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Review

Postoperative respiratory complications (PORC) in children with obstructive sleep apnea syndrome (OSAS) undergoing tonsillectomy: a narrative review

A. Groenendijk[1,2], V. Saldien[2]

[1]Faculty of Medicine and Health Sciences, University of Antwerp, Wilrijk, Belgium; [2]Department of Anesthesiology, University Hospital of Antwerp, Edegem, Belgium.

Corresponding author: A. Groenendijk, Department of Anesthesiology, University Hospital Antwerp, Drie Eikenstraat 655, 2650 Edegem, Belgium. Email : annegroenendijk@hotmail.com

Abstract

Background: **Obstructive sleep apnea syndrome (OSAS) in children often necessitates adenotonsillectomy as a primary intervention. However, postoperative respiratory complications (PORC) pose significant concerns in this population, warranting careful management and monitoring.**
Objective: **This narrative review aims to explore the prevalence, types, and risk factors associated with PORC in children undergoing adenotonsillectomy for OSAS. Additionally, current practices and guidelines for postoperative monitoring and management in this vulnerable population were investigated.**
Methods: **A comprehensive search of PubMed and the Cochrane Library was conducted from January till March 2024 to identify relevant studies. In addition, most recent guidelines of the American Academy of Otolaryngology–Head and Neck Surgery (AAO-HNS), the American Academy of Pediatrics (AAP), the European Respiratory Society (ERS), French Oto-Rhino-Laryngology – Head and Neck Surgery Society (SFORL) and the German guidelines regarding pediatric adenotonsillectomy were included.**
Results: **Twenty-nine studies addressing risk factors for PORC and 12 studies focusing on postoperative monitoring were included. PORC prevalence ranged from 1.4% to 30%, with desaturation being the most common. Identified risk factors included young age, presence and severity of OSAS, polysomnographic parameters, comorbidities, race, timing of surgery, and red cell width distribution. Guidelines varied in recommendations for inpatient admission and monitoring post-adenotonsillectomy. Notably, recent evidence suggests potential for monitoring in high-care wards or post-anesthesia care units, with selective use of pediatric intensive care units.**
Conclusion: **Various risk factors have been identified in predicting PORC following (adeno)tonsillectomy in children with OSAS such as age < 3 years, the presence of OSAS, presence of associated comorbidities, and PSG parameters. Recent guidelines suggest inpatient admission in the presence of specific risk factors. High-care wards or Post Anesthetic Care Units (PACUs) may suffice, avoiding unnecessary pediatric intensive care (PICU) admissions. A "grey zone" approach before deciding on further care is promising, but its optimal duration needs more research. Prospective studies are needed to refine and validate current guidelines, focusing on safely increasing the number of ambulatory (adeno)tonsillectomies.**

Keywords: **Pediatric obstructive sleep apnea syndrome, pediatric adenotonsillectomy, postoperative respiratory complications, pediatric patients, risk factors, postoperative monitoring.**

Introduction

Obstructive sleep apnea syndrome (OSAS) in children is characterized by partial or complete upper airway obstruction during sleep, leading to recurrent episodes of hypopnea/hypoxemia and a fragmented sleep pattern[1]. The prevalence of childhood OSAS is estimated to affect 1.0% to 5.7% of the pediatric population[2–5]. Among the various treatment modalities available, adenotonsillectomy stands as a primary intervention for alleviating upper airway obstruction in pediatric OSAS.

However, despite its efficacy, adenotonsillectomy is not without risk, and postoperative respiratory complications (PORC) are a well-recognized concern in this population[1,4]. These complications encompass a spectrum of issues ranging from mild desaturation to more severe events such as hypoxemia, broncho- and laryngospasm, apnea, increased respiratory effort, and even postoperative pulmonary edema[6].

Of particular note is the heightened vulnerability of children with OSAS to such respiratory complications following adenotonsillectomy[6]. Given the already compromised respiratory function in these individuals, the postoperative period presents a critical window where careful monitoring and management are paramount. Understanding the prevalence and nature of postoperative respiratory complications in this population is crucial for optimizing clinical outcomes and ensuring the safety of pediatric patients undergoing adenotonsillectomy for OSAS.

This narrative review aimed to explore the prevalence and types of PORC encountered in children undergoing adenotonsillectomy for OSAS. Additionally, the existing evidence regarding the identification of risk factors predictive of such complications and discuss current guidelines and recommendations for postoperative monitoring and management in this vulnerable population will be examined.

Objectives

1. Risk factors predicting the development of postoperative respiratory complications in children with OSAS after (adeno)tonsillectomy.
2. Postoperative monitoring regarding (adeno) tonsillectomy in children with OSAS.

Methods

A comprehensive search was conducted on PubMed and the Cochrane Library from January till March 2024 to identify relevant studies. The Pubmed search strategy utilized a combination of keywords and Medical Subject Headings (MeSH) terms to ensure inclusivity and relevance. For an overview of the included studies see Table I. The following search string was employed: ((Postoperative respiratory complications) AND (obstructive sleep apnea[MeSH Terms])) AND (children[MeSH Terms]). For the Cochrane Library search, the following search string was employed: postoperative respiratory complications in Title Abstract Keyword AND "obstructive sleep apnea" in Title Abstract Keyword AND children in Title Abstract Keyword. This strategy yielded a total of 170 articles. Duplicate articles were subsequently removed, resulting in 147 unique articles. These were screened based on title and abstract, leaving 54 articles for further review. Full texts were then sought for these 54 articles, with 10 articles unavailable for access. After screening for eligibility 29 articles were included regarding the objective 'risk factors predicting PORC' and 12 articles were included regarding 'postoperative monitoring', including 4 articles that covered both objectives. The Guidelines of the American Academy of Otolaryngology–Head and Neck Surgery (AAO-HNS), the American Academy of Pediatrics (AAP), the European Respiratory Society (ERS), French Oto-Rhino-Laryngology – Head and Neck Surgery Society (SFORL) and the German guidelines were also collected and selected for inclusion. Figure 1 displays a schematic overview of the selection process.

Results

Prevalence and types of postoperative respiratory complications

Twenty-nine studies were selected regarding the risk factors for developing PORC. An overview of the included studies, regarding the prevalence and risk factors of PORC is presented in Table I. Among these studies there were 21 retrospective studies, 4 prospective studies, 3 systematic reviews and 1 meta-analysis.

The prevalence of PORC varied from 1.4-30%[6-30], to even 60% in urgent cases[31]. Postoperative respiratory complications included desaturation, hypoxemia, bronchospasm, laryngospasm, apnea, increased respiratory effort, and postoperative pulmonary edema. The most common respiratory complication was desaturation <95% in 28.4-40.7%[9,31], <92% in 10.4%[32], <90% varying between 0.9-20%[7,8,10,11,20,22,33]. Broncho- or laryngospasm was reported in 0.6-6.6%[13,16,18,22,24,29].

The most common intervention was the administration of oxygen 0.9-28.4%[7–12,15,19–21,27,31,33]. A nasopharyngeal airway was used in 0.2-2.3% of cases[7–11,20]. Noninvasive ventilation (continuous positive airway pressure (CPAP) , bilevel positive airway pressure (BIPAP) or bag mask ventilation) was needed in 0.3-5.6%[8,9,11,12,18,20,21,33]. Re-intubation rates were overall rather low, occurring in 0-3.6% of cases[7–12,18–21,24,33] except for Brown et al. reporting a higher re-intubation rate of 11.1%[31]. It must be noted that in the latter study, the indication for urgent adenotonsillectomy was based on overnight desaturation <80%. However, this not

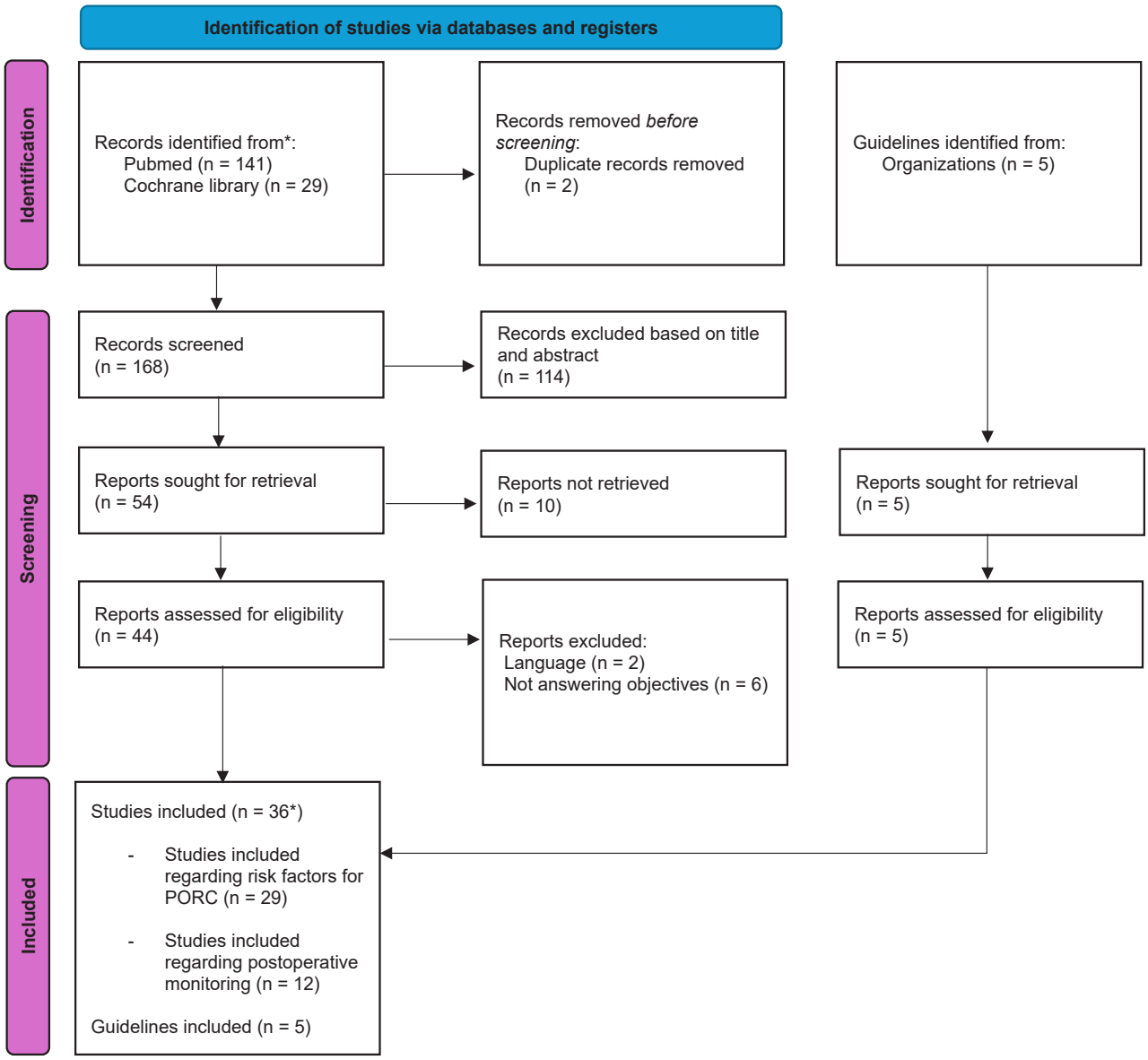

Fig. 1 — Schematic overview of the search strategy adapted from Page et al. (PRISMA 2020) 43
* Five studies were used to analyze both topics making the total number of included studies 36 instead of 41.

only represents the severity of OSAS since other underlying conditions such as asthma, respiratory infections and pulmonary hypertension may lead to lower overnight saturations and also impose a higher risk of developing PORC.

Identified risk factors

Age

In 10 studies young age was found to be a risk factor for PORC after adenotonsillectomy[7,8,11,12,18,20,21,23,24,32]. Even though there are a few research groups that set the limit at 2 years[8,11], most agree that children up to 3 years of age have a higher perioperative risk[7,17,18,20,21,24]. Statham et al. stated that children younger than 3 years have a nearly 2-fold increased risk for respiratory complications after adenotonsillectomy. The highest risk of developing PORC exist in children under 1 year of age. From the age of 1 year, the risk of developing PORC annually decreases with 78%[7]. A prospective study was not able to identify an age-related risk, but their population consisted of older children (aged 5-9 years)[10]. Two other research groups were also unable to demonstrate an age-related risk, about which one already stated that the group aged under 3 years was very small.

OSAS

Despite being a major indication for adenotonsillectomy, OSAS is an established risk factor for the development of PORC. A meta-analysis of 3,148 children found that children with OSAS have nearly 5 times more respiratory complications after adenotonsillectomy than children without OSAS[6]. Not only the presence but also the severity of OSAS is linked with the risk of developing PORC[8,12,17,19,20,24,26,29].

Table I. — Overview of included articles regarding risk factors of postoperative respiratory complications.

Study	Number of patients	Prevalence of PORC	Definition of PORC	Identified risk factors
Adenotonsillectomy Complications: A Meta-analysis[6]but differences between children with and without obstructive sleep apnea (OSA *De Luca Canto et al. 2015* **Meta-analysis**	N = 3148 N = 371	9.4% OSAS 41% Non-OSAS 11%	Not specified	**Presence of OSAS** OR = 4.90; 95% CI: 2.38–10.10
Adenotonsillectomy for Obstructive Sleep Apnea Syndrome in Young Children[7] *Statham et al. 2006* **Retrospective**	N = 2,315 Children <6 years who underwent adenotonsillectomy to treat OSAS	N = 149 (6.4%) < 3y, (9.8%) 3-5y, (4.3%)	3.7% Desaturation <90% requiring oxygen (n=86) Apnea and increased work of breathing, requiring: - 2.2% Nasopharyngeal airway (n=51) - 0.6% Intubation (n=13)	**Age <3 years** OR = 1.98; 95% CI: 1.41-2.77
Can Assessment for Obstructive Sleep Apnea Help Predict Postadenotonsillectomy Respiratory Complications?[8]who underwent adenotonsillectomy within 6 months of the preoperative study, were reviewed. The study focused on two variables: the obstructive apnea and hypopnea index and the oxygen saturation nadir. Medical charts were reviewed for postoperative respiratory complications.\nRESULTS: Three hundred forty-nine children were referred for sleep studies, and 163 met the inclusion criteria. Thirty-four children (21% *Wilson et al. 2000* **Retrospective**	N = 163 Children referred for sleep studies, who underwent adenotonsillectomy within 6 months	21% experienced postoperative respiratory complications requiring medical intervention. 15% required a minor intervention (n=24) 6% required a major intervention (n=10)	20% desaturation (n=33) 6% airway obstruction (n=10) 21% oxygen therapy (n=34) 4% PPV (n=6) 1% CPAP (n=2) 0,6% nasopharyngeal airway (n=1) 0,6% reintubation (n=1)	**Age < 2 years** adjusted OR= 4.3; 95% CI: 1.7–11 **Presence of associated medical condition** OR= 3; 95% CI: 1.4 – 6.5 **AHI index of 5 or more events per hour** 95% CI: 2.7–19.3; P < 0.001 **SpO2nadir 80% or less** OR= 6.4; 95% CI: 2.8 –14.5; P < 0.001 **Severity of OSAS** mild, moderate, and severe OSAS were associated with a 6, 14, and 31% incidence of respiratory compromise, respectively
Children with severe OSAS who have adenotonsillectomy in the morning are less likely to have postoperative desaturation than those operated in the afternoon[9] *Koomson et al. 2004* **Retrospective**	N = 88 Children having adenotonsillectomy with a polysomnographic diagnosis of severe OSAS within six months prior to operation.	28.4% (n=25)	Respiratory complications desaturation defined as a room air oxygen saturation less than 95%. Medical interventions 28.4% Oxygen administration (n=25) 2.3% Nasopharyngeal airway (n=2) 4.5% Bag mask ventilation (n=4) 1.1% Reintubation (n=1)	**Preoperative SpO2nadir** (< 80% vs >80%) **The time of day of surgery** (PM vs AM). Differences in age, weight, gender and the presence of an associated medical condition were not significant.

Table I (Continued). — Overview of included articles regarding risk factors of postoperative respiratory

Complications of adenotonsillectomy for obstructive sleep apnea in school-aged children[10] *Konstantinopoulou et al. 2015* **Prospective**	N = 221 aged 5–9 years with apnea hypopnea index 2–30 or obstructive apnea index 1–20 without comorbidities other than obesity/asthma	1.4% (n=3)	Hypoxemia (defined as a SpO2 <90% and requiring intervention) (n=2) Laryngo- or bronchospasm (n=1) Supplemental oxygen (n=2) Nasopharyngeal airway use (n=1) CPAP, BiPAP, prolonged postoperative endo-tracheal intubation or re-intubation (n=1)	There were no statistically significant associations between demographic parameters (gender, race, and obesity) or PSG parameters (apnea hypopnea index, %TST with SpO2<92%, SpO2nadir, % sleep time with end-tidal CO2>50mmHg) and complications.
Complications of adenotonsillectomy in children with OSAS younger than 2 years of age[29] *Slovik et al. 2003* **Retrospective**	N = 35 Children aged 6 - 23 months with OSAS proven by PSG	5.7% (n=2) 2.9% Hypercarbia (n=1) 2.9% Laryngospasm (n=1)	Airway complications such as oxygen desaturation below 90%	**OSAS severity** presence of severe OSAS in 100% of children with complications
Improving safety for day case adenotonsillectomy in paediatric obstructive sleep apnea[11] *Heward et al. 2022* **Retrospective**	N = 498 with clinically diagnosed OSAS Observed overnight (n= 355) Discharged after 4 hours (n = 138) Failed same-day discharge due to minor complications (n=5)	4,4% *Minor* - 1.4% Self-correcting desaturation (n=7) - 2.2% Desaturation requiring oxygen (n=11) *Moderate* - 0.2% High flow nasal oxygen (n=1) - 0.2% Laryngopharyngeal airway (n=1) - 0.2% CPAP (n=1) *Major* - 0.2% Intubation and ventilation (n=1)	Complications were defined as follows: 1) major— patient requiring PICU care 2) moderate— patient requiring pediatric HDU care 3) minor— patient requiring ward level care.	**Age** Minor complications were more common in children under 2 years old (16.7%) compared to 2-year-olds (10.5%) and those aged 3 years and older (4.1%). **Comorbidities** Patients with comorbidities had a significantly higher rate of post-operative complications (15.7%) compared to those without comorbidities (6.7%).
Polysomnography Parameters Assessing Gas Exchange Best Predict Postoperative Respiratory Complications Following Adenotonsillectomy in Children With Severe OSA[33] *Molero-Raminez et al. 2015* **Retrospective**	N = 158 5-9 years old Children undergoing AT for severe OSA (AOH>10)	Minor respiratory complications occurred in 19.6%. Major respiratory complications occurred in 21.5%.	Minor complications - Admission to ward, n = 91 (73.4%) - Desaturation event during admission, n = 22 (17.7%) - Need for supplemental oxygen late postoperative period n = 21 (16.9%) Major complications - Admission to PICU n = 33 (26.6%) - Need for reintubation n = 2 (1.1%) - Need for noninvasive ventilation n = 3 (1.6%)	**Oxygen desaturation index (ODI)** (P =.014) **SpO2nadir** (P =0.001) **Percentage of TST O2 <90%** (P <0.001).

Table I (Continued). — Overview of included articles regarding risk factors of postoperative respiratory

Polysomnography results versus clinical factors to predict postoperative respiratory complications following pediatric adenotonsillectomy[30]BMI, co-morbidities, etc. *Saur&Brietzke et al. 2015* **Systematic review**	Not specified	5.8% Major respiratory events	Major respiratory complications were defined as events that required significant medical intervention for the patient by a physician or nursing staff, including re-intubation, CPAP, BiPAP, insertion of a nasopharyngeal or oropharyngeal airway, bag mask ventilation, an un-planned admission, elevation of care to the ICU, pulmonary edema, or death.	For studies with extractable data, 102 of 112 patients (91.1%) with a postoperative respiratory complication had a clearly identifiable clinical risk factor, the remainder (8.9%) had only moderate or severe OSAS on PSG and no other predictor.
Polysomnography variables associated with postoperative respiratory issues in children < 3 Years of age undergoing adenotonsillectomy for obstructive sleep apnea[12]35 (17.9% *Billings et al. 2020* **Retrospective**	N = 195 < 3 years mean age of patients was 25.8 months (range 9–35 months)	20.5% required respiratory interventions	Required respiratory interventions 8.7% Oxygen < 2L/min (n = 17) 5.6% Oxygen > 2L/min (n = 11) 2.6% CPAP (n = 5) 3.6% Intubation (n = 7)	**AHI >12.7 events/hour** **>18.5 obstructive apneas** **SpO2nadir <72.5%** **Severity of OSAS** Severe OSAS (AHI >10) were more likely to require oxygen support (n = 25, 17.7%) in contrast to mild (AHI 1-5)-moderate (AHI 5-10) OSA (n = 3, 5.6%). **Age** Children who received oxygen support and who required intubation were significantly younger than those who did not (p < 0.005).
Post-operative Complications Following Adenotonsillectomy in Children With Severe Sleep Apnea-hypopnea Syndrome. Do They Need to be Admitted to an Intensive Care Unit?[13] *Del-Rio Camacho et al. 2014* **Retrospective**	N = 229	2.2%	0.9% Bronchospasm (n=2) 0.9% Laryngospasm (n=2) 0.4% Apnea after extubation (n=1)	**Presence of OSAS** p = 0.39 **Severe OSAS** p = 0.32
Post-tonsillectomy outcomes in children with MPS and obstructive sleep apnea[14] *Elwell et al. 2023* **Retrospective**	N = 24,700 Children who underwent adenotonsillectomy (40 children with MPS).	2.4% in children without MPS 15% in children with MPS	Not specified	**MPS** 6/40 (15%) vs. 586/24,660 (2.4%), P < 0.001
Post-tonsillectomy respiratory complications in children with sleep disordered breathing[15]a database query using Current Procedural Terminology (CPT *Moroco et al. 2020* **Retrospective**	N = 364 3-18.9 years old	2.2% (n=8) oxygen desaturations (< 95%) treated temporarily with supplemental oxygen via nasal cannula overnight prior to hospital discharge.	Any respiratory complications from minor, including mild desaturations (< 95%) and supplemental oxygen requirements, to more significant, including upgraded level of care, pediatric pulmonary consultation, or intubation	**Race** was found to be significantly related to risk of mild overnight desaturations (P = 0.023). Asian, American Indian/ Alaskan Native, Native Hawaiian/Pacific Islander, Multiracial or other races.

Table I (Continued). — Overview of included articles regarding risk factors of postoperative respiratory

Postoperative Complications After Adenotonsillectomy in Two Paediatric Groups: Obstructive Sleep Apnoea Syndrome and Recurrent Tonsillitis[16]with few complications. Moreover, patients over 3 years and without comorbidities do not present a higher rate of respiratory adverse events after the immediate postoperative period, and do not need systematic admission to a paediatric intensive care unit (PICU *Rodríguez-Catalán et al. 2020* **Retrospective**	N = 418 56.7% due to recurrent tonsillitis 43.3% because of OSAS	1.4% respiratory events (n=6)	1.4% Broncho-laryngeal spasm (n=6)	No risk factors identified
Postoperative respiratory complications after adenotonsillectomy in children with obstructive sleep apnea[17]but opinions differ regarding the polysomnography (PSG *Caetta et al. 2021* **Retrospective**	N = 560 children age <18 years with positive PSG (AHI > 2) who underwent adenotonsillectomy	2.7% < 3 years n = 5 (5.3%) > 3 years n = 10 (2.1%)	Minor complications including mild desaturation, stridor, croupy cough and laryngospasm Severe complications including prolonged desaturation, tachypnea, atelectasis, intercostal retraction and obstructive apnea requiring CPAP	Suggestive **Aged < 3 years** **AHI > 24** **SpO2nadir <80%**
Postoperative Respiratory Complications and Racial Disparities Following Inpatient Pediatric Tonsillectomy: A Cross-Sectional Study[18] *Kou et al. 2019* **Retrospective**	N = 30.617 Children who underwent inpatient adenotonsillectomy	2.4% Laryngo- or bronchospasm 0.6% Pneumonia 1.3% Postoperative pulmonary edema 0.6% Other respiratory complications 1.3%	Respiratory intervention rate 3.6% Postoperative intubation 1.9% Non-invasive mechanical ventilation 1.7% Prolonged mechanical ventilation 1.9%	**Age ≤3 years** (OR= 1.27, P < 0.001), **Male sex** (OR= 1.43, P < 0.001) **Obesity** (OR= 2.25, P < 0.001) **OSAS** (OR= 1.71, P < 0.001) **Prematurity** (OR= 3.93, P < 0.001) **Epilepsy** (OR= 3.44, P < 0.001) **Congenital heart disease** (OR= 2.43, P < 0.001), **Down syndrome** (OR= 1.30, P = 0.3) **Asthma** (OR= 2.04, P < 0.001). **Race** Afro-American children (OR= 1.5, 95% CI: 1.3-1.8)
Postoperative respiratory complications in children with obstructive sleep apnea syndrome[19] *Benedek et al. 2022* **Prospective**	N = 577 Children who had OSAS and underwent adenotonsillectomy	4.3%	Desaturations necessitating supplemental oxygen therapy n = 11 (1.9%) Apneas n = 6 (1%) Bronchopneumonia n = 1 (0.2%) Reintubation n = 4 (0.7%)	Postoperative oxygen desaturations were more marked in patients with comorbidities (p = 0.005). The **presence of comorbidity** increased the risk of PORCs (OR = 4.234, 95% CI: 3.226-5.241, P < 0.001) in patients without comorbidities **increased AHI** was the most strongly related factor to complications

Table I (Continued). — Overview of included articles regarding risk factors of postoperative respiratory

Predictors of overnight postoperative respiratory complications in obese children undergoing adenotonsillectomy for obstructive sleep apnea[32] *Lee et al. 2022* **Retrospective**	N = 155 Obese children who underwent adenotonsillectomy for OSAS	PACU respiratory events occurred in 26.6%. - Airway regression (15.7%) - Respiratory depression (13.6%) - O2 desaturation (5.2%) - major adverse respiratory event (3.2%). Overnight respiratory complications 15.6% - O2 desaturation (10.4%) - Airway regression (10.4%) - Respiratory depression (2.6%).	- O2 desaturation under 92% - Need for overnight airway support - Respiratory support regression - Respiratory depression - Broncho- or laryngospasm.	**Lower SpO2nadirs on PSG** were an independent predictor of PORC (OR = 0.953, 95% CI: 0.91–0.99, P = 0.021), as was **sleep time with O2 saturation < 90%** (OR = 1.04, 95% CI: 1.00–1.07, P = 0.048).
Predictors of Perioperative Complications in Higher Risk Children after Adenotonsillectomy for Obstructive Sleep Apnea: A Prospective Study[20] *Thongyam et al. 2014* **Prospective**	N = 329 Higher risk population	28%	Oxygen supplementation to maintain oxygen saturation levels >92% n = 63 (19%) Nasopharyngeal airway n = 20 (6.1%) High flow nasal cannula oxygen n = 1 (0.3%) CPAP n = 5 (1.5%) BIPAP n = 1 (0.3%) Intubation n = 2 (0.6%)	**AHI** **SpO2nadir** **Sleep time with SpO2 <90%** **Peak end-tidal CO2** **Sleep time with end-tidal CO2 >50 mmHg** **Age < 3 years** **Black race** suggestive, not significant
Predictors of postoperative respiratory complications in children undergoing adenotonsillectomy[21]bringing risk of perioperative respiratory adverse events (PRAEs *Katz et al. 2020* **Retrospective**	N= 374	17.6%	Desaturation requiring oxygen n = 58 (15.5%) Bag mask ventilation n = 1 (0.3%). Airway support n = 18 (4.8%) Intubation n = 1 (0.3%)	**Cardiac comorbidity** **Airway anomaly** **Age < 3 years**

Table I (Continued). — Overview of included articles regarding risk factors of postoperative respiratory

Red cell distribution width as a novel predictor of postoperative respiratory adverse events after adenotonsillectomy[22]a measure of erythrocyte size variability, has recently been linked to adverse outcomes in a variety of disorders. Red cell distribution width has also been found to be associated with severity of obstructive sleep apnea in adults due to hypoxia-mediated inflammation.\nAIM: The objective of this study was to evaluate whether elevated red cell distribution width is associated with postoperative respiratory adverse events in children with symptoms of sleep-disordered breathing.\nMETHODS: A prospective, observational, assessor-blinded study was conducted with consecutive children undergoing elective adenotonsillectomy for treatment of sleep-disordered breathing. Under general anesthesia, adenoidectomy was performed by curettage, and tonsillectomy was carried out by dissection. The primary outcome was the occurrence of an adverse event during emergence or in the postanesthesia care unit (PACU *Kozanhan & Lyisoy et al. 2017* **Prospective**	N = 287	30%, n = 86	Desaturation 18,5% Airway obstruction 13,2% Apnea 11,2% Severe cough 20,9% Laryngospasm 3,1% Bronchospasm 3,5% Stridor 5%	Optimal cutoff = 14.7. Using this cutoff resulted in 43.0% sensitivity, 98.0% specificity, 90.2% PPV, and 81.1% NPV.
Respiratory complications after diode-laser-assisted tonsillotomy[23]such as comorbidities or severe obstructive sleep apnea syndrome (OSAS *Fischer et al. 2014* **Retrospective**	N = 96	16.6% (n=16)	Oxygen desaturation less than 90 % measured by pulse oximetry or respiratory failure requiring manual ventilation support.	**Younger children** (3.1 vs. 4.0 years, p = 0.049, 95% CI: 1.7952−0.0048) **Suffered from nocturnal apneas** (OR = 5.00, p < 0.01, 95% CI: 1.4780–16.9152) **Suffered from relevant comorbidities** (OR = 4.84, p < 0.01, 95% CI; 1.5202–15.4091) **Diodelaser power higher than 13 W** was identified as a risk factor for the occurrence of a postoperative oropharyngeal edema (OR = 3.45, p < 0.01, 95 % CI: 1.3924–8.5602)

Table I (Continued). — Overview of included articles regarding risk factors of postoperative respiratory

Respiratory Complications of Adenotonsillectomy for Obstructive Sleep Apnea in the Pediatric Population[24]who underwent adenotonsillectomy for treatment of OSA. The prevalence of respiratory complications in the first 24 postoperative hours was measured. Patients with craniofacial malformations, obesity, and severe cardiovascular comorbidities were excluded. The prevalence of postoperative respiratory complications was compared with the severity of OSA according to the Apnea Hypopnea Index (AHI *Marrugo Pardo et al. 2018* **Retrospective**	N = 167	3.6%, n = 6 Major n = 5 - Laryngospasm n=2 - Bronchospasm n = 2 - Reintubation n = 1 Minor n = 1 - Hypoxemia n = 1	Minor complications include hypoxemia, hypercapnia, and apnea exacerbation events. Major complications include pulmonary edema, laryngospasm, and bronchospasm.	**Preoperative AHI > 44/h** **Age < 3 years** Association: SpO2nadir < 70%
Risk Factors for Post-Tonsillectomy Respiratory Events in Children With Severe Obstructive Sleep Apnea[25] *Lim et al. 2023* **Retrospective**	N = 887	14.8%, n = 131	Respiratory events were defined as desaturations below 90% while admitted and/or events requiring respiratory support (e.g., nasal cannula, CPAP, intubation).	**TST < 90%** (tb90) (OR = 1.10, 95% CI: 1.07–1.14, P < 0.001) **Black race** (OR = 2.34, 95% CI: 1.53–3.58, P < 0.001) **Primary neurologic co-morbidity** (OR = 3.27, 95% CI: 1.67–6.32, P < 0.001) **Down syndrome** (OR = 2.72, 95% CI: 1.25–5.94, P = 0.01) **Young age** (OR = 0.88, 95% CI: 0.84–0.94, P < 0.001)
The risk of postoperative respiratory complications following adenotonsillar surgery in children with or without obstructive sleep apnea: A systematic review and meta-analysis[26]with first-line treatment being adenotonsillar (AT *Keserü et al. 2022* **Systematic review** **Meta analysis**	A total of 19 studies were included in this meta-analysis, examining PORC following adenotonsillectomy surgery in 120,544 patients, with 59,323 of them involving OSAS.	Total 7.4% OSAS 9.7% Non-OSAS 4.3%	Minor complications: desaturations for any reason without the need for intervention Major complications: desaturation, laryngospasm, bronchospasm, pulmonary edema, or pneumonia requiring interventions, such as reintubation, naso- or oropharyngeal airway management or ventilation.	**Severity of OSAS** PORCs appeared more frequently in moderate (OR = 1.79, 95% CI: 1.004-3.194, P = 0.048) and severe OSAS (OR = 4.06, 95% CI: 1.68-9.81, P = 0.002) compared to non-OSAS patients. No significant difference was detected in the appearance of major complications (OR = 2.14, 95% CI: 0.67-6.86, P = 0.200) comparing OSAS and non-OSAS populations.

Table I (Continued). — Overview of included articles regarding risk factors of postoperative respiratory

Tonsillectomies and respiratory complications in children: A look at pre-op polysomnography risk factors and post-op admissions[27]and no postoperative respiratory complications were identified in children with an AHI less than 10.\nCONCLUSIONS: Our results indicate an association between an AHI ≥40 and respiratory complications following an adenotonsillectomy, but we were not able to observe any significant difference at a cutoff of 25. An association between BMI or O2 nadir and postoperative respiratory complication was not able to be identified. Our results support the importance of AHI as a predictor of postoperative respiratory complications in children undergoing tonsillectomy for OSA.","container-title":"International Journal of Pediatric Otorhinolaryngology","DOI":"10.1016/j.ijporl.2016.07.017","ISSN":"1872-8464","journalAbbreviation":"Int J Pediatr Otorhinolaryngol","language":"eng","note":"PMID: 27497419","page":"224-227","source":"PubMed","title":"Tonsillectomies and respiratory complications in children: A look at pre-op polysomnography risk factors and post-op admissions","title-short":"Tonsillectomies and respiratory complications in children","volume":"88","author":[{"family":"Kasle","given":"David"},{"family":"Virbalas","given":"Jordan"},{"family":"Bent","given":"John P."},{"family":"Cheng","given":"Jeffrey"}],"issued":{"date-parts":[["2016",9]]}}],"schema":"https://github.com/citation-style-language/schema/raw/master/csl-citation.json"} *Kasle et al. 2016* **Retrospective**	N = 86	11.6% Desaturation requiring oxygen n = 10 (11.6%) BIPAP n = 2 (2.3%)	Persistent oxygen desaturation requiring supplementary oxygen, laryngospasms, bronchospasms, need for medical therapy, and other respiratory complications requiring support while in the hospital.	**AHI >40** An association between BMI or SpO2nadir and PORC was not able to be identified. No significant association was found between the occurrence of complications and BMI (P = 0.20) or SpO2nadir (P = 0.09).
Tonsillectomy in Children with Down Syndrome: A National Cohort of Inpatients[28] *Baker et al. 2017* **Retrospective**	N = 7512 With Down syndrome, N = 353	1.5% 1.4% in Down Syndrome	ICD 9, 99739 respiratory complication not elsewhere classifiable	No statistically significant difference in experiencing PORC based on whether a patient had Down syndrome.

Table I (Continued). — Overview of included articles regarding risk factors of postoperative respiratory

Urgent Adenotonsillectomy. An Analysis of Risk Factors Associated with Postoperative Respiratory Morbidity[31]1999, and March 31, 2001, was reviewed. Two groups of children were identified from two different databases: the hospital database for surgical procedures (the study group *Brown et al. 2003* **Retrospective**	N = 54 Children undergoing urgent adenotonsillectomy	60%, n = 33 Oxygen administration 40.7%, n = 22 Major intervention 20.3%, n = 11 (reintubation, ventilation, and/or administration of racemic epinephrine or Ventolin) Reintubation 11.1% n = 6	The respiratory complications were classified as desaturation, defined as a recorded oxygen saturation less than 95%, and airway obstruction, identified in the chart record by such words as "stopped breathing" or "apnea." It was sometimes difficult to distinguish respiratory depression from airway obstruction, but if the medical notes documented that the child was repositioned or the airway was supported, an obstructed breathing pattern was inferred.	**Associated medical condition** (OR = 8.15, 95% CI: 1.81–36.73) **Preoperative SpO2nadir < 80%** (OR = 5.54, 95% CI: 1.15–26.72) Difference between < 3 and > 3 years of age P = 0.13
AHI: apnea hypo-apnea index; BiPAP: bi-level positive airway pressure; CI: confidence interval; CPAP: continuous positive airway pressure; ICU: intensive care unit; OSAS: obstructive sleep apnea syndrome; OR: odds ratio; PACU: post anesthetic care unit; PICU: pediatric intensive care unit; PORC: postoperative respiratory complications; PSG: polysomnography; SpO2nadir: lowest saturation measured; TST<90%: total sleeping time with saturation under 90%.				

Table II. — Overview of included articles regarding postoperative monitoring after (adeno)tonsillectomy in children with OSAS.

Study	Number of patients	Results	Recommendations
Ambulatory tonsillectomy for children with severe obstructive sleep apnea without risk factors[40]type, and timing of respiratory complications for patients with and without PSG following T&A, and discuss cases where disposition was changed due to PSG results.\nRESULTS: 1135 patients without risk factors underwent T&A for SDB or OSA. 196 (17% *Kong et al. 2020* **Retrospective**	N=1.135 without risk factors underwent AT for SDB or OSA.	PSG in children without AAO-HNS risk factors results in admission of otherwise healthy patients following AT who would have otherwise undergone ambulatory surgery.	PSG alone in pediatric patients with no AAO-HNS risk factors should not influence postoperative disposition. These patients should be monitored for 3 h post-AT and discharged in the absence of complications.
Assessing Frequency of Respiratory Complications in Children Undergoing Adenotonsillectomy[39]2009, to March 30, 2014.\nMEASUREMENTS AND MAIN RESULTS: Of the 165 children included in the study, 150 (91% *Baker et al. 2020* **Retrospective**	N=165 All children admitted to the ICU following AT	Most children admitted to the ICU following adenotonsillectomy in this population required no support after 2 hours. Preoperative factors such as obesity and abnormal sleep studies were not predictive of need for postoperative respiratory support.	Need for respiratory support at 2 hours may be a useful criterion for need for ICU level care in this population.

Table II (Continued). — Overview of included articles regarding postoperative monitoring after (adeno)tonsillectomy in children with OSAS.

Clinical outcomes in a high nursing ratio ward setting for children with obstructive sleep apnea at high risk after adenotonsillectomy[38] *Arachchi et al. 2016* **Retrospective**	N=343	In a cohort of children with known moderate-severe OSA, post-operative AE after AT were all managed in the HAU. All respiratory adverse events were of a mild nature: requiring oxygen (75%), repositioning or brief stimulation (16%), or only had a period of increased nursing observation (9%). There were no severe respiratory adverse events and no patients were admitted from the HAU to the ICU.	Post-operative care in HAU provides safe and effective care for high-risk children post-AT, minimizing admissions to ICU.
Day-case discharge criteria and safety of children undergoing adenoidectomy and tonsillectomy for obstructive symptoms-A systematic review[35] *Gowda et al. 2022* **Systematic review**	N=10.731	The proportion of children considered for planned day-case surgery ranged from 28.7%–100% based on individual criteria, with an average rate of successful same-day discharge of 96.1% in these patients.	Current literature suggests that daycase surgery is safe in carefully selected patients. Suggested day-case discharge criteria for adenoidectomy and tonsillectomy in children with OSA Pre-operative/patient factors - Age >2–3 years - Mild-to-moderate OSA (AHI <10, pulse oximetry >80%, ETCO2 <50 mmHg) - No significant medical comorbidities - Reliable caregiver - Live within 30 min of hospital Post-operative factors - 6-h observation period - EWS 0 on discharge - Pain controlled with non-opiate analgesia - Tolerating oral intake - No active vomiting - No active bleeding - Caregiver confidence to continue observations at home
Post-operative Complications Following Adenotonsillectomy in Children With Severe Sleep Apnea-hypopnea Syndrome. Do They Need to be Admitted to an Intensive Care Unit?[13] *del-Río Camacho et al. 2014* **Retrospective**	N = 229	All respiratory complications took place in the immediate post-operative period (operating theatre or anesthesia recovery), with none in the pediatric ward.	Children who undergo adenotonsillectomy, without any other comorbidities, malformation syndrome or neuromuscular disease, are more than 2 years old and have an immediate postoperative period without incidence, do not need to be systematically admitted to an intensive care unit and can be admitted to the ward, even if they present with severe OSAS.
Post-tonsillectomy respiratory complications in children with sleep disordered breathing[15]a database query using Current Procedural Terminology (CPT *Moroco et al. 2020* **Retrospective**	N = 364	In the present study, these patients had an overnight respiratory complication rate of 2.2%. All complications were mild, consisting of overnight desaturations which required supplemental oxygen prior to discharge. There were no severe respiratory complications requiring upgrade to PICU or home supplemental oxygen therapy.	A lack of significant postoperative respiratory complications or alterations in the clinical management of children with SDB without prior PSG supports the idea that such patients may safely be discharged from the hospital following tonsillectomy without overnight oxygen monitoring.

Table II (Continued). — Overview of included articles regarding postoperative monitoring after (adeno)tonsillectomy in children with OSAS.

Postoperative respiratory complications in children with obstructive sleep apnoea syndrome[19] *Benedek et al. 2022* **Prospective**	N = 577 Children who had OSAS and underwent AT	Postoperative oxygen desaturations were more marked in patients with comorbidities (p = 0.005). The presence of comorbidity increased the risk of PORC (odds ratio 4.234/3.226-5.241, 95% confidence intervals, p < 0.001).	Our data show that comorbidities significantly increase the risk for pulmonary complications after adenotonsillectomy in children with OSA, and these complications are more severe than in patients with OSA but without comorbidities. Pulmonary complications occur with increased OSA severity in patients without comorbidities, but complications usually occur within the first 2 hours postoperatively and these patients do not need intensive care observation.
Respiratory complications after adenotonsillectomy in high-risk children with obstructive sleep apnea: A retrospective cohort study[41]60% are secondary to airway/ respiratory events. Earlier studies identified that children aged <2 years, extremes of weight, with co-morbidities of craniofacial, neuromuscular, cardiac/respiratory disease, or severe OSA are at high risk for adverse post-operative respiratory events (AE *Ekstein et al. 2020* **Retrospective**	N = 3.997	90% of all 76 children who suffered an AE in the PACU had recurrent AEs in the PICU; however, among the 103 children who had no PACU event, 36 (35%) suffered AEs in the PICU, one of which was a major event. In contrast with otherwise healthy children undergoing TA who experience most AEs in the first hours post-operatively in the PACU, we report that high-risk children experience more AEs later, while in the PICU.	Among high-risk children undergoing TA, absence of adverse events in PACU during a 2-hour observation period does not predict absence of subsequent AEs in the PICU.
Respiratory Complications of Adenotonsillectomy for Obstructive Sleep Apnea in the Pediatric Population[24]who underwent adenotonsillectomy for treatment of OSA. The prevalence of respiratory complications in the first 24 postoperative hours was measured. Patients with craniofacial malformations, obesity, and severe cardiovascular comorbidities were excluded. The prevalence of postoperative respiratory complications was compared with the severity of OSA according to the Apnea Hypopnea Index (AHI *Marrugo et al. 2018* **Retrospective**	N = 167	The prevalence of postoperative respiratory complications was 3.59%. Statistical significance was found between the presence of respiratory complications and a preoperative AHI greater than or equal to 44, p < 0.04 (95% confidence interval (CI): (-28.91) - (0.62)). The group of patients younger than 3 years, compared to patients older than 3 years, had a higher incidence of respiratory complications in the immediate and early postoperative phase.	We suggest ambulatory management after 6 hours in Postanesthetic Care Unit (PACU) observation in patients older than 3 years, with AHI less than 44 and SpO2nadir greater than 70% in altitudes higher than 2.500 m.a.s.l.
Respiratory events after adenotonsillectomy requiring escalated admission status in children with obstructive sleep apnea[34]PICU admission status, and unscheduled escalation of care.\nRESULTS: Thirty-six (26.8% *Arambula et al. 2018* **Retrospective**	N = 133	Pediatric patients requiring post-AT PICU care have more risk factors for respiratory compromise. Total PACU time and total PACU time requiring supplemental oxygen may indicate patient risk for postoperative respiratory complications and need for intensive care.	Our study identified important variables associated with PICU admission, escalation of care, and severe respiratory events. These variables include younger age, higher preoperative AHI, greater number of comorbid risk factors for respiratory compromise, more total time spent in the PACU, greater percentage of PACU time spent on supplemental oxygen, and more hospital days requiring oxygen above baseline or interventions besides supplemental oxygen.

Table II (Continued). — Overview of included articles regarding postoperative monitoring after (adeno)tonsillectomy in children with OSAS.

Review of the Utility of Extended Recovery Room Observation after Adenotonsillectomy[37]where the post-operative level of care for high-risk adenotonsillectomy patients (general care vs. intensive care unit *Hazkani et al. 2023* **Retrospective**	N = 274	4.4% of patients were transferred from the PACU to the ICU due to respiratory distress. Of the patients admitted to general care, 1.5% secondarily developed respiratory compromise, requiring escalation of care.	The Grey Zone model accurately identifies patients requiring ICU-level care following adenotonsillectomy, allowing for a safe reduction in the utilization of ICU resources. Due to rare delayed respiratory events, overnight observation in this cohort is recommended.
Routine post-operative intensive care is not necessary for children with obstructive sleep apnea at high risk after adenotonsillectomy[36]to assess the appropriateness of this care plan.\nMETHODS: A retrospective chart review was carried out all children admitted to the pediatric intensive care unit after AT for OSA from January 2007 to December 2009. AE were classified as mild, including requirement for supplemental O2 or repositioning to improve airway or severe, including bag and mask ventilation, CPAP, re-intubation, placement of oropharyngeal airway or unplanned ICU admission for airway compromise.\nRESULTS: 72 children were identified (21 female, median age 2.8 years *Theilhaber et al. 2014*	N = 72	Our data confirm high rates of AE after AT for high risk patients, however, only 8% suffered a severe AE truly necessitating care in ICU. This outcome was very unlikely if an AE did not occur in PACU.	We therefore conclude that routine post-operative ICU care for high risk children may be avoided if prolonged monitoring in the PACU is possible, with admission to ICU reserved for high-risk children with an early AE.
AAO-HNS: American Academy of Otolaryngology–Head and Neck Surgery; AE: adverse events; AHI: apnea hypo-apnea index; AT: adenotonsillectomy; ETCO2: end-tidal carbon dioxide; EWS: early warning scale; HAU: high acuity unit; ICU: intensive care unit; OSA: obstructive sleep apnea; OSAS: obstructive sleep apnea syndrome; PACU: post anesthetic care unit; PICU: pediatric intensive care unit; PORC: postoperative respiratory complications; PSG: polysomnography; SDB: sleep disordered breathing; SpO2nadir: lowest saturation measured.			

Polysomnographic (PSG) results

A PSG is not always preformed but several studies suggest a predictive value of AHI, lowest saturation during PSG (SpO2nadir), total sleep time with saturation <90% (TST<90%) and oxygen desaturation index (ODI)[8,12,19,20,24,27,32–34]. While some studies found a significant increase in PORC risk at an AHI of >10 or >12.712, others only describe increase in PORC risk around an AHI of >24[17] or even only around >40[24,27.] SpO2nadir proved to be a significant predictor of PORC in several studies[8,9,12,20,31–33]. Most describe a SpO2nadir <80% as significant predictor[8,9,20,31–33], however one study suggested SpO2nadir onlyl to be significant when its <72.5%12. TST <90% is also found to be a significant factor for predicting PORC[20,25,32,33]. One retrospective study could not find a significance of PSG parameters other than AHI[27]. Three other studies were all unable to demonstrate a link between the PSG results and the occurrence of PORC[10,15,21].

Presence of other associated comorbidities

A very large retrospective study conducted by Kou et al. containing 30,617 children identified obesity, prematurity, epilepsy, congenital heart disease, Down syndrome and asthma as significant comorbidities[18]. Other high-risk comorbidities include respiratory drive disorders, chronic lung disease, mucopolyssaccharidoses (MPS), neuromuscular diseases, Prader-Willi syndrome and sickle cell anemia[8,11,14,19,21,23,25,31]. The mean age in the down syndrome group was higher than the rest of the study population. A retrospective analysis of the Down syndrome population undergoing adenotonsillectomy showed no difference in the prevalence of PORC compared to the non-Down syndrome group[28]. Where Kou et al. identified obesity as a risk factor[18], a smaller retrospective study claimed there is no association between BMI and the risk of PORC[27].

Race

Two studies concluded that African American or black race children had a higher risk of developing respiratory complications after (adeno) tonsillectomy[18,20]. Whereas another concluded that African American children did not develop more PORC, but that children at increased risk were more likely to be in the collective group of 'other origins'[15].

Timing of surgery

The difference in postoperative respiratory complications on terms of AM- or PM-surgery were analyzed in one study. Children undergoing AM surgery were less likely to develop postoperative desaturations[9]. The literature search found no other studies investigating the effect of timing.

Red cell width distribution (RWD)

Red cell width distribution (RWD) has emerged as a potential marker for assessing the risk of PORC in pediatric patients undergoing adenotonsillectomy for OSAS. Although RWD has been linked with OSAS severity in adults, its applicability in the pediatric population warrants further investigation. A prospective study involving 287 children evaluated the utility of RWD as a predictor of PORC in pediatric OSAS[22]. Their findings suggested a potential association between elevated RWD and the risk of PORC, with a cut-off value of 14.7 for RWD . However, it is important to note that this study represents only one study in this area.

Postoperative monitoring

Twelve articles (of which 10 retrospective studies, 1 prospective study and 1 systematic review) and 5 guidelines were included regarding the postoperative monitoring after (adeno) tonsillectomy.

Gowda et al. performed a systematic review including 15 studies containing 10,731 patients with OSAS. The proportion of children considered for planned day-case surgery ranged from 28.7%–100%. The overall successful same-day discharge rate was 96.1%. Suggested day-case discharge criteria, split into preoperative and postoperative criteria. Preoperative patient factors including age above 2–3 years, mild-to-moderate OSAS (AHI <10, pulse oximetry >80%, ETCO2 <50 mmHg), no significant medical comorbidities, reliable caregiver and live within 30 minutes of hospital. The postoperative factors including: 6-h observation period, early warning score 0 on discharge, pain controlled with non-opiate analgesia, tolerating oral intake, no active vomiting, no active bleeding and caregiver confidence to continue observations at home[35].

Guidelines provide different recommendations for inpatient admission. European guidelines recommend inpatient monitoring if a child presents with one or more risk factors such as age, severity of OSAS or comorbidity[2], while American guidelines primarily emphasize age and the severity of OSAS[1,5]. The American Academy of Otolaryngology–Head and Neck Surgery (AAOHNS) is rather cautious mentioning an AHI ≥10 as severe OSAS in need for inpatient management[5] whereas the American Academy of Pediatrics (AAP) rather uses a higher AHI of >24[1]

and the European guidelines even use an AHI of >26[2]. For a comprehensive overview of the different guidelines see Table III.

When inpatient admission is indicated, in most cases there is no need for Pediatric Intensive Care Unit (PICU) admission[13,19,36,37]. The use of a high acuity unit to help reduce intensive care admissions was suggested by a retrospective study conducted amongst children with moderate to severe OSA[38]. A couple studies suggested using a 2-4 hour period on Post Anesthetic Care Unit (PACU) as a 'grey zone' determining the rest of the postoperative course assuming the absence of PORC in the first few hours postop exclude events needing ICU care[13,19,36,37]. A retrospective study of 165 high risk children (under 3 years of age, diagnosis of severe OSAS or comorbidities) finding need for respiratory support at 2 hours may be a useful criterion for need for ICU level care in this population[39].

Some research groups go even further and claim that PSG alone in pediatric patients with no AAO-HNS risk factors should not influence postoperative disposition. These patients should be monitored for 3 h post-(adeno)tonsillectomy and discharged home in the absence of complications[40]. However, this must be interpreted with caution since a retrospective study among high-risk children undergoing (adeno) tonsillectomy found that the absence of adverse events in PACU during a 2-hour observation period does not predict the absence of subsequent adverse events in the PICU[41]. Another retrospective study also described 1.5% of patients needing escalation of care after late developing respiratory compromise[37].

Discussion

Our review provided widely varying prevalence's of PORC. This may be attributed to the widespread variability in the definition of PORC, which remains a challenge in the literature. While some studies define PORC as mild desaturations below 95%9 or 92%32, others adopt stricter criteria, such as desaturations below 90%[7,8,10,11,20,22] or the need for intervention[12,21]. There is also variation between different study populations. While some studies include all children undergoing tonsillectomy, others include specific age groups, or only children with OSAS or even only with severe OSAS, or only urgent cases.

The generally low prevalence of PORC indicates that the absolute number of children in the complication group is low, and static analysis in terms of risk factors is often difficult and rather unreliable. Considering this, the study conducted by Kou et al, encompassing 30,617 participants, emerges as a highly influential contribution within this field of research. Key risk factors for developing PORC include young age (typically younger than 3 years), the presence and severity of OSAS, and the presence of comorbidities. PSG data, including the AHI, SpO2 nadir, and the percentage of TST <90%, also appear to have predictive value for developing PORC. While PSG is the gold standard for assessing OSAS severity, its routine use is limited by factors such as cost and availability, and it is primarily recommended in high-risk groups such as young children and those with comorbidities or craniofacial abnormalities[2–5].

Additional potential risk factors predicting PORC are RWD22 and PM surgery[9]. The latter presents a novel perspective on optimizing adenotonsillectomy surgery planning, suggesting a preference for morning operation room schedules to mitigate the risks associated with late afternoon surgeries. Both risk factors have been documented in only one study each, underscoring the necessity for further extensive research before definitive conclusions can be drawn.

Recently, various guidelines have been published regarding postoperative care after tonsillectomy. Highlighting risk factors that may increase the likelihood of PORC and require in patient admission. While guidelines acknowledge the importance of postoperative monitoring, there is a lack of clear consensus on the optimal location and intensity of monitoring. Recent evidence suggests that in many cases, PICU admission may not be necessary, with monitoring on a high-care ward or PACU equipped with oximetry being sufficient for early recognition and management of PORC. Considering that most PORC can be managed with repositioning and oxygen administration and the need for reintubation extremely rare.

In addition to current practices, studies have explored the concept of utilizing a "grey zone" within the PACU for observation following adenotonsillectomy. This approach involves monitoring patients for a defined period, typically ranging from 2 to 4 hours, to assess for the absence of immediate PORC before determining further care pathways. However, the optimal duration of observation in this "grey zone" remains a topic of ongoing discussion and investigation within the medical community. This strategy aims to balance the need for vigilant monitoring with the efficient allocation of healthcare resources, but its precise implementation and duration warrant further research and consensus-building.

Limitations

Retrospective studies are commonly utilized to investigate PORC in children undergoing

Table III. — Overview of different guidelines regarding PSG testing and postoperative monitoring .

Guidelines	Pre-operative polysomnography recommended	Risk factors of PORC	In patient admission recommended 1 or more of the following:
ERS[2]	In the presence of: - obesity - craniofacial deformities - neuromuscular disorders - complex abnormalities (e.g. Chiari malformation, Down syndrome and Prader–Willi syndrome) Or when the need for treatment is unclear.	- AHI >26 episodes·h−1 - Oximetry recording with three or more clusters of desaturation (≥4%) events and at least three desaturations to <90% - Age <3 years - Obesity or low weight - Neuromuscular, craniofacial, or genetic disorders.	- Presence of ≥1 risk factor
German S1[3]	- Age <2 years - Obesity (>95th percentile) - Trisomy 21 - Craniofacial malformation - Dysgnathia - Neuromuscular disease - Mucopolysaccharidosis - Prader-Willi syndrome - Chiari 2 malformation - Achondroplasia - Sickle cell anemia	- Age <3 years - Obesity - Respiratory drive disorders - Chiari-2 malformation - Chronic lung diseases - Heart defects or cardiac involvement due to OSA (right heart failure) - Craniofacial malformations - Critical postoperative events in the recovery room within 2 hours - Mucopolysaccharidoses - Musculoskeletal diseases - Neuromuscular diseases - Prader-Willi syndrome - Sickle cell anemia - Trisomy 21	Pediatric unit - Presence of ≥1 risk factor Medium care or intensive care unit when: - Severe OSAS - Significant risk factor - Need for intervention in recovery room (CPAP or mechanical ventilation)
SFORL[4]	- Doubt as to the efficacy of tonsillectomy: - Children with morbid obesity - Cranio-facial - Upper Airway malformation - Neuromuscular disease - Failure of clinical examination to explain respiratory disorder: absence of tonsillar or adenoid obstacle - Elevated surgical risk: hemostasis disorder, cardiac abnormality	- Age <3 years - Craniofacial or upper airway malformation - Neuromuscular disease with pharyngeal hypotonia - Signs of right heart failure and elevated pulmonary arterial pressure - Morbid obesity - Metabolic disease with UA submucosal conjunctive tissue infiltration - Respiratory disease following recent upper or lower respiratory tract infection	- Clinical criteria for perioperative respiratory risk - Hemostasis abnormality - Respiratory difficulty on anesthesia induction or at awakening in the recovery room ≥1 Peri-operative respiratory risk factor → Continuous pulse oximetry for 24 hours
AAO-HNS[5]	- <2 years - Obesity - Down syndrome - Craniofacial abnormalities - Neuromuscular disorders - Sickle cell disease - Mucopolysaccharidoses		- <3 years - Severe OSAS - AHI ≥10 - Oxygen saturations nadir <80%
AAP[1]		- <3 years - Severe OSAS - Presence of cardiac complications - Failure to thrive - Obesity - Presence of upper respiratory tract infection - Medical comorbidities - Craniofacial anomalies - Genetic syndromes - Neuromuscular disease	- <3 years - Severe OSAS - AHI ≥24 - Oxygen saturation nadir <80% - Peak end tidal CO2 ≥60mmHg

AAP: American Academy of Pediatrics; AAO-HNS: American Academy of Otolaryngology–Head and Neck Surgery AHI: apnea hypo-apnea index; CO2: carbon dioxide; ERS: European Respiratory Society; OSAS: obstructive sleep apnea syndrome; PSG: polysomnography; SFORL: French Oto-Rhino-Laryngology Head and Neck Surgery Society.

adenotonsillectomy. However, reliance on retrospective data may pose challenges due to variability in data quality and completeness. Inadequate documentation or inconsistencies in patient records can lead to missing or inaccurate data, potentially impacting the reliability and generalizability of study findings.

It is important to acknowledge the potential for bias introduced by the single-author selection process of the included studies. While every effort was made to conduct a thorough and comprehensive search, the reliance on a sole reviewer can impact the comprehensiveness and validity of the review's findings.

Another limitation is that the majority of studies measure desaturation as outcome describing it as a complication. However, desaturation is more correctly described as a symptom of which the underlying etiology of desaturation can be various.

Finally, this review mainly encompasses mainly patient related risk factors for PORC. However, other potential risk factors have been identified, such as surgery methods. Since this is outside of the scope of this review, the reader is referred elsewhere[42].

Conclusion

PORC in children after (adeno)tonsillectomy is a topic for which much of research has been conducted. Many retrospective studies have identified various risk factors in predicting PORC following (adeno)tonsillectomy in children with OSAS, such as age < 3 years, the presence of OSAS, presence of associated comorbidities, and PSG parameters of which AHI, SpO2nadir, and TST <90%. Recent guidelines suggest inpatient admission in the presence of specific risk factors. Monitoring in high-care wards or PACUs with oximetry may suffice, avoiding unnecessary pediatric intensive care admissions. A "grey zone" approach in PACUs monitors patients for a limited amount of time to detect immediate PORC before deciding on further care, but its optimal duration needs more research. The scientific landscape now needs prospective studies to refine and validate postoperative management guidelines, focusing on safely increasing the number of ambulatory (adeno) tonsillectomies.

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References

1. Marcus CL, Brooks LJ, Ward SD, Draper KA, Gozal D, Halbower AC, e.a. Diagnosis and Management of Childhood Obstructive Sleep Apnea Syndrome. Pediatrics. 1 september 2012;130(3):e714-55.
2. Athanasios G. Kaditis, Maria Luz Alonso Alvarez, An Boudewyns, Emmanouel I. Alexopoulos, Refika Ersu, Koen Joosten, e.a. Obstructive sleep disordered breathing in 2- to 18-year-old children: diagnosis and management. Eur Respir J. 1 januari 2016;47(1):69.
3. Badelt G, Goeters C, Becke-Jakob K, Deitmer T, Eich C, Höhne C, e.a. [German S1 guideline: obstructive sleep apnea in the context of tonsil surgery with or without adenoidectomy in children-perioperative management]. HNO. januari 2021;69(1):3-13.
4. Lescanne E, Chiron B, Constant I, Couloigner V, Fauroux B, Hassani Y, e.a. Pediatric tonsillectomy: clinical practice guidelines. Eur Ann Otorhinolaryngol Head Neck Dis. oktober 2012;129(5):264-71.
5. Mitchell RB, Archer SM, Ishman SL, Rosenfeld RM, Coles S, Finestone SA, e.a. Clinical Practice Guideline: Tonsillectomy in Children (Update)-Executive Summary. Otolaryngol--Head Neck Surg Off J Am Acad Otolaryngol-Head Neck Surg. februari 2019;160(2):187-205.
6. De Luca Canto G, Pachêco-Pereira C, Aydinoz S, Bhattacharjee R, Tan HL, Kheirandish-Gozal L, e.a. Adenotonsillectomy Complications: A Meta-analysis. Pediatrics. oktober 2015;136(4):702-18.
7. Statham MM, Elluru RG, Buncher R, Kalra M. Adenotonsillectomy for obstructive sleep apnea syndrome in young children: prevalence of pulmonary complications. Arch Otolaryngol Head Neck Surg. mei 2006;132(5):476-80.
8. Wilson K, Lakheeram I, Morielli A, Brouillette R, Brown K. Can assessment for obstructive sleep apnea help predict postadenotonsillectomy respiratory complications? Anesthesiology. februari 2002;96(2):313-22.
9. Koomson A, Morin I, Brouillette R, Brown KA. Children with severe OSAS who have adenotonsillectomy in the morning are less likely to have postoperative desaturation than those operated in the afternoon. Can J Anaesth J Can Anesth. januari 2004;51(1):62-7.
10. Konstantinopoulou S, Gallagher P, Elden L, Garetz SL, Mitchell RB, Redline S, e.a. Complications of adenotonsillectomy for obstructive sleep apnea in school-aged children. Int J Pediatr Otorhinolaryngol. februari 2015;79(2):240-5.
11. Heward E, Bateman N, Schaefer S, Bruce IA, Rajai A, Vetuz G, e.a. Improving safety for day case adenotonsillectomy in paediatric obstructive sleep apnoea. Clin Otolaryngol Off J ENT-UK Off J Neth Soc Oto-Rhino-Laryngol Cervico-Facial Surg. januari 2022;47(1):181-6.
12. Billings KR, Somani SN, Lavin J, Bhushan B. Polysomnography variables associated with postoperative respiratory issues in children <3 Years of age undergoing adenotonsillectomy for obstructive sleep apnea. Int J Pediatr Otorhinolaryngol. oktober 2020;137:110215.
13. del-Río Camacho G, Martínez González M, Sanabria Brossart J, Gutiérrez Moreno E, Gómez García T, Troncoso Acevedo F. Post-operative complications following adenotonsillectomy in children with severe sleep apnea-hypopnea syndrome. Do they need to be admitted to an intensive care unit? Acta Otorrinolaringol Esp. 2014;65(5):302-7.
14. Elwell Z, Mancuso D, Wolter NE, Propst EJ, Valdez T, Scheffler P. Post-tonsillectomy outcomes in children with mucopolysaccharidosis and obstructive sleep apnea. J Otolaryngol - Head Neck Surg J Oto-Rhino-Laryngol Chir Cervico-Faciale. 24 december 2023;52(1):87.
15. Moroco AE, Saadi RA, Wilson MN. Post-tonsillectomy respiratory complications in children with sleep disordered breathing. Int J Pediatr Otorhinolaryngol. april 2020;131:109852.

16. Rodríguez-Catalán J, Fernández-Cantalejo Padial J, Rodríguez Rodríguez P, González Galán F, Del-Río Camacho G. Postoperative complications after adenotonsillectomy in two paediatric groups: Obstructive sleep apnoea syndrome and recurrent tonsillitis. Acta Otorrinolaringol Esp. 2020;71(1):32-9.
17. Caetta A, Timashpolsky A, Tominaga SM, D'Souza N, Goldstein NA. Postoperative respiratory complications after adenotonsillectomy in children with obstructive sleep apnea. Int J Pediatr Otorhinolaryngol. september 2021;148:110835.
18. Kou YF, Sakai M, Shah GB, Mitchell RB, Johnson RF. Postoperative respiratory complications and racial disparities following inpatient pediatric tonsillectomy: A cross-sectional study. The Laryngoscope. april 2019;129(4):995-1000.
19. Benedek P, Keserü F, Kiss G, Bella Z, Rovó L, Katona G, e.a. Postoperative respiratory complications in children with obstructive sleep apnoea syndrome. Acta Otorhinolaryngol Ital Organo Uff Della Soc Ital Otorinolaringol E Chir Cerv-facc. april 2022;42(2):162-8.
20. Thongyam A, Marcus CL, Lockman JL, Cornaglia MA, Caroff A, Gallagher PR, e.a. Predictors of perioperative complications in higher risk children after adenotonsillectomy for obstructive sleep apnea: a prospective study. Otolaryngol--Head Neck Surg Off J Am Acad Otolaryngol-Head Neck Surg. december 2014;151(6):1046-54.
21. Katz SL, Monsour A, Barrowman N, Hoey L, Bromwich M, Momoli F, e.a. Predictors of postoperative respiratory complications in children undergoing adenotonsillectomy. J Clin Sleep Med JCSM Off Publ Am Acad Sleep Med. 15 januari 2020;16(1):41-8.
22. Kozanhan B, Iyisoy MS. Red cell distribution width as a novel predictor of postoperative respiratory adverse events after adenotonsillectomy. Paediatr Anaesth. juni 2017;27(6):609-15.
23. Fischer M, Horn IS, Quante M, Merkenschlager A, Schnoor J, Kaisers UX, e.a. Respiratory complications after diode-laser-assisted tonsillotomy. Eur Arch Oto-Rhino-Laryngol Off J Eur Fed Oto-Rhino-Laryngol Soc EUFOS Affil Ger Soc Oto-Rhino-Laryngol - Head Neck Surg. augustus 2014;271(8):2317-24.
24. Marrugo Pardo G, Romero Moreno LF, Beltrán Erazo P, Villalobos Aguirre C. Respiratory Complications of Adenotonsillectomy for Obstructive Sleep Apnea in the Pediatric Population. Sleep Disord. 2018;2018:1968985.
25. Lim J, Garigipati P, Liu K, Johnson RF, Liu C. Risk Factors for Post-Tonsillectomy Respiratory Events in Children With Severe Obstructive Sleep Apnea. The Laryngoscope. mei 2023;133(5):1251-6.
26. Keserű F, Sipos Z, Farkas N, Hegyi P, Juhász MF, Jászai VA, e.a. The risk of postoperative respiratory complications following adenotonsillar surgery in children with or without obstructive sleep apnea: A systematic review and meta-analysis. Pediatr Pulmonol. december 2022;57(12):2889-902.
27. Kasle D, Virbalas J, Bent JP, Cheng J. Tonsillectomies and respiratory complications in children: A look at pre-op polysomnography risk factors and post-op admissions. Int J Pediatr Otorhinolaryngol. september 2016;88:224-7.
28. Baker AB, Farhood Z, Brandstetter KA, Teufel RJ, LaRosa A, White DR. Tonsillectomy in Children with Down Syndrome: A National Cohort of Inpatients. Otolaryngol--Head Neck Surg Off J Am Acad Otolaryngol-Head Neck Surg. september 2017;157(3):499-503.
29. Slovik Y, Tal A, Shapira Y, Tarasiuk A, Leiberman A. Complications of adenotonsillectomy in children with OSAS younger than 2 years of age. Int J Pediatr Otorhinolaryngol. augustus 2003;67(8):847-51.
30. Saur JS, Brietzke SE. Polysomnography results versus clinical factors to predict post-operative respiratory complications following pediatric adenotonsillectomy. Int J Pediatr Otorhinolaryngol. juli 2017;98:136-42.
31. 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. september 2003;99(3):586-95.
32. Lee TC, Wulfovich S, Kettler E, Nation J. Predictors of overnight postoperative respiratory complications in obese children undergoing adenotonsillectomy for obstructive sleep apnea. Int J Pediatr Otorhinolaryngol. november 2022;162:111334.
33. Molero-Ramirez H, Tamae Kakazu M, Baroody F, Bhattacharjee R. Polysomnography Parameters Assessing Gas Exchange Best Predict Postoperative Respiratory Complications Following Adenotonsillectomy in Children With Severe OSA. J Clin Sleep Med JCSM Off Publ Am Acad Sleep Med. 15 september 2019;15(9):1251-9.
34. Arambula AM, Xie DX, Whigham AS. Respiratory events after adenotonsillectomy requiring escalated admission status in children with obstructive sleep apnea. Int J Pediatr Otorhinolaryngol. april 2018;107:31-6.
35. Gowda S, Leong WS, Edafe O. Day-case discharge criteria and safety of children undergoing adenoidectomy and tonsillectomy for obstructive symptoms-A systematic review. Clin Otolaryngol Off J ENT-UK Off J Neth Soc Oto-Rhino-Laryngol Cervico-Facial Surg. september 2022;47(5):553-60.
36. Theilhaber M, Arachchi S, Armstrong DS, Davey MJ, Nixon GM. Routine post-operative intensive care is not necessary for children with obstructive sleep apnea at high risk after adenotonsillectomy. Int J Pediatr Otorhinolaryngol. mei 2014;78(5):744-7.
37. Hazkani I, Serino MA, Thompson DM, Lavin J. Review of the Utility of Extended Recovery Room Observation after Adenotonsillectomy. The Laryngoscope. december 2023;133(12):3582-7.
38. Arachchi S, Armstrong DS, Roberts N, Baxter M, McLeod S, Davey MJ, e.a. Clinical outcomes in a high nursing ratio ward setting for children with obstructive sleep apnea at high risk after adenotonsillectomy. Int J Pediatr Otorhinolaryngol. maart 2016;82:54-7.
39. Baker AK, Carroll CL, Grindle CR, Sala KA, Cowl AS. Assessing Frequency of Respiratory Complications in Children Undergoing Adenotonsillectomy. Pediatr Crit Care Med J Soc Crit Care Med World Fed Pediatr Intensive Crit Care Soc. juli 2020;21(7):e426-30.
40. Kong DK, Kong AM, Wasserman I, Villavisanis DF, Hackett AM. Ambulatory tonsillectomy for children with severe obstructive sleep apnea without risk factors. Am J Otolaryngol. 2020;41(4):102467.
41. Ekstein M, Zac L, Schvartz R, Goren O, Weiniger CF, DeRowe A, e.a. Respiratory complications after adenotonsillectomy in high-risk children with obstructive sleep apnea: A retrospective cohort study. Acta Anaesthesiol Scand. maart 2020;64(3):292-300.
42. Jaensch SL, Cheng AT, Waters KA. Adenotonsillectomy for Obstructive Sleep Apnea in Children. Otolaryngol Clin North Am. juni 2024;57(3):407-19.
43. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, e.a. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 29 maart 2021;372:n71.

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