Challenges in paediatric ambulatory anesthesia

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Purpose of review
Clinical studies and new guidelines are frequently being published in the area of preoperative fasting. A growing population of patients with obstructive sleep apnea is being referred for outpatient procedures including adenotonsillectomy.

Recent findings
Recently published preoperative fasting guidelines for pediatric patients are covered along with studies comparing gastric volume following different fasting intervals. Pediatric obstructive sleep apnea is discussed. Clinical presentation, severity, perioperative risks, and controversies as whether outpatient procedures are suitable for these patients are presented. New data covering different perioperative aspects are presented.

Summary
A more liberal preoperative intake is encouraged with fasting for 2 h for clear liquids, 4 h for breast milk, 6 h for formula and light meals, and 8 h for heavy meals is widely accepted. Interpersonal variation in residual gastric volume exists. Children with obstructive sleep apnea under 3 years of age and those with severe obstructive sleep apnea and comorbidities are not candidates for ambulatory surgery. Polysomnography has specific preoperative indications. Dexmedetomidine can decrease emergence agitation and has an opioid-sparing effect. Intravenous acetaminophen is presented as an opioid-sparing analgesic. Dexamethasone is effective in preventing postoperative nausea without increased risk of bleeding. Surgical techniques may affect postoperative pain.

Keywords
adenotonsillectomy, outpatient surgery, pediatric obstructive sleep apnea, postoperative agitation, preoperative fasting

INTRODUCTION

An estimated 2.3 million ambulatory anesthesia episodes of care took place for children under 15 years in 2006 in the USA [1]. Of those, more than 0.5 million outpatient tonsillectomy procedures were performed [2]. Preoperative fasting and obstructive sleep apnea syndrome (OSAS) will be discussed in relation to ambulatory surgery.

PREOPERATIVE FASTING: IS THERE A DIFFERENCE FOR AMBULATORY SURGERY?

The relationship between preoperative fasting and risk of pulmonary aspiration of gastric contents is an area of constant interest. In assessing the risk of pulmonary aspiration, gastric volume is used as a surrogate to guide perioperative fasting. The practice of anesthesia has changed dramatically in recommendations for preoperative fasting.

A recent meta-analysis by the American Society of Anesthesiologists methodology group for randomized controlled trials in children reports higher gastric pH values (category A1 evidence) and equivocal findings regarding differences in gastric volume in children given clear liquids 2–4 h before a procedure vs. fasting more than 4 h before a procedure (category C1 evidence). Ingestion volume varies between 2 ml/kg to unrestricted amounts.

Based on the evidence from the meta-analysis and the agreement of the consultants and ASA members, clear liquids are appropriate up to 2 h before elective procedures requiring general anesthesia, regional anesthesia, or monitored anesthesia care. The literature is insufficient but the

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KEY POINTS

- Appropriate preoperative fasting for healthy children undergoing elective procedures is 2 h for clear liquids, 4 h for breast milk, 6 h for formula, nonhuman milk, and light meals, and 8 h for fatty meals.
- Diagnosis of pediatric OSAS is based on multiple criteria. Polysomnography is recommended for children at higher risk of perioperative respiratory complications or children in whom the diagnosis of OSAS is not certain.
- Children with OSAS should be admitted following adenotonsillectomy if they are younger than 3 years or if they have severe OSAS documented by polysomnography or other associated comorbidities.
- Dexmedetomidine decreases intraoperative opioid requirements, the incidence of severe emergence agitation, and need for rescue morphine in the post-anesthesia care unit. Intraoperative bradycardia and lower SBP, secondary to its use, usually do not require intervention.

consultants agree that fasting from breast milk should be maintained for 4 h. Fasting from formula, nonhuman milk, and light meal should be for 6 h, and fasting from fatty meal should be at least 8 h [3▪▪]. Guidelines from the European Society of Anaesthesiologists also have the same recommendations [4▪▪].

Using MRI to calculate gastric fluid volume in healthy volunteers aged 6–14 years, Schmitz *et al.* [5▪] confirmed that emptying of clear liquids occurs in an exponential manner, with the median half time of less than 30 min, and prefasting volume is reached at 90 min, with considerable interindividual variation.

An observational study, also using MRI to determine gastric volume, found no correlation between fasting times and gastric content volume for patients following the guidelines of 2 h for clear liquids and 4 h for formula/solid food. Specifically, there were no differences in the formula/solid food group between 4–6 h and more than 6 h fasting. Interestingly, three patients who followed the guidelines and had more than 6 h of formula/solid food fasting had higher gastric volume (>4 ml/kg). Although the sample size is small, the study results stress the need for smooth induction even in patients who followed the recommended guidelines [6▪].

Brady *et al.* [7] after reviewing the published controlled trials concluded in their Cochrane meta-analysis review that there is no evidence that children who are denied oral fluids for more than 6 h preoperatively benefit in terms of intraoperative gastric volume and pH compared with children permitted unlimited fluids up to 2 h, preoperatively. Children permitted fluids have a more comfortable preoperative experience in terms of thirst and hunger. This evidence applies only to children who are considered to be at normal risk of aspiration/regurgitation during anesthesia.

OBSTRUCTIVE SLEEP APNEA SYNDROME AND AMBULATORY SURGERY

OSAS is a disorder of breathing during sleep characterized by prolonged partial upper airway obstruction and/or intermittent complete obstruction that disturb normal ventilation during sleep and normal sleep patterns [8].

Types of sleep apnea include central (absent gas flow, lack of respiratory effort), obstructive (absent gas flow, upper airway obstruction, and paradoxical movements of rib cage and abdominal muscles), and mixed (due to both central nervous system defect and obstructive problems).

The prevalence of OSAS diagnosed by varying criteria has ranged widely from 0.1 to 13%, but most studies report a number between 1 and 4%. Sleep-disordered breathing is more common among boys and obese children. There is no clear difference in prevalence based on age. Some data do suggest a higher prevalence among African–American, compared with white children in the USA, although differences in prevalence based on race or ethnicity among other populations worldwide remain less clear [9].

Obstructive events in children with OSAS occur primarily during rapid eye movement (REM) sleep [10]. Although the REM density increases during the night, the degree of obstructive apnea does not change significantly across the REM cycles [11].

Risk factors for OSAS in children include obesity, adenotonsillar hypertrophy, craniofacial abnormalities that cause upper airway narrowing, decreased muscle tone from congenital or acquired disorders, and Down syndrome [12▪].

DIAGNOSIS OF OBSTRUCTIVE SLEEP APNEA SYNDROME

Diagnosis of OSAS cannot be made on history or physical examination alone. The American Academy of Sleep Medicine set forth all of the following criteria for diagnosing pediatric OSAS [13]:

(1) Snoring and/or labored or obstructed breathing.
(2) At least one of the following: paradoxical breathing, movement arousals, diaphoresis, neck

hyperextension, excessive daytime sleepiness, hyperactivity or aggressive behavior, impaired growth, morning headaches, or enuresis.
(3) Polysomnography (PSG) shows more than one respiratory event per hour [apnea hypopnea index (AHI) > 1/h].
(4) PSG demonstrates respiratory-related arousals, oxygen desaturation, hypercapnia, or negative esophageal pressure.
(5) Conditions are not better explained by another sleep disorder, medical or neurological condition, medication use, or substance abuse.

PSG is the gold standard for diagnosis of OSAS. It is the electronic recording of simultaneous physiologic variables including gas exchange, respiratory effort, airflow, snoring, sleep stage, body position, limb movement and heart rhythm. Obstructive apnea occurs when there is more than 90% reduction of airflow despite continuing respiratory effort, scored when the event lasts at least two missed breaths. Obstructive hypopnea occurs when there is more than 50% reduction of airflow with associated respiratory effort, scored when at least two missed breaths and more than 3% drop in oxygen saturation or arousal occurs. AHI is the total number of apnea/hypopnea events per hour.

In recently published guidelines by the American Academy of Otolaryngology, prior to tonsillectomy in children, clinicians are advised to refer children with sleep-disordered breathing for polysomnography if they have obesity, Down syndrome, craniofacial abnormalities, neuromuscular disorders, sickle cell disease, or mucopolysaccharidoses. Polysomnography is also advocated for patients in whom the need for surgery is uncertain or when there is discordance between tonsillar size and the reported severity of sleep-disordered breathing. Clinicians are advised to communicate the results of PSG to the anesthesiologist prior to induction of anesthesia [14■■].

Although there are no validated severity scales of PSG in children, several publications support defining severe OSAS as having an oxygen saturation nadir below 80% and an AHI of 10 or more obstructive events. In contrast, normal PSG has oxygen nadir saturation above 92% and an AHI of one or lower [14■■]. Mild and moderate OSAS have AHI of 1–4 and 5–9, respectively [15].

Complications of untreated OSAS include decreased growth (more energy expenditure at night), impaired neurocognitive function (lower intelligence quotient scores and higher attention deficit hyperactivity disorder scores) [16], pulmonary hypertension [17], and cor pulmonale (as a result of hypoxemia), systemic hypertension, and metabolic syndrome (increased insulin resistance) [18].

PREOPERATIVE ASSESSMENT AND MANAGEMENT

Preoperative assessment includes history of snoring, witnessed airway obstruction, and assessment of comorbidities. Physical examination aims at assessing the airway, and signs of cardiovascular involvement. Polysomnography data should be reviewed, if available. Cardiac evaluation is recommended in patients with signs of right ventricular dysfunction, systemic hypertension, or recurrent episodes of desaturations below 70% [19]. Although routine blood-gas analysis is not usually indicated, a basic metabolic panel may show metabolic alkalosis in response to chronic hypercarbia, and a hemoglobin level may identify the patients with severe prolonged hypoxemia [20].

Limited literature is available to demonstrate the safety of preoperative sedation in children with OSAS. Seventy children (40% of whom with severe OSAS diagnosed by PSG) were given sedation with only two adverse events (one was a self-limited desaturation and the other was hypoxemia after extubation) [21]. Another chart review of 65 cases identified no adverse effect [22]. Based on the available literature, sedation can be given to anxious children preoperatively, but monitoring is required until recovery has been demonstrated.

ANESTHETIC MANAGEMENT

There is no consensus regarding the best method for induction of anesthesia in children with OSAS. Among the children presented for adenotonsillectomy, children with OSAS had more complications during induction of anesthesia compared with children with adenotonsillitis. They were more likely to have Cormack–Lehane laryngeal view of two or more. They had more supraglottic obstruction, oxygen desaturation, breath holding, and were more likely to require more than one attempt at intubation [23]. Intravenous induction is well tolerated and resulted in fewer less perioperative respiratory complications in the general pediatric population [24■,25■■]. Intravenous induction was also recommended by some authors for patients with suspected difficult mask ventilation [19].

Recurrent hypoxemia in children is associated with increased analgesic sensitivity to opiates. Patients with severe preoperative hypoxemia, with oxygen nadir below 85%, demonstrated 50% reduction in the total morphine analgesic dose requirement compared with patients with oxygen nadir above 85% [26]. Patients with mild and moderate sleep apnea had the same opioid requirements compared with the patients without OSAS [23].

A retrospective study of children with OSAS undergoing adenotonsillecotmy demonstrated a reduction in major medical interventions in children with recurrent profound hypoxemia (from 29.6 to 11.3%) when lower morphine-equivalent doses are administered. Major medical interventions included airway instrumentation, bag/mask ventilation or administration of medication by a physician [27▪].

Dexmedetomidine has been used for analgesia and prevention of emergence agitation in children with OSAS undergoing adenotonsillectomy. In a well controlled prospective study, Patel *et al.* [28▪▪] used a bolus of 2 $\mu g\,kg^{-1}$ over 10 min followed by an infusion of 0.7 $\mu g\,kg^{-1}\,h^{-1}$ compared with fentanyl 1 $\mu g\,kg^{-1}$. Sevoflurane with 60% nitrous oxide was used for maintenance and all patients received rectal acetaminophen and intravenous dexamethasone. In the dexmedetomidine group, patients demonstrated statistically significant lower heart rate and SBP intraoperatively (although none required intervention). Minimum alveolar concentration of sevoflurane was lower. Fewer patients required intraoperative rescue fentanyl (9.8 vs. 36%), showed severe emergence agitation on arrival to the post-anesthesia care unit (PACU) (18 vs. 45.9%), required rescue morphine in PACU (16.3 vs. 47.5%), and had an episode of desaturation below 95% (18 vs. 40.9%). Time to awakening and time to extubation were lower in the dexmedetomidine group.

Dexamethasone is used to decrease postoperative nausea and vomiting (PONV) after tonsillectomy. Czarnetzki *et al.* [29] found that dexamethasone decreased the risk of PONV in a dose-dependent matter but also increased the risk of postoperative bleeding. The increased risk of bleeding was not reproducible in other studies [30], as well as the dose-dependent effect on PONV [31]. A recent Cochrane review of 19 randomized, placebo-controlled, double-blinded studies concluded that children receiving a single intraoperative dose of dexamethasone (dose range 0.15–0.5 mg/kg) were half as likely to vomit in the first 24 h compared with children receiving placebo. They were also more likely to advance to a soft/solid diet on post-tonsillectomy day 1, and they have less pain than the placebo group. Authors concluded that a single intravenous dose of dexamethasone is an effective, well tolerated, and inexpensive treatment for reducing morbidity from pediatric tonsillectomy [32▪▪].

NSAIDs have the theoretical risk of increasing postoperative bleeding. An updated Cochrane review of 15 randomized controlled trials demonstrated that NSAIDs did not cause any increase in bleeding that required a surgical intervention, and did not increase the incidence of postoperative bleeding not requiring surgical intervention [33].

Rawlinson *et al.* [34] compared codeine to fentanyl and diclofenac and found no difference in PONV, and pain scores between the two groups. Intravenous acetaminophen (15 mg/kg) was found to have similar analgesic properties compared with tramadol (1 mg/kg) when used in conjunction with midazolam and fentanyl with no difference in PONV and readiness for discharge from PACU [35▪▪].

Modern technology-assisted techniques for tonsillectomy (e.g, vessel sealing systems) offer less surgical time, less perioperative bleeding, and less postoperative pain compared with conventional techniques [36]. Local anesthetic infiltration in the tonsillar fossa has not been proven to be effective for postoperative pain control [37▪▪].

Laryngeal mask airway (LMA) has been used for adenotonsillecotmy. Doksrod *et al.* [38▪] compared reinforced LMA to endotracheal tube and found a 4-min shorter time to extubation, and significantly lower maximal pain during first 4 h in the LMA group. Five patients (8%) required change to endotracheal tube. Incidence of patients who required change to endotracheal tube was much higher in another series (17%) [39▪]. This aspect could be related to surgical training as well.

After completion of the procedure, patients should be awake and be able to maintain their upper airway patency. Deep extubation is not recommended in patients with severe OSAS or those with comorbidities because they are at risk of persistent OSAS after surgery. Before extubation, a nasal airway can be placed in patients with severe sleep apnea. The lateral decubitus or prone position can help relieve airway obstruction after extubation.

POSTOPERATIVE CONSIDERATIONS

Children with OSAS are at increased risk of postoperative respiratory complications. Of 2315 patients younger than 6 years undergoing an adenotonsillectomy for treatment of OSAS, 149 (6.4%) developed a postoperative respiratory complication including oxygen desaturation below 90%, apnea or increased work of breathing (requiring insertion of nasopharyngeal airway, continuous positive pressure ventilation, or endotracheal intubation), or atelectasis, pneumothorax, and pulmonary edema as evidenced by chest radiograph changes. Children younger than 3 years were at a greater risk for developing a postoperative respiratory complication compared with those aged 3–5 years (9.8 vs. 4.9%, $P < 0.001$) even though there was a lower incidence of comorbid medical conditions in this cohort [40].

Several publications looked at the clinical features that predict respiratory compromise after adenotonsillectomy. Gerber *et al.* [41] showed that the risk of respiratory compromise significantly increased in patients younger than 3 years, and in those who had neuromuscular disorders, chromosomal abnormalities, or an upper respiratory tract infection within 4 weeks of surgery. Blum and McGowan [42] concluded in their review that history of prematurity, significant neurological or neuromuscular disease, and echocardiographic evidence of pulmonary hypertension increased the risk.

Enlarged lingual tonsils was found to contribute to persistent obstructive sleep apnea after adenotonsillectomy and was found to be more prevalent in patients with Down syndrome [43]. Mallampati scale score of 3 or 4, retroposition of the mandible, enlargement of nasal inferior turbinate, and deviated nasal septum, were associated with persistent abnormal sleep study after adenotonsillectomy [44].

WHICH PATIENTS ARE SUITABLE FOR AMBULATORY SURGERY?

Children with OSAS documented in the results of polysomnography should be admitted for inpatient, overnight monitoring if they are under the age of 3 years or have severe OSAS (apnea-hypopnea index of 10 or more events per hour, oxygen desaturation nadir less than 80%, or both). In addition, children with comorbidities listed below are not candidates for ambulatory surgery. According to the American Academy of Pediatrics clinical practice guidelines, children with OSAS are at a high risk for postoperative complications following adenotonsillectomy if they have any of the following conditions [45]:

(1) cardiac complications of OSAS (e.g., right ventricular hypertrophy);
(2) craniofacial disorders;
(3) neuromuscular disorders;
(4) cerebral palsy;
(5) Down syndrome;
(6) failure to thrive;
(7) morbid obesity;
(8) prematurity;
(9) sickle cell disease;
(10) central hypoventilation syndromes;
(11) genetic/metabolic/storage disease; and
(12) chronic lung disease.

CONCLUSION

Although recent practice guidelines regarding preoperative fasting in healthy children are well established, interpersonal variation in the gastric volume can be significant. Smooth induction of anesthesia and vigilance are of utmost importance to prevent complications related to pulmonary aspiration. As a growing population of patients with OSAS is managed on an ambulatory basis, new selection criteria are being established. Multimodal opioid-sparing analgesia decreases perioperative respiratory complications. New surgical techniques and pharmacologic agents to decrease morbidity and improve outcomes are evolving. These new advances will continue to ensure that pediatric patients can be managed safely and efficiently in ambulatory centers.

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Conflicts of interest

There are no conflicts of interest.

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