Elective Procedures

Anaesthesia for paediatric ear, nose, and throat surgery

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ADENOTONSILLECTOMY

Tonsillectomy is one of the most frequently performed surgical operations in children. According to the Department of Health Hospital Episode Statistics (http://www.hesonline.nhs.uk), 25 000 tonsillectomies and 6500 adenoidectomies were performed in children under 15 years of age in England in 2003.[4] The tonsils and adenoids are lymphoid tissues forming part of the Waldeyer's ring encircling the pharynx. They appear in the second year of life, are largest between 4 and 7 years of age and then regress. Children with adenotonsillar hypertrophy can present with nasal obstruction, recurrent infections, secretory otitis media and deafness (secondary to Eustachian tube dysfunction), and obstructive sleep apnoea (OSA). Tonsillectomy is indicated in children with recurrent tonsillitis if they have had five or more episodes of sore throat per year because of tonsillitis, or if symptoms have persisted for at least 1 year and are disabling, that is, interfering with normal functioning (SIGN publication no. 34, available from http://www.sign.ac.uk). Other indications for tonsillectomy include chronic tonsillitis, peritonsillar abscess, and OSA. Adenoidectomy is indicated when there is evidence of enlarged adenoids causing nasal obstruction, OSA, or hearing loss. In the presence of OSA, adenotonsillectomy eliminates obstruction in 85 – 95% of children, yielding improvement of symptoms and quality of life.

Preoperative assessment

In your preoperative assessment you need to elicit features of OSA, especially in the younger child, in whom obstructive symptoms rather than recurrent infections are commonly the indication for surgery (prevalence of OSA 1 – 3%).

Symptoms of OSA include heavy snoring, apnoeas, restless sleep, extended neck position during sleep, and daytime hypersomnolence. Over time, this can lead to neurocognitive impairment, behaviour problems, failure to thrive, and rarely cor pulmonale.

Children with severe OSA have a higher incidence of perioperative complications and may need postoperative HDU/ICU care. Specifically, they are at an increased risk of desaturation, laryngospasm, and developing airway obstruction during induction of anaesthesia.[2] They have increased sensitivity to the respiratory depressant effects of sedatives and opioids and a diminished ventilatory response to CO_2 compared with normal.[2,3] The overall incidence of postoperative respiratory complications in children with severe OSA is 16 – 27% compared with an incidence of 1% in children without OSA. Other risk factors for respiratory complications include age >3 years, craniofacial abnormalities, neuromuscular disorders, failure to thrive, and obesity.[3]

Preoperative investigations are not routinely indicated for patients undergoing adenotonsillectomy (NICE Guideline on Preoperative Tests, available from http://www.nice.org.uk). It is difficult to confirm the diagnosis and quantify the severity of OSA. The gold standard for diagnosis is nocturnal polysomnography, but there is a great deal of variability in scoring methods between different sleep laboratories, and the test is expensive to perform.

Recent studies suggest that overnight oximetry to score the frequency and depth of desaturation events may be useful in identifying patients with severe OSA.[4] In children with long-standing OSA, a full blood count will reveal polycythaemia and an ECG may show a right ventricular strain pattern.

Summary

Children account for approximately one-third of all patients undergoing ear, nose, and throat (ENT) surgery. Procedures range from simple day-case operations, such as myringotomy, to complex airway reconstruction surgery undertaken in specialist centres. This article describes the anaesthetic management of some of the commonly performed paediatric ENT procedures, including adenotonsillectomy, oesophagoscopy, and middle ear surgery. Paediatric bronchoscopy is discussed in detail in a separate article, page 173.

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Anaesthetic considerations

The main areas of anaesthetic concern are airway management, provision of analgesia, and prevention of postoperative nausea and vomiting (PONV).

Airway management

Sharing the airway with the surgeon, remote access, and the need to prevent soiling of the respiratory tract are factors that need to be taken into consideration in airway management. Two techniques are commonly used: the tracheal tube and the reinforced laryngeal mask airway (LMA).[5,6] The advantages and disadvantages of these techniques are compared in Table1.

The tracheal tube provides a definitive airway, and a 'south-facing' RAE tube positioned in the midline provides good surgical access. The disadvantages of intubation are that muscle paralysis or a deep plane of anaesthesia are required, bronchial intubation or accidental extubation can occur with surgical movement of the neck, and there is variable protection against airway soiling. The dilemma of whether to extubate the patient when fully awake and able to protect their airway or still deeply anaesthetized to avoid a stormy emergence and bleeding always exists. The reinforced LMA offers a good airway with no soiling of the respiratory tract, avoidance of the use of neuromuscular blocking agents, smooth emergence, and airway protection until awake. To avoid soiling the laryngeal inlet, the LMA should be removed with the cuff still inflated. To ensure best surgical access, the smallest LMA for size should be used, and when positioned correctly, the cuff should not be visible once the Boyle-Davis gag has been opened to its fullest extent. An incorrectly sized LMA, or too large a blade on the mouth gag, can cause obstruction.

The main disadvantages of the LMA are that it does not offer the definitive airway provided by a tracheal tube and it may restrict surgical access in younger patients. However, with both the tracheal tube and the LMA, dislodgement or compression can occur during positioning of the mouth gag, and airway patency must be re-confirmed before surgery proceeds.

A postal survey of anaesthetic techniques used in paediatric tonsillectomy in the UK in 1996 – 7 suggested that only 16% of anaesthetists used the reinforced LMA routinely.[7] I.V. induction with propofol, tracheal intubation with succinylcholine, and spontaneous ventilation with isoflurane were the commonest anaesthetic techniques.[7] Concern about the danger of succinylcholine-induced hyperkalaemic cardiac arrest in children with undiagnosed muscle disease has led to a decline in the use of this drug for elective intubation. Alternative techniques for intubation include deep inhalation anaesthesia, combinations of propofol with a short-acting opioid, or the use of a short-acting non-depolarizing neuromuscular blocking agent during light anaesthesia.

Analgesia

Adequate postoperative analgesia is best provided with a combination of simple analgesics and small doses of opioids. Paracetamol[8] and NSAIDs have a morphine-sparing effect. The concerns around the potential for increased perioperative bleeding with NSAIDs have largely been discounted. The exception is ketorolac, which you should avoid. Administering the simple oral analgesics before operation is safe and ensures effectiveness by the end of surgery. Alternatively, the rectal route can be used after induction of anaesthesia. However, this route is less acceptable to many patients and will not achieve

Table 1. *Comparison of the LMA and the tracheal tube for tonsillectomy*

	LMA	Tracheal tube
Advantages	Straightforward airway	More secure airway
	No soiling of airway with blood	Good surgical access
	Smooth emergence	
	Paralysis not required	
	Airway protection until awake	
	Minimizes trauma to the airway	
Disadvantages	Less secure airway	Risk of airway trauma
	May impair surgical access	Oesophageal/bronchial intubation
		Requires paralysis
		Soiling of airway with blood
		Problems associated with extubation

therapeutic levels by the end of surgery in most cases.

A single dose of dexamethasone $0.1 - 0.5mg.kg^{-1}$ has also been shown to reduce postoperative analgesic requirements, whereas local anaesthetic infiltration of the tonsillar bed has not been found to be superior to placebo. Regular doses of paracetamol and an NSAID after operation provide good analgesia. Recently, concerns have been raised about respiratory depression and even death following use of codeine for postoperative analgesia. The current UK recommendation is to avoid codeine in any child with history of OSA undergoing (adeno)tonsillectomy, and in any child under 12 years old.[9]

Prevention of postoperative nausea and vomiting (PONV)
The incidence of PONV can be as high as 70% after adenotonsillectomy and a multimodal approach is indicated to combat this.

Minimizing starvation, avoiding the use of nitrous oxide (N_2O), and balanced analgesia with prophylactic administration of antiemetics reduce the incidence of PONV. A combination of ondansetron $0.1 - 0.2mg.kg^{-1}$ and dexamethasone $0.1 - 0.5mg.kg^{-1}$ (maximum 8mg) intraoperatively has been shown to greatly reduce the incidence of PONV.[9] Intraoperative fluid administration has also been shown to decrease the incidence of postoperative nausea. Rescue antiemesis can be provided by further doses of ondansetron with or without cyclizine $0.5 - 1mg.kg^{-1}$ (up to 50mg).

Special considerations
Severe OSA
In general, sedative premedication and long-acting opioids are best avoided in patients with severe OSA. Inhalation induction is preferred, as airway obstruction commonly occurs during induction, and children with associated craniofacial anomalies may prove to be difficult to intubate.[2] Consideration should be given to the use of a small dose of fentanyl to supplement simple analgesia, as this is associated with less postoperative respiratory depression.

The incidence of complications varies with the time of day that the procedure is performed. Children undergoing surgery in the morning have fewer desaturations than those undergoing the same procedure in the afternoon. Close postoperative monitoring and the availability of an ICU bed is required.

Day-case tonsillectomy
Successful and safe implementation of day-case tonsillectomy requires careful patient selection. Exclusion criteria include age >3 years, significant co-morbidity, OSA, and living further than a one hour drive from the hospital or having no private transport. Thought also needs to be given to the risk of early

haemorrhage and the management of postoperative pain and PONV.

The incidence of early postoperative bleeding is <1% and the majority of these occur within the first 4h after surgery. An extended observation period of 4 – 6h before discharge is therefore recommended; this limits surgery to morning lists. A multimodal analgesic and antiemetic regimen as previously discussed is very important, as the main reasons for overnight admission are PONV, pain, and poor oral intake.

Bleeding tonsil
Haemorrhage is the most serious complication after tonsillectomy and can occur within the first 24h (primary haemorrhage) or up to 28 days after surgery (secondary haemorrhage). In the National Prospective Tonsillectomy Audit (July 2003 – September 2004), the incidence of post-tonsillectomy haemorrhage patients was 3.5% and the overall rate of return to theatre was 0.9%. The incidence of primary haemorrhage was 0.6% and the majority of these occurred within the first 6h after operation. Factors influencing haemorrhage rates were age (lower rates in children than adults), indication for surgery (highest rates with quinsy and recurrent tonsillitis, lowest with obstructive symptoms), and surgical technique (higher rates with use of diathermy and disposable equipment, lowest with blunt dissection).

The anaesthetic considerations in bleeding tonsil include hypovolaemia, the risk of pulmonary aspiration (swallowed blood with or without oral intake), potential for a difficult intubation because of excessive bleeding obscuring the view with or without oedema after earlier airway instrumentation, a second general anaesthetic, and the stress to both child and parents. Blood loss is because of venous or capillary ooze from the tonsillar bed and is difficult to measure, as it occurs over several hours and is partly swallowed.

Excessive blood loss may lead to the child spitting blood. In these cases, the child is likely to be seriously hypovolaemic, anaemic, and potentially difficult to intubate because of poor visualization of the larynx. Tachycardia, tachypnoea, delayed capillary refill, and decreased urine output are early indicators of hypovolaemia, whereas hypotension and altered sensorium are indicators of advanced volume depletion. Preoperative resuscitation (guided by trends in monitoring) is essential, even if this requires the insertion of an interosseous needle. Induction of anaesthesia in a hypovolaemic child can precipitate cardiovascular collapse. Haemoglobin and coagulation variables should be checked. Blood and blood products should be immediately available and transfused as necessary. Before induction, in addition to the standard equipment, a selection of laryngoscope blades, smaller than expected tracheal tubes, and two suction catheters should be immediately available. Anaesthesia is induced once the

child is haemodynamically stable. Preoxygenation and rapid sequence induction with slight head-down positioning of the patient ensures rapid control of the airway and protection from pulmonary aspiration. Consider adopting the left lateral position if bleeding is excessive. Controlled ventilation provides good conditions for haemostasis.

Fluid resuscitation and transfusion of blood and blood products should continue intraoperatively as necessary. Once haemostasis is achieved, a large-bore stomach tube is passed under direct vision and the stomach emptied. Neuromuscular block is antagonized and the trachea is extubated, with the child fully awake in the recovery position. After operation, the child should be monitored closely for any recurrence of bleeding.

OESOPHAGOSCOPY

Rigid oesophagoscopy is performed for the removal of an ingested foreign body. History of ingestion, dysphagia, and odynophagia are the usual presenting symptoms, whereas a previous stricture is a predisposing factor for obstruction. The commonest site of impaction of the foreign body is at the level of the cricopharyngeus muscle. Oesophagoscopy should be performed in all cases of suspected impacted foreign body to prevent complications of perforation, mediastinitis, and fistula formation.

Anaesthetic considerations include management of the shared airway and the risk of pulmonary aspiration or oesophageal perforation during the procedure. A rapid sequence induction protects against pulmonary aspiration and ensures rapid control of the airway. The tracheal tube should be secured on the left side to allow easier access for the endoscopy. Adequate depth of anaesthesia and muscle relaxation during the procedure are essential to reduce the risk of oesophageal perforation. Analgesia is provided by a combination of intravenously or rectally administered simple analgesics and a small dose of opioid. The patient is extubated when fully awake. If oesophageal perforation is suspected, withold oral intake, commence IV antibiotics, and observe the patient closely for features of mediastinitis, such as severe chest pain, pyrexia, and subcutaneous emphysema.

EAR SURGERY

The most common surgical procedures on the ear are those performed to treat otitis media and its complications. Otitis media is the second most prevalent illness of childhood. This is because of a combination of factors including Eustachian tube dysfunction and an increased susceptibility to upper respiratory tract infection (URTI) in early childhood. The short Eustachian tube in young children predisposes to reflux of nasopharyngeal secretions into the middle ear space and thus to recurrent infections. Oedema of the Eustachian tube mucosa secondary to recurrent URTI, and mechanical obstruction of the Eustachian tube orifice by enlarged adenoids, lead to a negative pressure in the middle ear and a transudative effusion (secretory otitis media). Children with otitis media present with deafness and complications such as perforation, ossicular chain damage, and cholesteatoma. Surgery is performed to improve hearing and to eradicate middle-ear disease.

MYRINGOTOMY

Myringotomy and insertion of pressure-equalizing tubes are used to improve middle-ear aeration and hearing in chronic otitis media. It is a short procedure performed as a day-case. The preoperative assessment should elicit features of URTI, as otitis media is associated with recurrent URTI and these children can consequently have increased airway irritability. A small percentage of this population may also display symptoms of OSA secondary to adenoidal hypertrophy. The anaesthetic technique usually involves the patient breathing spontaneously via a facemask or LMA, with the head positioned to one side. Mild postoperative pain can occur in up to 75% of patients, but this can be avoided with the preoperative administration of paracetamol, NSAIDs, or both.[11]

MYRINGOPLASTY, TYMPANOPLASTY, AND MASTOIDECTOMY

Children with complications of chronic otitis media need more complex ear surgery. Myringoplasty involves repair of a tympanic membrane perforation in a dry ear. Tympanoplasty is performed when there is extensive middle-ear damage and involves reconstruction of the tympanic membrane and the ossicular chain. The approach to the ear can be permeatal or postaural, the latter providing better surgical access. Two surgical techniques of tympanic membrane grafting are used, the underlay and the overlay. The underlay technique involves elevation of a tympanomeatal flap and placing the graft material underneath (or medial to) the eardrum.

The overlay technique involves stripping the lateral epithelium off the eardrum and placing the graft material on the outer side of (or distal to) the eardrum. Various graft materials may be used, the most common being temporalis fascia, tragal perichondrium, and fat.

Mastoidectomy is performed to eradicate chronic suppurative middle-ear disease. The anaesthetic considerations associated with these three procedures are similar; therefore, we shall described their anaesthetic management collectively.

Anaesthetic considerations

Typically, these procedures are performed in the older child or teenager and can be of prolonged duration. The main factors that have a bearing on anaesthetic management are the effect of N_2O on the middle ear, the need for a bloodless operative

field, the use of facial nerve monitoring by the surgeon, and the high associated incidence of PONV.

As the relative solubility of N_2O in blood is 34 times that of nitrogen, it diffuses across into the non-compliant middle-ear cavity much more rapidly than nitrogen can leave. This can lead to pressures as high as 350 mm H_2O within 30 min of commencing N_2O, especially in the presence of Eustachian tube dysfunction.[12]

Displacement of tympanoplasty grafts, worsening of deafness, rupture of the tympanic membrane, and increased PONV have all been associated with elevated middle-ear pressures. In addition, after discontinuation of N_2O, rapid re-absorption of the gas leads to negative pressures in the middle ear and this can lead to 'lifting off' of the underlay tympanic membrane graft. As the middle ear remains open until the surgeon places the graft over the tympanic membrane, N_2O can be used up to 10 – 15min before graft placement and then discontinued. However, it may be best to avoid its use in middle-ear surgery completely.

Any bleeding during middle-ear surgery distorts the view through the operating microscope and can make the procedure difficult. Venous ooze can be minimized by a head-up tilt of 10° – 15° and ensuring unimpeded venous drainage. Epinephrine infiltration by the surgeon, relative hypotension (mean arterial pressure 10 – 20%, normal), and avoidance of tachycardia minimize arterial bleeding.

In its course through the temporal bone, the facial nerve runs through the middle ear in close relation to the ossicles and through the mastoid before emerging from the stylomastoid foramen. Therefore, it is vulnerable to damage during middle-ear surgery, especially as the disease process can distort the anatomical relationship of the nerve to the ear structures and make identification difficult. Intraoperative facial nerve monitoring is useful for identification and preservation of the nerve during ear surgery. A single dose of a short-intermediate acting relaxant can be used to aid tracheal intubation, its effects should have worn off sufficiently before the stage in the operation when facial nerve monitoring is required. However, it may be prudent to avoid the use of relaxants altogether by using other agents to facilitate intubation or by avoiding intubation. Whether using a tracheal tube or an LMA, the patient requires controlled ventilation for this procedure. Much of the surgery is performed using an operating microscope; therefore, if paralysis is to be avoided, a deep plane of anaesthesia is required to guarantee immobility. Controlled ventilation also allows control of the end-tidal CO_2, which helps to minimize bleeding.

The options for airway management are a tracheal tube or a reinforced LMA. The advantages of a tracheal tube over an LMA are a secure airway and ease of controlled ventilation, though a stormy emergence contributing to graft displacement is a potential problem. Smoother emergence can be ensured by tracheal extubation in a deep plane of anaesthesia. A reinforced LMA has the potential advantages of less airway stimulation and smooth emergence, but care must be taken to limit airway inflation pressures in order to prevent gastric distension during controlled ventilation.

For either technique and where available, maintenance of anaesthesia with propofol and remifentanil, or sevoflurane and remifentanil, offers many advantages. They allow controlled ventilation without neuromuscular blocking agents, thus permitting unimpeded facial nerve monitoring. Remifentanil provides a titratable degree of hypotension while maintaining a stable heart rate and provides excellent operating conditions. The use of TIVA is also associated with a lower incidence of PONV.[13]

Analgesia and antiemesis
A multimodal approach provides good analgesia and minimizes opioid-induced PONV. Oral paracetamol and NSAIDs given before operation are better accepted by the older child; alternatively, these can be given rectally or intravenously during surgery. As remifentanil has no residual analgesic effect after termination of the infusion, a small dose of morphine should be given 30 – 40 min before the end of the procedure to ensure adequate analgesia on awakening. A greater auricular nerve block has been shown to reduce postoperative opioid requirement. Postoperative analgesia is provided by regular, simple analgesics and small doses of opioids if necessary.

Routine prophylactic ondansetron and dexamethasone are indicated because of the emetogenic potential of middle-ear surgery. Avoiding prolonged starvation, adequate hydration, avoiding N_2O, use of TIVA, and balanced analgesia also help decrease PONV.

BONE-ANCHORED HEARING AID
The bone-anchored hearing aid (BAHA) is a surgically implantable system for the treatment of conductive deafness in children with chronic ear infections or congenital external auditory canal atresia who cannot benefit from conventional hearing aids. It allows sound to be conducted through the bone rather than via the middle ear, a process known as direct bone conduction. The procedure involves two short operations. Firstly, a titanium fixture is implanted into the mastoid bone and this over time integrates with the bone of the skull. Around 6 months later, at a second operation, an external abutment is placed over the fixture and this allows a sound processor to be connected.

The majority of children presenting for BAHA implant have associated congenital anomalies, the commonest being Goldenhar's syndrome (26%) and Treacher Collins syndrome (21%).[13] There is also a high incidence of congenital heart disease (19%) and craniofacial anomalies. The main anaesthetic concern is an increased incidence of difficult intubation. In most instances, after inhalation induction, the airway can be safely and easily maintained using a reinforced LMA. However, equipment for fibreoptic intubation and appropriately trained staff should be available in the event of a need for intubation. Analgesia is provided with a combination of paracetamol, NSAID, and a small dose of opioid. Routine antiemetics are indicated, as PONV is common.

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