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REVIEW ARTICLE

Anesthesia for the Child with an Upper Respiratory Tract Infection: Still a Dilemma?

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One of the most controversial issues in pediatric anesthesia has revolved around the decision to proceed with anesthesia and surgery for the child who presents with an upper respiratory tract infection (URI). In the past, doctrine dictated that children with URIs have their surgery postponed until the child was symptom free. This practice was based on the empirically supported premise that anesthesia increased the risk of serious complications and complicated the child's postoperative course. Although recent clinical data confirm that some children with URIs are at increased risk of perioperative complications, these complications can, for the most part, be anticipated, recognized, and treated. Although the child with a URI still presents a challenge, anesthesiologists are now in a better position to make informed decisions regarding the assessment and management of these children, such that blanket cancellation has now become a thing of the past.

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Traditionally, children who present for elective surgery with an upper respiratory tract infection (URI) have had their procedure postponed at least until they are asymptomatic. The rationale for this practice was based on empirically derived data suggesting an association between the administration of anesthesia to a child with a URI and the appearance of respiratory complications. More recent scientific data have, in essence, confirmed these observations (1–3) although, for certain pediatric surgical populations, there appears to be no increased risk (4,5). These studies also showed that despite a general increase in the incidence of perioperative respiratory complications in children with URIs, most were manageable with minimal associated morbidity.

Despite the importance of this clinical problem, there is still no consensus regarding the optimal anesthetic management of children with URIs who require elective surgery. Although several studies have addressed this issue, it has been difficult to develop evidence-based practice guidelines given differences in study design, URI criteria, and outcomes.

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The debate surrounding the decision to cancel or proceed with elective surgery for the patient with a URI is not new. In a 1955 commentary, Ellis (6), while recognizing the potential for complications, made a case for proceeding with surgery despite the presence of a URI: "...although anesthesia may not be good treatment for the common cold, might it not be a good way of passing the time till the cold is gone?"

Although a few studies had touched on the subject of complications associated with respiratory infections, the primary impetus to cancel surgery for children with URIs came after a 1979 case series described by McGill et al. (7). This report identified 11 children who developed significant perioperative complications, including atelectasis. Of the 11, all but 1 had reported a respiratory infection in the month preceding surgery.

In 1987, Tait and Knight (4,8) reported on 2 series of children requiring elective surgical procedures. In the first, 3585 cases were reviewed retrospectively from the medical records (8). Results showed no increased risk of complications in children with URIs but showed a 3.5-fold increase in the prevalence of respiratory complications in children with a recent URI (<2 wk) compared with control children. Because of the potential for selection bias in this study, a subsequent prospective study was performed (4). This study included 489 children who received halothane anesthesia by face mask for myringotomy and tube placement. These children were divided into three groups (control, recent URI, and active URI) based on the

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presence or absence of *a priori*–defined symptom criteria. Results showed no differences among these groups with respect to the risk of perioperative laryngospasm, bronchospasm, or apnea. The authors concluded that blanket surgery cancellation for children undergoing short procedures with halothane anesthesia in which the trachea is not instrumented might be unnecessary.

In apparent contrast to these two studies, De Soto et al. (9) found that children with symptoms of a URI had a significant increase in the risk of postoperative arterial oxygen desaturation. Other investigators subsequently confirmed this observation, although it should be noted that all children in these studies responded rapidly after oxygen administration (10,11). In a related study, Kinouchi et al. (12) determined that children with URIs desaturated more rapidly than uninfected children after an apneic episode. Other specific complications have been associated with the presence of a URI, including bronchospasm (11,13) and laryngospasm (1,14,15). In a longitudinal study by Cohen and Cameron (1) involving more than 20,000 children, those with symptoms of a URI were 2–7 times more likely to experience respiratory-related complications and 11 times more likely if their tracheas were intubated. Although important, this study was limited by incomplete documentation of the timing and nature of the URI symptoms.

Despite the importance of all these studies in determining outcome in children with URIs, none could identify risk factors that predicted these outcomes. However, Parnis et al. (2), in a study of 2051 pediatric surgical patients, identified 8 clinical predictors of anesthetic complications. These predictors included airway management (endotracheal tube [ETT] > laryngeal mask airway [LMA] > face mask), the parents' statement that the child had a "cold," a history of snoring, passive smoking, induction anesthetic (thiopental > halothane > sevoflurane > propofol), presence of sputum, presence of nasal congestion, and use of an anticholinesterase (muscle relaxant not reversed > reversed). The presence of a respiratory infection was also implicated as a risk factor for airway complications in a study by Bordet et al. (16).

Similar to Parnis et al.'s (2) study, Tait et al. (3) examined the incidence of and risk factors for adverse respiratory events in 1078 children undergoing a variety of surgical procedures. Results showed that children with active and recent URIs (in the last 4 wk) had significantly more episodes of overall respiratory events, breath-holding, major arterial oxygen desaturation (Spo_2 <90%), and severe coughing compared with children with no URIs. Independent risk factors for adverse respiratory events in children with active URIs included use of an ETT in a child <5 yr old, prematurity (<37 wk), history of reactive airway disease, paternal smoking, surgery involving the airway, presence of copious secretions, and presence of nasal congestion.

All the studies outlined previously describe children who, despite the presence of a URI, had been otherwise healthy. For these children, postponing surgery has little effect on their surgical condition or outcome. However, there are many children in whom the benefits of expedient surgery may outweigh the potential risks associated with a URI. Children who require urgent corrective or palliative surgery for congenital cardiac disease, for example, may have compromised cardiopulmonary systems that may be further exacerbated by a URI. Yet there are very few data regarding outcome in children who present for cardiac surgery while harboring a URI. In a recent study by Malviya et al. (17), the presence of a URI was found to be predictive of postoperative bacterial infections and multiple complications in children undergoing corrective cardiac surgery. However, the presence of a URI did not appear to affect the patients' overall length of hospital stay or the development of any long-term sequelae.

Despite the increased risk of respiratory events in children with URIs, there appears to be very little residual morbidity. Indeed, there are no cases in the pediatric and adult anesthesia closed claims literature implicating URIs with serious adverse events (18,19). Although there are a few reports of atelectasis in children with URIs (7,20), two large-scale studies involving children with URIs revealed minimal morbidity (2,3). In one of these, 3 children out of 1078 developed adverse sequelae requiring rehospitalization (3). Two children with active URIs were admitted for pneumonia after surgery, and one child with a history of a recent URI was admitted for stridor. All children had uneventful recoveries.

Despite the apparently infrequent morbidity, there are reports of deaths in children with URIs after surgery (21,22). In one report (22), a 15-mo-old girl with a history of URI in the 2 wk before surgery developed laryngospasm after tracheal extubation and had a subsequent cardiac arrest. Although the URI was implicated in her death, several other factors, including premature tracheal extubation and inadequate monitoring, were likely contributory (23). In another case report, a 3-yr-old child died after anesthesia for cautery of the nose (21). The child had a history of URI within 2 wk before surgery. Postmortem examination elicited evidence of viral myocarditis. Among high-risk children with URIs undergoing cardiac procedures, Malviya et al. (17,24) found no increase in mortality.

Airway Hyperreactivity

Typically, children experience six to eight URIs per year, and this may be even more frequent among

young children attending nursery school or day care (25). Of these infections, approximately 95% are of viral etiology and represent a spectrum of viral species. Approximately 30%–40% of URIs are caused by rhinoviruses; however, other viruses—including coronavirus, respiratory syncytial virus, and parainfluenza virus—contribute significantly to the etiology of the disease. The differential diagnosis of a URI is further confounded because many illnesses are characterized by URI-like symptoms. In addition to the common cold (nasopharyngitis), patients may present with undiagnosed infections including croup (laryngotracheobronchitis), influenza, bronchiolitis, herpes simplex, pneumonia, epiglottitis, and strep throat. Furthermore, patients may present with URI-like symptoms of noninfectious etiology, such as allergic or vasomotor rhinitis.

Although most viral URIs are self-limiting, they may produce airway hyperreactivity that persists for several weeks after infection. Several studies have demonstrated significant decreases in airway conductance in volunteers with URIs when challenged by cold air, histamine, or citric acid aerosols (26,27). These effects were shown to persist for up to 6 wk after the URI and thus may have important implications for children requiring anesthesia in the acute and convalescent periods, particularly if the trachea requires intubation.

Viral invasion of the respiratory mucosa may render the airway sensitive to secretions or potentially irritant anesthetic gases. There is also increasing evidence that chemical mediators and neurologic reflexes play an important role in the etiology of bronchoconstriction. For example, release of inflammatory mediators, such as bradykinin, prostaglandin, histamine, and interleukin, at the sites of viral damage, has been associated with bronchoconstriction (25,28,29). Studies also show that bronchial hyperreactivity resulting from viral infections may be neurally mediated. Atropine, for example, has been shown to block airway hyperreactivity, and this suggests a vagal component to the response (26,27). Normally, stimulation of muscarinic receptors (M_2) on the vagal nerve endings inhibits the release of acetylcholine; however, in the infected individual, it is thought that these receptors may be inhibited by viral neuraminidases, thus resulting in an increase in acetylcholine release and bronchoconstriction (30). Other mechanisms of viral-induced airway hyperresponsiveness have been postulated. For example, studies suggest that viral infections increase the response of airway smooth muscle to tachykinins (31,32). Tachykinins are a group of neuropeptides that reside in the vagal afferent C-fibers of the airways and are important in smooth muscle contraction. Under normal circumstances, tachykinins are inactivated by neutral endopeptidase; however, it is thought that during viral infections, the activity of this enzyme is inhibited such that the constrictor response of smooth muscle to tachykinins is enhanced (31,32).

Although the designation of a URI implies restriction of the disease to the upper airways, several studies have shown that URIs may also produce pulmonary function abnormalities (33–35). In a study by Collier et al. (35), children with URIs were shown to exhibit spirometric changes including decreased forced vital capacity, forced expired volume in 1 s, and peak expiratory flow. Cate et al. (34) showed that volunteers infected with rhinovirus had significant decreases in diffusion capacity. Furthermore, Dueck et al. (36) showed that in sheep, the pulmonary changes associated with anesthesia (e.g., decreased functional residual capacity and increased intrapulmonary shunting) were enhanced during parainfluenza infection.

Preoperative Assessment

A suggested algorithm for the assessment and management of the child with a URI is presented in Figure 1. If the child is presenting for an emergent procedure, the presence of a URI should be elicited if possible, because this knowledge will alert the anesthesiologist to the potential for complications and may permit modification of the anesthetic management to reduce any risk. Children presenting for elective procedures with symptoms of a URI require careful preoperative assessment, including a detailed history and physical. The lungs should be auscultated to exclude any lower respiratory tract involvement, and a chest radiograph should be considered if the examination is questionable. The patient should be evaluated for fever, dyspnea, productive cough, sputum production, nasal congestion, lethargy, and wheezing. In two large-scale prospective studies, nasal congestion, sputum production, and a history of reactive airway disease were identified as predictors of adverse respiratory events (2,3). Valuable information regarding the nature of presenting symptoms can also be gleaned from the parents, because they are usually acutely attuned to their child's condition and may be able to help distinguish between an infectious and noninfectious condition. In a study by Schreiner et al. (14), confirmation of a URI by a parent was found to be a better predictor of laryngospasm than reliance on symptom criteria alone. In children with congenital heart disease, diagnosis of a URI may be further complicated because URI symptoms can be confused with those of congestive heart failure.

In general, children presenting with symptoms of an uncomplicated URI and who are afebrile with clear secretions and appear otherwise healthy, or those with noninfectious conditions, should be able to undergo surgery. Rolf and Coté (11) suggest that "children with

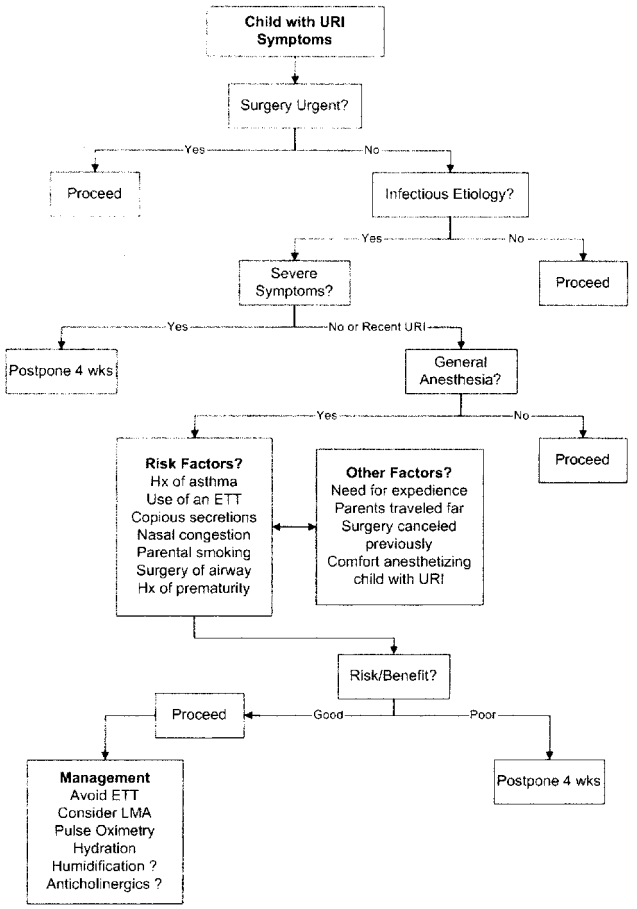

Figure 1. Suggested algorithm for the assessment and anesthetic management of the child with an upper respiratory infection. URI = upper respiratory infection; Hx = history; ETT = endotracheal tube; LMA = laryngeal mask airway.

a mild URI may be safely anesthetized, since the problems encountered are generally easily treated and without long-term sequelae." Children with more severe symptoms—including mucopurulent secretions, productive cough, fever >38°C, lethargy, or signs of pulmonary involvement—should have their elective surgery postponed for a minimum of 4 wk. Similarly, if a bacterial infection is suspected, patients should be placed on antibiotic therapy, and their surgery should be postponed for ≥4 wk. Although it is relatively easy to make the decision to cancel or proceed in children who are healthy with minimal symptoms or who are overtly sick, the decision becomes harder for children who, for example, present with a few symptoms such as nasal congestion and a slight nonproductive cough for a procedure requiring use of an ETT.

Although laboratory tests are available to confirm the diagnosis of a URI, none are cost-effective or practical in a busy surgical setting. The analysis of nasopharyngeal swabs or aspirates for viral isolation is not practical and, depending on the manner in which the sample is collected and on the phase of the infection, may offer limited sensitivity (2,4). Measurement of white blood cells counts as an indicator of infection is also of limited use, because patients with URIs do not necessarily present with increased white blood cell counts. The chest radiograph is also of little utility for children with URIs except in certain circumstances (e.g., cardiac surgery). Furthermore, chest radiograph findings typically lag behind the presentation of clinical symptoms in children with lower respiratory infections.

In assessing the suitability of any child with a URI for surgery, it is important to assess the risk/benefit ratio. This should involve consideration of the child's presenting symptoms and age, the urgency of the surgery, comorbid conditions (e.g., asthma or cardiac disease), and the type of surgery. Another consideration is the frequency of URIs experienced by the child. In the case of the child who experiences six to eight URIs per year, it may be difficult to precisely target a period when the child is symptom free for elective surgery. Decisions regarding canceling or proceeding with surgery for children with URIs should be made on a case-by-case basis by considering the presence of identified risk factors and bearing in mind the anesthesiologist's own comfort and experience with anesthetizing children with URIs. Awareness of the risk factors and the potential for complications in these children is imperative for optimizing management strategies and responding appropriately to events should they occur.

Cancellation of Surgery for the Child with a URI

As mentioned previously, postponement of surgery because of a URI was once commonplace. Although blanket cancellation of surgery because of a URI avoids the potential for complications, it may also impose emotional and economic burdens on the parents (37,38). Furthermore, blanket cancellation may not always be practical in today's health care environment of increasing caseloads and pressures to expedite surgery. Indeed, a national survey suggests that anesthesiologists today appear less likely to cancel surgery because of a URI (39). In this survey, 40.4% of anesthesiologists with <10 yr in practice reported "seldom" (1%–25% of the time) canceling because of a URI, compared with 27.2% of those with more than 10 yr of experience.

The decision of how long to postpone surgery requires a balance between the need to proceed with the procedure and the time required for resolution of symptoms and diminished risk. Unfortunately, there is no consensus on the optimal time to wait before surgery is rescheduled. In a survey of anesthesiologists, most reported waiting 3–4 wk before proceeding

with surgery (39). The rationale for this time period is founded on the observation that airway hyperreactivity persists for several weeks after a URI (26,27). Indeed, some studies suggest that patients recovering from a URI have a similar or increased risk of complications compared with those who have acute symptoms[1] (3). Skolnick et al.[1] demonstrated that the risk of respiratory complications was greatest in the 3 days after a URI but remained increased for up to 6 wk after the URI. Tait et al. (3) found that the risk remained increased for 4 wk after a URI. Although these data suggest that postponement of anesthesia and surgery for 4 wk is prudent, Berry (40) suggests that a 1- to 2-wk delay may be all that is required for children with uncomplicated nasopharyngitis.

Anesthetic Management

Management of the child with a URI is directed at minimizing secretions and avoiding stimulation of a potentially sensitive airway. Because sputum and copious secretions have been identified as risk factors, it is important that the airway be suctioned (under deep anesthesia) to remove excess secretions. This not only reduces airway irritation from secretions, but also may be important in preventing mucus from plugging a bronchus or ETT (41).

Because viral infections affect the nature and quality of secretions, it is important to ensure that the patient is adequately hydrated. IV hydration should be instituted in all patients unless the procedure is very short. Humidification may also be important in children with URIs, particularly for long cases. Although there are no data from controlled trials to support the efficacy of this practice in children with URIs, humidification may help to minimize drying and inspissation of secretions by anesthetic and carrier gases and may maintain adequate ciliary clearance mechanisms. In one report, 35.2% of anesthesiologists reported using humidification often for children with URIs (39). The use of anticholinergics such as glycopyrrolate or atropine may be useful in reducing secretions and attenuating vagally-mediated hyperreactivity. One-third of anesthesiologists reported using anticholinergics frequently (39). The benefits of anticholinergics for perioperative outcomes in children with URIs, however, remains open to further investigation. Bronchodilator premedication has also been suggested as a means to reduce autonomically mediated airway complications. However, in one study, Elwood et al. (5) showed that premedication with either albuterol or ipratropium had no effect on URI-related respiratory complications. Recently, however, Silvanus et al. (42) showed that in adult patients with bronchial hyperreactivity, preoperative treatment with combined corticosteroids and salbutamol minimized intubation-evoked bronchoconstriction more effectively than inhaled salbutamol alone.

Use of an ETT should be avoided if possible, because its use, particularly in young children, significantly increases the risk of airway complications (1,3). Although a face mask is associated with the least incidence of complications, it may not be appropriate for certain cases. For example, an ETT is likely the airway of choice for surgery of the oropharynx and neck, major thoracic and abdominal surgery, and operations lasting more than a couple of hours. The LMA, however, has been shown to provide a safe alternative for some procedures in which an ETT might otherwise be used. One study showed that the LMA is associated with fewer episodes of respiratory complications, including bronchospasm and arterial oxygen desaturation (43). In another, Tartari et al. (44) showed that use of a LMA was associated with a significantly reduced incidence of postoperative adverse events. In any case, all patients should be monitored continuously by pulse oximetry, particularly during the placement and removal of an ETT and in the immediate postoperative period (3).

The choice of anesthetic for induction and maintenance has been shown to be important in children with URIs. In the past, halothane was considered the volatile anesthetic of choice in these children; however, in many hospitals today, halothane has largely been replaced by sevoflurane, particularly for induction. Rieger et al. (45) showed that the incidence of complications in children with mild URIs was similar between sevoflurane and halothane but that sevoflurane provided a more rapid recovery profile. Other studies, however, suggest that sevoflurane results in fewer complications than halothane (2,3), particularly when sevoflurane is used for both induction and maintenance (3).

Regardless of the induction drug used, it is imperative that the depth of anesthesia be sufficient to obtund the airway reflexes, particularly when an ETT is placed. The optimal depth of anesthesia at which tracheal extubation should occur is less clear. Although some clinicians prefer to extubate under deep anesthesia to avoid reflex constriction of the airways, others prefer to extubate when the patient is awake, believing that a patient with intact reflexes is in a better position to clear secretions and respond to the tactile stimulation of ETT removal. In children without URIs, the data on awake versus deep extubation are equivocal. In one study, Patel et al. (46) found no difference in emergence complications after awake versus deep extubation, whereas Pounder et al. (47) showed that

[1] Skolnick ET, Vomvolakis M, Buck KA. A prospective evaluation of children with upper respiratory infections undergoing a standardized anesthetic and the incidence of adverse respiratory events [abstract]. Anesthesiology 1998;89:A1309.

awake extubation was associated with an increased risk of arterial oxygen desaturation. Kitching et al. (48) showed that awake removal of an LMA was associated with a more frequent incidence of coughing. Pappas et al. (49) showed that airway complications were unaffected by awake LMA removal during sevoflurane anesthesia but were increased when isoflurane was used. Although there are no randomized studies addressing this issue in children with URIs, one observational study showed no difference in the incidence of complications between children with URIs who were extubated under deep anesthesia versus awake (3).

Future Directions

Traditionally, the response to URI-related complications has been reactive; i.e., a problem is identified, and corrective action is taken. Yet as we gain greater understanding of the risks associated with anesthetizing the child with a URI and the mechanisms of viral-induced airway hyperreactivity, it may be possible to be more proactive in minimizing the risks. Although the currently available anticholinergics may have some benefit for children with URIs, they are nonselective in terms of their effect on the muscarinic receptors (M_2 and M_3) responsible for airway reactivity. Jacoby and Hirshman (28) make a good case for the development of anticholinergic drugs that would selectively block the M_3 receptors on airway smooth muscle that cause bronchoconstriction without blocking the vagal M_2 receptors responsible for the inhibition of acetylcholine. Other promising developments include the use of recombinant human neutral endopeptidases to replace the natural forms lost during viral infections (24).

Summary

Although past practices championed blanket cancellation of surgery for the child with a URI, there is a growing body of literature that now supports selective cancellation of surgery for these children (37). Whereas most studies agree that children with active and recent URIs are at increased risk for perioperative complications, these events, for the most part, are manageable and have no long-term adverse sequelae. Furthermore, these studies have identified several independent factors that place the child with a URI at risk such that anesthesiologists are now in a better position to make informed decisions regarding the suitability of proceeding with surgery for these children.

Most practitioners would agree that children with mild uncomplicated URIs undergoing procedures that do not involve instrumentation of the airway can be safely anesthetized without any increase in risk (3,4,11,37,50,51). Furthermore, most would agree that any child with severe symptoms should have surgery postponed for at least 4 wk. The dilemma therefore arises with an otherwise healthy child whose symptoms lie between these extremes, who has associated risk factors, or who is asymptomatic but has a recent history of URI. Decisions regarding the suitability of proceeding with anesthesia for these children must be considered on a case-by-case basis, bearing in mind the presence of identified risk factors (e.g., reactive airway disease, ETT use, type of surgery, and presence of nasal congestion and sputum), the need for expedient surgery, and the anesthesiologists' experience and comfort with anesthetizing the child with a URI. Consideration of these elements, together with a tincture of common sense and good judgment, is critical as a means to assess the individual risk/benefit profiles, identify and prepare for potential complications, and optimize the anesthetic management accordingly.

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