



Anesthesia in children with a cold

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Purpose of review

Common colds are infections of mostly viral origin that frequently occur in childhood. The overall anesthetic risk in children with respiratory tract infections is increased because of the increased incidence of perioperative respiratory adverse events (PRAEs). Although the morbidity and mortality of PRAE are low when managed by experienced anesthesiologists, careful preoperative assessment and perioperative anesthetic care are indispensable.

Recent findings

This review summarizes recent studies to give a brief overview and background information with regard to the pathophysiological mechanisms of upper respiratory tract infections, risk factors for PRAE in children with a cold, management of anesthesia and prevention and treatment of frequently observed adverse events as well as a proposal for a decision algorithm.

Summary

Children with a cold can be safely anesthetized under certain circumstances; however, anesthesia in children with symptomatic infections with wheezing, purulent secretion, fever and reduced general condition should be postponed for at least 2 weeks. Anesthetic treatment options for children with infection of the upper airway with a runny nose and cough include preoperative inhalational therapy with salbutamol, avoidance of endotracheal intubation whenever possible, use of a face mask or laryngeal mask, intravenous induction with propofol and avoidance of desflurane. Prevention, early recognition and immediate treatment of complications by an experienced anesthesiologist are crucial.

Keywords

adverse events, pediatric anesthesia, perioperative complications, respiratory complications, upper respiratory tract infection

INTRODUCTION

Anesthesia for elective surgery in pediatric patients with a recent upper respiratory tract infection (URI) was commonly postponed for several weeks in the past. The cancellation of a 'case' can have important social, economic, and emotional consequences for the child and the family as well as for the medical team.

The argument for postponing anesthesia in a child suffering from a cold was usually based on an increased risk of perioperative respiratory adverse events (PRAEs), which can occur up to 6 weeks after the disease. The airway is defined as 'hyper-reactive' in this time period, and the pathophysiological mechanisms underlying URIs seem to be similar to those of asthma.

Today there is a notable trend for anesthesia to be safely performed in children with a cold when a careful assessment of potential risks and benefits for the child is implemented and safety precautions are taken.

'COMMON COLD'

A 'common cold' is one of the most frequent infectious diseases in early childhood. Although the term 'cold' has not been specified, it is used in the clinical setting to describe various types of mild infections of the upper respiratory tract within the anatomical divisions of the nasal mucosa, throat, sinuses, pharynx/hypopharynx, tonsils, and larynx.

The symptoms of a 'cold' can include a sore or scratchy throat and a hoarse voice, which is soon

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KEY POINTS

- Viral invasion of the respiratory epithelium and mucosa during a 'cold' can lead to persistent bronchial hyper-reactivity and bronchoconstriction for up to 6 weeks, which is similar to the pathophysiology of asthma bronchiale.
- Careful preoperative assessment helps the anesthesiologist to decide when to postpone a case to prevent increased morbidity and avoidable cancellations.
- The best anesthetic management should include pretreatment with salbutamol, the use of propofol and avoidance of airway manipulation whenever possible.
- The experience of the anesthesiologist is crucial to prevent and treat perioperative complications.

accompanied by a runny nose, sneezing and a cough. The initial watery nasal congestion often becomes a purulent nasal congestion with mouth breathing. Fever is usually present in children but not in adults. The cold is often accompanied by malaise, that is, 'feeling unwell', which presents as fatigue, headache, myalgia, and loss of appetite [1].

URIs are very frequent in childhood, and the mean annual incidence of respiratory illnesses per child is higher in younger children: infants and preschool children have 6–8 colds a year [2]. The cold is usually a self-limited illness of benign nature and lasts for 7–10 days, but in some of the patients, the symptoms can still be present after 3 weeks.

There are more than 200 viruses associated with a cold; the most common viruses are rhino, corona, respiratory syncytial, influenza and parainfluenza viruses [3]. The viral invasion into the respiratory epithelium and mucosa leads to airway inflammation, edema, dyscriny, and bronchoconstriction, which sensitizes the airway to secretions and volatile agents [4]. Moreover, the viral infection interacts with the autonomic nervous system because viral neuraminidases can inhibit the cholinergic muscarinic M2 receptors, which is followed by an increased release of acetylcholine and consecutive bronchoconstriction [5].

Bronchial hyper-reactivity may also result from the virally induced liberation of tachykinin and neuropeptidases with a constriction of smooth muscles in the respiratory tract for weeks. Bronchial hyper-reactivity can persist for up to 6 weeks or even longer, that is, well beyond disappearance of all clinical symptoms [6–8]. Bronchial hyper-reactivity

can trigger severe complications in the perioperative period, particularly functional obstruction of the upper airway (laryngospasm) and the lower airway (bronchospasm), both of which can lead to fatal hypoxemia, which is the main cause of perioperative morbidity and mortality in children [9,10].

RISK FACTORS IN CHILDREN WITH A COLD

Perioperative respiratory adverse events are a major risk for perioperative morbidity and cause 30% of perioperative cardiac arrests in children [10].

Typical adverse events in children with respiratory tract infection are laryngospasm, bronchospasm, breath holding, atelectasis, arterial oxygen desaturation, bacterial pneumonia, and unplanned hospital admission [11,12].

The general incidence of serious outcomes after PRAE is, however, low in children; many events have an uneventful course when they are recognized early and immediately treated in a competent manner by an experienced specialist.

Independent risk factors for PRAEs have been identified by several authors and can be differentiated into three general entities: child-specific, anesthesia-specific and surgery-specific risks [13–16] (given below).

Risk factors for PRAEs are as follows:

- (1) Child-specific risk factors
 - (a) Age below 6 years, particularly infants below 1 year
 - (b) Clinical signs of URI
 - (i) Nasal viscous congestion, 'green runny nose'
 - (ii) Purulent secretion, moist cough
 - (iii) Coexisting diseases like otitis media
 - (c) Primary pulmonary morbidity [respiratory syncytial virus (RSV) infection, asthma bronchiale, prematurity, bronchopulmonary dysplasia, cystic fibrosis, pulmonary hypertension, etc.]
 - (d) Infectious disease with significant impairment of the child's general condition (malaise, fever $>38.5^{\circ}\text{C}$, bacterial superinfection)
 - (e) Parental confirmation of the child's symptoms, parental belief, 'the child has a cold'
 - (f) Passive smoke exposure
- (2) Anesthesia-specific risks
 - (a) Instrumental manipulation of the airway (endotracheal intubation, bronchoscopy)
 - (b) Airway management (endotracheal intubation $>$ laryngeal mask airway (LMA) $>$ face mask)

- (c) Anesthetic agents (desflurane > sevoflurane > propofol)
 - (d) Experience/specialization of the anesthesiologist in pediatric anesthesia
- (3) Surgery-specific risks
- (a) Airway surgery, ear nose throat (ENT) surgery, eye surgery
 - (b) Upper abdominal surgery, cardiac surgery

Child-specific risk factors

Children presenting with signs of a serious infection, bacterial superinfection, or impairment of the lower respiratory tract are at an increased risk for adverse events; signs of serious or systemic infection include fever above 38.5°C, dyspnea, wheezing, purulent secretion and cough, pneumonia, and otitis media. The parents have important influence, as passive smoking is a predictor of adverse events as well as the parents' belief that 'their child has a cold'.

Children with any respiratory or pulmonary comorbidity are at an increased risk of respiratory complications. von Ungern-Sternberg *et al.* [17²²] showed in a cohort study of more than 9000 pediatric anesthesia cases that a present or recent URI increased the risk for adverse events, particularly in children with symptoms such as a moist cough, green runny nose, and fever. This is the first study that included children with acute signs of infection whose surgery and anesthesia usually would have been cancelled in other institutions.

Respiratory syncytial virus infection

Infants suffering from RSV infection are at a specifically increased risk when they have to be anesthetized [18,19].

There are several case reports of protracted anesthesiologic courses with prolonged intubation and oxygenation and ventilation problems. However, it remains unclear whether there is a correlation between RSV infection and asthma in the later childhood. Joehr provides strong advice to perform preoperative point of care testing for RSV and to cancel elective surgery when active RSV infection is suspected.

Surgery/anesthesia-specific risk factors

It has been shown that any manipulation of the upper airway of the child results in a significant increase of the risk of PRAE [20,21]. Such manipulation can include the instrumental manipulation of the airway itself, for example, with bronchoscopy,

or invasive airway management, for example, endotracheal intubation. Surgery near the airway, such as ENT surgery or eye surgery, and surgery with impairment of respiratory function, such as upper abdominal surgery or cardiac surgery, are also associated with increased risk [22].

Anesthetic agents can have an important influence on airway resistance. Desflurane should be strictly avoided because of its bronchoconstrictory characteristics [23].

WHEN AND FOR HOW LONG SHOULD THE ANESTHESIOLOGIST CANCEL OR POSTPONE SURGERY AND ANESTHESIA?

The questions of whether to cancel surgery and anesthesia for a child with an URI and how long to delay the procedure, if it is postponed, have not been ultimately answered. However, there is a consensus that it is no longer mandatory to postpone surgery for a period of 6 weeks. Several authors have proposed a delay of at least 2 weeks when acute clinical signs of an infection are observed [12,24].

PERIOPERATIVE ANESTHESIOLOGICAL MANAGEMENT

The key points to optimize anesthesiologic management for children with a cold are identifying risk factors for PRAE and providing the best perioperative medical management and anesthetic care. With the attention of an experienced pediatric anesthesiologist, PRAEs can be prevented in many cases and thus rarely lead to serious perioperative morbidity and mortality.

Pretreatment with salbutamol

Salbutamol is a bronchodilating beta-mimetic agent whose effectiveness in the prevention and treatment of perioperative bronchospasm in asthmatic children and those with obstructed airways is well known [25,26]. The pathophysiology of bronchial hyper-reactivity during and after an URI is similar to that of asthma bronchiale; therefore salbutamol is expected to be effective in these patients, as well. The preventive effects of salbutamol when given as a premedication agent were studied by von Ungern-Sternberg *et al.* [27], who showed in a prospective observational study that the premedication of children with a recent URI with high-dose inhalational salbutamol (2.5–5 mg) reduced the risk of PRAEs by at least 35%. Hence, salbutamol pretreatment should be considered in all children presenting with a URI or a moist cough.

Lidocaine

Lidocaine is widely used in airway management in adult and pediatric anesthesia. Some authors state that its topical use has protective effects against coughing and laryngospasm [28], whereas others did not find positive effects or even showed an increase in respiratory adverse events [29]. Hamilton *et al.* [29] investigated more than 1000 children for elective general anesthesia with endotracheal intubation and found a significantly higher rate of desaturation in children treated with topical lidocaine compared with the placebo group. In this study, no difference in the incidence of laryngospasm was found. These findings are consistent with those of von Ungern-Sternberg *et al.*'s [17^{***}] results in the cohort study.

There is still a lack of evidence for the preventive effects of intravenous lidocaine on the incidence of PRAEs. Sanikop and Bhat [30] showed that 1.5 mg/kg lidocaine given 2 min before extubation resulted in a decrease in postextubational laryngospasm and coughing with statistical significance and clinical relevance. The preliminary results of other investigations on intravenous lidocaine are consistent with these results; final publications are expected in the near future (Erb TO, personal communication).

Desflurane

Desflurane is a third-generation volatile anesthetic that provides rapid and predictable emergence and early recovery [31]. Its use is well tolerated and efficacious in general anesthesia in adults without pulmonary comorbidity when the concentration is restricted to 1 MAC (minimal alveolar concentration) [32^{*}]. At higher concentrations (1.5 MAC), desflurane causes an increase in total respiratory resistance that may be explained by the direct bronchoconstrictive effect of desflurane on airway receptors [33,34].

These findings are even more obvious in children with asthma or airway susceptibility. Several studies found relevant negative effects on airway resistance and the incidence of respiratory complications. In von Ungern-Sternberg *et al.*'s [17^{***}] cohort study, the relative risk for bronchospasm under inhaled anesthesia maintenance with desflurane was more than six-fold higher than that with sevoflurane, and the overall relative risk for PRAE with LMA was reduced by 5.43 times if no desflurane was used.

Propofol vs. sevoflurane

Propofol is widely used in pediatric anesthesia, as it has a series of beneficial effects including rapid onset

and smooth induction, improved quality of emergence from anesthesia, and the reliable prevention of postoperative nausea and vomiting [35]. Intravenous induction with propofol itself can be described as a safety margin because the intravenous line is already established and thus not necessary to implement during the critical interval of anesthesia induction; if complications occur, they can be treated without any loss of time. Furthermore, propofol was shown to have bronchodilating effects similar to those of volatile anesthetics. In a study comparing propofol and sevoflurane for procedural sedation for MRI, apnea with laryngospasm occurred more often during anesthesia with sevoflurane compared with propofol. However, the incidence of coughing and breath-holding was higher in the propofol group [36].

von Ungern-Sternberg *et al.* [17^{***}] suggest that 'intravenous anesthesia with propofol might be associated with lower incidence of PRAE with a better preventive effect when used as a maintenance drug compared to sevoflurane', and Lerman [37] comments on the findings that 'one should anticipate a reduced frequency of PRAEs after intravenous induction of anesthesia than after inhalational induction, even when a minimally noxious agent such as sevoflurane is used'.

Airway management

Intubation of the trachea and the endotracheal tube itself are strong stimuli for a hyper-reactive airway, and the incidence of adverse events is significantly increased. There is strong evidence that the use of an endotracheal tube should be avoided whenever possible, particularly in infants and preschool children. Use of a face mask is associated with a decreased frequency of adverse events [13,17^{***}] but in many cases is not the appropriate airway, especially in ENT surgery. Supraglottic airway systems, primarily the laryngeal mask, provide a well established alternative to endotracheal intubation. A study found no difference between the laryngeal mask and the face mask with regard to the occurrence of perioperative bronchospasm, but the use of the laryngeal mask was associated with a significantly higher risk of laryngospasm, although to a lesser extent than with the use of tracheal tube [17^{***}]. These findings are consistent with previous studies [24].

Experience of the anesthesiologist

Several authors demonstrated that the experience of the anesthesiologist has an important effect on adverse events. Schreiner *et al.* [14] were one of the first authors to report an increased risk of

laryngospasm in children with an URI who had their anesthesia supervised by a less experienced anesthesiologist. Mamie *et al.* [20] found a 2.74-fold increase in the risk of respiratory adverse events when children undergoing anesthesia for ENT surgery were treated by nonspecialized residents, even in the absence of clinical signs of an infection. von Ungern-Sternberg *et al.* [17^{**}] showed that the competent management of the airway by a consultant pediatric anesthesiologist resulted in a significantly decreased incidence of stridor and laryngospasm.

ADVERSE EVENTS

The main goal of the anesthetist providing care for a child with a cold is to prevent perioperative adverse events. However, if these events occur, they have to be recognized and treated immediately in a competent manner. The most frequent complications, laryngospasm and bronchospasm, are presumed to be caused by airway irritation. They can occur at any stage of anesthesia, but most often they are accompanied by an inadequate depth of anesthesia and/or

airway stimuli such as laryngoscopy, intubation, extubation, or secretion.

Laryngospasm

Laryngospasm is a phenomenon that occurs primarily in anesthetized children. It is defined as a laryngeal or respiratory reflex to excitatory stimuli with a prolonged closure of the vocal cords or the vocal cords and the false folds [38]. This protective reflex can be life-threatening in anesthesia, as hypoxemia resulting from the closure effect is the most frequent cause of morbidity in anesthetized children [9,10]. The highest incidence of laryngospasm occurs in infants, in children with URIs, in children undergoing airway surgery, and in children being cared for by an inexperienced anesthesiologist [39].

The prevention of laryngospasm is important and is arguably the 'best treatment'. When laryngospasm occurs, it is treatable with airway-opening maneuvers, deepening of sedation, application of continuous positive airway pressure and muscle relaxation [40,41^{*}].

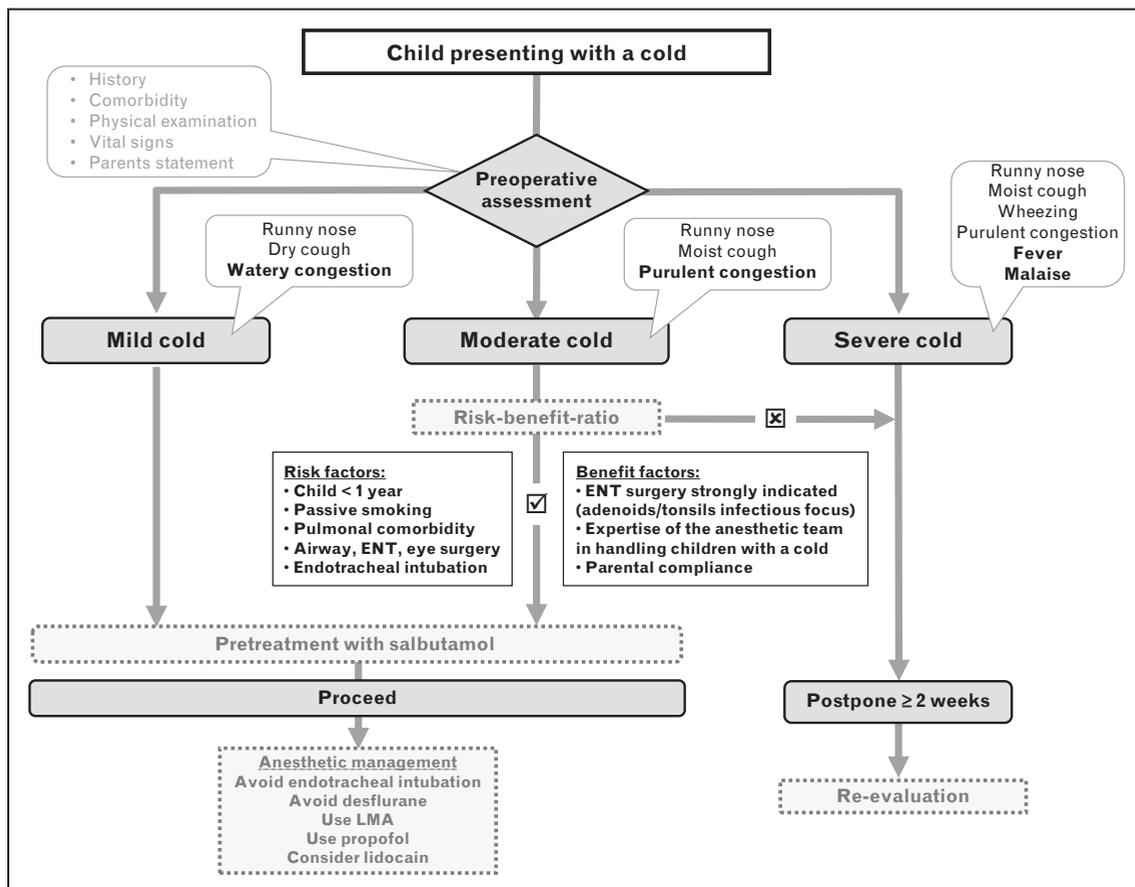


FIGURE 1. Proposal for a decision algorithm for a 'child presenting with a cold'. Modified from [43]. LMA, laryngeal mask airway.

Bronchospasm

Bronchospasm during anesthesia is characterized by an expiratory wheezing, prolonged expiration, and/or increased pressure during intermittent positive pressure ventilation (IPPV) or decreased tidal volumes during pressure-controlled ventilation (PCV). It is usually triggered by airway irritation, especially in patients with a pre-existing airway disease. To prevent serious desaturation, a rapid recognition and treatment of the problem is important and includes ceasing the stimulation, deepening the anesthesia, and administering bronchodilators, adrenaline, or salbutamol [42] (given below).

Adverse events – laryngospasm and bronchospasm:

- (1) Prevention of laryngospasm and bronchospasm
 - (a) Detect children at risk (children with a cold, infants, passive smoker, surgery near airway)
 - (b) Avoid endotracheal intubation, use laryngeal mask
 - (c) Provide adequate anesthetic depth
 - (d) Avoid any manipulation of the airway during emergence of anesthesia
 - (e) Use recruitment maneuver for extubation of the trachea
 - (f) Extubate the trachea either in deep anesthesia or after complete emergence
- (2) Therapy of laryngospasm
 - (a) Provide 100% oxygen
 - (b) Open the airway (jaw thrust)
 - (c) Use continuous positive airway pressure (CPAP)
 - (d) Deepen sedation/anesthesia (e.g. propofol)
 - (e) In case of persistent laryngospasm: administer neuromuscular blocking agents
 - (f) Safeguard oxygenation by mask ventilation (endotracheal intubation is rarely necessary)
- (3) Therapy of bronchospasm
 - (a) Provide 100% oxygen
 - (b) Cease stimulation
 - (c) Deepen anesthesia
 - (d) Give adrenaline or salbutamol

CONCLUSION

With the high incidence of URIs in children and the increased perioperative risk, anesthesiologists are often confronted with decisions that need to be made about the best management for these children.

Blanket cancellation as performed in the past is no longer indicated, and the literature supports selective decisions on a case-by-case basis.

Figure 1 gives a proposal for a decision algorithm when a child with a cold presents.

Acknowledgements

None.

Conflicts of interest

There are no conflicts of interest.

REFERENCES AND RECOMMENDED READING

Papers of particular interest, published within the annual period of review, have been highlighted as:

- of special interest
- of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (pp. 393–394).

1. Heikkinen T, Järvinen A. The common cold. *Lancet* 2003; 361:51–59.
 2. Monto AS, Ullmann BM. Acute respiratory illness in an American community: the Tecumseh study. *J Am Med Assoc* 1974; 227:164–169.
 3. Mäkelä MJ, Puhakka T, Ruuskanen O, *et al.* Viruses and bacteria in the etiology of the common cold. *J Clin Microbiol* 1998; 36:539–542.
 4. Jacoby DB, Hirshman CA. General anesthesia in patients with viral respiratory infections: an unsound sleep? *Anesthesiology* 1991; 74:969–972.
 5. Malisse M, Habre W. Paediatric anaesthesia and upper respiratory tract infections. *Rev Med Suisse* 2010; 6:380–383.
 6. Empey DW, Laitinen LA, Jacobs L, *et al.* Mechanisms of bronchial hyper-reactivity in normal subjects after upper respiratory tract infection. *Am Rev Respir Dis* 1976; 113:131–139.
 7. Little JW, Hall WJ, Douglas RG Jr, *et al.* Airway hyperreactivity and peripheral airway dysfunction in influenza A infection. *Am Rev Respir Dis* 1978; 118:295–303.
 8. Aquilina AT, Hall WJ, Douglas RG Jr, *et al.* Airway reactivity in subjects with viral upper respiratory tract infections: the effects of exercise and cold air. *Am Rev Respir Dis* 1978; 117:47–53.
 9. Morray JP, Geiduschek JM, Ramamoorthy C, *et al.* Anesthesia-related cardiac arrest in children: initial findings of the Pediatric Perioperative Cardiac Arrest (POCA) Registry. *Anesthesiology* 2000; 93:6–14.
 10. Bhananker SM, Ramamoorthy C, Geiduschek JM, *et al.* Anesthesia-related cardiac arrest in children: update from the Pediatric Perioperative Cardiac Arrest Registry. *Anesth Analg* 2007; 105:344–350.
 11. Tait AR, Malviya S, Voepel-Lewis T, *et al.* Risk factors for perioperative adverse respiratory events in children with upper respiratory tract infections. *Anesthesiology* 2001; 95:299–306.
 12. von Ungern-Sternberg BS, Boda K, Schwab C, *et al.* Laryngeal mask airway is associated with an increased incidence of adverse respiratory events in children with recent upper respiratory tract infections. *Anesthesiology* 2007; 107:714–719.
 13. Parnis SJ, Barker DS, Van Der Walt JH. Clinical predictors of anaesthetic complications in children with respiratory tract infections. *Paediatr Anaesth* 2001; 11:29–40.
 14. Schreiner MS, O'Hara I, Markakis D, *et al.* Do children who experience laryngospasm have an increased risk of upper respiratory tract infection? *Anesthesiology* 1996; 85:475–480.
 15. Tait AR, Knight P. The effects of general anesthesia on upper respiratory tract infections in children. *Anesthesiology* 1987; 67:930–935.
 16. Tait AR, Knight PR. Intraoperative respiratory complications in patients with upper respiratory tract infections. *Can J Anaesthesia* 1987; 34:300–303.
 17. von Ungern-Sternberg, Boda K, Chambers NA, *et al.* Risk assessment for ■ respiratory complications in paediatric anaesthesia: a prospective cohort study. *Lancet* 2010; 376:773–783.
- This is the largest cohort study on respiratory complications in pediatric anesthesia in healthy children and children with clinical symptoms of pulmonary comorbidity. The findings have important influence on anesthetic management.
18. Cox RG. Repair of incarcerated inguinal hernia in an infant with acute viral bronchiolitis. *Can J Anaesth* 2004; 51:68–71.
 19. Woerner J, Joehr M, Berger TM, *et al.* Infections with respiratory syncytial virus. Underestimated risk during anaesthesia in infants. *Anaesthesist* 2009; 58:1041–1044.
 20. Mamie C, Habre W, Delhumeau C, *et al.* Incidence and risk factors of perioperative respiratory adverse events in children undergoing elective surgery. *Paediatr Anaesth* 2004; 14:218–224.

21. Tomaske M, Gerber AC, Weiss M. Anesthesia and periinterventional morbidity of rigid bronchoscopy for tracheobronchial foreign body diagnosis and removal. *Pediatr Anesth* 2006; 16:123–129.
22. Malviya S, Voepel-Lewis T, Siewert M, *et al.* Risk factors for adverse post-operative outcomes in children presenting for cardiac surgery with upper respiratory tract infections. *Anesthesiology* 2003; 98:628–632.
23. von Ungern-Sternberg BS, Saudan S, Petak F, *et al.* Desflurane but not sevoflurane impairs airway and respiratory tissue mechanics in children with susceptible airways. *Anesthesiology* 2008; 108:216–224.
24. Rachel Homer J, Elwood T, Peterson D, *et al.* Risk factors for adverse events in children with colds emerging from anesthesia: a logistic regression. *Paediatr Anaesth* 2007; 17:154–161.
25. Scalfaro P, Sly PD, Sims C, *et al.* Salbutamol prevents the increase of respiratory resistance caused by tracheal intubation during sevoflurane anesthesia in asthmatic children. *Anesth Analg* 2001; 93:898–902.
26. Zachary CY, Evans R. Perioperative management for childhood asthma. *Ann Allergy Asthma Immunol* 1996; 77:468–472.
27. von Ungern Sternberg BS, Habre W, Erb TO, *et al.* Salbutamol premedication in children with a recent respiratory tract infection. *Pediatr Anesth* 2009; 19:1064–1069.
28. Abouleish A, Berman J, Nguyen NC, *et al.* Topical lidocaine as adjunct to intubation without muscle relaxant in pediatric patients. *Anesth Analg* 1999; 89:1328.
29. Hamilton ND, Hegarty M, Calder A, *et al.* Does topical lidocaine before tracheal intubation attenuate airway responses in children? An observational audit. *Pediatr Anesth* 2011; 2011. doi: 10.1111/j.1460-9592.2011.03772.x [Epub ahead of print].
30. Sanikop CS, Bhat S. Efficacy of intravenous lidocaine in prevention of post extubation laryngospasm in children undergoing cleft palate surgeries. *Indian J Anaesth* 2010; 54:132–136.
31. Jakobsson J. Desflurane: a clinical update of a third-generation inhaled anaesthetic. *Acta Anaesth Scand* 2011. doi: 10.1111/j.1399-6576.2011.02600.x [Epub ahead of print].
32. Nyktari V, Papaioannou A, Volakakis N, *et al.* Respiratory resistance during anaesthesia with isoflurane, sevoflurane, and desflurane: a randomized clinical trial. *Br J Anaesth* 2011; 107:454–461.
This clinical trial demonstrated that desflurane significantly increases both total and airway resistance in healthy patients in higher concentrations.
33. Satoh JI, Yamakage M, Kobayashi T, *et al.* Desflurane but not sevoflurane can increase lung resistance via tachykinin pathways. *Br J Anaesth* 2009; 102:704–713.
34. Satoh JI, Yamakage M. Desflurane induces airway contraction mainly by activating transient receptor potential A1 of sensory C-fibers. *J Anesth* 2009; 23:620–623.
35. Lerman J, Jöhr M. Inhalational anesthesia vs. total intravenous anesthesia (TIVA) for pediatric anesthesia. *Pediatr Anesth* 2009; 19:521–534.
36. Oberer C, Ungern-Sternberg BS, Frei FJ, *et al.* Respiratory reflex responses of the larynx differ between sevofluran and propofol in pediatric patients. *Anesthesiology* 2005; 103:1142–1148.
37. Lerman J. Perioperative respiratory complications in children. *Lancet* 2010; 376:745–746.
38. Fink BR. The etiology and treatment of laryngeal spasm. *Anesthesiology* 1956; 17:569–577.
39. Morray JP. Cardiac arrest in anesthetized children: recent advances and challenges for the future. *Pediatr Anesth* 2011; 21:722–729.
40. Al-almi AA, Zestos MM, Baraka AS. Pediatric laryngospasm: prevention and treatment. *Curr Opin Anaesthesiol* 2009; 22:388–395.
41. Weiss M, Engelhardt T. Proposal for the management of the unexpected difficult pediatric airway. *Pediatr Anesth* 2010; 20:454–464.
This is the first algorithm for the unexpected difficult airway in pediatric anesthesia; the article highlights the importance of clear strategies to cope with airway obstruction as well as difficult endotracheal intubation.
42. Westhorpe RN, Ludbrook GL, Helps SC. Crisis management during anaesthesia: bronchospasm. *Qual Saf Healthcare* 2005; 14:e7.
43. Tait AR, Malviya S. Anesthesia for the child with an upper respiratory tract infection: still a dilemma? *Anesth Analg* 2005; 100:59–65.