# Update on ENT anaesthesia in children

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## Abstract

This article is an update of anaesthesia for common paediatric ear, nose and throat (ENT) procedures. ENT pathology is the most common indication for surgery in children. An increasing number are performed as day cases, even in the presence of comorbidities such as obstructive sleep apnoea, but judicious selection of suitable children remains important. Considerations include severity of disease, known difficult airway, complex comorbidities and the surgical centre. The anaesthetic management of frequently performed paediatric ENT procedures will be discussed, including the potential role for dexmedetomidine and recent advances using transnasal humidified rapid insufflation ventilatory exchange.

**Keywords** Adenotonsillectomy; dexmedetomidine; obstructive sleep apnoea; otolaryngology; paediatrics; transnasal humidified rapid-insufflation ventilatory exchange

**Royal College of Anaesthetists CPD Matrix:** 2A01; 2D02; 2D05; 3A02; 3D00

## Learning objectives

After reading this article, you should:

- have an awareness of pertinent points of preoperative assessment of children for common ENT procedures, particularly adenotonsillectomy and the current evidence for management of children with upper respiratory tract infections (URTI)
- understand the implications of obstructive sleep apnoea in children for perioperative management for perioperative management
- comprehend the anaesthetic considerations for common ENT procedures, including laser surgery
- be familiar with potential roles of dexmedetomidine in ENT surgery
- be aware of alternative techniques for oxygenation using Transnasal Humidified Rapid-Insufflation Ventilatory Exchange (THRIVE)

The majority of paediatric ear, nose and throat (ENT) surgeries are performed as elective day case procedures. This provides the anaesthetist with numerous challenges: high-turnover lists; shared airway; comorbidities with anaesthetic significance; increasing incidence of obesity and its clinical sequelae; increased risk of perioperative respiratory adverse events (PRAE); and postoperative nausea and vomiting (PONV). This review is an update on the perioperative anaesthesia management of children coming for common ENT procedures.

## Preoperative assessment

In addition to standard enquiries, preoperative assessment of children undergoing ENT procedures should specifically focus on several commonly encountered issues: recent upper respiratory tract infection (URTI), obesity, sleep-disordered breathing (SDB), and congenital syndromes.

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### Upper respiratory tract infection

Postponement of a child with an active or recent URTI is a common dilemma in ENT surgery. The duration of airway susceptibility and bronchial hyper reactivity in children following a URTI has been much debated, but is known to persist well beyond symptom resolution. The highest risk of perioperative respiratory adverse event (PRAE; for example: oxygen desaturation, bronchospasm, cough, laryngospasm, or airway obstruction) occurs within 2 weeks of symptoms.[1] Cancellation and postponement of at least 2 weeks is recommended when children are unwell with systemic symptoms of severe URTI (purulent secretions/fever/malaise/wheezing). However, in the absence of systemic symptoms, ENT surgeries which address the underlying infection, such as myringotomy or tonsillectomy, will often proceed in the face of mild to moderate symptoms of URTI. In these cases, benefits often outweigh the approximately two- to threefold increased risk of PRAE. In most other ENT surgeries, the increased risks from recent or current mild URTI can be partially mitigated by strategies such as avoidance of airway instrumentation, with facemask or LMA being preferable to endotracheal intubation, avoidance of irritant volatile anaesthetics such as desflurane, and the use of propofol over inhalational techniques.[2]

Though ENT surgery is a risk factor for PRAE in children with recent URTI, many centres favour the use of total intravenous anaesthesia (TIVA) as the standard technique for these procedures, especially in the context of URTI. TIVA has been shown to reduce airway reactivity, laryngospasm, bronchospasm and emergence coughing.[3,4]

The avoidance of volatile agents at induction alone has been shown to reduce the risk of PRAE. In a recent randomized control trial, intravenous induction significantly reduced risk of PRAE compared to inhalational induction in the context of current (within 2 weeks) URTI.[4]

Though perioperative optimization of anaesthetic technique and provider experience appear key components for risk reduction, shared decision making with caregivers and surgeon remains

crucial, with attention to the implications and risk of PRAE if the surgery were to proceed.

### Sleep-disordered breathing (SDB) and obstructive sleep apnoea (OSA)

SDB refers to abnormalities of respiratory pattern or the adequacy of ventilation during sleep and describes a range of symptoms ranging from primary snoring to obstructive sleep apnoea (OSA). SDB is the most common indication for adenotonsillectomy (T&A) in children.

The consequences of SDB/OSA include:[5]

- increased risk for PRAE such as airway obstruction, laryngospasm and oxygen desaturation
- increased sensitivity to the respiratory depressant effect of opioids, requiring very careful titration of perioperative opioids and subsequent monitoring
- behavioural issues and learning difficulties increasing perioperative challenges
- systemic inflammatory response with endothelial dysfunction that may contribute to an increased risk for end-organ morbidity in severe OSA
- cardiac sequelae including increased sympathetic activity and nocturnal hypertension.

Controversies remain with admission criteria for children with SDB/OSA particularly those undergoing tonsillectomy, with little consensus. While polysomnography (PSG) remains the gold standard for SDB/OSA, it is a resource-intensive investigation that requires an overnight stay in hospital which is infrequently available. As severity of SDB is correlated with comorbidity and perioperative complications, it is predictive of need for admission. Although many attempts have been made to devise risk stratification or identification tools validated against PSG to assess severity, there is no consensus of such systems to enable admission planning. Of note, smartphone-based home oximeters are actively being investigated as inexpensive alternatives for the diagnosis of OSA in children, and may allow early identification for the purposes of risk stratification and disposition planning.[6] However, decisions regarding admission still remain centre- and sometimes surgeon-specific.

### Other comorbidities

Any congenital, chromosomal or syndromal abnormality should be explored for anaesthetic significance. Commonly encountered examples include: children with trisomy 21, branchial arch abnormalities and children with cleft lip and/or palate. Coagulopathy, from etiologies that include von Willebrand disease and hemophilia, is a rare, but significant comorbidity to consider in most ENT surgeries.

### Advances in ENT anaesthesia: transnasal humidified rapid insufflation ventilatory exchange (THRIVE)

Rigid bronchoscopy and suspension laryngoscopy are commonly performed diagnostic and therapeutic procedures in paediatrics and require spontaneous ventilation for dynamic assessments of vocal cord function, laryngomalacia and tracheomalacia. The challenge for anaesthetists is maintaining adequate depth of anaesthesia while avoiding apnoea, hypoxemia and hypercapnia without endotracheal intubation. Oxygenation may be maintained by passive insufflation into the pharynx via laryngoscopic or bronchoscopic sideport, but surgery is often disrupted with the periodic need to manage apnoea/hypoventilation by mask ventilation or intubation, especially in neonates and infants.

Transnasal humidified oxygenation and ventilatory exchange (THRIVE) has recently emerged within paediatric anaesthesia as an exciting advance in airway surgery particularly in children with abnormal airways (Box 1).[7] Nasal high flow has been used within paediatric setting for many years in the neonatal and paediatric intensive care as part of non-invasive respiratory support strategies. Several centres have now used THRIVE for paediatric airway surgery for vocal cord surgery, airway cysts, papillomas and foreign bodies.[7] Our centre has adopted its use in challenging airway cases, particularly in young infants and neonates for aryepiglottoplasty, and other laser airway surgery, finding improved oxygenation and surgical conditions using flow rates of 2 L/kg/min with easily titratable fractional inspired O2 concentration.

## Common ENT procedures

### Myringotomy and tympanostomy tubes

**Anaesthetic considerations:** This is usually a quick procedure performed as a day case. Emphasis should be on appropriate analgesia and quick recovery.

**Preoperatively:** Many children have had this procedure before, resulting in anxiety surrounding repeat anaesthetics. Analgesia with oral paracetamol (acetaminophen) with or without a non-steroidal anti-inflammatory drug (NSAID) is appropriate. Identify those with active or recent URTI, common in children undergoing this operation.

**Advantages and limitations of transnasal humidified oxygenation and ventilatory exchange (THRIVE) in paediatric ENT surgery**

| Advantages | Limitations |
|---|---|
| • Uninterrupted oxygenation from induction | • Optimum use requires experience with TIVA[b] |
| • Unobstructed surgical field | • Difficulty monitoring $ETCO_2$[c] |
| • Titratable oxygen/air mixture | • Transcutaneous monitoring can be required |
| • Provides CPAP[a] | • Role of $CO_2$ clearance requires further study |
| • Well tolerated and can be used preinduction and for postoperative support | • Rigid Bronchoscope in very young infants may potentially obstruct adequate gas flow |
| • Easy to use | |
| • Transportable | |

[a] CPAP: Continuous positive airway pressure.
[b] TIVA: Total intravenous anaesthesia.
[c] $ETCO_2$: End-tidal carbon dioxide.

**Box 1**

**Intraoperatively:** The airway can be maintained either with a facemask or an LMA while the child breathes spontaneously. Ondansetron 0.15 mg/kg intravenously (IV) can be considered for anti-emesis. An intraoperative opioid may be necessary for those children having repeated surgery, for example fentanyl 1 μg/kg IV.

**Postoperatively:** Analgesic requirements are highly variable between children. IV opioids are rarely required.

### Adenotonsillectomy

T&A is the most commonly performed operation in children, indicated primarily for the treatment of sleep disordered breathing, rather than recurrent tonsillitis. Surgery is often booked as a day case and anaesthetic management should be tailored to this.

**Anaesthetic considerations:** OSA and its sequelae as discussed; shared airway; potential difficult airway (obstruction, bleeding); challenge of balancing management of postoperative pain and risk of postoperative airway complications; postoperative nausea and vomiting (PONV) and postoperative bleeding.

**Preoperatively:** Assessment should include an assessment of severity of OSA (Table 1) and screening for high-risk features (Box 2) that might predict postoperative respiratory adverse events, which have an estimated incidence of up to 40% in this population. As previously discussed, the classification of severity of OSA/SDB remains challenging in practice. However, while previous studies have recommended high-dependency care admission for all those patients with high-risk features, recent literature does not support this practice. Rather, many patients can be assessed in the post-anaesthetic care unit for signs of airway obstruction, desaturation or prolonged oxygen requirement.[6] Box 2 describes patient features that should trigger consideration for postoperative admission to high-dependency care.

Premedication in all children for T&A should include acetaminophen and NSAID unless contraindicated. NSAIDs reduce PONV, which may either be due to improved pain control or a reduction in opioid use.

**Intraoperative management:** This procedure can be performed with oral RAE endotracheal tube or flexible LMA. Vigilance will detect obstruction of the airway when the surgeon places the mouth guard. TIVA has been shown to decrease postoperative nausea and vomiting, and thus may be preferred to volatile maintenance anaesthesia.

**Analgesia:** T&A is a painful procedure and opioids are usually required. Care should be taken with children with OSA. Use of adjuncts such as dexamethasone, dexmedetomidine (see below), and ketamine have all been shown to reduce analgesic requirements following T&A. Small doses of intraoperative morphine (0.05 mg/kg) or fentanyl (1–2 μg/kg) are well tolerated and can be titrated to respiratory rate.

Dexmedetomidine is a potent and highly selective $\alpha_2$-adrenoceptor agonist. Its sedative, anxiolytic and analgesic properties combined with its preservation of respiratory drive and pharyngeal tone lends itself as a useful adjunct for T&A. A recent meta-analysis of dexmedetomidine in adenotonsillectomy for OSA has shown that its use reduces opiate requirements, emergence

**Signs and symptoms suggestive of sleep-disordered breathing in children**

| Night-time Symptoms | Day-time Symptoms | Signs |
|---|---|---|
| Snoring | Day-time sleepiness (rare in children with OSA) | Obesity |
| Apnoea | Hyperactivity | Tonsillar hypertrophy |
| Arousals or wakening | Poor concentration | Mouth-breathing |
| Restless sleep | Lethargy | Failure to thrive |
| Night sweats | Social withdrawal | Apnoea-hypopnea index >2 events/hr |
| Difficult to rouse in the morning | Poor school performance | |

OSA: obstructive sleep apnoea.

**Table 1**

**High-risk features for postoperative respiratory complications in children with obstructive sleep apnoea (OSA) undergoing adenotonsillectomy and an example of institutional recommendations for features that require high-dependency unit admission[6]**

| High-risk features | Suggested PICU[a] admission |
|---|---|
| • Age younger than 3 years<br>• Weight <5th or >95th percentile<br>• Craniofacial abnormalities<br>• Severe OSA as measured on polysomnography (PSG)<br>• Cardiac disease<br>• Prematurity<br>• Hypotonia | • Severe respiratory event in the OR or PACU[b] (e.g. laryngospasm)<br>• Oxygen saturation <90% on room air in the PACU<br>• Oxygen requirement in the PACU exceeding 40% $FiO_2$[c] by facemask<br>• Age <24 months<br>• AHI[d] >24<br>• Significant comorbidity<br>  ○ Down syndrome<br>  ○ Pierre-Robin sequence<br>  ○ Neurodevelopmental or neuromuscular disease |

[a] PICU: Paediatric intensive care unit.
[b] PACU: Post-anaesthetic care unit.
[c] $FiO_2$: Fractional inspired oxygen content.
[d] AHI: Apnoea-hypopnea index.

**Box 2**

agitation and episodes of desaturation in the post-anaesthesia care unit.[8]

Dual antiemetics of IV ondansetron 0.15 mg/kg (max 4 mg) and IV dexamethasone 0.15 mg/kg (max 8 mg) are recommended as routine for tonsillectomy and adenoidectomy by the Association of Paediatric Anaesthetists of Great Britain and Ireland.

**Postoperative management:** Previously, postoperative analgesia included codeine; however, with concern for codeine 'ultra-metabolizers' within the population being overdosed with standard dosing of codeine, its use has declined. Though the safety profiles for analgesics of equivalent efficacy to codeine have not been fully established, multimodal postoperative analgesia with small doses of oral morphine are now used. Lauder et al. has written an excellent summary of the issues surrounding pain management in adenotonsillectomy.[9]

Nine per cent of children less than 4 years old have an unplanned admission following T&A, most commonly as a consequence of vomiting, rather than for surgical reasons. Postoperative primary haemorrhage (within 6 hours) is an uncommon, but life-threatening complication requiring emergent operative management with considerations that include full stomach, soiled airway and hypovolemic shock.

### Removal of inhaled foreign body

Children under 3 years of age are most likely to inhale foreign bodies. Diagnosis is made from history, examination and radiography. Organic materials are the most commonly inhaled foreign bodies. Rigid bronchoscopy is required to retrieve the foreign body, either at the presenting centre or a specialist paediatric centre if appropriate.

**Anaesthetic considerations:** This is an emergency and should be expedited if the child is symptomatic. If the child is stable, many institutions will opt to wait until normal working hours when more experienced staff are present and the child is fasted appropriately. Removal involves a shared and unprotected airway with risk of further aspiration.

**Preoperatively:** History and physical should briefly confirm the suspected diagnosis, but interventions that distress the child may worsen respiratory status and should be avoided. Chest radiograph may indicate side and severity of obstruction.

**Intraoperatively:** Whether children should be kept spontaneously breathing is a matter of ongoing debate. Spontaneously breathing patients have improved ventilation/perfusion matching and decreased risk of barotrauma. However, desaturations and respiratory acidosis are common. THRIVE may be considered if the patient is spontaneously breathing. Positive pressure ventilation offers better oxygenation and ventilation, better operating conditions, decreased recovery time, and less opioid requirements.[10] Ventilation is performed through a port on the rigid bronchoscope.

Traditionally, this procedure has been performed with a sevoflurane-based anaesthetic. Many centres now use TIVA with propofol and remifentanil. Advantages include better control over the depth of anaesthesia and less pollution within the operating room. In our institution, we use TIVA, in combination with dexmedetomidine infusions and spontaneous ventilation for rigid bronchoscopy; the level of anaesthesia is slowly increased until the respiratory rate halves from its initial value. The vocal cords are then sprayed with lidocaine to decrease laryngeal reflexes, and reduce the risk of coughing and laryngospasm with the rigid bronchoscope.

**Postoperatively:** The risk of adverse events (desaturation, haemorrhage, laryngospasm, pneumothorax) following surgery was 9.5% in a recent study, but if the patients were symptomatic preoperatively the rate was nearly four times higher at 36.5%. Postoperative disposition needs to be evaluated on a patient-by-patient basis.

### Laser surgery of the larynx

Laser is used for:

- laryngeal papilloma treatment
- supraglottoplasty or epiglottopexy for laryngomalacia
- haemangiomata
- oral lesions.

**Anaesthetic considerations:** Preparation for these cases is key. Complete airway obstruction is a possibility. Standard laser safety protocols should be followed. Postoperative care and monitoring should be arranged preoperatively.

**Preoperatively:** A thorough history and examination of the child, with surgical and radiological input to assess the anatomical location of the lesion, degree of airway obstruction and its nature (e.g. fixed, dynamic or both). Assess anaesthetic records from previous surgery. This information will help determine the anticipated degree of difficulty in maintaining an airway during anaesthesia, whether the child can or should be intubated, what size endotracheal tube to use, or whether a spontaneously ventilating technique is required.

**Intraoperatively:** The method of anaesthesia depends on the child, degree of airway obstruction, and surgical or anaesthetic preference. Prior to induction, the surgeon should be in the operating room, with equipment ready (surgical tracheostomy or rigid bronchoscope), in case the airway becomes compromised. Traditionally, an inhalational induction is used in children with lesions that may potentially obstruct the airway. A TIVA technique using propofol and remifentanil titrated to maintain spontaneous ventilation is an alternative in experienced hands, again with consideration to the addition of dexmedetomidine. Anaesthetizing the airway with topical local anaesthetic and maintaining an adequate depth of anaesthesia is essential.

Endotracheal tubes specifically designed for use with laser are not available in smaller sizes and there is a risk of airway fire with standard tubes. Standard endotracheal tubes can be inserted for laser surgery, removed prior laser use and then re-inserted. Some anaesthetists and surgeons prefer techniques where the child is not intubated, but the airway insufflated with oxygen using the surgical laryngoscope. Spontaneous ventilation is often preferred as high frequency jet ventilation may cause barotrauma and potential seeding of papilloma within the airway. THRIVE may have potential role for such cases and is used successfully in our centre.

**Postoperatively:** The location and level of care should be determined preoperatively. Bleeding and oedema are typically minimal after laser surgery and obstructive symptoms often show immediate improvement. Children who have had topical local anaesthetic to their airway should be kept nil by mouth for two hours postoperatively.

### Mastoidectomy, myringoplasty and cochlear implantation

**Anaesthetic considerations:** Presence of a co-existing syndrome; long procedure with minimal stimulation; requirement for a 'bloodless surgical field'; PONV prophylaxis; remote airway access; facial nerve monitoring; potentially a day case procedure.

**Preoperatively:** Premedication with paracetamol with or without an NSAID. Assess for bleeding diatheses and risk factors for PONV. Awareness of hearing deficit and assess for URTI or otitis media as these children are at risk of bacterial meningitis. All children with a sensorineural hearing deficit should have an ECG to exclude long QT syndrome that comprises part of Jervell Lange-Nielsen syndrome.

**Intraoperatively:** Surgery can be prolonged, and are often non-stimulating. Anaesthetizing the vocal cords with topical local anaesthetic may help to prevent coughing on extubation. TIVA is one option to improve tolerance of an endotracheal tube, reduce the risk of PONV and avoid large fluctuations in blood pressure. By avoiding hypertension and hypercarbia, the anaesthetist can aid the surgeon by reducing bleeding within the operative field.

Middle ear surgery is associated with a risk of PONV. Single agent prophylaxis with ondansetron 0.15 mg/kg is indicated and dual therapy (dexamethasone 0.15 mg/kg and ondansetron 0.15 mg/kg) should be considered if there are other risk factors for PONV. Intravenous hydration, using TIVA and avoiding long-acting opioids further reduce the risk of PONV.

With intraoperative facial nerve monitoring, the use of long-acting neuromuscular blocking drugs is precluded during the maintenance phase. If neuromuscular block is needed for intubation, choose a dose and an agent that ensures rapid return of function.

**Postoperatively:** Pain and PONV are the commonest problems, with bleeding a rare occurrence. Pre-emptive analgesia and anti-emesis is desirable. PACU should have the skills to manage those children with a hearing deficit. Cochlear implants are not activated for a couple of weeks postoperatively and so hearing deficit will be unchanged in PACU. ◆

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