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RETROSPECTIVE STUDY

Is Post-Operative High Dependency Admission Required for Children with Obstructive Sleep Apnea after Adenotonsillectomy?

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Abstract

Background: Most clinical units admit paediatric obstructive sleep apnoea (OSA) patients to high dependency unit (HDU) following adenotonsillectomy.

Objective: We aim to assess the necessity of HDU admissions for paediatric OSA patients following adenotonsillectomy.

Methods: A retrospective cohort study was performed for paediatric OSA patients who underwent adenotonsillectomy between 2010 to 2014.

Results: 285 patients were included in the study. 64 out of 285 (22.5%) patients suffered post-operative morbidity, which were all respiratory adverse events (RAE). Amongst these patients, 56 out of 64 required interventions. However, majority of these patients (48/64) required simple interventions. Only a minority (8/64) received interventions for severe RAE. Multivariate analysis shows that patients with perioperative anaesthetic events and high BMI are more likely to develop post-operative RAE.

Conclusion: Our results suggest that routine HDU admission is not necessary for paediatric OSA patients undergoing adenotonsillectomy. Selective HDU admission is advocated for at-risk patients.

Introduction

The commonest cause of paediatric obstructive sleep apnoea (OSA) is the disproportionate adenotonsillar hypertrophy in relation to craniofacial growth and airway calibre [1,2]. In recent years, there is an increasing awareness of paediatric OSA, leading to increasing number of adenotonsillectomy being performed for this indication [3,4]. Adenotonsillectomy has been shown to confer improvement in child behaviour and quality of life [5]. In up to 79% of patients, it can lead to normalisation of polysomnography [3,4,5].

It is a routine clinical practice in most units for these paediatric OSA patients to be admitted to high dependency unit for overnight monitoring [6]. The main objective is to monitor for potential respiratory adverse events (RAE), such as airway compromise and desaturations. These can occur as a result of ongoing obstructive sleep events, lingering effect of anaesthetic agents/narcotics or less commonly, negative pressure pulmonary oedema [7]. In our unit, it is routine for patients to be monitored in the Post Anaesthesia Care Unit (PACU) and then admitted to high dependency unit (HDU) for overnight observation following adenotonsillectomy.

However, HDU beds are limited and this can occasionally lead to delay of the operation. In addition, there is increasing evidence to suggest intensive monitoring in the first postoperative night in this patient group is not always necessary [1,8] owing to overall low incidence of morbidity and mortality. Some units go as far as to suggest adenotonsillectomy as a day-case procedure for paediatric OSA patients [9]. Furthermore, high dependency admission is associated with higher

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Table 1: Classification of mild and severe respiratory adverse events.

Interventions required for mild adverse events	Interventions required for severe adverse events
Repositioning	Oropharyngeal airway
Supplemental oxygen	Nebulised medicines
	Bag mask ventilation
	Non-Invasive Ventilation (e.g., CPAP/BiPAP)
	Re-intubation/prolonged intubation
	Unplanned Intensive Care Unit admission

healthcare cost, as well as additional strain on nursing manpower.

Given the trend of evidence in the current literature, we aim to investigate the incidence and severity of post-operative morbidity and mortality in paediatric patients following adenotonsillectomy during their admission in HDU. In doing so, we hope to streamline post-operative care for this group of patients whilst ensuring judicious and adequate use of resources.

Objectives

Our study objectives and rationales are as below.

Identify morbidity and mortality rates of post-adenotonsillectomy paediatric OSA patients

Determining the overall morbidity and mortality rates of the patients during their post-operative course will help provide a guide to the necessity and utility of HDU admission for this group of patients.

Identify the timing and location of which the morbidity or mortality occurs

Having an understanding of the commonest time frame of which the morbidity/mortality occurs can help us anticipate and provide timely interventions. In addition, patients can develop morbidity/mortality whilst being monitored in PACU or HDU. Identifying the commonest setting where the morbidity/mortality occurs can help us refine our post-operative patient care workflow.

Identify interventions required for patients who suffered morbidity/mortality

The interventions serve as a surrogate marker of severity of the morbidity/mortality and will also aid in the decision of whether HDU admission is required.

Identify risk factors that predispose to post-operative morbidity & mortality

The prognostic peri-operative factors will allow us to risk-stratify and identify patient groups who are more likely to benefit from HDU overnight monitoring.

Methods

Subject recruitment

This is a retrospective cohort study that received ethics approval from the SingHealth Centralised Institutional Review Board (CIRB), Singapore. The hospital admissions and discharge database were searched from year 2010 to 2014 using parameters of high dependency admission, children < 18-years-old, diagnosis of obstructive sleep apnoea and surgical codes for adenotonsillectomy. Medical records of patients who meet the inclusion criteria were reviewed.

Data analysis

Demographics and details of our patient population including age, OSA severity, weight, body mass index (BMI), co-morbidities (including lung disease, craniofacial abnormalities, syndromes, cardiac disease, and neuromuscular disease), presence of perioperative anaesthetic events, incidence of post-operative morbidity and mortalities, timing and location at which the morbidity/mortality occurred, interventions were used for data analysis. The morbidity or adverse events were classified into mild or severe based on the interventions received, with reference to the classifications made by Theilhaber, et al. and Brown, et al. [8,10] (Table 1).

Definitions

The following definitions were established with reference to the following clinical practice guidelines:

1. Clinical practice guideline 'Polysomnography for Sleep-Disordered Breathing Prior to Tonsillectomy in Children' [11].
2. 2012 American Association of Pediatrics Clinical Practice Guidelines: Diagnosis and Management of Childhood Obstructive Sleep Apnea Syndrome [12].

- Diagnosis of OSA is made clinically and/or quantitatively through polysomnography (AHI > 1).
- Severe OSA is defined as AHI >10 or oxygen saturation < 80% during polysomnography.
- High BMI or obesity is defined as weight > 90th centile for age.
- Postoperative desaturation is defined as any recorded oxygen saturation < 96%.

Statistical analysis

Variables were analysed using IBM SPSS (Version 19; SPSS Inc., Chicago, IL). Categorical variables were summarized using frequencies, and continuous variables were reported as mean ± SD.

To evaluate the potential perioperative anaesthetic events that are likely to be associated with post-operative RAE, potential risk factors were evaluated by univariate logistic regression analysis followed by multivariate logistic regression that included variables significant at $p \leq 0.20$ in the univariate analysis. Associations between categorical variables were tested using Fisher's exact test with the Mantel-Haenszel odds ratio and 95% confidence interval. The threshold for statistical significance was $P \leq 0.05$.

Results

Demographics

A total of 285 children fit the inclusion criteria and were included in the study. Mean age of the children at the time of operation was 8 years (range 10 months - 19 years). Mean weight was 45 kg (range 9.1 - 150.9 kg) and mean BMI was 24 kg/m^2 (range 13.4 - 58.3). Objective quantification of OSA severity by polysomnography was available for 209 of children, with a mean Apnoea-Hypopnea Index (AHI) of 31/hour and mean lowest oxygen saturation (Lsats) of 82%. For the 76 children without polysomnography readings, clinical and qualitative assessments were performed to establish a clinical diagnosis of OSAS, as per 2012 AAP guidelines [12].

Morbidity/Mortality

A total of 64 out of 285 children (22.5%) experienced a post-operative morbidity. These were all respiratory adverse events which presented as desaturations. The mean level of desaturation was 88.9% (range 57 - 94%). There was no mortality.

Location and timing

Out of the 64 patients who experienced desaturations, 31 (48.4%) and 33 (51.6%) children desaturated in the PACU and HDU respectively. The mean time at which the RAE occurs was 245 minutes (range 12 - 1800 minutes). The median and mode time of the RAE were 90 and 94 minutes respectively.

Interventions required

Out of the 64 patients who suffered RAE, 56 children required interventions for their RAE. 48 children (16.8%) received interventions for mild RAE, and 8 children (2.8%) received interventions for severe RAE. Among the 8 children with severe RAE (3.2% of our series of 285 patients), the interventions received included 1 or more of the following - oropharyngeal airway (2), nebulised bronchodilation medications (3), bag-mask ventilation (2), positive pressure ventilation (2) and unplanned ICU admission (1) (Table 2).

Table 2: Characteristics of patients who suffered severe respiratory adverse event.

Patient	Age (yrs/Sex)	Location of Adverse Event	Timing of Adverse Event (mins)	Severe AE desaturation SpO_2 level (%)	Intervention	Relevant Past Medical History	Weight category*	Anaesthetic complication	OSA severity#
1	10/M	PACU	60	89	Jaw lift, oxygen, bag mask ventilation	Allergic Rhinitis (AR)	Overweight	No	NA
2	8/M	PACU	21	70	Bag mask ventilation	Cleft palate, recurrent OME, Thalassemia minor	Healthy weight	No	NA
3	5/M	PACU	Immediate	57	Oxygen, oral airway, PEEP^	Asthma, AR	Overweight	Yes	NA
4	4/M	PACU	35	NA	Oxygen, nebuliser	AR	Overweight	No	Severe
5	2/M	PACU	66	NA	Oxygen, oral airway, nebuliser	AR	Healthy weight	No	NA
6	15/M	HD	780	92	Oxygen, ICU admission	Nephrotic syndrome	Overweight	Yes	Severe
7	5/F	HD	127	92	Oxygen, nebuliser	-	Overweight	Yes	Severe
8	15/M	HD	236	89	BiPAP	AR	Overweight	No	NA

*: Weight category is categorised according to recommendations by Singapore's Health Promotion Board where Overweight is defined as BMI > 90th centile for age. Where BMI is not available, weight > 90th centile for age is used instead; #: OSA severity - NA implies that polysomnography was not done for the patient; ^: PEEP - Positive End Expiratory Pressure.

Predictors of post-operative morbidity/mortality

After adjusting for confounders in multivariate analy-

Table 3: Univariate and multivariate logistic regression analysis results assessing variables for developing post-operative respiratory adverse events.

Variables	Univariate analysis		[a]Multivariate analysis	
	Odds Ratio (95% CI)	p-value	Odds Ratio (95% CI)	p-value
Anaesthetic events	6.58 (1.67, 25.6)	**0.007**	7.18 (1.76, 29.29)	**0.006**
High BMI (> 90^{th} centile)	2.24 (1.02, 4.90)	**0.044**	2.37 (1.05, 5.32)	**0.037**
Pre-existing airway problems	0.62 (0.26, 1.51)	0.29		
Neuromuscular disease	0.76 (0.16, 3.56)	0.73		
Syndromes	0.76 (0.16, 3.56)	0.73		
Craniofacial abnormalities	0.76 (0.16, 3.56)	0.73		
Severe OSA	0.80 (0.32, 2.0)	0.63		
Age < 3 years	1.58 (0.31, 8.13)	0.58		

[a]: Only includes variables significant at $p \le 0.20$ in univariate analysis.

Table 4: Summary of studies investigating post-adenotonsillectomy morbidity rates for paediatric patients.

Authors	Study design	Patients	Incidence (No. [%]) of morbidity	Time of morbidity	Definition of morbidity/ respiratory adverse event (AE)
Theilhaber, et al. [8]	Retrospective	OSA patients admitted to ICU post-adenotonsillectomy	26/72 [36.1]	Median time = 165 minutes	• Mild AE : Saturation < 95% requiring supplementary O_2 or repositioning • Severe AE : desaturation treated by bag & mask ventilation, CPAP, BiPAP, oropharyngeal airway or re-intubation, and unplanned ICU admission
Kieran, et al. [13]	Retrospective	OSA and Non-OSA patients	294/4092 [7.2]	-	• Saturations < 90%
Statham, et al. [14]	Retrospective	OSA patients	149/2315 [6.4]	-	• SpO_2 < 90% requiring O_2 supplementation or diuretic therapy • Apnoea/increased work of breathing requiring nasopharygeal airway support/CPAP/intubation & mechanical ventilation • Chest radiographic evidence of atelectasis, infiltrates, edema, pneumomediastinum, pneumothorax, or pleural effusion
Kalra, et al. [15]	Retrospective	OSA patients	198/3739 [5.3]	-	• SpO_2 < 90% requiring O_2 supplementation for > 8 hrs or diuretics • Apnoea/increased work of breathing requiring nasopharygeal airway support/CPAP/intubation & mechanical ventilation • Chest radiographic evidence of atelectasis, infiltrates, edema & air fluid collection in pleural cavity

Brown, et al. [10]	Retrospective	OSA patients a) Urgent adenotonsillectomy* b) Elective adenotonsillectomy	a) 33/54 [61] b) 16/44 [36]	a) Minor intervention group [22/33]: • 36.4% < 1 hr post-op Major intervention group [11/33]: • 72.7% < 1 hr post-op b) Not documented	• Saturation < 95% or • Airway obstruction or • Requiring intervention
Wilson, et al. [16]	Retrospective	OSA patients	34/163 [21]	-	• Saturation < 95% or • Airway obstruction or • Requiring medical interventions eg. O_2 administration, jaw thrust, artificial airway, positive pressure ventilation, reintubation
Biavati, et al. [17]	Retrospective	Patients with obstructed breathing during sleep	8/355 [2.25]	-	• Upper airway obstruction, oxygen desaturations less than 90% and interventions (eg placement of a nasopharyngeal airway, endotracheal intubation, or administration of supplementary oxygen) • A planned post-operative admission with interventions • An unplanned post-operative admission • Readmission after discharge for airway complications, or any airway complication that was managed on an outpatient basis
Gerber, et al. [18]	Prospective	OSA and non-OSA patients	44/29 [15.1]	-	At least 1 of the following occurring ≥ 2 hrs after surgery: • O_2 saturation level < 90% for ≥ 10 sec • An obstructive breathing pattern • Respiratory distress requiring intervention
Rosen, et al. [19]	Retrospective	OSA patients	10/37 [27]	'within hours of surgery'	• Saturations < 80% or • Snoring, increased respiratory effort, or • Requiring intervention eg. repositioning, supplemental oxygen, CPAP/BiPAP, prolonged intubation or reintubation

McColley, et al. [20]	Retrospective	OSA patients	16/69 [23]	'Up to 14 hours after completion of the operative procedure'	• Saturations ≤ 70% and/or • Hypercapnia (PaCO > 45 mmHg) • Requiring nurse/physician intervention
Wiatrak, et al. [21]	Retrospective	OSA and non-OSA patients	14/20 [70]	-	• O_2 desaturation > 90% requiring any combination of supplemental oxygen, placement of a nasopharyngeal airway, or endotracheal intubation • Postoperative obstruction apnoea, manifested by a cessation of airflow in the presence of respiratory muscle activity for > 10 s • Post-operative central apnoea, manifested by a cessation of airflow for periods > 10s with no observable respiratory muscle activity

*: Urgent adenotonsillectomy is defined by Brown, et al. as adenotonsillectomy being performed during same hospital admission following diagnosis of OSA in a sleep study.

sis, presence of perioperative anaesthetic events (Odds Ratio 7.18, 95% CI 1.76 - 29.29, p = 0.006) and high BMI (Odds Ratio 2.37, 95% CI 1.05 - 5.32, p = 0.037) were found to be statistically significant in predisposing to post-operative RAE. Other factors such as the presence of comorbidities, severe OSA and age < 3 years were also analysed, but did not achieve statistical significance (Table 3).

Discussion

Our data shows a morbidity rate of 22.5%, which is comparable to that in the current literature (Table 4). However, it is important to note that the definition of respiratory morbidities as well as patient profiles vary between authors. For instance, Kieran, et al. included non-OSA patients in their analysis of post-operative respiratory morbidities and thus showed a lower complication rate of 7.2%. Theilhaber, et al. focused their analysis on a high-risk cohort (patients admitted to ICU following adenotonsillectomy) and therefore showed a higher complication rate of 36%. Therefore, it is important to interpret these morbidity rates in their respective contexts.

Despite the relatively high incidence of respiratory adverse events shown in our data, majority of these were mild RAE (56 out of 64), which required only simple intervention such as repositioning, and supplemental oxygen, which did not require HDU expertise. This is similar to the findings of other authors [8,10,16], suggesting that routine HDU admission is not required for paediatric OSA patients following adenotonsillectomy.

The location for post-operative monitoring for paediatric adenotonsillectomy patients has always been a topic of contention. Theilhaber, et al. demonstrated that majority of their severe adverse events occurred at the PACU within 2 hours after surgery [8]. On the basis of their findings, the authors recommended that patients be observed up to 2 hours in PACU and then to general ward [8]. Our routine workflow involves observing the patients in PACU before admitting the patient to HDU for overnight monitoring. Whilst our data shows that the occurrence of RAE in the PACU (48.4%) and HDU (51.6%) are comparable, most of these events occurred within the first few hours of surgery (moved from 'results'). It should also be noted that our mean time of RAE occurrence was skewed by an outlier who desaturated at 1800 minutes. Hence, we are inclined to agree with the approach of Theihaber, et al. given that PACU is the ideal place to monitor for potential RAE following adenotonsillectomy. This is especially so, given that PACU is equipped with highly trained staff with the experience to monitoring of vital signs, recognize post-anaesthesia complications such as respiratory distress and perform airway management should these complications occur.

Several authors have shown that post-operative respiratory compromise can be anticipated in certain patient groups. Common predisposing factors include young age, severe OSA, high BMI and presence of co-morbidities [8,10,16,17,19,20]. In addition to these factors, our data showed that presence of peri-operative anaesthetic events can predispose to post-operative respiratory adverse events. In our study, patients with peri-operative anaesthetic events were 7.18 times more likely to develop of post-operative respiratory compromise. These anaesthetics events included difficult intubation, difficult

Table 5: Summary of research studies investigating risk factors for post-adenotonsillectomy respiratory adverse events in paediatric OSA patients.

Authors	Statistically significant risk factors[a]
Kieran, et al. [13]	Univariate analysis: Age < 2 Age < 3 Weight < 20 kg Weight < 15 kg OSA Tonsillitis Multivariate analysis: Weight < 20 kg OSA (clinical diagnosis) Neurologic disease Cardiac disease Pulmonary disease Trisomy 21 Other syndrome
Statham, et al. [14]	Age < 3 Age < 2
Brown, et al. [10]	Associated medical condition SaO_2 nadir < 80%
Wilson, et al. [16]	SaO_2 nadir ≤ 80% OAH ≥ 5/hr
Biavati, et al. [17]	1) Associated medical condition: a) Cerebral palsy b) Seizures c) Congenital heart disease 2) Age ≤ 3 3) Prematurity
Rosen, et al. [19]	1) Age (< 2) 2) Associated medical problems (eg craniofacial abnormalities, hypotonia, morbid obesity) 3) Polysomnogram RDI (> 40) 4) Polysomnogram O_2 saturation nadir (< 70%) 5) UPPP performed with T&A
McColley, et al. [20]	Univariate Analysis: 1) Age < 3 2) Obstructive Event Index > 10/hr 3) Failure to thrive 4) Cardiac abnormality 5) Craniofacial abnormality 6) Chest film abnormality <u>Multivariate logistic regression</u> 1) Age < 3 2) OEI > 10/h

[a]: p-value ≤ 0.05, OEI = Obstructive Event Index; RDI = Respiratory Disturbance Index; UPPP = Uvulopalatopharyngoplasty; T&A = Tonsillectomy and Adenoidectomy; SaO_2 = Arterial Saturation of Oxygen; OAH index = Obstructive Apnoea-Hypopnea index.

ventilation, laryngospasm, bronchospasm, desaturation and accidental dislodgement of endotracheal tube. Of note, these anaesthetic events mostly relate to abnormal or hyper-reactive airway. Therefore, it is not surprising that these patients are predisposed to respiratory adverse events in the post-operative period. These are patient groups who would benefit from post-operative close monitoring in the HDU.

Multiple other studies have found that children younger than 3 years are predisposed to respiratory compromise following adenotonsillectomy [16,17,19]. This is postulated to be secondary to their narrower airway and inadequate neuromuscular control of the upper airway. However, our study did not find statistical significance in this factor ($p = 0.58$). This could be explained by the fact that the mean age in our study population is 8.64, which is higher than that of other studies, which ranges from 4.3 - 5.7 [16,17,19].

Some of the studies also found an association between severe OSA and increased risks of postoperative respiratory compromise [10,16,19]. This is postulated to be secondary to increased risk of residual apnoea and hypopnea episodes. Of our 285 patients, 209 had polysomnography. We took the definition of severe OSA as AHI > 10 or oxygen (O_2) saturation of less than 80%, or both, in concordance to the clinical practice guideline 'Polysomnography for Sleep-Disordered Breathing Prior to Tonsillectomy in Children' [11]. In patients with polysomnography done, 175/209 (83.7%) had severe OSA. Majority did not have complications (145/175, 82.9%). We did not find statistical significance in the association between severity of OSA and risk of developing post-operative respiratory events ($p = 0.63$). Due to variation in the definition of OSA severity amongst authors of previous studies, it was difficult to examine the validity of severe OSA as a predictor of post-operative respiratory events. Brown, et al. took the definition of O_2 saturation less than 80% [10], Rosen, et al. defined 'high-risk PSG' as respiratory distress index > 40 and O_2 saturations < 70% [19], whereas Wilson, et al. found that AHI > 5 was associated with more post-operative respiratory complications [16].

We postulated that craniofacial abnormalities such as retrognathia or midface hypoplasia would predispose to post-operative respiratory adverse events owing to narrowing of the upper airway. Similarly, we hypothesized that patients with syndromes such as trisomy 21, Pierre Robin syndrome and Goldenhar syndrome are likely to have post-operative increased collapsibility of airway from the interplay of abnormal anatomic and neuromuscular factors. However, in our study, none of these factors showed statistical significance. These patient categories represent a very small group within our entire study population. Hence, statistical analyses for these groups are underpowered. Some of the other studies have shown craniofacial abnormalities and syndromes to be significant in predisposing OSA patients to postoperative respiratory complications [13,19]. Other at-risk groups that can be identified pre-operatively, as investigated by other authors, are shown in Table 5.

It must be considered that in the interests of patient safety, a retrospective study on postoperative high dependency admission outcomes was conducted, rather than a prospective randomised controlled trial. However, an attempt to eliminate bias and confounding factors could be made possible by matching protocols within the study population. Chiefly, the severity of OSA would have been important to match prior to comparing outcomes such as RAE incidence and onset. In this regard, the lack of quantitative data on OSA severity limited our study's ability to comprehensively evaluate OSA severity as a predictor of postoperative respiratory complications. In turn, this limited attempts to propose preoperative risk stratification groups for paediatric patients undergoing elective adenotonsillectomy.

This, along with other risk factors, would have been useful in future development of an elective high dependency admission criteria for paediatric patients undergoing adenotonsillectomy for obstructive sleep apnoea [6].

Conclusion

Routine HD admission is not necessary for all paediatric patients undergoing adenotonsillectomy for OSA. Selective HDU admission should be advocated for at-risk patients. Monitoring at the PACU setting in the initial hours following the operation can be beneficial and may help to negate HDU admission.

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