Death or Neurologic Injury After Tonsillectomy in Children with a Focus on Obstructive Sleep Apnea: Houston, We Have a Problem!

Charles J. Coté, MD,* Karen L. Posner, PhD,† and Karen B. Domino, MD, MPH†

BACKGROUND: Obesity is epidemic in the United States and with it comes an increased incidence of obstructive sleep apnea (OSA). Evidence regarding opioid sensitivity as well as recent descriptions of deaths after tonsillectomy prompted a survey of all members of the Society for Pediatric Anesthesia regarding adverse events in children undergoing tonsillectomy.
METHODS: An electronic survey was sent to 2377 members of the Society for Pediatric Anesthesia. Additionally, data from the American Society of Anesthesiologists Closed Claims Project were obtained. Adverse events during or after tonsillectomy with or without adenoidectomy in children were included. Children at risk for OSA were identified as either having a positive history for OSA or a post hoc application of the American Society of Anesthesiologists OSA practice guidelines. These children were compared with all other children by Fisher exact test for proportions and *t* test for continuous variables.
RESULTS: A total of 129 cases were identified from the 731 replies to the survey, with 92 meeting inclusion criteria for having adequate data. Another 19 cases with adequate data were identified from the 45 from the American Society of Anesthesiologists Closed Claims Project. A total of 111 cases were included in the final analysis. Death and permanent neurologic injury occurred in 86 (77%) cases and were reported in the operating room, postanesthesia care unit, on the ward, and at home. Sixty-three (57%) children fulfilled American Society of Anesthesiologists criteria to be at risk for OSA. Children categorized as at risk for OSA were more likely than other children to be obese and to have comorbidities ($P < 0.0001$). A larger proportion of at risk children had the event attributed to apnea ($P = 0.016$), whereas all others had a larger proportion of events attributed to hemorrhage ($P = 0.006$).
CONCLUSIONS: Deaths or neurologic injury after tonsillectomy due to apparent apnea in children suggest that at least 16 children could have been rescued had respiratory monitoring been continued throughout first- and second-stage recovery, as well as on the ward during the first postoperative night. A validated pediatric-specific risk assessment scoring system is needed to assist with identifying children at risk for OSA who are not appropriate to be cared for on an outpatient basis. (Anesth Analg 2013;XX:XX–XX)

One of the most frequent indications for tonsillectomy in children is for management of sleep-disordered breathing due to airway obstruction.[1–4] Sleep-disordered breathing and obstructive sleep apnea (OSA) are often associated with obesity, which has become pandemic.[5–7] With the need to preserve medical resources, increasing numbers of procedures are conducted on an outpatient basis; this has created the perfect storm where children may be incompletely assessed before their anesthetic and cared for as an outpatient with inadequate postoperative observation. This is of particular concern with the opioid sensitivity reported in children with OSA, i.e., what would be considered a normal dose of opioid may be a relative overdose in OSA children.[8]

The American Society of Anesthesiologists (ASA) proposed practice guidelines and a risk identification scoring system to assess potential OSA patients who may require more extensive postanesthesia observation.[9] Likewise, pediatric otolaryngologists published guidelines regarding the need for increased vigilance.[10] Unfortunately, some children have died or suffered neurologic injury as a result of apnea after tonsillectomy. We conducted a 2-stage investigation: (1) a survey of members of the Society for Pediatric Anesthesia and (2) a query from the ASA Closed Claims Project to investigate factors associated with adverse events in children undergoing tonsillectomy.

METHODS

An anonymous electronic survey (Partners Human Research IRB exemption, Protocol #2010-P-002757/1; Massachusetts General Hospital, Boston, MA) was e-mailed to members of the Society for Pediatric Anesthesia (1995 active, 34 affiliates, 102 fellows, 106 residents, 22 retired, and 118 international). Two rounds of follow-up surveys were sent at 2-month intervals, including an added question which asked if the first survey was completed, so as to exclude duplicates.

From the *Department of Anesthesia, Critical Care, and Pain Medicine, Harvard Medical School/The MassGeneral Hospital for Children, Boston, Massachusetts; and †Department of Anesthesiology and Pain Medicine, University of Washington, Seattle, Washington.

Accepted for publication March 25, 2013.

Funding: Supported in part by the American Society of Anesthesiologists (ASA), Park Ridge, IL. All opinions expressed are those of the authors and do not reflect the policy of the ASA.

The authors declare no conflict of interest.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.anesthesia-analgesia.org).

Reprints will not be available from the authors.

Address correspondence to Charles J. Coté, MD, Department of Anesthesia and Critical Care, The MassGeneral Hospital for Children, 55 Fruit St., Boston, MA 02114. Address e-mail to cjcote@partners.org.

DOI: 10.1213/ANE.0b013e318294fc47

In addition, a formal query was conducted using the ASA Closed Claims Project database (University of Washington IRB #21618 and #43939; written patient consent waived by IRB) for cases involving otolaryngology procedures from 1990 to 2011. Summaries of 45 cases were compared with survey cases (age, gender, year of event, cause of event) to identify possible duplicates from the 2 data sources.

Inclusion criteria for electronic survey cases were those in which a child died or nearly died after tonsillectomy. Inclusion criteria for case selection from the ASA Closed Claims Project were tonsillectomy or tonsillectomy with adenoidectomy with death or adverse event due to surgical hemorrhage or adverse anesthetic event, or with death or adverse event at home or in hospital. Cases with inadequate information were excluded.

Definition of Variables

The ASA's Practice Guidelines for the Perioperative Management of Patients with Obstructive Sleep Apnea[9] (Appendix 1, see Supplemental Digital content 1, http://links.lww.com/AA/A550) was used to categorize children potentially at risk for OSA from survey reports and the ASA Closed Claims Project unless they were already labeled as having OSA by the surgeon, family, or anesthesiologist; factors such as obesity (≥95th percentile for age using standard gender-specific growth curves) + history of snoring + 1 other risk factor fulfilled our interpretation of the ASA OSA criteria. If a child's weight was provided, we used standard growth curves to determine that the child was ≥95th percentile for age and gender. Children whose ASA OSA risk score was ≥5 were categorized as at risk for OSA for comparison with "all others," i.e., children judged not to be at risk for OSA.

Events were classified as surgical, anesthesia, or nursing related. All events reported as hemorrhage were considered surgical. Postextubation respiratory events or events during the conduct of anesthesia were attributed to anesthetic management. If an event occurred in the postanesthesia care unit (PACU) or on the floor that was attributed to apnea, this was classified as a PACU or floor nursing observation problem.

Statistical Methods

At risk for OSA cases were compared with all others by Fisher exact test for proportions and t test for age using Levene test for equality of variances. For cross-tabulation tables with any cell having an expected value <5, P-values were calculated by Monte Carlo calculations using 10,000 random tables. For cross-tabulation tables with >4 cells and a distribution achieving statistical significance, post hoc Fisher exact test was performed on reduced 2 × 2 tables of the variables of interest (present/absent) between the 2 groups. For all statistical tests, a P value of <0.05 was considered statistically significant. Statistical calculations were conducted with SPSS version 18.0.3 (IBM, Chicago, IL).

RESULTS

Seven hundred thirty-one surveys were returned (approximately 30%) yielding 129 possible adverse events after tonsillectomy; 1 was a duplicate when compared with the Closed Claims cases and was therefore deleted, and there were 36 additional cases that had insufficient data; thus 92 surveys met inclusion criteria with adequate data for analysis. Since some surveys were incomplete, it is possible that we actually underestimated the magnitude of the injuries. The ASA Closed Claims query yielded 45 additional cases, of which 23 did not meet inclusion criteria due to surgical procedure (e.g., adenoidectomy without tonsillectomy). Three claims were excluded due to inadequate data, leaving 19 that met inclusion criteria and had adequate data for analysis. Thus 111 surveys/reports meeting inclusion criteria and with adequate data for interpretation (Fig. 1) formed the final cohort for analysis. These cases occurred in 1990 to

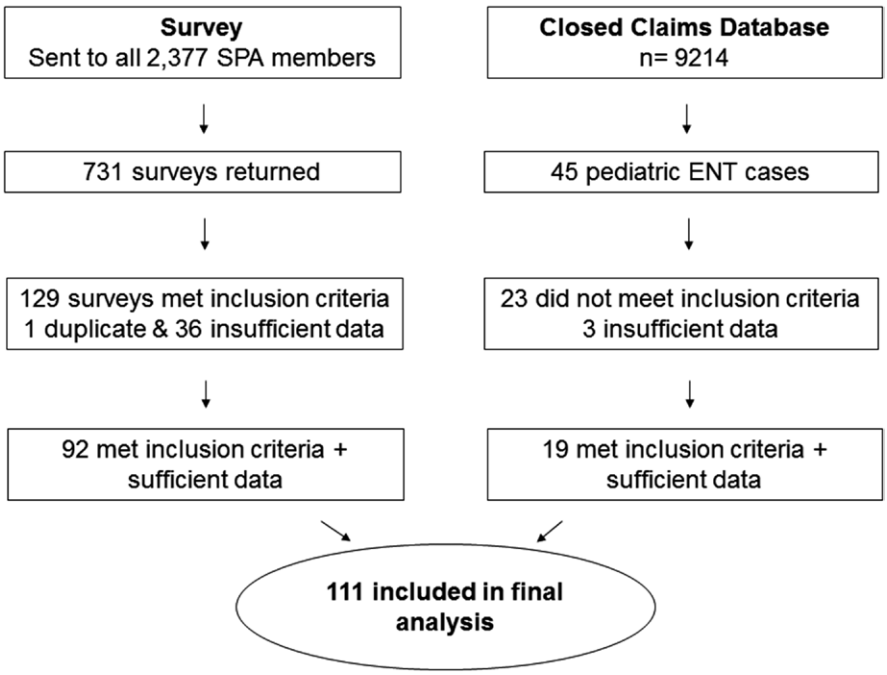

Figure 1. Scheme for source of cases and inclusion criteria for final analysis. ENT = ear, nose, and throat.

2010, with more than half of the cases occurring in 2004 or later. More than half (57%) of the children met criteria for at risk for OSA. Table 1 presents demographics, indications for surgery, and comorbidities. Half of the children were 4 to 8 years of age and another 27% were younger, with no difference in age between children at risk for OSA and all others (Table 1). At-risk children were more likely to be obese than other children ($P < 0.0001$, Table 1). Ethnicity was associated with the categorization of patients being at risk for OSA ($P < 0.0001$). Higher ASA physical status was also associated with patients categorized as being at risk for OSA ($P < 0.0001$, Table 1).

Death (66%) was the most common outcome, followed by permanent neurologic injury (11%), and prolonged hospitalization (10%, Table 2). A larger proportion of at risk for OSA children had the event attributed to apnea ($P = 0.016$) whereas all others had a larger proportion attributed to hemorrhage ($P = 0.006$, Fig. 2). The adverse events took place in a variety of locations (e.g., operating room, PACU, ward, after discharge) with no difference between children categorized as at risk for OSA versus all others (Table 2). When events occurred after surgery, approximately half (58% of all 80 postoperative events, 77% of 61 postoperative events with specific timing known) occurred within 24 hours of the procedure. Of the total 63 events that occurred within 24 hours of the procedure, 30 (48%) occurred after discharge from the hospital. There was no difference between children at risk for OSA or all others in the timing of postoperative adverse events. Among the 80 total cases with postoperative events, 40 (50%) were reported to have received postoperative opioids including 14 (61%) of the 23 children with postoperative apnea events that occurred within 24 hours postoperatively. There were 4 children who were reported to have received postoperative opioids and had an apnea event >24 hours after the procedure. Cases with an event in the operating room either due to anesthesia or surgical issues are described in Table 3.

There were 13 children who suffered an event in the PACU. Several of these were attributed to opioid overdose, 6 attributed to apnea, 1 attributed to aspiration of a blood clot, and 1 attributed to cardiac arrest without details provided. Two deaths occurred in the PACU after monitors were removed from the child. One 5-year-old child in a first-stage PACU who received morphine and midazolam to

Table 1. Patient Demographics

	Overall ($N = 111$)	Children at risk for OSA ($n = 63$)	All other children ($n = 48$)	P
Patient age ($n = 107$)[a]				0.354
Mean (SD)[a]	6.5 (4.2)	6.2 ± 3.9	7.0 ± 4.6	
Range[a]	1–19	1–17	2–19	
Age groups (y) ($n = 107$)[a]				0.544
1–3	29 (27%)	19 (31%)	10 (22%)	
4–8	53 (50%)	29 (48%)	24 (52%)	
9–12	13 (12%)	8 (13%)	5 (11%)	
13–19	12 (11%)	5 (8%)	7 (15%)	
Ethnicity				<0.0001
Caucasian	44 (40%)	19 (30%)	25 (52%)	
African American	26 (23%)	20 (32%)	6 (13%)	
Hispanic	14 (13%)	11 (17%)	3 (6%)	
Asian	3 (3%)	3 (5%)	0	
Other	4 (4%)	4 (6%)	0	
Not provided	20 (18%)	6 (10%)	14 (29%)	
ASA physical status ($n = 102$)[a]				<0.0001
ASA I	32 (31%)	7 (12%)	25 (60%)	
ASA II	47 (46%)	34 (57%)	13 (31%)	
ASA III	22 (22%)	18 (30%)	4 (10%)	
ASA IV	1 (1%)	1 (2%)	0 (0%)	
Indication for surgery				<0.0001
Obstructive sleep apnea	45 (41%)	45 (71%)	0 (0%)	
Recurrent tonsillitis plus airway obstruction or noisy breathing	26 (23%)	9 (14%)	17 (35%)	
Airway obstruction or noisy breathing	15 (14%)	9 (14%)	6 (13%)	
Recurrent tonsillitis	8 (7%)	0 (0%)	8 (17%)	
Not provided	17 (15%)	0 (0%)	17 (35%)	
Comorbidities				
Congenital syndrome	6 (5%)	4 (6%)	2 (4%)	0.697
Cardiac	3 (3%)	2 (3%)	1 (2%)	1.000
Pulmonary	10 (9%)	6 (10%)	4 (8%)	1.000
Seizures	2 (2%)	2 (3%)	0 (0%)	0.505
Bleeding diathesis	5 (4%)	3 (5%)	2 (4%)	1.000
Developmental delay	6 (5%)	4 (6%)	2 (4%)	0.697
Obesity	32 (29%)	29 (46%)	3 (6%)	<0.0001
Other	5 (4%)	4 (6%)	1 (2%)	0.387

Percentages based on $N = 111$ unless otherwise indicated.

OSA = obstructive sleep apnea.

[a]Cases with missing data excluded.

P-values by *t* test (age), χ^2 (age groups), Fisher exact test (individual comorbidities), and Fisher exact test with Monte Carlo significance calculated by 10,000 random tables for all other categorical variables.

Table 2. Outcome, Venue of Event, and Attributed Cause of the Event

	Overall (*N* = 111)	Children at risk for OSA (*n* = 63)	All other children (*n* = 48)	*P*
Outcome				0.035
Death	73 (66%)	42 (67%)	31 (65%)	
Permanent neurologic injury	13 (11%)	4 (6%)	9 (19%)	
Prolonged hospitalization	11 (10%)	6 (10%)	5 (10%)	
No harm	3 (3%)	1 (2%)	2 (4%)	
Not provided or unknown	11 (10%)	10 (16%)	1 (2%)	
Location of event				0.218
In the operating room	18 (16%)	9 (14%)	9 (19%)	
Postanesthesia care unit	13 (12%)	6 (10%)	7 (15%)	
On a ward	12 (11%)	9 (14%)	3 (6%)	
In an automobile	2 (2%)	0 (0%)	2 (4%)	
At home	53 (48%)	29 (46%)	24 (50%)	
Not provided or unknown	13 (12%)	10 (16%)	3 (6%)	
Attributed cause of event				0.018
Hemorrhage	31 (28%)	11 (17%)	20 (42%)[a]	
Apnea	40 (36%)	29 (46%)[b]	11 (23%)	
Other	17 (15%)	9 (14%)	8 (17%)	
Not provided or unknown	23 (21%)	14 (22%)	9 (19%)	

OSA = obstructive sleep apnea.
[a]Hemorrhage versus all other causes $P = 0.006$ by Fisher exact test.
[b]Apnea versus all other causes $P = 0.016$ by Fisher exact test.
P-values by χ^2 (cause of event) or Fisher exact test with Monte Carlo significance calculated by 10,000 random tables (all others).

treat emergence agitation was left in his father's arms without monitors and the father thought his child was sleeping. The second death was a 3 year old in a second-stage PACU without monitoring. The mother was reclining in the same stretcher as her child, and this parent also thought her child was sleeping. One child with known OSA was admitted overnight and discharged the following morning, but was found dead approximately 48 hours after surgery. Table 4 presents sample surgical, anesthesia or combined adverse events.

Comorbidities played an important role in some of these adverse outcomes. Two children who had Williams syndrome (supravalvular aortic stenosis, abnormal coronary vessels, pulmonary stenosis) died during the induction or emergence from anesthesia; it is unclear whether these children had an established preoperative diagnosis.

Surgical complications included a variety of problems including kinking of the tracheal tube with a Dingman retractor, laceration of the carotid vessel, and hemorrhage either immediately during the case or a number of days postoperatively. Some of the children who experienced hemorrhage were able to be rescued, whereas others either died at home, in the emergency room, or were unable to be rescued in the operating room. Our data did not seem to provide any time-based relationship for these hemorrhages, i.e., they did not occur at the classic first 4 hours after surgery or on day 5 when the eschar separates. Further data are presented for all cases in Appendix 2 (see Supplemental Digital Content 2, http://links.lww.com/AA/A551).

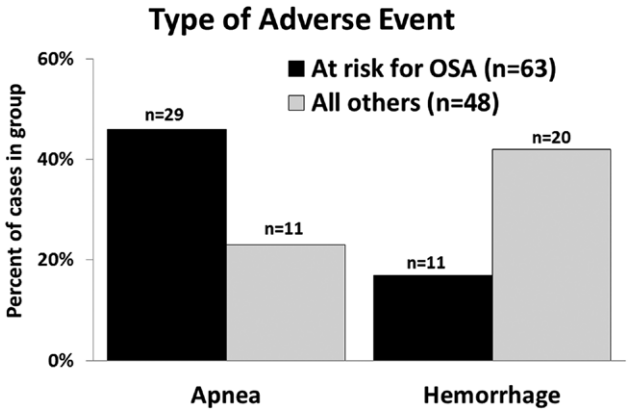

Figure 2. A larger proportion of at risk for obstructive sleep apnea (OSA) children had the event attributed to apnea ($P = 0.016$) whereas all others had a larger proportion of events attributed to hemorrhage ($P = 0.006$). *P*-values by Fisher exact test.

DISCUSSION

Perioperative deaths associated with tonsillectomy are thankfully uncommon.[11] The incidence of hemorrhage in our database (approximately 28%) is similar to the 3 reviews of otolaryngology-related malpractice cases.[12–14] However, the seemingly larger percentage of severe adverse outcomes (death and neurologic injury) in our database related to apparent respiratory events (36%) compared with these otolaryngology reports (17%) could, in part, be related to observer bias with anesthesiologists more likely to report respiratory events and surgeons to report hemorrhagic events. Importantly, apnea was reported in 29 of 63 children categorized as at risk for OSA; these outcomes occurred in the PACU, on the ward, and at home.

Tonsillectomy-related malpractice settlements occur against anesthesiologists more commonly than against surgeons and settle for nearly 5-fold larger awards because of the devastating outcomes.[12–14] Medication-related lawsuits reported inappropriate prescribing of opioids.[12] One report described 11 postoperative deaths or neurologic injuries due to airway-related events, including a number of respiratory arrests of unclear etiology;[13] these may have been related to opioid-induced apnea. Another review of adverse legal outcomes after tonsillectomy attributed approximately 17% of cases to postoperative medication issues.[14]

Table 3. Adverse Events That Occurred in the Operating Room

Problem	*n*	Event	Age (y)	Outcome
Anesthesia event	9	3 missed extubations	3, 4, 4	2 deaths, 1 not reported
		1 tracheal tube kink	5	Cardiac arrest but no harm
		1 esophageal misplacement	6	Death
		3 laryngospasms after extubation	3, 5, 12	2 deaths, 1 not reported
		1 laryngospasm in PACU, also intravascular injection of local by surgeon	5 5	Died 3 d later
Morbid obesity and unrecognized pulmonary hypertension due to OSA	1	Cardiac arrest on induction	15	Death Autopsy showed cardiac hypertrophy and evidence of pulmonary hypertension
Coagulopathy	1	Abnormal coagulation profile ignored by both anesthesiologist and surgeon; massive hemorrhage	3	No outcome reported
Sickle cell disease	1	Not transfused preoperatively; anoxic event possibly attributable to acute sickling	3	No harm
Unrecognized congenital heart disease Williams syndrome	2	One arrested and died on induction and the other on emergence from anesthesia	5, 6	Outcome not reported, 1 death
Duchenne muscular dystrophy	1	Arrested at the end of the case	6	Not reported
Extubated, obstructed, adenoid tissue in tracheal tube	1	Unable to clear airway	3	Neurologic injury
Transected carotid artery	1	Carotid tied off	6	Stroke followed by death
Return to OR with hemorrhage 2 d later	1	Unable to intubate	16	Death

OSA = obstructive sleep apnea; OR = operating room; PACU = postanesthesia care unit.

That article discussed abnormal cytochromes resulting in rapid metabolism of codeine to morphine as possibly contributory. Compression of an endotracheal tube by a mouth gag was also described, and this case was possibly 1 of the cases in our database. Anoxic intraoperative and postoperative events accounted for verdicts as large as $45 million.[14] Negligent postoperative care, negligent anesthesia care, and overprescribing of opioids were among the common allegations.

A 32-question survey similar to ours was recently conducted by the Patient Safety and Quality Improvement Committee of the American Academic of Otolaryngology—Head and Neck Surgery.[15] They reported 55 deaths or neurologic injury of which 40 were children. Six were attributed to bleeding, 9 to "med-narcotic," and 16 were described as unexplained cause; of the latter group, 1 was in hospital and the remaining 15 occurred out of hospital.[15] In the ear-nose-throat (ENT) survey, 8 pediatric deaths implicated opioid overdose including several that suggested the caregiver administering larger than prescribed doses or additional nonprescribed opioid medications. At least 2 cases in our study were also attributed to the administration of additional doses of medication than what was prescribed, thus these cases may be overlaps between the 2 surveys. Ten deaths reported in the ENT survey occurred in children with OSA. They found that "events unrelated to bleeding accounted for a preponderance of deaths and anoxic brain injury." Since the timing of these surveys overlapped, there is no way of knowing how many of these cases were also reported to us by anesthesiologists; however, the message is clear from both surveys: unexpected deaths are occurring at home after discharge from medical supervision.

These cases collected from surgeons and anesthesiologists emphasize the need for better procedures for assessing perioperative risks after tonsillectomy. In particular, those with the potential for OSA need better evaluations to allow the surgical/anesthesia team to improve the safety net. At present, a formal sleep polysomnogram is the very expensive "gold standard"; perhaps further study of the minimal cost McGill overnight oximetry test is needed.[16,17] This is a

Table 4. Sample Cases Describing Surgical and Anesthesia Adverse Events

Case	Narrative
Anesthesia event	3 year old was extubated, there was no blood pressure or oxygen saturation on arrival in PACU; the child died.
Anesthesia event	After extubation, a 3 year old developed laryngospasm, postobstructive pulmonary edema, required ECMO and died.
Possible rapid codeine metabolizer	A 9 year old was discharged after overnight observation and found dead that night, high morphine levels found; possible rapid codeine metabolizer.
Anesthesia event	A 4 year old developed apnea in PACU, was given multiple doses of naloxone, and discharged on codeine. Apnea spells occurred at home but the parents decided not to go to the hospital and he was found dead the next morning.
Surgical/anesthesia event	A 5 year old suffered cardiac arrest in the operating room due to kinking of tracheal tube by Dingman retractor; permanent neurologic injury resulted.
Nursing event	A 6 year old developed apnea and respiratory arrest 10 h after surgery on the ward with death as the outcome.
Anesthesia event	A morbidly obese 15-year-old 250-kg teenager arrested on induction of anesthesia; death.
Anesthesia/surgical event	An obese 2-year-old child with a positive OSA history was found dead at home 2 h after discharge. The child left with the grandmother's boyfriend while the mother and grandmother went shopping.
Anesthesia/surgical event	An 8-year-old obese child with a positive history for OSA spent the first night in the pediatric intensive care unit, was discharged home the next morning, and found dead that night.

PACU = postanesthesia care unit; ECMO = extracorporeal circulation membrane oxygenation; OSA = obstructive sleep apnea.

simple quantitation of desaturation nadir episodes based on a scale of 1 to 4 for events with hemoglobin saturations of <90%, <85%, and <80% during sleep.

Given that tonsillectomy is one of the most common outpatient surgical procedures performed in children (approximately 530,000 per year in children <15 years of age in the United States),[10,18] it is important to accurately assess the safety of outpatient surgery. Despite great performance pressure to efficiently operate and discharge patients, some children are not appropriate candidates for outpatient tonsillectomy.[9] The Subcommittee on Obstructive Sleep Apnea of the Section on Pediatric Pulmonology of the American Academy of Pediatrics[19] and the Clinical Practice Guideline for Tonsillectomy from the American Academy of Otolaryngology—Head and Neck Surgery both suggest that children with OSA and other medical/social issues "should be treated in an inpatient setting."[10]

Obesity, a history of OSA, and the need for postoperative opioid markedly increase the potential for adverse postoperative respiratory events. Children undergoing tonsillectomy may have a worsening of airway obstruction on the first night of surgery.[16,20] Additionally, children with severe OSA, who exhibit desaturation during a sleep study, may have a heightened analgesic and respiratory sensitivity to opioids (average requirements approximately 50% less than for children undergoing tonsillectomy for recurrent tonsillitis).[17,21,22] This opioid sensitivity may be related to hypoxia-induced opioid receptor regulation;[23,24] animal models have confirmed this observation.[25–27] Thus the standard dose of opioid may actually be an overdose in a child with OSA. Furthermore, there are increasing reports of children who are ultrarapid metabolizers of codeine (duplicated genes) which may accelerate its conversion to morphine and thus result in overdose.[28–32] Conversely, children who lack the cytochrome to convert codeine to morphine may not obtain any opioid analgesia and achieve their analgesia simply from the coadministration of acetaminophen.[33]

Obesity is epidemic and frequently associated with OSA.[1,3,5] Our data confirm this positive association and, unfortunately, also document preventable adverse outcomes. Some deaths were clearly related to less than ideal anesthetic management and/or poor surgical management. It is a major concern that 13 children experienced an event in the PACU either immediately on admission or within the first 3 hours; 10 children likely should have been rescued with more timely intervention. The subtleness and rapidity of the apnea in the 2 children who died in the PACU after monitors were removed emphasize the need for continuous monitoring. Of the 32 children labeled as obese, 28 died or suffered neurologic injury regardless of the described indications for surgery. The cause of the event in obese children was attributed to apnea in 19, hemorrhage in 6, and unknown in 3.

Limitations of our study include the large number of questionnaires that were not completed, provided partial information, or had reporting bias. There is also the potential that some cases were reported more than once from any 1 institution. However, by cross-checking age, ethnicity, year of the event, and descriptive text, we were only able to identify 1 duplicate. Furthermore, the survey did not define apnea or hemorrhage when eliciting the cause of the event, so there is a possibility of inconsistency in attribution. It is highly likely that the questionnaire survey performed by the ENT surgeons and our survey greatly underestimated the number of children with these adverse outcomes. In addition, the ASA Closed Claims cases had extracted data not specifically addressing the issue of OSA; these records had significant deficits in the information we were seeking. Our study does not shed light on the overall safety or risk of performing tonsillectomy on an outpatient basis as we lack a denominator for risk calculation.

Identification of children at risk for OSA is essential for all children undergoing anesthesia. Perianesthetic risk is likely increased if the surgery involves a major body cavity or the airway and if there will be need for postoperative opioids. Conversely, risk is likely quite minimal if it is a peripheral procedure and there is no need for opioids. Because tonsillectomy involves the airway and also the need for postoperative opioids, this procedure when combined with the diagnosis of OSA places children at increased risk for adverse perioperative events. Our analysis and results suggest that the identification scoring system for assessing perianesthetic risk developed by the ASA which includes predisposing physical characteristics, historical questions regarding airway obstruction, and daytime somnolence due to interrupted sleep patterns appears to have merit.[9] Unfortunately that guideline was meant to be applicable to adults and children. Table 5 presents a list of pediatric-specific signs and symptoms of OSA that may further help identify children at risk.

Our data also suggest that ethnicity may be another important variant since 20 of 26 African American, 11 of 14 Hispanic, and 3 of 3 Asian children were described in this

Table 5. Risk Factors and Symptoms of Obstructive Sleep Apnea

Risk factor
Obesity as well as increasing obesity
Positive family history
Ethnicity (African American)
History of reactive airway disease
Congenital airway abnormality (e.g., mid facial hypoplasia)
Congenital syndrome (e.g., Down syndrome)
Male gender
Enlarged tonsils
Symptoms
Loud snoring (heard through closed door)
Gasps at night
Pauses in breathing at night
Night terrors
Restless sleep
Confusion arousals
Mouth breathing
Drooling
Sleep walking
Unusual sleep positions
Difficult to awaken in the morning
Daytime irritability
Morning headache
Daytime somnolence
Enuresis
Poor school performance
Frequent upper respiratory infections

Risk factors and symptoms abstracted from the following references: Refs.[2–5,9,10,15,16,19,34–38].

cohort as having a history consistent with being at risk for OSA. The incidence of OSA may be 4 or more times greater in African American children,[4] and they also exhibit more profound desaturation with obstructive events compared with Caucasian children.[34–37] In addition, our data suggest that higher ASA physical status was associated with patients who were at risk for OSA. The OSA identification scoring system for assessing perianesthetic risk developed by the ASA appears to have merit; modification of the guideline with more pediatric-specific language would need to be validated.

In conclusion, it is imperative that the surgeon and anesthesiologist identify children at risk for OSA.[39] Children who are obese (gender-specific weight or body mass index ≥95th percentile) and who have other clinical indicators of OSA (Table 5) even in the absence of a sleep polysomnogram may be at risk.[40,41] Despite the need for cost containment, we must recommend a more considered management of at-risk children since 10 deaths or neurologic injury occurred at home, 2 in the PACU, and 3 on the ward within 24 hours of surgery. These children could have been rescued had proper monitoring been continued throughout first- and second-stage recovery, as well as on the ward during the first postoperative night.[22] In addition, practitioners must be aware of the marked opioid sensitivity of these children and therefore reduce the usual opioid dose by approximately 50%.[8,17] Further consideration should be given to the possibility of rapid codeine metabolizers that would place them at additional risk.[29,31] It may be safer to avoid the use of codeine altogether and use alternate opioid analgesics.[33] The Food and Drug Administration has recently issued a "black box" warning regarding the use of codeine in children undergoing tonsillectomy.[a] Death after tonsillectomy related to hemorrhage may not be preventable, but death due to apnea is preventable. It is for these at-risk children that we need to develop an improved safety net. The ASA OSA guideline was an important first step in this direction, but further multi-institution prospective study of a pediatric-specific risk identification and assessment scoring system is needed.

DISCLOSURES

Name: Charles J. Coté, MD.
Contribution: This author contributed to study design, conduct of the study, data collection, data analysis, and manuscript preparation.
Attestation: Charles Coté attests to the integrity of the original data and the analysis reported in this manuscript, and has approved the final manuscript.
Name: Karen L. Posner, PhD.
Contribution: This author helped with data collection, data analysis, and manuscript preparation.
Attestation: Karen Posner attests to the integrity of the original data and the analysis reported in this manuscript, and has approved the final manuscript. Karen Posner is the archival author.

[a]U.S. Food and Drug Administration. Codeine Use in Certain Children After Tonsillectomy and/or Adenoidectomy: Drug Safety Communication—Risk of Rare, But Life-Threatening Adverse Events or Death. Available at: http://www.fda.gov/Safety/MedWatch/SafetyInformation/SafetyAlertsforHumanMedicalProducts/ucm315627.htm. Accessed February 22, 2013.

Name: Karen B. Domino, MD, MPH.
Contribution: This author helped with data collection and manuscript preparation.
Attestation: Karen Domino attests to having approved the final manuscript.
This manuscript was handled by: Peter J. Davis, MD.

ACKNOWLEDGMENTS

We would like to thank the leadership of the Society for Pediatric Anesthesia for facilitating the survey. We also thank Lynn Akerlund for her excellent assistance in manuscript preparation.

REFERENCES

1. Costa DJ, Mitchell R. Adenotonsillectomy for obstructive sleep apnea in obese children: a meta-analysis. Otolaryngol Head Neck Surg 2009;140:455–60
2. Friedman M, Wilson M, Lin HC, Chang HW. Updated systematic review of tonsillectomy and adenoidectomy for treatment of pediatric obstructive sleep apnea/hypopnea syndrome. Otolaryngol Head Neck Surg 2009;140:800–8
3. Mitchell RB, Boss EF. Pediatric obstructive sleep apnea in obese and normal-weight children: impact of adenotonsillectomy on quality-of-life and behavior. Dev Neuropsychol 2009;34:650–61
4. Lumeng JC, Chervin RD. Epidemiology of pediatric obstructive sleep apnea. Proc Am Thorac Soc 2008;5:242–52
5. Arens R, Muzumdar H. Childhood obesity and obstructive sleep apnea syndrome. J Appl Physiol 2010;108:436–44
6. Bhattacharjee R, Kim J, Kheirandish-Gozal L, Gozal D. Obesity and obstructive sleep apnea syndrome in children: a tale of inflammatory cascades. Pediatr Pulmonol 2011;46:313–23
7. Carter R 3rd, Watenpaugh DE. Obesity and obstructive sleep apnea: or is it OSA and obesity? Pathophysiology 2008;15:71–7
8. Brown KA, Laferrière A, Lakheeram I, Moss IR. Recurrent hypoxemia in children is associated with increased analgesic sensitivity to opiates. Anesthesiology 2006;105:665–9
9. Gross JB, Bachenberg KL, Benumof JL, Caplan RA, Connis RT, Coté CJ, Nickinovich DG, Prachand V, Ward DS, Weaver EM, Ydens L, Yu S; American Society of Anesthesiologists Task Force on Perioperative Management. Practice guidelines for the perioperative management of patients with obstructive sleep apnea: a report by the American Society of Anesthesiologists Task Force on Perioperative Management of patients with obstructive sleep apnea. Anesthesiology 2006;104:1081–93; quiz 1117–8
10. Baugh RF, Archer SM, Mitchell RB, Rosenfeld RM, Amin R, Burns JJ, Darrow DH, Giordano T, Litman RS, Li KK, Mannix ME, Schwartz RH, Setzen G, Wald ER, Wall E, Sandberg G, Patel MM; American Academy of Otolaryngology-Head and Neck Surgery Foundation. Clinical practice guideline: tonsillectomy in children. Otolaryngol Head Neck Surg 2011;144:S1–30
11. Bhattacharyya N. Ambulatory pediatric otolaryngologic procedures in the United States: characteristics and perioperative safety. Laryngoscope 2010;120:821–5
12. Simonsen AR, Duncavage JA, Becker SS. A review of malpractice cases after tonsillectomy and adenoidectomy. Int J Pediatr Otorhinolaryngol 2010;74:977–9
13. Morris LG, Lieberman SM, Reitzen SD, Edelstein DR, Ziff DJ, Katz A, Komisar A. Characteristics and outcomes of malpractice claims after tonsillectomy. Otolaryngol Head Neck Surg 2008;138:315–20
14. Stevenson AN, Myer CM 3rd, Shuler MD, Singer PS. Complications and legal outcomes of tonsillectomy malpractice claims. Laryngoscope 2012;122:71–4
15. Goldman JL, Baugh RF, Davies L, Skinner ML, Stachler RJ, Brereton J, Eisenberg LD, Roberson DW, Brenner MJ. Mortality and major morbidity after tonsillectomy: etiologic factors and strategies for prevention. Laryngoscope 4-17-2013 [Epub ahead of print]
16. Brown KA, Morin I, Hickey C, Manoukian JJ, Nixon GM, Brouillette RT. Urgent adenotonsillectomy: an analysis of risk factors associated with postoperative respiratory morbidity. Anesthesiology 2003;99:586–95
17. Brown KA, Laferrière A, Moss IR. Recurrent hypoxemia in young children with obstructive sleep apnea is associated with

reduced opioid requirement for analgesia. Anesthesiology 2004;100:806–10
18. Cullen KA, Hall MJ, Golosinskiy A. Ambulatory surgery in the United States, 2006. Natl Health Stat Report 2009;1–25
19. Marcus CL, Brooks LJ, Draper KA, Gozal D, Halbower AC, Jones J, Schechter MS, Sheldon SH, Spruyt K, Ward SD, Lehmann C, Shiffman RN; American Academy of Pediatrics. Diagnosis and management of childhood obstructive sleep apnea syndrome. Pediatrics 2012;130:576–84
20. Nixon GM, Kermack AS, McGregor CD, Davis GM, Manoukian JJ, Brown KA, Brouillette RT. Sleep and breathing on the first night after adenotonsillectomy for obstructive sleep apnea. Pediatr Pulmonol 2005;39:332–8
21. Waters KA, McBrien F, Stewart P, Hinder M, Wharton S. Effects of OSA, inhalational anesthesia, and fentanyl on the airway and ventilation of children. J Appl Physiol 2002;92:1987–94
22. Raghavendran S, Bagry H, Detheux G, Zhang X, Brouillette RT, Brown KA. An anesthetic management protocol to decrease respiratory complications after adenotonsillectomy in children with severe sleep apnea. Anesth Analg 2010;110:1093–101
23. Hambrecht VS, Vlisides PE, Row BW, Gozal D, Baghdoyan HA, Lydic R. G proteins in rat prefrontal cortex (PFC) are differentially activated as a function of oxygen status and PFC region. J Chem Neuroanat 2009;37:112–7
24. Peng PH, Huang HS, Lee YJ, Chen YS, Ma MC. Novel role for the delta-opioid receptor in hypoxic preconditioning in rat retinas. J Neurochem 2009;108:741–54
25. Laferrière A, Liu JK, Moss IR. Neurokinin-1 versus mu-opioid receptor binding in rat nucleus tractus solitarius after single and recurrent intermittent hypoxia. Brain Res Bull 2003;59:307–13
26. Lalley PM. Mu-opioid receptor agonist effects on medullary respiratory neurons in the cat: evidence for involvement in certain types of ventilatory disturbances. Am J Physiol Regul Integr Comp Physiol 2003;285:R1287–304
27. Moss IR, Laferrière A. Central neuropeptide systems and respiratory control during development. Respir Physiol Neurobiol 2002;131:15–27
28. Chen ZR, Somogyi AA, Reynolds G, Bochner F. Disposition and metabolism of codeine after single and chronic doses in one poor and seven extensive metabolisers. Br J Clin Pharmacol 1991;31:381–90
29. Gasche Y, Daali Y, Fathi M, Chiappe A, Cottini S, Dayer P, Desmeules J. Codeine intoxication associated with ultrarapid CYP2D6 metabolism. N Engl J Med 2004;351:2827–31
30. Kirchheiner J, Schmidt H, Tzvetkov M, Keulen JT, Lötsch J, Roots I, Brockmöller J. Pharmacokinetics of codeine and its metabolite morphine in ultra-rapid metabolizers due to CYP2D6 duplication. Pharmacogenomics J 2007;7:257–65
31. Voronov P, Przybylo HJ, Jagannathan N. Apnea in a child after oral codeine: a genetic variant—an ultra-rapid metabolizer. Paediatr Anaesth 2007;17:684–7
32. Kelly LE, Rieder M, van den Anker J, Malkin B, Ross C, Neely MN, Carleton B, Hayden MR, Madadi P, Koren G. More codeine fatalities after tonsillectomy in North American children. Pediatrics 2012;129:e1343–7
33. Pickering AE, Bridge HS, Nolan J, Stoddart PA. Double-blind, placebo-controlled analgesic study of ibuprofen or rofecoxib in combination with paracetamol for tonsillectomy in children. Br J Anaesth 2002;88:72–7
34. Redline S, Tishler PV, Schluchter M, Aylor J, Clark K, Graham G. Risk factors for sleep-disordered breathing in children. Associations with obesity, race, and respiratory problems. Am J Respir Crit Care Med 1999;159:1527–32
35. Redline S, Tishler PV, Hans MG, Tosteson TD, Strohl KP, Spry K. Racial differences in sleep-disordered breathing in African-Americans and Caucasians. Am J Respir Crit Care Med 1997;155:186–92
36. Stepanski E, Zayyad A, Nigro C, Lopata M, Basner R. Sleep-disordered breathing in a predominantly African-American pediatric population. J Sleep Res 1999;8:65–70
37. Boss EF, Smith DF, Ishman SL. Racial/ethnic and socioeconomic disparities in the diagnosis and treatment of sleep-disordered breathing in children. Int J Pediatr Otorhinolaryngol 2011;75:299–307
38. Su MS, Li AM, So HK, Au CT, Ho C, Wing YK. Nocturnal enuresis in children: prevalence, correlates, and relationship with obstructive sleep apnea. J Pediatr 2011;159:238–42.e1
39. Coté CJ, Sheldon SH. Obstructive sleep apnea and tonsillectomy: do we have a new indication for extended postoperative observation? Can J Anaesth 2004;51:6–12
40. Wilson K, Lakheeram I, Morielli A, Brouillette R, Brown K. Can assessment for obstructive sleep apnea help predict postadenotonsillectomy respiratory complications? Anesthesiology 2002;96:313–22
41. Nixon GM, Kermack AS, Davis GM, Manoukian JJ, Brown KA, Brouillette RT. Planning adenotonsillectomy in children with obstructive sleep apnea: the role of overnight oximetry. Pediatrics 2004;113:e19–25