also more compliant, and the diaphragmatic contribution to ventilation is greater, rendering young patients more vulnerable to atelectasis under mechanical ventilation[7,11].

These physiological traits are further exacerbated in the setting of emergency orthopedic surgery, where children often arrive with trauma, pain, or hemodynamic instability. The presence of acute stress, hypovolemia, or blood loss can worsen oxygen delivery and reduce the margin of safety against hypoxemia[2,3]. Age is a particularly strong predictor: infants younger than one year are consistently reported to have higher rates of perioperative respiratory adverse events (PRAEs), reflecting both airway anatomy and immature ventilatory control[2,3,4].

Comorbidities also interact with baseline physiology. A history of upper respiratory tract infection (URTI) increases airway reactivity, leading to laryngospasm, bronchospasm, and desaturation[3,4,5]. The COLDS score, validated as a risk assessment tool, incorporates clinical variables such as

recent URTI, onset of symptoms, airway device, age, and anesthetic technique, demonstrating predictive value for PRAEs[4,5]. Similarly, exposure to passive smoking and pre-existing respiratory disease amplify baseline airway vulnerability, highlighting the importance of careful preoperative screening[5,9].

Another crucial aspect is the influence of anesthetic agents on pediatric physiology. Volatile anesthetics such as sevoflurane can exacerbate airway reactivity in susceptible children, whereas intravenous induction with propofol has been associated with reduced PRAEs in those with URTIs[9,11]. Dexmedetomidine has recently emerged as a promising adjunct, demonstrating protective effects against airway events, cough, and breath-holding in meta-analyses of pediatric patients[6,12]. Such pharmacologic strategies directly address the physiological vulnerabilities of the pediatric airway and may mitigate risk during high-stakes emergency procedures.

Taken together, these developmental features—small airway caliber, low functional residual capacity, high oxygen consumption, and increased airway reactivity—create a fragile balance that is easily disrupted during anesthesia. Recognizing these vulnerabilities and integrating risk prediction tools such as the COLDS score[4,5], along with evidence-based anesthetic strategies[6,7,9,12], is essential to reduce the incidence and severity of acute respiratory complications in children undergoing emergency orthopedic surgery.

Epidemiology of Respiratory Complications in Pediatric Surgery

Perioperative respiratory adverse events (PRAEs) represent the most common group of complications in pediatric anesthesia and are a leading cause of perioperative morbidity in children[2,3]. Their reported incidence varies widely, ranging from 15% to more than 30% depending on population characteristics, case urgency, and study methodology[2,3,5]. In a prospective observational study from Ethiopia, the overall incidence of PRAEs among pediatric surgical patients was 26.2%, with desaturation, laryngospasm, and bronchospasm being the most frequently observed events[2]. Similarly, a Korean study of children undergoing general anesthesia with an active upper respiratory tract infection reported PRAE rates of nearly 30%, underscoring the heightened risk associated with concurrent airway inflammation[9].

Age is consistently identified as a key determinant of PRAE incidence. Infants younger than one year, and especially those under six months, experience higher complication rates than older children, reflecting developmental differences in airway anatomy and ventilatory physiology[3,4]. A multicenter analysis validating the COLDS score found that younger age and active respiratory infection were among the most predictive factors for PRAEs, reinforcing the need for structured preoperative risk assessment[4,5].

Type of surgery also influences epidemiology. Orthopedic procedures, particularly emergency interventions following trauma, often involve children in suboptimal physiological states, sometimes with limited fasting or concurrent injuries, thereby compounding respiratory risk[1,2]. While

large-scale datasets rarely isolate orthopedic emergencies as a separate category, available data indicate that urgency itself is an independent predictor of adverse events, largely due to the inability to optimize preoperative status[1,2,3].

Environmental and comorbidity factors further contribute to variability. Exposure to passive smoking, a well-established predictor, has been linked to nearly double the risk of PRAEs in children presenting for elective or emergency procedures[5,9]. Pre-existing asthma, obstructive sleep apnea, and recent URTI substantially elevate the likelihood of laryngospasm and bronchospasm[3,4,11]. Seasonal peaks, coinciding with viral epidemics, have also been associated with increased incidence of perioperative airway events[3].

Recent evidence suggests that COVID-19 may have temporarily altered the epidemiological landscape. A Korean study noted that children recovering from recent SARS-CoV-2 infection were at elevated risk of PRAEs, particularly when undergoing general anesthesia for urgent procedures[8]. This finding underscores the dynamic nature of epidemiology and the importance of integrating contemporary public health factors into perioperative planning.

Overall, epidemiological data confirm that PRAEs are both common and clinically significant in pediatric surgery, with higher incidence in younger children, those with comorbidities or airway infections, and in the context of emergency procedures[2,8,9]. This consistent pattern highlights the need for vigilant preoperative screening, individualized anesthetic planning, and heightened intraoperative monitoring in emergency orthopedic surgery where baseline risk is already elevated.

Clinical Predictors / Risk Factors

Identifying children at higher risk for perioperative respiratory adverse events (PRAEs) is essential for guiding anesthetic planning, particularly in the emergency orthopedic setting where optimization time is limited. The literature consistently highlights a cluster of clinical predictors that significantly increase the likelihood of laryngospasm, bronchospasm, desaturation, and other acute respiratory complications.

Age and developmental physiology are among the most robust predictors. Infants, especially those under one year, are significantly more vulnerable due to immature respiratory control, narrow airways, and higher oxygen consumption[2,3,4]. Large prospective and multicenter studies confirm that younger children experience PRAEs more frequently than older counterparts, independent of other comorbidities[2,3]. This age effect persists across surgical specialties and is particularly relevant in emergency cases where airway manipulation is often unavoidable.

Recent or active upper respiratory tract infection (URTI) is another critical factor. Viral infections increase airway hyperreactivity and mucosal edema, predisposing to laryngospasm, bronchospasm, and hypoxemia[3,4,5]. The COLDS score, specifically designed to predict PRAEs, incorporates the presence and timing of URTI symptoms, showing strong predictive validity in multiple cohorts[4,5]. Children with symptoms such as rhinorrhea, cough, or fever within two weeks of surgery are at substantially higher risk, and while elective surgeries can often be delayed, emergency orthopedic procedures rarely allow postponement. In these cases, anesthesiologists must adopt

heightened vigilance and tailored strategies to mitigate risk.

Comorbid respiratory and systemic conditions further amplify risk. Asthma, bronchopulmonary dysplasia, and obstructive sleep apnea are repeatedly associated with increased PRAEs, largely due to heightened airway reactivity and impaired ventilatory reserve[1,3,11]. Obesity, which is increasingly prevalent in pediatric populations, contributes additional challenges by reducing lung compliance and predisposing to airway collapse[1,3]. Children with high ASA physical status (≥3) have significantly higher rates of adverse events, reflecting the interaction between systemic illness and airway vulnerability[2,3].

Environmental factors, particularly passive smoking, have been identified as independent predictors of PRAEs. Studies demonstrate that children exposed to household tobacco smoke experience nearly double the risk of perioperative airway events, even after adjusting for age and URTI status[5,9]. This emphasizes the importance of thorough preoperative history-taking in both elective and emergency contexts.

Surgical urgency and trauma-related factors also play pivotal roles. Emergency procedures inherently increase risk due to limited preoperative evaluation, inadequate fasting, and hemodynamic instability[2,3]. Orthopedic trauma in particular may be associated with airway contamination (e.g., aspiration of blood or gastric contents), pain-related respiratory compromise, or concurrent thoracic injuries, all of which exacerbate anesthetic vulnerability.

Finally, anesthetic management choices intersect with patient-level predictors to shape outcomes. Airway device selection is a key variable: the use of tracheal tubes is associated with higher rates of PRAEs compared to supraglottic airway devices, particularly in the presence of URTI[9,11]. Inhalational induction with sevoflurane increases airway reactivity in susceptible patients, whereas intravenous induction with propofol is consistently associated with fewer PRAEs[9,11]. Adjunctive pharmacologic agents such as dexmedetomidine have been shown in meta-analyses to reduce the risk of laryngospasm and breath-holding, suggesting an important preventive role in high-risk populations[6,12].

In summary, the main predictors of perioperative respiratory complications in pediatric patients are younger age, recent URTI, comorbid respiratory disease, high ASA status, obesity, passive smoking exposure, and the urgent nature of surgery[2–5,9,11]. The interaction between these factors underscores the multifactorial nature of PRAEs, reinforcing the need for structured preoperative assessment tools such as the COLDS score[4,5] and careful anesthetic planning tailored to each child's risk profile.

Types of Respiratory Complications Observed

Perioperative respiratory adverse events (PRAEs) in children encompass a spectrum of acute complications, many of which can escalate rapidly if not recognized and managed promptly. The most frequently reported events include laryngospasm, bronchospasm, oxygen desaturation, hypoxemia, breath-holding, and the need for unplanned airway interventions such as reintubation or prolonged ventilation[2,5]. Although the absolute incidence varies by population and study design, these compli-

cations consistently rank as the most common causes of perioperative morbidity in pediatric anesthesia[2,3].

Laryngospasm is one of the hallmark airway emergencies in children. It arises from reflex glottic closure triggered by airway irritation, often in the context of URTI, airway secretions, or manipulation during intubation or extubation[3,5,9]. Infants and toddlers are at particularly high risk due to increased airway reactivity and narrow subglottic anatomy[3]. Reported incidence ranges from 1% to 4% in general pediatric anesthesia, but can rise to 10% or more in children with recent URTI[3,4]. Failure to break laryngospasm promptly can result in severe hypoxemia, bradycardia, and even cardiac arrest[1,3].

Bronchospasm, defined by expiratory wheezing, increased airway resistance, and reduced tidal volumes, is another major event. It is more likely in children with asthma, URTI, or exposure to passive smoking[1,3,5]. Inhalational induction with sevoflurane is associated with increased bronchospasm risk, whereas propofol induction reduces its incidence[9,11]. The presence of pre-existing airway disease, such as asthma or bronchopulmonary dysplasia, further heightens vulnerability[1,3].

Oxygen desaturation and hypoxemia represent common downstream manifestations of airway obstruction or hypoventilation. Due to their limited functional residual capacity and high oxygen consumption, children desaturate rapidly compared with adults[1,7]. Large cohort studies report desaturation in up to 20–25% of children undergoing anesthesia, particularly in infants and those with comorbid respiratory disease[5]. These episodes may occur during induction, maintenance, or emergence, especially if airway devices are malpositioned or secretions are present[3,5].

Breath-holding and apnea are also common events, often precipitated by inhalational induction or stimulation during emergence. While typically self-limiting, these episodes can exacerbate hypoxemia in children with low pulmonary reserve[3,9].

Airway obstruction due to soft tissue collapse, enlarged tonsils/adenoids, or malposition of airway devices is another significant contributor. Children with obstructive sleep apnea or obesity are disproportionately affected, reflecting both anatomical and physiological predispositions[11].

Severe complications, although less frequent, include aspiration, pulmonary edema, and the need for unplanned postoperative ventilation[3]. Emergency orthopedic surgery carries a unique risk of aspiration, particularly in trauma patients with inadequate fasting or gastric content regurgitation. In rare cases, PRAEs culminate in cardiac arrest or require intensive care admission, highlighting their potential severity[1,3].

Emerging evidence also points to post-COVID-19 vulnerability: children with recent SARS-CoV-2 infection undergoing anesthesia demonstrated higher rates of PRAEs, including desaturation and bronchospasm[8]. This underscores the importance of continuously reassessing epidemiological factors in light of new pathogens or public health changes.

In summary, the most relevant respiratory complications in pediatric anesthesia are laryngospasm, bronchospasm, desaturation, hypoxemia, and airway obstruction[3,9]. Each carries the potential for rapid deterioration in oxygenation and hemodynamics

due to pediatric physiological vulnerabilities[1,7]. Awareness of these events, coupled with early recognition and rapid intervention, is central to improving outcomes in children undergoing emergency orthopedic surgery.

Anesthetic Strategies for Prevention and Management

The prevention and management of perioperative respiratory adverse events (PRAEs) in children rely on a combination of structured preoperative assessment, careful anesthetic technique, pharmacologic adjuncts, lung-protective ventilation, and vigilant emergence and recovery care. These strategies are particularly relevant in the emergency orthopedic context, where baseline risks are magnified by urgency and limited preparation time.

Preoperative evaluation: Risk stratification is fundamental. Tools such as the COLDS score incorporate clinical variables including symptoms of upper respiratory tract infection (URTI), comorbidities, airway device choice, age, and surgical urgency, and have been validated as predictors of PRAEs[4,5]. Even in emergencies, obtaining information about passive smoking exposure, asthma, or recent URTI helps anticipate complications[5,9]. In elective surgery, deferring procedures in children with active URTI is standard practice[3,4], but in urgent orthopedic trauma cases, emphasis must be placed on preparation, suction readiness, and bronchodilator optimization in vulnerable children[1,3,11].

Airway management and induction technique: The choice of airway device significantly influences respiratory outcomes. Tracheal intubation, although often required in trauma cases, carries higher risk of PRAEs than supraglottic airway devices[9,11]. Where feasible, supraglottic devices or regional anesthesia reduce airway stimulation and event rates[3,11]. For induction, propofol is preferred in high-risk children due to its bronchodilatory profile and lower association with airway events compared to sevoflurane[9,11]. Inhalational induction remains common in infants where IV access is difficult but is associated with increased laryngospasm and breath-holding[3,9]. Ketamine is advantageous in unstable trauma patients, as it preserves airway reflexes and provides bronchodilation[1,3].

Pharmacologic adjuncts: Adjunctive medications can further mitigate risk. Dexmedetomidine has demonstrated protective effects in meta-analyses, lowering the incidence of laryngospasm, cough, and breath-holding[6,12]. In asthmatic children, preoperative β_2-agonists reduce the likelihood of intraoperative bronchospasm[1,3,11]. Anticholinergic agents such as atropine or glycopyrrolate may also be beneficial in younger children to reduce secretions and vagal reflexes[3].

Ventilation strategies: Protective lung ventilation is recommended across pediatric populations. Low tidal volumes, moderate PEEP, and recruitment maneuvers decrease atelectasis and improve oxygenation[7]. Avoidance of unnecessarily high FiO_2 prevents absorption atelectasis. These strategies are critical in long orthopedic procedures, where immobilization and surgical positioning may compromise pulmonary mechanics[2,7].

Emergence and extubation: The period of emergence is a recognized high-risk window. Smooth extubation at an adequate depth of anesthesia can reduce laryngospasm, while awake extubation may be prefe-

rable in trauma patients with high aspiration risk[3,9]. Airway suctioning and the use of lidocaine—either IV or topical—have been reported to blunt airway reflexes and reduce PRAEs[9,11]. Extubation strategy should therefore be individualized according to risk profile and surgical context.

Postoperative monitoring: Close observation in the post-anesthesia care unit (PACU) is critical. Most PRAEs occur immediately after extubation, underscoring the need for continuous monitoring of oxygen saturation and readiness for airway interventions[2,3]. Children with comorbidities, severe URTI, or intraoperative PRAEs may require extended monitoring or higher-level care[8]. Recent evidence further suggests that children recovering from COVID-19 infection may be particularly vulnerable to PRAEs, emphasizing the importance of incorporating contemporary epidemiologic factors into risk assessment[8].

Discussion

Acute respiratory complications remain the most frequent perioperative adverse events in pediatric anesthesia and are a major driver of morbidity. Their relevance is heightened in emergency orthopedic procedures, where urgency, trauma physiology, and limited optimization increase the risk of laryngospasm, bronchospasm, desaturation, and other airway events[2,3,5]. The consistency of predictors across different cohorts—age, recent upper respiratory tract infection (URTI), comorbid disease, and passive smoke exposure—suggests that most risks are identifiable in advance, even when surgery cannot be delayed[2,3,5]. The challenge lies not in recognizing vulnerability, but in adapting anesthetic strategies to mitigate it under emergency conditions.

Risk Stratification and Predictive Models

The COLDS score has emerged as a validated framework to quantify PRAE risk, integrating symptom severity, infection timing, comorbidities, device choice, and surgical urgency[4,5]. Its predictive accuracy has been confirmed across different populations, making it a useful guide even in urgent surgery. However, orthopedic trauma adds variables not captured by COLDS, such as aspiration risk, hypovolemia, and polytrauma, which may further compromise airway safety[2,3]. A potential future direction is the adaptation of this score to "COLDS-plus," incorporating emergency-specific parameters. Additionally, the COVID-19 pandemic introduced new epidemiologic nuances, as recent infection is now recognized as a distinct predictor of respiratory instability[8]. Incorporating these evolving factors is essential for accurate risk estimation.

Airway Management and Induction Choices

Airway manipulation is a central determinant of PRAEs. Supraglottic devices are associated with lower incidence of laryngospasm and bronchospasm compared to tracheal intubation[9,11]. However, the emergency orthopedic context often necessitates definitive airway protection, particularly in trauma with aspiration risk or need for controlled ventilation[2,3]. In such cases, the anesthesiologist must balance the benefits of security against the increased risk of reactivity. Induction techniques also shape outcomes: intravenous induction with propofol reduces airway hyperreactivity compared

to inhalational sevoflurane, while ketamine offers advantages in trauma due to its bronchodilatory and hemodynamic profile[1,9,11]. These choices illustrate the tension between physiology and clinical imperatives, highlighting the need for individualized planning.

Pharmacologic Interventions

Adjunctive pharmacology plays an important supportive role. Dexmedetomidine has repeatedly shown efficacy in lowering laryngospasm, coughing, and breath-holding, making it a promising tool for children at high risk[6,12]. In asthmatic patients, inhaled β_2-agonists reduce intraoperative bronchospasm and improve perioperative stability[1,3]. Anticholinergics remain selectively useful in infants or children with excessive secretions[3]. Importantly, these agents should not be viewed as isolated solutions but as complementary to foundational strategies such as minimizing airway manipulation and ensuring appropriate depth of anesthesia.

Ventilation Strategies

Protective ventilation is strongly supported by pediatric physiology. Low tidal volumes, moderate PEEP, and recruitment maneuvers reduce atelectasis and improve oxygenation[7]. Avoiding excessive FiO_2 prevents absorption atelectasis, while tailoring ventilation to surgical positioning and trauma physiology preserves functional residual capacity[2,7]. These strategies are particularly relevant in long orthopedic procedures requiring traction or immobilization, where pulmonary mechanics are further compromised. The challenge in emergency settings is the consistent application of these protective strategies under time pressure, which argues for institutional protocols and standardization.

Emergence and Postoperative Surveillance

Emergence is widely recognized as the phase of greatest vulnerability. Laryngospasm and desaturation frequently cluster during extubation and immediate recovery[3,9]. Strategies such as extubation under deep anesthesia to minimize reflex activation, or awake extubation when aspiration risk dominates, can both be effective if tailored to context. Lidocaine has been reported to blunt airway reflexes and reduce PRAEs[9,11]. Postoperative monitoring is equally critical, since most respiratory events occur within the first hour of recovery[2,3]. Continuous pulse oximetry and extended observation in high-risk children—those with URTI, comorbidities, or intraoperative events—are essential. In children recovering from COVID-19, close monitoring is particularly warranted due to higher airway reactivity[8].

Implications for Emergency Orthopedic Surgery

While much of the evidence derives from elective or mixed pediatric populations, extrapolation to orthopedic emergencies is reasonable. These procedures often involve polytrauma, hemorrhage, and suboptimal fasting, all of which increase airway and aspiration risk[2,3]. The anesthetic strategy in this setting must prioritize airway protection while mitigating PRAEs through careful induction, adjunctive pharmacology, lung-protective ventilation, and structured postoperative care. The combination of urgency and high baseline risk makes standardized protocols and team preparedness especially important.

Limitations of Current Evidence and Future Directions

Most available studies are observational, single-center, and heterogeneous in PRAE definitions[2,3]. Evidence on dexmedetomidine, though promising, is largely drawn from elective surgery[6,12]. Ventilation strategies are grounded in physiology and supported by narrative reviews, but high-quality pediatric trauma-specific data are scarce[7]. To advance the field, prospective multicenter registries focusing on pediatric orthopedic emergencies are needed, along with randomized comparisons of induction techniques, airway devices, and adjunctive agents in children with URTI who cannot delay surgery. Quality-of-life measures and long-term outcomes should also be integrated, as most studies emphasize only immediate events.

Conclusion

Acute respiratory complications remain the most frequent and concerning perioperative events in pediatric anesthesia, and their impact is magnified in the setting of emergency orthopedic surgery. The combination of urgent surgical indication, limited preoperative optimization, and the intrinsic physiological vulnerability of children—such as low functional residual capacity and high oxygen consumption—makes this population particularly prone to rapid deterioration when respiratory instability occurs.

Across the literature, several consistent predictors of adverse outcomes are identified, including young age, recent or active upper respiratory tract infection, underlying pulmonary disease, and environmental exposures such as passive smoking. Although surgical delay is often not feasible in emergencies, structured risk assessment remains essential, guiding anesthesiologists in tailoring anesthetic plans and preparing for early recognition and rapid intervention when complications arise.

Effective mitigation requires an integrated strategy. This includes careful choice of airway device and induction technique, judicious use of pharmacologic adjuncts, adherence to lung-protective ventilation strategies, and deliberate planning for extubation. Postoperative monitoring is equally critical, as most respiratory events occur in the immediate recovery phase. Taken together, these measures form a bundled approach that has the potential to significantly reduce morbidity.

In conclusion, while current evidence is limited by heterogeneity and lack of trauma-specific data, the principles established across pediatric anesthesia remain highly applicable to emergency orthopedic surgery. The development of prospective multicenter studies and trauma-focused registries will be essential to refine these strategies further. Until such evidence is available, systematic application of risk stratification, protective anesthetic techniques, and vigilant perioperative care remains the most effective pathway to improving outcomes for this vulnerable patient group.

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