Critical Care Resources Utilized in High-Risk Adenotonsillectomy Patients

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Objective: Children at high risk for respiratory complication after adenotonsillectomy are often admitted to a pediatric intensive care unit (PICU) postoperatively. Although many patients receive care in such units, it is unknown how many utilize critical care resources.

Methods: A review was conducted to audit intensive care needs of postadenotonsillectomy patients admitted to the PICU at a tertiary, academic, pediatric hospital between July 2013 and March 2017. Demographic information, ICU indication, polysomnogram results, and comorbidities were collected. Patients were defined as needing ICU resources based on supplemental oxygen requirements greater than 2 L between 2 to 24 hours postoperatively, more than two desaturation events in a 2-hour period, or more than hourly nursing intervention. Factors associated with utilization of ICU resources were assessed.

Results: One hundred and ten patients were admitted to the PICU after adenotonsillectomy. Median age was 4.2 years, median body mass index was 90.8 percentile, and median apnea hypopnea index (AHI) was 34.3. Twenty patients (18.2%) utilized ICU resources by criteria defined. Of these patients, 14 were known to need such resources by 2 hours postoperatively (70%, negative predictive value 93.8%). Neither AHI nor obesity status was correlated with need for resources; however, resource need was associated with young age, gastrostomy tube status, and neuromuscular disorders (P = 0.048, P = 0.002 and 0.013, respectively).

Conclusion: Most high-risk adenotonsillectomy patients do not utilize critical care resources despite their increased perioperative risk. Patients with respiratory complications are frequently identifiable within the first 2 hours of surgery.

Key Words: Adenotonsillectomy, severe obstructive sleep apnea, high risk, intensive care unit, efficiency.

Level of Evidence: 4

INTRODUCTION

Adenotonsillectomy (T&A) is one of the most common surgical procedures performed on the pediatric patient. Over several decades, the predominant indication for this operation has shifted from recurrent tonsillitis to adenotonsillar hypertrophy with sleep disordered breathing/obstructive sleep apnea (OSA).1 As this shift has occurred, multiple studies subsequently have identified risk factors for postoperative respiratory complications, including age less than 2 years, severe OSA on polysomnogram (PSG), body mass index (BMI) less than fifth percentile, obesity, craniofacial anomalies, neuromuscular disease, and complex cardiac disease.2–7 Identification of these respiratory events has led to uncertainty in preoperative selection of the appropriate postoperative location in these high-risk patients.

Selection of the appropriate postoperative location for the high-risk T&A patient is critical because unanticipated intensive care unit admission (UIA) rate is a validated metric of patient safety due to its association with adverse events (AE).8 Several studies have analyzed UIAs in postoperative pediatric patients and have identified airway procedures, higher American Society of Anesthesiologists Classification score, longer anesthesia time, multiple procedures, and infants less than 1 year of age as risk factors.3–11 Because high-risk adenotonsillectomy patients routinely fall into this category, many practitioners admit these patients to a pediatric intensive care unit (PICU) for postoperative observation to avoid a UIA or other AE outside the ICU setting.

With increasing emphasis on value in healthcare and an urgent need to reduce unnecessary costs, this practice now comes into question. Some institutions have been able to address this conundrum through observation of patients in intermediate care units; however, the feasibility of this model is not universal, leaving many surgeons to make their best estimation of appropriate level of care based on preoperative assessments. To date, there are no studies that have investigated the degree to which high-risk T&A patients admitted to the PICU utilize resources exclusive to an ICU setting.

The purpose of this study is to examine the resource utilization patterns of patients admitted to the ICU after T&A. Secondarily, we aim to determine if any specific factors predicted need for ICU resources in the high-risk
population. It was hypothesized that the majority of ICU admission in high-risk T&A patients do not utilize ICU-level resources and that most would be appropriately cared for in lower levels of care. It was further hypothesized that, in patients who utilized ICU-level resources, this need would be apparent within the first 2 hours postoperatively.

MATERIALS AND METHODS

At our institution, a process improvement team was assembled to assess for opportunities to improve care efficiency in the postoperative PICU population. Initial data gathering was aimed at identifying these opportunities. Institutional review board approval was obtained through Ann & Robert H. Lurie Children’s Hospital of Chicago. A chart review of all patients undergoing adenotonsillectomy or tonsillectomy who were admitted to the PICU between July 1, 2013, and March 31, 2017, was conducted. Data obtained included patient age, sex, medical comorbidities, BMI, percentiles, and apnea hypopnea index (AHI) and oxygen (\(O_2\)) nadir on PSG (if available). Charts were analyzed for reason for ICU admission, number and degree of oxygen desaturation events within 24 hours postoperatively, interventions required for treatment of desaturations, methods of supplemental oxygen administration throughout the stay, and PICU length of stay (LOS). Nursing documentation was also reviewed to assess for evidence of high nursing demand.

Patients were deemed to have utilized ICU-level resources if any of the following criteria were met: 1) oxygen supplementation was \(> 2\) L nasal cannula (NC) at any point between 2 to 24 hours postoperatively; 2) more than two desaturation events occurred in any 2-hour period after completion of the first hour in PACU; or 3) more than hourly nursing intervention was apparent on documentation after completion of the first hour in PACU. In patients deemed to have utilized ICU resources, patients were further assessed for whether need for these resources was present in the first 2 hours after surgery. Supplemental oxygen thresholds were determined by the maximum level of oxygen permitted in the surgical observation unit of our hospital. The presence of multiple desaturations was deemed to need PICU-level care because this finding is an indicator of the potential need for escalation of airway support or nursing care beyond what can be maintained by a 6:1 nurse to patient ratio. Similarly, the final criterion was selected due to the limitations in safe care in units with high nurse-to-patient ratios. Cutoff of 2 hours was selected because it has previously been defined as the period during which most post-T&A respiratory events begin to arise.11

Patients categorized as needing ICU-level resources were then compared to those deemed not to need such resources to determine whether any patient factors correlated with resource needs. Statistical analysis was performed with SAS Ver. 9.4 (SAS Institute Inc., Cary, NC), using \(t\) test (Mann–Whitney), chi-square Fisher exact, and multivariate regression as appropriate, with \(P < 0.05\) being considered significant.

RESULTS

Demographics

During the period studied, a total of 4,870 patients underwent either tonsillectomy or T&A at our tertiary children’s medical center. Of these, 110 patients (2.3\%) were admitted to the PICU postoperatively. Median age of these patients was 4.2 years (range 9 months–18 years) and 67 patients were male (60.9\%). Median body mass index was 90.8 percentile (range 0.02–99.9 percentile). Patients had a median number of one comorbid condition (range 0–4) (Table I). Polysomnogram data was available on 94 of the patients admitted to the PICU with a median AHI of 34.3 (range 0.5–118) and median O2 nadir of 78\%.

The most common indication for admission to the PICU was isolated severe OSA on PSG in 61 patients (55.5\%). Twenty-one patients had multiple indications for admission (19.1\%) (Table II). Ten patients (9.1\%) were unanticipated admissions due to decline in patient status in the perioperative period, making the overall UIA rate for T&A at our tertiary children’s medical center 0.21\%.

<table>
<thead>
<tr>
<th>TABLE I. Medical Comorbidities of High-Risk Adenotonsillectomy Patients Admitted to the PICU Postoperatively.</th>
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<tbody>
<tr>
<td><strong>Number (%)</strong></td>
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<tr>
<td>Cardiac disorder</td>
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<tr>
<td>Congenital heart</td>
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<tr>
<td>Other cardiac</td>
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<tr>
<td>Craniofacial anomaly</td>
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<td>Chromosomal anomaly</td>
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<tr>
<td>Neurologic disorder</td>
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<tr>
<td>Cerebral palsy/neuromuscular</td>
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<tr>
<td>Other neurologic</td>
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<tr>
<td>Gastrostomy tube status</td>
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<tr>
<td>Asthma/reactive airway</td>
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<tr>
<td>Diaphragmatic hernia</td>
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<tr>
<td>Endocrine disorder</td>
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<tr>
<td>Hematologic disorder</td>
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<tr>
<td>Prematurity</td>
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<tr>
<td>(&lt; 28) weeks</td>
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<tr>
<td>28–32 weeks</td>
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<tr>
<td>32–37 weeks</td>
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<tr>
<td>Abnormal BMI percentile</td>
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<td>(&lt; 5) percentile</td>
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<td>5–95 percentile</td>
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<tr>
<td>95–99 percentile</td>
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<td>(&gt; 99) percentile</td>
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Multiple comorbidities present in several patients. PICU = pediatric intensive care unit.

Intensive Care Unit Resource Utilization

Analysis of ICU resource utilization revealed that of 110 patients admitted to the ICU, only 20 (18.2\%) utilized ICU-level resources as defined by the criteria above. Of these 20 patients, eight (40\%) were not predicted to need such resources prior to surgery. The remaining two UIAs were characterized by 1) desaturations resolving with blow-by oxygen in the first hour after surgery, and 2) postoperative delirium with breath holding (resolving in the first hour). Neither of these met the defined criteria for needing ICU resources. In patients needing ICU-level resources, this was identified within 2 hours postoperatively in 14 (70\%) patients. If this 2-hour observation
period in high-risk T&A patients was viewed as a test, the negative predictive value (NPV) would be 93.8%. Positive predictive value (PPV), sensitivity, and specificity would be 100%, 70%, and 100%, respectively.

Of the 20 patients utilizing ICU-level resources, the most common resource utilized was supplemental oxygen greater than 2 L NC in seven patients (Table III). Only two patients were intubated, one while still in the operating room and the other shortly after arrival to PACU, well within a 2-hour postoperative window. Of the six patients who established ICU resource need beyond 2 hours postoperatively, four needed increased nursing observation; one needed high-flow nasal cannula; and one needed continuous positive airway pressure. Patients utilizing resources had median ICU LOS of 39.4 hours (interquartile range [IQR] 22.2–61.4). This was significantly longer for those not utilizing resources, with a median of 24.1 hours (IQR 20.7–26.7, P = 0.002) (Fig. 1).

Patient Factors Associated With Need for Intensive Care Unit Resource

Statistical analysis of factors associated with ICU resource utilization revealed an association between ICU resource use and young age (P = 0.048), neuromuscular/neurologic comorbidity (P = 0.013), and gastrostomy tube status (P = 0.002) (Fig. 2). No associations were found between resource need and weight class, AHI, O2 nadir, cardiovascular comorbidity, history of prematurity, or history of asthma (Fig. 3). Of note, patient BMI was assessed both as a categorical variable using commonly accepted BMI cutoffs as well as a continuous variable. In neither statistical analysis of other comorbidities was not performed due to inadequate sample size. Despite a statistical association between need for ICU admission and young age, neuromuscular/neurologic comorbidity, and gastrostomy tube status, none of these factors were significant when multivariate regression was performed.

Subgroup Analysis: Unanticipated Intensive Care Unit Admission

In the subset of patients who were UIAs, median age was 2.9 years (range 19 months–6 years). Median BMI was the 51st percentile (range 3.7–97 percentile), with only one patient being defined as obese by Centers for Disease Control and Prevention guidelines. No polysomnogram data was available for five of 10 patients. In the patients for whom polysomnogram data was available, the median AHI and O2 nadir were 5.6 (range 0.5–12) and 83% (range 78–85%), respectively. Five of the 10 patients (50%) had neurologic comorbidities, with neuromuscular disorders being present in four. Two patients had gastrostomy tubes. The reason for admission to the PICU was multiple desaturations in three patients, high oxygen demand in four, advanced airway support including nasal trumpet in one, and bilevel positive airway pressure (BiPAP) in two.

DISCUSSION

Although T&A is a very safe procedure, multiple studies have identified patients who have greater potential to develop complications, mostly respiratory, in the postoperative period.2–7 Current guidelines from the American Academy of Otolaryngology–Head and Neck Surgery recommend overnight observation of these high-risk patients utilizing ICU-level resources after adenotonsillectomy in high-risk patients admitted to the ICU postoperatively.

Fig. 1. The association between ICU length of stay (hours) and utilization of ICU-level resources after adenotonsillectomy in high-risk patients admitted to the ICU postoperatively.

ICU = intensive care unit.

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risk patients; however, recommendations regarding PICU candidacy remain elusive.\textsuperscript{13}

Due to concern for respiratory events and a desire to avoid UIAs, many surgeons elect to observe high-risk T&A patients in the PICU. Although such a practice is undoubtedly safe, the true rate of resource utilization is unclear. The aim of this study was to review all post-T&A admissions to the PICU at our institution to assess the frequency with which resources exclusive to an ICU setting were utilized.

The definition of need for ICU-level resources requires some justification. Patients were deemed to have utilized ICU-level care if 1) oxygen supplementation was greater than 2 L NC at any point between 2 to 24 hours postoperatively; 2) more than two desaturation events occurred in any 2-hour period after completion of the first hour in PACU; or 3) more than hourly nursing intervention was apparent on documentation after completion of the first hour in PACU. Oxygen thresholds were determined by the maximum level of oxygen supported in the extended observation unit at our hospital. The 2-hour cutoff for oxygen thresholds was selected because this puts the patient outside the typical window for postoperative delirium and laryngospasm and depicts the patient’s true postoperative baseline after oxygen weaning. The remaining criteria were justified by nursing burden in a setting with nurse to patient ratio of 5:1—benchmark to California legislation—after the typical 1-hour PACU recovery time.\textsuperscript{14}

Our data demonstrates that, even among the high-risk T&A population, only 18.2% of patients admitted to the ICU postoperatively utilized ICU-level resources. This finding is concordant with other recent studies that note the rate of major respiratory AEs after T&A to be low, even among high-risk patients.\textsuperscript{12,15,16} Although these studies highlight rates of both minor and major AEs, they omit the overall nursing burden of the patient, which is a critical element of the appropriate level of care that represented 20% of those utilizing PICU resources in our review. Other factors of these studies also limit their ability to provide insight into ICU resource necessity. In the study by Hill et al.,\textsuperscript{16} desaturations below 90% were listed as minor complications; however, they do not describe the frequency of the events and whether saturations correct spontaneously. Similarly, mild AEs were defined by Thielhaber\textsuperscript{12} as saturations falling below 95%, an event that may be managed outside of an ICU.

Our study is the first to investigate the overall utilization of resources that are exclusive to the ICU in high-risk post-T&A patients. Provided that a care unit has continuous oxygen monitoring, patients having occasional, isolated, self-resolving desaturations may be safely cared for outside of an ICU setting. Given that polysomnography is not universally recommended in the otherwise healthy patient,\textsuperscript{17} many patients with undocumented severe OSA who undergo T&A based on history alone are, in fact, observed in this way at our hospital. Conversely, patients with desaturation events less than 90% who are occurring frequently require repeated attention from a nurse and may not be safely cared for in units with high patient-to-nurse ratios.

Although not every high-risk T&A patient needs ICU resources, the challenge continues to lie in how to accurately identify the patient who does. After all, the

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**Fig. 2.** Factors associated with utilization of ICU-level resources among high-risk adenotonsillectomy patients admitted to the ICU postoperatively: (A) patient age, (B) presence of neurological or neuromuscular comorbidity, (C) gastrostomy tube status. ICU = intensive care unit.
surgeon’s motivation for selecting ICU as a postoperative destination is an effort to avoid UIAs or other adverse event in patients. Interestingly, of the patients who utilized ICU resources in our study, 40% were UIAs and not predicted to need such resources prior to surgery. These patients were not obese and, in those who had preoperative polysomnogram, the degree of OSA was usually not severe. Although no true risk-adjusted benchmark for UIAs is established in children, UIA rates have been described in the literature to range from 0.06% to 2.6%.9–11 Because the overall rate of UIA at our institution after T&A is 0.21%, these miscalculations represent the unpredictable nature of this population rather than poor preoperative planning.

In comparing patients utilizing ICU resources to those for whom resources were not necessary, our cohort demonstrated an association between resource need and young age, neurological/neuromuscular comorbidity, and gastrostomy tube status. Interestingly, gastrostomy tube status was the only factor for which more patients utilized resources than not. The reason for this is unclear and may be attributed to confounding factors in a medically complex patient. Another explanation, however, may be that patients with gastrostomy tube status often have dysphagia, and poor control of secretions in the perioperative period may lead to increased oxygen requirements or other airway support. There was no pattern to specific resource need in gastrostomy patients, which included multiple desaturations, oxygen support, and BiPAP need. Given that the overall cohort of gastrostomy tube patients was small, however, additional studies would be necessary prior to making any final conclusions.

It should be noted that half of the UIA patients had a neurologic disorder, suggesting a possible opportunity to adjust preoperative ICU admission guidelines at our hospital. No associations were found between severity of OSA by both AHI and O2 nadir, high-risk BMI, history of cardiac disease, asthma, or prematurity. In all prior studies describing risk factors for respiratory complications, patients with high-risk comorbidities were compared to that of the general, healthy adenotonsillectomy population.2–7 In looking only at patients admitted to the ICU postoperatively, our study demonstrates that, whereas these patients do represent a higher risk for respiratory events compared to a healthy patient, the overall rate of such events remains low and difficult to predict preoperatively.

Of the patients who utilized ICU resources, 70% declared this resource need within 2 hours of surgery. Theilhaber’s data12 suggests that extended observation in a PACU would capture the majority of severe AEs with an NPV of 98.3%. Our NPV of 93.8% supports these findings and confirms that extended observation may identify not only AEs but also the overall level of resource utilization that a patient will need in the postoperative period.

**CONCLUSION**

Obesity and AHI are traditionally thought to be comorbidities that predict the need for PICU observation.
after adenotonsillectomy. Our findings, however, strongly suggest that PICU level of care is not necessary and may represent an overutilization of resources. These children could perhaps be best allocated to an overnight observation status and still remain in the hospital should the need for escalated care arise. We show that the primary factors driving PICU level of care are age, neurological status, and presence of a gastrostomy tube.

With the ever changing landscape of healthcare and emphasis on value-based care, physician involvement in PI projects such as this provide an opportunity to reassess our current methods of postoperative risk stratification. Physician stakeholder voice and involvement in PI work will become increasingly essential to maintain quality while lowering cost as reimbursement transitions from fee-for-service to value-based care or possibly even bundled payments.

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BIBLIOGRAPHY