

Original Investigation

Postoperative Complications in Pediatric Tonsillectomy and Adenoidectomy in Ambulatory vs Inpatient Settings

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IMPORTANCE A large-scale review is needed to characterize the rates of airway, respiratory, and cardiovascular complications after pediatric tonsillectomy and adenoidectomy (T&A) for inpatient and ambulatory cohorts.

OBJECTIVE To identify risk factors for postoperative complications stratified by age and operative facility type among children undergoing T&A.

DESIGN, SETTING, AND PARTICIPANTS This retrospective review included 115 214 children undergoing T&A in hospitals, hospital-based facilities (HBF), and free-standing facilities (FSF) in California from January 1, 2005, to December 31, 2010. The analysis used the State of California Office of Statewide Health Planning and Development private inpatient data and Emergency Department and Ambulatory Surgery public data. Inpatient (n = 18 622) and ambulatory (n = 96 592) cohorts were identified by codes from the *International Classification of Diseases, Ninth Revision*, and *Current Procedural Terminology*. Data were collected from September 2011 to March 2012 and analyzed from March through May 2012.

MAIN OUTCOMES AND MEASURES Rates of airway, respiratory, and cardiovascular complications.

RESULTS A total of 18 622 inpatients (51% male; 49% female; mean age, 5.4 [range, 0-17] years) and 96 592 ambulatory patients (37% male; 35% female; 28%, masked; mean age, 7.6 [range, 0-17] years) underwent analysis. The ratio of ambulatory to inpatient procedures was 5:1. Inpatients demonstrated more comorbidities (≤ 8 , compared with ≤ 4 for HBF and ≤ 3 for FSF patients) and, in general, their complication rates were 2 to 5 times higher (seen in 1% to 12% of patients) than those in HBFs (0.2% to 5%), and more than 10 times higher than those in the FSFs (0% to 0.38%), with rates varying markedly by age range and facility type. Tonsillectomy and adenoidectomy was associated with increased risk for all complication types in both settings, reaching an odds ratio of 8.5 (95% CI, 6.6-11.1) for respiratory complications in the ambulatory setting. Inpatients aged 0 to 9 years experienced higher rates of airway and respiratory complications, peaking at an odds ratio of 7.5 (95% CI, 3.1-18.2) for airway complications in the group aged 0 to 11 months.

CONCLUSIONS AND RELEVANCE Large numbers of pediatric patients undergo T&A in ambulatory settings despite higher rates of complications in younger patients and patients with more comorbidities. Fortunately, a high percentage of these patients has been appropriately triaged to the inpatient setting. Further research is needed to elucidate the subgroups that warrant postoperative hospitalization.

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The combination of tonsillectomy and adenoidectomy (T&A) is one of the most frequently performed procedures in children, with more than 500 000 operations each year in the United States.¹⁻⁴ Given that obstructive sleep apnea (OSA) is one of the most common indications for this surgery, identification of those patients who may be at high risk for postoperative oxygen desaturation and other airway-related complications is important.^{1,2,5-8} This need has become especially relevant because the surgery increasingly has been performed in an outpatient setting. Data from the National Survey for Ambulatory Surgery from 1996 to 2006 indicate that more than 95% of these procedures are performed in the ambulatory arena.⁹ Admission to the pediatric intensive care unit was recommended routinely in the past for patients with severe OSA undergoing T&A because of their propensity for marked hypoxia and oxygen desaturation when entering rapid eye-movement sleep stages.¹⁰ However, subsequent studies^{7,11,12} support outpatient performance of T&A and cite low incidence of adverse respiratory events and need for unplanned admission, even in patients with OSA. Outpatient management reduces costs while allowing children to recover in home environments, a more convenient setting for caregivers.^{7,13}

The American Society for Anesthesiologists, American Academy of Otolaryngology-Head and Neck Surgery (AAOHN), and American Academy of Pediatrics all provide guidelines that address postoperative management of patients with OSA after T&A. The American Academy of Pediatrics and AAOHN suggest similar risk factors for postoperative complications and recommend inpatient management for patients who are obese, have complicated medical histories, have severe OSA (defined as an apnea-hypopnea index of >10 by the AAOHN and >24 by the American Academy of Pediatrics), and are younger than 3 years.^{14,15} This list relates to a higher rate of postoperative complications seen in younger children who have little respiratory and hemodynamic reserve.^{12,16,17} However, the guidelines suggest that further research is needed to guide this topic. For example, the American Society for Anesthesiologists finds the literature to be insufficient in guiding which patients can be treated safely without admission.¹⁸ Similarly, the AAOHN guideline notes that this recommendation is supported by evidence that is not conclusive and encourages clinicians to remain watchful for new information. Thus, in a climate of increasing outpatient T&A procedures driven by decreased costs in that setting, we sought to increase the understanding of risk factors for complications in patients undergoing T&A, including underlying conditions and treatment location. Our aim is to provide information that will guide triage of patients to an inpatient procedure when appropriate. We queried the rates of airway, respiratory, and cardiovascular complications of patients undergoing T&A in an inpatient vs an ambulatory setting and how these rates may differ when stratified by age.

Methods

We examined the State of California Office of Statewide Health Planning and Development (OSHPD) private inpatient data set

and the State of California OSHPD Emergency Department and Ambulatory Surgery (EDAS) public data set. Both data sets were queried from January 1, 2005, to December 31, 2010. Query of the OSHPD private inpatient data set was approved under the state-approved Stanford Pediatric CAT research group headed by one of us (P.H.W.). This study was approved by the institutional review board of Stanford University. The institutional review board waived the need for informed consent.

The study cohort included pediatric patients younger than 18 years who had undergone a tonsillectomy with or without adenoidectomy based on the *International Classification of Diseases, Ninth Revision (ICD-9)*, for the OSHPD inpatient data set and on the *Current Procedural Terminology* codes for the ambulatory EDAS data set. For inpatients, any patient whose T&A did not occur on day 0 or 1 of admission was excluded. Both data sets include as many as 25 diagnosis codes for each patient and demographic and discharge information. All diagnostic ICD-9 codes were reviewed and categorized into diagnoses associated with the procedure (eg, tonsillitis, adenotonsillar hypertrophy, and OSA-related diagnoses), underlying conditions, or complications. Multiple complication categories were created, including airway, respiratory, and cardiovascular groupings. Examples of airway complication codes included stridor, laryngeal spasm, and edema of the larynx. Respiratory complication codes included pneumonia, pulmonary collapse, apnea, and respiratory failure. Cardiovascular-related codes included cardiac arrest, tachycardia, hematemesis, and hemorrhage from the throat.

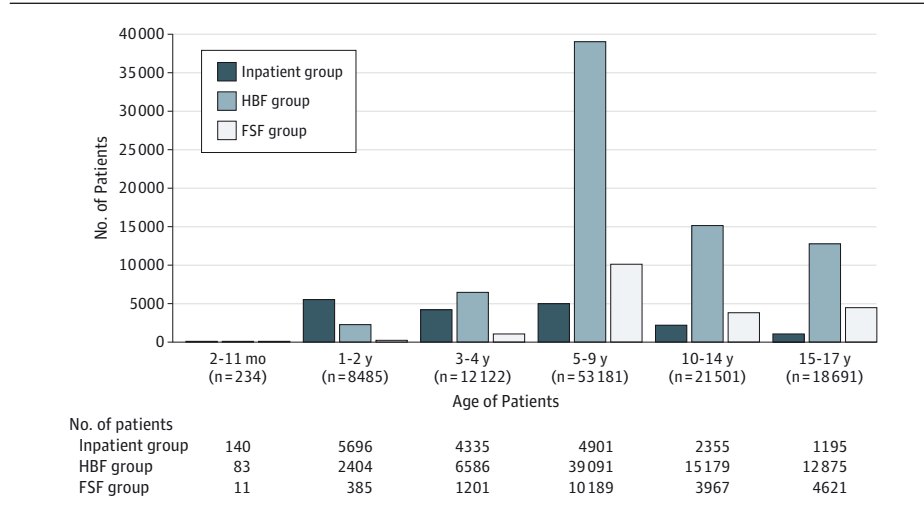
Underlying comorbid condition categories included airway, respiratory, cardiovascular, hypertension, congenital, neuromuscular, endocrine and metabolic, hematologic, liver and kidney, gastrointestinal tract, infectious, and obesity. These categories were defined after all codes reported for patients in the database were compiled from the most to the least frequent. Any code that appeared 10 times or more in the entire set was assigned to a complication or a comorbidity category based on the experience of the authors. These codes were then reviewed with the coders at Lucile Packard Children's Hospital and other anesthesiologists for confirmation of the validity of the assignment. Categories of comorbidities were generally created based on physiologic and pathologic areas of concern for anesthesiologists.

Data were analyzed from March to May 2012. Logistic regressions for outcomes used rates for patients undergoing inguinal hernia repair as a baseline reference and included predictor variables of age, sex, presence of OSA-related disease, T&A, and the underlying comorbidity categories. Outcomes included airway, respiratory, and cardiovascular complications. We used SAS software (version 9.2; SAS Institute Inc). Significance was noted for predictors with $P < .05$.

Results

The inpatient California OSHPD data set from 2005 to 2010 included a mean of 250 812 total pediatric discharges per year (51% male), with 1% representing pediatric patients undergoing T&A (about 2500 procedures per year; 60% male). The in-

Figure 1. Age Distribution of Patients by Facility Type



Number of patients undergoing tonsillectomy and adenoidectomy procedures in California from January 1, 2005, to December 31, 2010, based on State of California Office of Statewide Health Planning and Development data sets. FSF indicates free-standing facility; HBF, hospital-based facility (ambulatory).

Table 1. Comorbidities by Facility Type

No. of Comorbid Diagnoses	Patient Group, %		
	Inpatient (n = 18 622)	HBF (n = 76 218)	FSF (n = 20 374)
0	44.6	69.4	84.6
1	28.0	23.5	13.7
2	14.7	5.8	1.7
3	6.6	1.1	0.1
4	3.5	0.2	0
5	1.7	0	0
6	0.5	0	0
7	0.3	0	0
8	0.1	0	0
9	0	0	0
10	0	0	0

Abbreviations: FSF, free-standing facility; HBF, hospital-based facility (ambulatory).

patient cohort included 18 622 inpatients for analysis (51% male; 49% female). The California EDAS data set from 2005 to 2010 included a mean of 173 413 discharges per year (41% male), with 15% representing pediatric patients undergoing T&A (about 25 000 procedures per year; 37% male, 35% female, 28% sex masked). These samples constituted a total cohort of 96 592 outpatients for analysis. The mean age of patients undergoing T&A was 5.4 (range, 1-17) years for inpatients compared with 7.6 (range, 1-17) years for ambulatory patients. The overall age distribution by facility type is shown in Figure 1 and highlights that, although most patients 2 years and younger underwent inpatient procedures, most procedures were performed in an ambulatory hospital-based setting.

Patients at each type of facility presented with comorbidities ranging in number from 0 to 10. These percentages are displayed in Table 1 and demonstrate that most patients seen in ambulatory free-standing facilities (FSFs) had no comorbidities, and no patients in FSFs had more than 3 comorbidities. In contrast, patients in ambulatory hospital-based facilities (HBFs) and inpatients had as many as 4 and 8 comorbidities, respectively. The inpatient group was also notable for a larger

percentage of obese children; obesity rates ranged from 8% to 9% for inpatients, 3% to 4% for patients at ambulatory HBFs, and 0% to 0.5% for patients at FSFs.

Complication rates with total patient numbers, stratified by age and facility type, are presented in Figure 2. In general, complication rates were 2 to 5 times higher for inpatients (seen in 1% to 12% of patients) than for patients seen in ambulatory HBFs (0.2% to 5%) and more than 10 times higher than those for patients seen in FSFs (0% to 0.38%), with rates varying markedly by age range and facility type. For all settings, the most common category of complications related to the respiratory system, followed by complications involving the airway or the cardiovascular system.

Results of logistic regressions looking at age and comorbid factors predictive of airway, respiratory, or cardiovascular complications are displayed in Table 2 and Table 3, respectively. These factors are compared with those in patients undergoing inguinal hernia repair as a reference. Compared with hernia surgery, T&A in any setting was highly predictive of all types of complications. Odds ratios for inpatient vs FSF centers were as follows: 6.4 vs 5.1 for airway complications

($P < .001$ and $P = .002$, respectively), 2.5 and 8.5 for respiratory complications ($P < .001$ for both), and 2.3 and 4.6 for cardiovascular complications ($P < .001$ for both).

Table 2 demonstrates a markedly increased odds for airway complications for the youngest inpatients (OR, 7.5; 95% CI, 3.1-18.2) and a slightly increased odds for respiratory complications (OR, 3.1; 95% CI, 2.2-4.4). However, no increase was seen in the odds for cardiovascular complications.

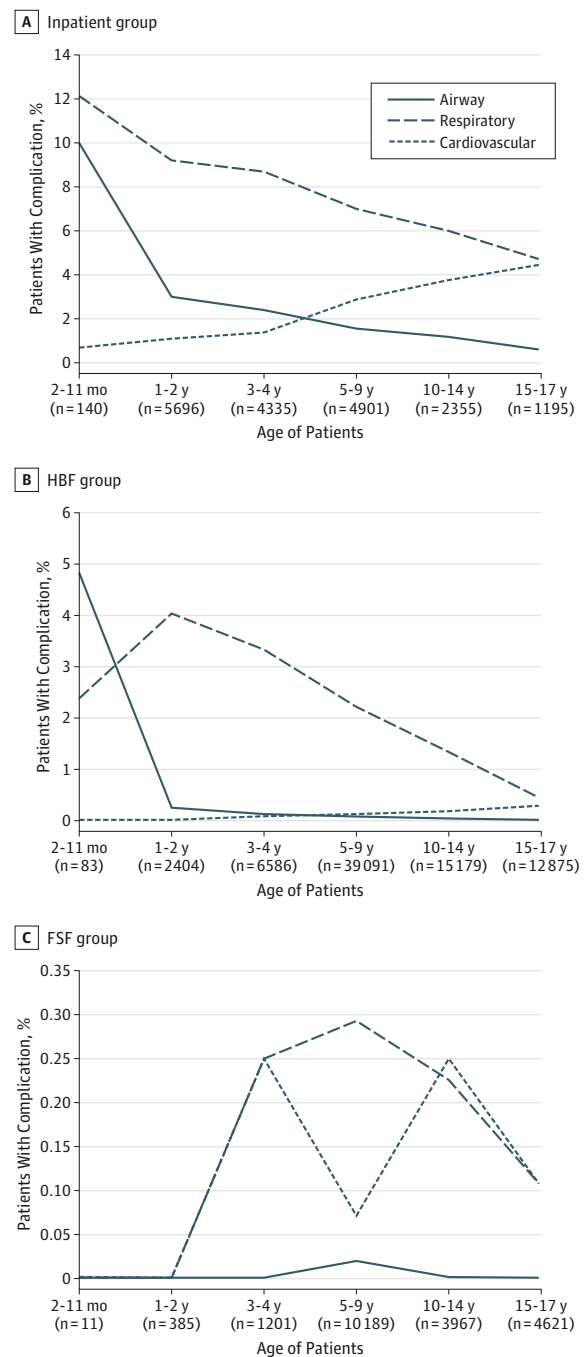
Comorbidities found to be highly predictive for any complication category in the inpatient or FSF settings are displayed in Table 3. For inpatients, comorbidities related to airway, respiratory, or cardiovascular disorders (ORs, 3.8 [95% CI, 2.9-5.0], 2.4 [95% CI, 2.0-3.0], and 2.2 [95% CI, 1.7-2.9], respectively; $P < .001$) increased the risk for airway complications. Respiratory complications were increased in patients with respiratory (OR, 2.8; 95% CI, 2.5-3.1) and cardiovascular (OR, 2.2; 95% CI, 1.9-2.6) comorbidities or in those with obesity (OR, 2.2; 95% CI, 1.9-2.7). Only cardiovascular comorbidities correlated with cardiovascular complications in this setting (OR, 4.0; 95% CI, 3.1-5.2).

In the ambulatory FSF setting, airway comorbidities pushed the risk for airway complications higher than any other correlation (OR, 15.7; 95% CI, 7.5-32.5). Unlike the risk in the inpatient cohort, respiratory and cardiovascular comorbidities did not increase the risk, but gastrointestinal tract (OR, 5.0; 95% CI, 2.4-10.2) and infectious disease (OR, 3.3; 95% CI, 1.9-5.8) comorbidities did. Similarly, only gastrointestinal tract-related disorders caused a significant increase in respiratory complications (OR, 8.1; 95% CI, 6.8-9.6). Cardiovascular complications were only strongly correlated with cardiovascular comorbidities (OR, 5.8; 95% CI, 2.2-15.2) or hypertension (OR, 13.1; 95% CI, 3.0-57.7). Obesity did not have a significant influence on any type of complication in the FSF setting.

Discussion

Using 2 large data sets, we were able to identify 18 622 inpatients and 96 592 ambulatory patients younger than 18 years who underwent T&A in California from 2005 to 2010. Our results show that most patients undergoing T&A are cared for in an ambulatory setting, with many cared for in FSFs. Although most of the youngest patients underwent surgery in hospitals, 2883 of 8719 patients younger than 3 years (33.1%) were not admitted after surgery, and 396 (4.5%) were treated in FSFs. This distribution occurred despite guidelines from the AAOHNS and American Academy of Pediatrics recommending admission for patients younger than 3 years.^{14,15} Similar results were found by Goyal et al¹⁹ using the Pediatric Health Information System database and identifying children who underwent T&A based on ICD-9 coding. Data from the 43 hospitals included in the Pediatric Health Information System database demonstrated the following admission rates: 87% for those younger than 2 years, 69% for those aged 2 to 3 years, 34% for those aged 3 to 5 years, and 20% for children older than 5 years. This disregard of guidelines for admission is somewhat concerning.

Figure 2. Complication Rates in Different Facilities Stratified by Age and Complication Type



FSF indicates free-standing facilities; HBF, hospital-based facilities (ambulatory).

On results of logistic regression, we found the highest ORs for airway and respiratory complications in the youngest cohorts. We are not surprised to see airway and respiratory complication risks and rates moving together because issues with the airway can have repercussions on respiratory status. Our finding that respiratory complications were more common than complications in other categories and were generally highest

Table 2. Logistic Regressions for Ages Predictive of Complications

Patient Age	Complications, OR (95% CI) ^a		
	Airway	Respiratory	Cardiovascular
0-11 mo	7.5 (3.1-18.2)	3.1 (2.2-4.4)	0.4 (0.3-0.7)
1-2 y	5.1 (2.3-10.9)	2.5 (1.9-3.4)	0.3 (0.2-0.4)
3-4 y	4.0 (1.8-8.7)	2.2 (1.7-3.0)	0.4 (0.2-0.5)
5-9 y	2.6 (1.2-5.7)	1.6 (1.2-2.1)	0.7 (0.5-1.0)
10-14 y	2.0 (0.9-4.7)	1.2 (0.9-1.6)	0.9 (0.6-1.2)

Abbreviation: OR, odds ratio.

^a Inpatients undergoing tonsillectomy and adenoidectomy are compared with those undergoing hernia repair (reference).

Table 3. Logistic Regressions for Comorbidities Predictive of Complications

Comorbidity by Facility Type	Complication, OR (95% CI) ^a		
	Airway	Respiratory	Cardiovascular
Inpatient			
Airway	3.8 (2.9-5.0)	1.3 (1.0-1.6)	1.2 (0.8-1.7)
Respiratory	2.4 (2.0-3.0)	2.8 (2.5-3.1)	1.3 (1.1-1.6)
Cardiovascular	2.2 (1.7-2.9)	2.2 (1.9-2.6)	4.0 (3.1-5.2)
GI tract	1.4 (1.1-1.9)	1.7 (1.4-1.9)	1.6 (1.3-2.1)
Infectious disease	1.8 (1.4-2.4)	1.9 (1.7-2.2)	1.4 (1.1-1.8)
Hypertension	1.1 (0.5-2.3)	1.2 (0.8-1.9)	1.9 (1.1-3.2)
Obesity	1.2 (0.8-1.8)	2.2 (1.9-2.7)	0.6 (0.4-0.9)
Ambulatory FSF			
Airway	15.7 (7.5-32.5)	1.3 (0.8-2.2)	1.2 (0.2-9.1)
Respiratory	1.5 (0.9-2.6)	1.4 (1.2-1.6)	1.0 (0.6-1.6)
Cardiovascular	0.9 (0.2-4.5)	1.2 (0.7-2.0)	5.8 (2.2-15.2)
GI tract	5.0 (2.4-10.2)	8.1 (6.8-9.6)	1.6 (0.6-4.4)
Infectious disease	3.3 (1.9-5.8)	0.7 (0.6-0.9)	0.9 (0.4-1.8)
Hypertension	9.7 (0.9-101.3)	0.9 (0.2-3.8)	13.1 (3.0-57.7)
Obesity	0.3 (0.0-2.2)	1.5 (1.2-2.0)	1.5 (0.7-3.4)

Abbreviations: FSF, free-standing facility; GI, gastrointestinal; OR, odds ratio.

^a Inpatients undergoing tonsillectomy and adenoidectomy are compared with those undergoing hernia repair (reference).

in the youngest children are supported by a recent prospective study by Thongyam et al²⁰ that followed up 329 children with OSA for 2 weeks after T&A. Those children younger than 3 years were at significantly higher risk for respiratory complications.

Our data demonstrating higher complication rates in the youngest children are consistent with published data. Multiple retrospective studies have also reported higher rates of airway-related complications, respiratory compromise, and overall major or minor complications in patients younger than 3 years after T&A.^{5,12,21-24} These findings are supported by those of a meta-analysis⁶ describing a statistically significant greater rate of overall complications for children younger than 3 years, in addition to a statistically significant increase in unplanned admissions for this age group.

Although some investigators^{17,25,26} have not found complication differences between age groups, those reviewed cohorts have included smaller sample sizes ranging from 86 to 127 patients. Because our data are based on such a large cohort, and the complication rates are relatively small, we understand how studies with relatively few patients may fail to demonstrate this increased risk. Similarly, because our FSF data for children younger than 3 years had such small overall numbers, we are not surprised that complications were not revealed in this cohort. We also believe that small numbers in

the HBF cohort may have spuriously shown a lower rate of respiratory complications for children aged 0 to 11 months than for those aged 1 to 2 years.

Our data demonstrate that in addition to age, underlying comorbidities may increase complication rates for patients undergoing T&A in the following 3 major categories: airway, respiratory, and cardiovascular. A few prior studies similarly found increased airway and respiratory complications in patients with comorbidities. For example, a prospective study by Youshani et al⁷ reported a 29.7% rate of airway complications after T&A in children with comorbidities compared with a 6.1% rate in those without. A retrospective review by Rosen et al¹⁰ showed that all respiratory complications after T&A for OSA occurred in patients with associated comorbidities. Brown et al²⁷ also focused on postoperative respiratory complications and reported an OR of 8.15 for children with an associated medical condition who underwent urgent T&A. Overall these results provide further evidence that patients with comorbidities have complications at much higher rates, and the fact that patients with multiple comorbidities tend to be treated in the hospital setting is reassuring: 1.8% of patients in FSFs have 2 or more comorbid diagnoses and only 7.1% of patients have 2 or more comorbid diagnoses in ambulatory HBFs. Because inpatients are more likely to have multiple underlying conditions that make them more prone to complications, we are not

surprised by the observed correlation of more complications in this cohort. Given that government reimbursement for health care is moving toward holding back payments for complications in a variety of procedures,²⁸ this increased inpatient complication risk should be factored into any policies regarding reimbursement changes.

Gastrointestinal tract disorders seem to increase the concern for airway and respiratory complications. Any conditions that decrease gastric emptying could markedly increase the chances of issues in both these areas. We cannot make any conclusions about why these complications may be increased in this setting, but a difference in screening criteria or preparation may be present for patients treated in the HBF vs the FSF centers. Various infectious diseases, particularly upper respiratory tract infections, can greatly increase the chances of airway complications, such as laryngospasm. A possible tendency to be more lax in screening for these disorders in the FSFs could explain this finding. A similar explanation might help to understand the increased odds of cardiovascular complications seen for hypertension in this setting. Finally, we are not surprised that cardiovascular comorbidities tend to increase the chance for cardiovascular complications. Patients with altered cardiac status will be more likely to be sensitive to anesthetic effects on their cardiovascular system and will have less reserve in the event of any minor or major events during surgery.

We acknowledge that a weakness of our study is age masking of the ambulatory data. Because the only ambulatory data set available at the time of this research was the public data set, and procedures in younger children are relatively rare, young patients are dropped from the data set by California to protect their identities. We cannot know whether the dropped patients would be more prone to complications than those remaining in the data set, but we have no reason to presume so. Thus we may assume that the complication rates for those patients mirror the rates for those left in the set. Although the overall total number of younger patients is unknowable, the likelihood of complication risk is fairly safely presumed. Therefore, we believe that our study echoes the results of most prior reports, which show that being younger is a risk factor for complications related primarily to airway concerns. The fact that

any of these younger patients at higher risk for airway complications are being sent home immediately after procedures is cause for concern.

Another acknowledged weakness is the lack of information available for ambulatory patients during the first 24 hours after surgery, when many complications related to the airway and respiratory and cardiovascular systems are likely to occur. Because all complications in this study were coded during the admitted time frame for each setting, these complication rates can help to guide where the surgery should take place, but they cannot adequately address which patients should be admitted. This issue could also be a reason why the HBFs and FSFs have such low complication rates: any potential complications occurring after discharge would not be captured as they would be for admitted patients. Although the true incidence of complications and risk factors is impossible to discern using these administrative data sets, differences and changes noted between care settings are likely robust because the same biases and errors in coding are likely to be equally present throughout the system.

Conclusions

An ambulatory surgical approach for T&A is being used for most pediatric patients, including some of those in the youngest groups, despite an increased risk for complications related to the airway. Our study supports prior work that suggests that patients younger than 3 years and those with multiple comorbidities should be cared for in the hospital, because they have relatively high rates of complications. In-hospital monitoring of patients with airway disorders should be considered, given the marked increase in airway complications seen in the outpatients with airway comorbidities. Preparation of patients in the outpatient and FSF arena deserves future study, because an increased risk for complications related to gastrointestinal tract, infectious, and hypertensive disorders is seen in that setting. As economic incentives increase for ambulatory and FSF surgery center care, attention to vulnerable populations is critical. Further study is warranted to delineate which patients require admission after T&A.

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Study concept and design: Amoils, Chang, Honkanen.

Acquisition, analysis, or interpretation of data: Chang, Saynina, Wise, Honkanen.

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