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Fast-tracking Pediatric Ambulatory Anesthesia: Challenges and Controversies

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The Upper Respiratory Tract Infection Dilemma

Most anesthesiologists agree that the presence of an acute purulent upper respiratory tract infection (URI), fever or any symptomatology of a lower respiratory infection would be sufficient grounds to postpone an elective surgical procedure. However, the child with a nonpurulent active or recent URI (within 4 weeks) nearly always presents a conundrum even for the most experienced anesthesiologists.

It has been documented that 20-30% of all children have a runny nose a significant part of the year. In the preanesthetic evaluation we must rely on history, physical, and occasionally laboratory data to decide whether to proceed with the anesthetic. A differential diagnosis of a child with a runny nose should include:

Noninfectious causes
- Allergic Rhinitis: Seasonal, perennial
- Vasomotor Rhinitis: Emotional (crying), temperature

Infectious Causes
- Viral infections
  - Nasopharyngitis (common cold)
  - Flu syndrome (upper and lower respiratory tract)
  - Laryngotracheal bronchitis (infectious croup)
- Viral exanthems
  - Measles
  - Chicken pox
- Acute bacterial infections
  - Acute epiglottitis
  - Meningitis
  - Streptococcal tonsillitis

Previous studies have shown that children with a URI, particularly those less than 1 year of age, have an increased risk of respiratory related adverse events intraoperatively and postoperatively.[1,2] Also symptomatic infants with a URI have decreased time to desaturation during apnea.[2] Endotracheal intubation (ETT) has been shown to be a major risk factor for hypoxemia, bronchospasm and atelectasis in children with a URI.[1-3] Temporary airway hyperactivity is known to exist for 6 weeks after a viral infection.[4]

One recent study looked at 2051 children of which 22.3% had symptoms of URI on the day of surgery, 45.8% had a "cold" in the preceding 6 weeks and 30% were asymptomatic controls.[5] Forty of the 2051 children did not proceed to anesthesia and surgery on the basis of the preanesthetic consult. The nonanesthetized children were more likely to have runny nose, cough, wheezing, malaise and fever and were said to have a cold by the parents. There is some bias in this study first because the policy in this hospital is to reschedule elective cases with a URI if they are under 12 months of age and require intubation and the second bias is the use of anesthesiologists to record adverse events occurring during anesthesia rather than an independent observer who was blinded to the patients perioperative condition.

Significant patient predictors were parental confirmation of the child's URI symptoms, presence of nasal secretions, history of snoring, passive smoke exposure and sputum production. As far as anesthetic risk factors, choice of airway management was identified as an independent risk factor for postoperative adverse events, specifically the risk was higher with ETT than with LMA or face mask use respectively.

Thiopental for induction was associated with the highest probability of an adverse event followed by

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TRANSFORMING PATIENT SAFETY THROUGH EDUCATION AND ADVOCACY

halothane and sevoflurane with propofol having the lowest probability. Propofol depresses laryngeal reflexes and may decrease airway responsiveness by relaxation of bronchial smooth muscle.[6,7] The administration of neostigmine was the final predictor. Children who had muscle relaxants reversed had a lower probability of an adverse event than those who did not. Residual neuromuscular blockade may have subtle effects on outcomes and atropine administration with neostigmine may have the beneficial effect of decreasing secretions.

In conclusion, this study suggests children whose parents say they have a cold, who are snorers, passive smokers, have nasal congestion or a productive cough have a higher risk of anesthetic complications. Intubation increases the risk of complications and with LMA or face mask use the probability is decreased. Propofol is the safest intravenous induction agent and muscle relaxants should always be reversed. It is prudent to cancel non-urgent surgery if the patient wheezes, is febrile, is suffering malaise or if the child is very young (<1 year of age).

In a prospective study with 1078 patients comprising roughly equal thirds having active URI symptoms, recent URI symptoms within the previous 4 weeks, or no URI symptoms, respiratory adverse events were most prevalent in the active URI group.[8] There was also a significantly higher incidence of desaturation in both the active (15.7%) and recent (14.7%) URI groups versus the non-URI group. There was no statistically significant difference in the incidence of bronchospasm or laryngospasm between groups. In this study only nine of 407 patients (2.2%) with an active URI confirmed by the parent required succinylcholine for management of laryngospasm, and only three children – one with a recent URI and two with active URIs – required unanticipated admission to hospital.

By employing logistic regression[8] in 1078 children with active, recent or no URI symptoms, patient risk factors associated with adverse outcomes included copious secretions (P=0.0001), ex-premature infants (P=0.007), nasal congestion (P=0.014), parental smoking (P=0.018), and reactive airway disease (P=0.028). ASA status did not correlate with adverse outcomes.

The specific role age plays in the presence of URI has not been elaborated in all studies, but this study[6] showed that infants less than 6 months old with active URIs had a higher incidence of bronchospasm (20.8% versus 4.7%, P=0.08) than older children. This same study also showed that children under 2 years old had a higher incidence of oxygen desaturation than older children (21.5% versus 12.5%, P=0.023).

Anesthetic risk factors identified ETT in children under 5 years of age as an independent risk factor for postoperative respiratory adverse events (P=0.0002).[8] Of note, duration of anesthesia and awake versus deep extubation were not identified as risk factors. Children with active URIs had the lowest incidence of problems when induced and maintained with sevoflurane. There was a high incidence of adverse respiratory events in children undergoing airway surgery eg. tonsillectomy and adenoidectomy, direct laryngoscopy and bronchoscopy in all 3 groups.

The conclusions of this study were children with active and recent URI's (within 4 weeks) are at increased risk for adverse respiratory events particularly if they have a history of reactive airway disease, require surgery involving the airway, have a history of prematurity, are exposed to environmental tobacco smoke, have nasal congestion or copious secretions or require placement of an endotracheal tube.

Schreiner found URIs a predictor of increased risk of laryngospasm[9] while by Tait and Knight's definition it was not.[10,11] Risk of laryngospasm has been found to be 10 fold higher in children exposed to tobacco smoke.[12] Children with a URI within 30 days prior to surgery had a 2.3 fold higher risk of laryngospasm.[13] Comparison of ETT with laryngeal mask airway (LMA) use in children with a URI showed a significant lower incidence of mild bronchospasm, major desaturation events (oxygen saturation < 90%) and overall respiratory events with LMA use.[14] The incidence of laryngospasm was equal.

A study in 831 children (27% of whom presented with a recent URI within the last 2 weeks before anesthesia) demonstrated that LMA use in children with a recent URI was associated with a higher incidence of laryngospasm, cough and oxygen desaturation compared with healthy children. However, if anesthesiologists allow a 2 week interval after a URI, the use of an LMA was confirmed to be a safe technique.[15]

In 20 children age 1-6 undergoing elective surgery with tracheal intubation those with either a respiratory tract infection in the past 2 weeks before surgery or asthma had an increase in airway resistance with desflurane as opposed to sevoflurane or propofol, questioning the use of desflurane in children with airway susceptibility.[16]

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ANESTHESIOLOGY 2012
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In afebrile ASA I or II children having either a URI within 6 weeks or an active URI disease undergoing noncavitary, nonairway surgery for less than 3 hours, pretreatment with bronchodilators prior to anesthesia (either inhaled ipratropium or albuterol) showed no decrease in adverse airway events.[17] A more recent article showed preoperative salbutamol in children with a recent URI (≤2 weeks) decreased the incidence of laryngospasm, bronchospasm, oxygen desaturation (<95%) and severe coughing with LMA or endotracheal tube use.[18]

In a risk assessment study, URI was associated with an increased risk for perioperative respiratory adverse events only when symptoms were present or less than 2 weeks before the procedure.[19] However, in another study assessing risk factors for adverse events in children with colds emerging from anesthesia a correlation with respiratory adverse events occurred if peak URI symptoms have occurred within the preceding 4 weeks.[20]

There is risk to anesthesia even in children without URIs. The child with a URI has an increased risk for laryngospasm, bronchospasm, desaturation and postintubation croup especially if someone in the home smokes. Not all children with a URI should be anesthetized but careful consideration should be given to severity of presenting symptoms, a patients respiratory history, need for endotracheal intubation, choice of anesthetic agent and the anesthesiologists overall comfort with anesthetizing children with URIs.

We must wait 4-6 weeks to decrease these risks as compared to the normal child. We can tailor our anesthetic to decrease these risks (propofol, LMA or face mask instead of ETT) but they cannot be reduced to zero. Good judgment, common sense, clinical experience and informed consent of parents must be used when deciding whether to cancel or proceed and discussions should be documented in the chart.

Obstructive Sleep Apnea

Sleep apnea is a sleep-related breathing disorder in children characterized by a periodic cessation of air exchange, with apnea episodes lasting >10 seconds and an apnea/hypopnea index (AHI) – total number of obstructive episodes per hour of sleep >5.[21] Air flow cessation is confirmed by auscultation or oxygen desaturation <92%. Types of sleep apnea include central (absent gas flow, lack of respiratory effort), obstructive (absent gas flow, upper airway obstruction and paradoxical movement of rib cage and abdominal muscles) and mixed (due to both CNS defect and obstructive problems). Diagnosis is made by clinical assessment (a history of snoring and restless sleep), nocturnal pulse oximetry or polysomnography studies (PSG).

Obstructive sleep apnea syndrome (OSAS) is manifest by episodes that disturb sleep and ventilation. These episodes occur more frequently during REM sleep and increase in frequency as more time is spent in REM sleep periods as the night progresses. OSAS occurs in children of all ages (about 2% of all children) but more commonly in children 3-7 years of age. It occurs equally among boys and girls but the prevalence may be higher in African American individuals.[22] Childhood obesity is increasing in modern societies and OSAS is increased in children with obesity. Signs of OSAS are sleep disturbances (including daytime sleepiness), failure to thrive from poor intake due to tonsillar hypertrophy, speech disorders, and decreased size (decreased growth hormone release during disturbed REM sleep). This syndrome can cause significant cardiac, pulmonary and CNS impairment due to chronic oxygen desaturation. In children with OSAS and morbid obesity the incidence of hypertension and diabetes are seen at much higher rates. Therefore it is important that prior to surgery that the cardiovascular status be evaluated in this group of children. Although right ventricular dysfunction is classic, biventricular hypertrophy can develop. It is more likely to be seen in patients with severe OSAS but has been reported in patients with only mild OSAS.[23] Pulmonary vasoconstriction can increase pulmonary vascular resistance with resultant decrease in cardiac output due to cor pulmonale. Relief of the tonsillar/adenoidal obstruction can reverse many of these problems and prevent progression of others (pulmonary hypertension and cor pulmonale). Cardiac evaluation is recommended for any child with signs of right ventricular dysfunction, systemic hypertension or multiple episodes of desaturation below 70%. Electrocardiogram and chest radiograph are not sensitive tools; echocardiography is recommended.[24]

Patients that are at high risk for postoperative upper airway obstruction after tonsillectomy and/or adenoidectomy for OSAS include age < 2 yr, craniofacial anomalies, failure to thrive, hypotonia, morbid obesity, previous upper airway trauma, cor pulmonale, a polysomnogram with a respiratory distress index (RDI) > 40 or O_2 saturation nadir <70% or patients undergoing an additional uvulopalato pharyngoplasty (UPPP).[25] If upper airway

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obstruction occurs postoperatively in these patients, nasal CPAP/BIPAP should be considered as a therapeutic intervention.[25]

The American Academy of Pediatrics Clinical Practice Guidelines[22] give the following recommendations for inpatient monitoring in patients at high risk for postoperative complications that have OSAS and are undergoing adenotonsillectomy. These include:

Age younger than 3 years
Severe OSAS on polysomnography
Cardiac complications of OSAS (eg right ventricular hypertrophy)
Recent respiratory infection
Craniofacial disorders
Neuromuscular disorders
Cerebral palsy
Down syndrome
Failure to thrive
Obesity
Prematurity
Sickle cell disease
Central hypoventilation syndromes Genetic/metabolic/storage disease
Chronic lung disease

As far as outpatient surgery for adenotonsillectomy in patients with OSAS, children age 1-18 years without underlying medical conditions, neuromuscular disease or craniofacial abnormalities with mild sleep apnea (<15 obstructive events per hour) will have improvement of their airway obstruction documented by polysomnography the night of surgery and do not need to be monitored intensively. In these patients a smaller number of obstructive events and fewer severe oxygen desaturations occurred on the operative night.[26] Based on this and other studies it is possible to consider discharge to home for children age 3-12 years if they meet these criteria. However, in children with severe obstructive sleep apnea (AHI >16.4 events/hr, SaO_2 <85%) obstructive events occurred more frequently on the first night after adenotonsillectomy suggesting overnight monitoring with pulse oximetry is indicated.[27]

OSAS patients with preoperative nocturnal oximetry oxygen saturation of 80% or less had an increase from 20% of postoperative respiratory complications to 50%. Usually these children were younger (<2 years) and had an associated medical condition.[28] Sixty percent of OSAS patients requiring urgent adenotonsillectomy had postoperative respiratory complications. Risk factors for respiratory complications were again an associated medical condition and preoperative nocturnal oxygen saturation nadir less than 80%. Atropine administration at induction decreased the risk of postoperative respiratory complications. There was an 11.1% incidence of reintubation and a 9.3% incidence of postoperative pneumonia in this urgent adenotonsillectomy group.[29]

Children with severe OSAS who had adenotonsillectomy in the morning were less likely to have postoperative desaturation than those who were operated in the afternoon.[30] The shortened time interval between postoperative morphine dosing and bedtime may contribute to the incidence of postoperative desaturation because of an exaggerated respiratory depressive response to opioids which has been reported in children with severe OSAS.[31] There is a strong possibility that the combination of opioids and sleep promote desaturation in these patients.

Children with OSAS in general may have a diminished ventilatory response to CO_2 rebreathing compared with normal children.[32] Therefore drugs known to cause ventilatory depression (sedative hypnotics, anxiolytics, narcotics and inhaled agents) must be used judiciously in these patients as they may be more sensitive to their effects. Preoperative administration of midazolam 0.5 mg/kg in 70 children undergoing adenotonsillectomy for OSAS (diagnosed as severe in 40% of subjects by polysomnography) resulted in 2 children having respiratory events; one had a self limited desaturation event before surgery and one had a postoperative obstruction with desaturation requiring a nasal airway.[33] Patients with OSAS can receive sedatives but require monitoring.

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ANESTHESIOLOGY 2012
TRANSFORMING PATIENT SAFETY THROUGH EDUCATION AND ADVOCACY

During inhalational induction of anesthesia, children with OSAS are at a high risk for airway obstruction due to relaxation of the genioglossus muscle. Positioning in an upright or lateral position, use of jaw thrust maneuver, delivery of positive pressure by face mask and placement of an oral airway may aid in relieving the obstruction.[34,35] Once anesthesia is induced and intravenous access is established, a single dose of IV propofol 1.5-2 mg/kg (lean body weight) may facilitate tracheal intubation.[36]

Children with OSAS usually need pain medication after surgery yet chronic hypoxemia renders them more susceptible to the respiratory depressant effects of opioids.[37,38] Younger aged patients or those with preoperative nocturnal oxygen saturation less than 85% had reduced morphine requirement possibly due to up-regulation of central opioid receptors consequent to recurrent hypoxemia.[39] Children whose minimum nocturnal saturation was less than 85% required one half of the dose of opioids for similar pain scores after T & A surgery compared with children whose minimal saturation was 85% or greater.[40]

One technique for opioid administration is that after tracheal intubation and spontaneous ventilation is restored, small incremental aliquots of IV morphine (10-20 ug/kg) or fentanyl (0.2-0.5 ug/kg) can be administered. If apnea occurs after the first aliquot of opioid, the child may be considered opioid sensitive. If they continue to breathe additional increments up to the standard total dose of 50-100 ug/kg of morphine can be administerd.[36] Drugs for pain management to decrease opioid use include ketamine 0.1 mg/kg[41] IV, or peritonsillar infiltration of ketamine 0.5 to 1 mg/kg given 3 minutes before surgery[42], dexamethasone 0.0625-1 mg/kg (maximum 25 mg) with an average dose of 0.5 mg/kg and IV acetaminophen 15 mg/kg (maximum 75 mg/kg/d, children 2-12 years).[43-45]

Concern over dexamethasone use in tonsillectomy patients in respect to postoperative bleeding was raised in an article that compared three doses of dexamethasone 0.05 mg/kg, 0.15 mg/kg and 0.5 mg/kg. The primary objective was a decrease in nausea and vomiting and the secondary objective was postoperative analgesia. Regardless of the dose, children who received dexamethasone needed less rescue analgesia and antiemetics, however the larger dose 0.5 mg/kg was associated with the highest decrease in postoperative nausea and vomiting (PONV). Of concern was that both the 0.5 mg/kg dose and the 0.05 mg/kg dose of dexamethasone were associated with a higher incidence of postoperative bleeding. The problem with this study was the lack of standardization of surgeon, surgical technique and use of nonsteroidal antinflammatory drugs. This study has too many flaws to change the practice of giving dexamethasone to tonsillectomy patients and needs to be repeated with bleeding as a primary outcome in relation to dexamethasone use.[46] In a more recent retrospective review of 2788 children age 2-18 undergoing tonsillectomy were given either 0.5 mg/kg or 1.0 mg/kg of dexamethasone. The study was adjusted for age, sex, primary diagnosis (sleep related disorder and infectious tonsillitis) and surgical technique, either extracapsular electrosurgical tonsillectomy, extracapsular radiofrequency ablation tonsillectomy or intracapsular microdebrider tonsillotomy. Perioperative dexamethasone administration was not associated with a dose dependent elevation of postoperative hemorrhage.[47] A recent Cochrane review of 19 randomized placebo controlled, double blinded studies conclude 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 hours and had less pain than the placebo group.[48]

A recent report of adenotonsillectomy for children who demonstrated recurrent episodes of profound hypoxemia (<80% saturation) during the perioperative sleep study demonstrated that a decrease in major medical respiratory interventions by >50% was accomplished by administration of dexamethasone 0.3 mg/kg (maximum 10 mg) and the titration of morphine 0.02 mg/kg.[49]

Nonsteroidal anti-inflammatory drugs (NSAIDS) have been avoided in post-tonsillectomy patients because of reports of association postoperative bleeding. However, a systematic review did not find an increased risk of reoperation for bleeding and found less vomiting when NSAIDS were part of an analgesic regimen.[50] The use of NSAIDS after attainment of hemostasis is reasonable.[51]

Emergence delirium may be decreased with a single IV bolus dose of dexmedetomidine 0.5 ug/kg given 5 minutes before the end of surgery thus providing a smoother transition to the post anesthesia care unit.[52] A prospective study of 122 patients, age 2-10 years undergoing tonsillectomy with sevoflurane anesthesia received IV dexmedetomidine 2 ug/kg over 10 min followed by 0.7 ug/kg/hr and were compared to a group receiving IV fentanyl 1 ug/kg. The dexmedetomidine group needed less rescue analgesics with fentanyl, had a lower heart rate

and systolic blood pressure and also required less morphine in their postoperative period. Severe emergence agitation on arrival to PACU was lower and the duration was shorter in the dexmedetomidine subjects.[53]

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 intensive care unit admission is reserved for very severe OSAS, very young children, morbid obesity (BMI >40) and those with comorbidities that cannot be managed in a regular unit.[54] Asthma is also associated with an increased risk of respiratory complications after adenotonsillectomy and these children may need a higher level of monitoring postoperatively.[55] Patients with mild to moderate obstructive disease (AHI <10) and no comorbidities can usually be discharged home the same day if they are greater than 3 years of age.

However, there have been fatalities reported in children with OSAS given oral codeine for pain management at home. These children may be part of a group of extensive or ultra rapid metabolizers that have a greater production of potent morphine from its parent drug codeine. The genetic pattern occurs in 1-10% of individuals of European descent but up to 30% of North African descendants and must be considered with codeine use.[56]

Although the respiratory distress index improves in children with severe sleep apnea and in obese children with OSAS after adenotonsillectomy, OSAS may not resolve in the majority of these children. In addition, enlarged lingual tonsils were found to contribute to persistent OSAS after adenotonsillectomy in children and was found to be more prevalent in patients with Down syndrome.[57] It is important to realize that these children may have increased anesthetic risk and need special care if they return for other surgeries.

What is the Youngest Age Appropriate for Outpatient Surgery?

Apnea Risk

There is little specific evidence of the risk of apnea in full term infants. There are facilities that feel comfortable performing outpatient surgeries if the infant is born at greater than 37 weeks gestational age. However, other ambulatory centers prefer to wait until the infant is 2-4 weeks of age to ensure decreased physiologic jaundice, decreased pulmonary vascular resistance and to give time for the ductus arteriosus to close. As far as sudden infant death syndrome (SIDS) there is no evidence anesthesia increases the risk.[58] However, if the patient has a sibling with a history of SIDS or if the mother has abused drugs in her pregnancy the risk increases many fold. The infants whose histories suggest a high risk for SIDS should be monitored closely for a longer perioperative period.

In the premature infant apnea is more likely to occur as well as other airway complications such as atelectasis, aspiration pneumonia, stridor and coughing with desaturation in infants undergoing inguinal herniorrhaphy.[59] The best evidence based data is found in Cote's[60] combined analysis of 255 preterm infants undergoing inguinal herniorrhaphy under general anesthesia. Apnea was defined as >15 seconds without bradycardia or <15 seconds when accompanied by bradycardia. Apnea was strongly and inversely related to both gestational age (GA) and post conceptual age (PCA), continuing apnea at home and anemia (<10 gm/dl). In the nonanemic infant with a GA of 32 weeks and a PCA of 56 weeks or with a GA of 35 weeks and a PCA of 54 weeks, the probability of apnea was less than 1%.

Caffeine has been shown to decrease the risk of apnea in preterm infants undergoing general anesthesia. In 32 preterm infants (37-44 weeks post-conceptual age) who received IV caffeine 10 mg/kg or placebo – the caffeine group had no postoperative bradycardia, prolonged apnea, periodic breathing or postoperative oxygen saturation <90% while 81% of the patients in the control group had prolonged apnea at 4-6 hours postoperatively.[61] A systematic review supported the evidence that caffeine administration reduces apnea risk.[62]

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ANESTHESIOLOGY 2012
TRANSFORMING PATIENT SAFETY THROUGH EDUCATION AND ADVOCACY

Anesthetic Technique

Spinal anesthesia alone has been shown to have a lower incidence of postoperative apnea and bradycardia in former premature infants when compared to spinal plus sedation or general anesthesia.[63] Also a decreased incidence of oxygen desaturation and bradycardia has been seen.[64] Central apnea was not reduced – so obstructive apnea may play a role with sedation or general anesthesia.[65] Spinal anesthesia may be indicated in high risk infants. A Cochrane review that was based on evaluating all the previous trials (which actually included only 108 patients) stated there is not enough evidence to show whether or not spinal anesthesia improves outcomes for a preterm baby having surgery for inguinal hernia and that a large well designed randomized control trial is needed.[66] Still the chance for cardiopulmonary events are increased in these infants and the same postoperative monitoring as for general anesthesia is indicated.[67,68]

Patients less than 60 weeks post conceptual age for hernia repair had shorter times to extubation with no postoperative apnea after thiopental or halothane induction with desflurane maintenance than either halothane or sevoflurane for the entire anesthetic.[69] Avoidance of opioids where possible, using regional anesthetic techniques and nonopioid systemic analgesics such as acetaminophen and nonsteroidal anti-inflammatory agents may decrease the risk of apnea.

Recommendations

The recommendation for outpatient surgery in infants born before 37 weeks may be 50-52 weeks PCA as long as there is no anemia, on going apnea or coexisting disease, if a risk of apnea in 5% of the patients is accepted. However, looking at the evidence based literature to decrease the risk of apnea to <1%, patients should be greater than 54 weeks PCA without anemia, ongoing apnea or other significant medical problems. Recent recommendations are that infants with a PCA of less than 46 weeks should be admitted for continuous monitoring for at least 12 h postoperatively. In infants with a PCA between 46 and 60 weeks with a history of apnea at home, chronic lung disease, neurological disease or anemia, 12 h of respiratory monitoring is recommended. The otherwise healthy infant in this PCA group should be monitored for 6 h postoperatively.[70] Postoperative monitoring recommendations should include oxygen saturation, heart rate and impedance pneumography and that the infants are apnea free before discharge.

Caffeine or spinal anesthesia may decrease the risk of apnea but patients should not be discharged if they are not eligible for anesthesia on an outpatient basis by the previously stated criteria. Full term infants are acceptable for outpatient procedures provided that they are otherwise healthy and the procedure is not likely to result in significant physiologic changes or postoperative pain requiring opioid medication and the anesthetic is uneventful. Even in term infants some facilities will not allow outpatient surgery until they are 44-46 weeks post conceptual age or may require longer observation if younger e.g. 4 hours.

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American Society of Anesthesiologists
ANESTHESIOLOGY 2012
TRANSFORMING PATIENT SAFETY THROUGH EDUCATION AND ADVOCACY

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