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OSAHS

Postoperative respiratory complications in children with obstructive sleep apnoea syndrome

Complicanze respiratorie postoperatorie nei pazienti pediatrici affetti da sindrome delle apnee ostruttive notturne

Pálma Benedek[1,3], Fanni Keserü[1,3], Gabriella Kiss[2], Zsolt Bella[3], László Rovó[3], Gábor Katona[1], András Bikov[4], Balázs Csoma[5], Zsófia Lázár[5]

[1] Department of Otolaryngology, Heim Pál National Institute of Paediatrics, Budapest, Hungary; [2] Department of Anaesthesiology and Intensive Care, Heim Pál National Institute of Paediatrics, Budapest, Hungary; [3] Department of Oto-Rhino-Laryngology and Head-Neck Surgery, University of Szeged, Szeged, Hungary; [4] Wythenshawe Hospital, Manchester University NHS Foundation Trust, Manchester, United Kingdom; [5] Department of Pulmonology, Semmelweis University, Budapest, Hungary

SUMMARY

Objective. We aimed to prospectively assess the effect of comorbidities on the occurrence of postoperative respiratory complications (PoRCs) after adenotonsillectomy in children with obstructive sleep apnoea syndrome (OSA) and whether otherwise healthy children need a higher level of postoperative monitoring.

Methods. 577 children who had OSA and underwent adenotonsillectomy were enrolled. The effects of demographics, comorbidities and OSA on PoRCs were investigated with logistic regression analysis.

Results. The PoRC rate was 4.3%. Postoperative oxygen desaturations were more marked in patients with comorbidities ($p = 0.005$). The presence of comorbidity increased the risk of PoRCs (odds ratio 4.234/3.226-5.241, 95% confidence intervals, $p < 0.001$). There was no difference in apnoea-hypopnoea index (AHI) values between comorbid patients with and without PoRCs [8.2 (3.8-50.2) *vs* 14.3 (11.7-23.3)]. ($p = 0.37$). In the group of patients without comorbidities, PoRCs were associated with a higher AHI [14.7 (3.4-51.3) *vs* 3.9 (2.0- 8.0), $p < 0.001$].

Conclusions. Comorbidities are more closely linked with PoRCs than OSA severity. In patients without comorbidity, PoRCs are associated with OSA severity and usually occur within the first 2 hours after the intervention.

KEY WORDS: sleep breathing disorders, obstructive sleep apnoea, apnoea-hypopnoea index, postoperative monitoring, comorbidity, respiratory complications

RIASSUNTO

***Obiettivo**. Abbiamo valutato prospetticamente l'effetto delle comorbilità sull'insorgenza di complicanze respiratorie postoperatorie (PoRC) dopo adenotonsillectomia in bambini con sindrome delle apnee ostruttive del sonno (OSA) e se tali bambini altrimenti sani necessitano di un livello più elevato di monitoraggio postoperatorio.*

***Metodi**. Sono stati arruolati 577 bambini con OSA e sottoposti ad adenotonsillectomia. Gli effetti dei dati demografici, delle comorbilità e dell'OSA sui PoRC sono stati studiati con l'analisi di regressione logistica.*

***Risultati**. Il tasso di PoRC è stato del 4,3%. Le desaturazioni di ossigeno postoperatorie erano più marcate nei pazienti con comorbilità ($p = 0,005$). La presenza di comorbilità ha aumentato il rischio di PoRC (odds ratio 4,234 /3,226-5,241, intervalli di confidenza 95%/, $p < 0,001$). Non c'era differenza nei valori dell'indice di apnea-ipopnea (AHI) tra i pazienti con comorbilità con e senza PoRC (8,2 (3,8-50,2) vs 14,3 (11,7-23,3) ($p = 0,37$), ma nel gruppo di pazienti senza comorbilità. I PoRC erano associati a un AHI più elevato (14,7 (3,4-51,3) rispetto a 3,9 (2,0-8,0), $p < 0,001$).*

***Conclusioni**. Le comorbilità sono più strettamente legate ai PoRC rispetto alla gravità dell'OSA. Nei pazienti senza comorbidità le PoRC sono associati alla gravità dell'OSA e di solito si verificano entro le prime 2 ore dopo l'intervento.*

PAROLE CHIAVE: *disturbi respiratori del sonno, apnea ostruttiva del sonno, indice apnea-ipopnea, monitoraggio postoperatorio, comorbilità, complicanze respiratorie*

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Correspondence
Pálma Benedek
Department of Otolaryngology, Heim Pál National Institute of Paediatrics, Budapest, Hungary, Üllői Street 86, Budapest, H-1089, Hungary.
Tel. +36 309150865
E-mail: dr.benedek.palma@gmail.com

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Introduction

Sleep disordered breathing (SDB) is a continuum from habitual snoring through upper airway resistance syndrome to obstructive sleep apnoea (OSA). OSA is the most severe form of SDB, characterised by repetitive, partial, or complete upper airway obstruction during sleep that disturbs normal breathing and fragments the sleep pattern [1]. The prevalence of OSA is 1-3% among children, and 3-12% of the paediatric population suffers from snoring [2]. Aetiology, symptoms, diagnostic methods, and treatment in paediatric OSA are different from those in adults [1], although sleep fragmentation and gas exchange abnormality can lead to severe cardiovascular, neurological, olfactory, and behavioural disorders in the paediatric population as well [3]. Children with OSA are more likely to exhibit behavioural and integration problems, hyperactivity, and learning difficulties depending on the severity and duration of the disease [4]. The main predisposing factor for OSA in childhood is adenotonsillar hypertrophy [2], but there are other risk factors including obesity, craniofacial malformations, the presence of glycogen storage disorders, sickle cell anaemia, achondroplasia, prematurity and neuromuscular disorders [1].

Regarding treatment, the most common ear-nose-throat (ENT) surgical procedure in children is adenoid and/or tonsil surgery [1]. One of the most common and important complications is bleeding [5], but respiratory complications are equally significant occurring up to several hours postoperatively. These complications include exacerbation of apnoea, desaturation, laryngospasm, bronchospasm, pulmonary oedema and atelectasia, pneumothorax, pneumomediastinum and pleural exudates [6,7]. Postoperative respiratory complications (PoRC) after adenotonsillectomy were recorded 10 times more frequently among patients with OSA than in those without by Jaryszak et al. [8]. They found correlation between PoRC and higher AHI, hypopnoea index, BMI and lower nadir oxygen saturation. In addition, craniofacial and neuromuscular comorbidities, upper airway inflammation (allergic or vasomotor rhinitis) and obesity accompanying OSA further and markedly elevate the risk for PoRCs [9,10].

The European Respiratory Society (ERS) states that the risk factors for PoRCs include age under 3 years, an apnoea-hypopnoea index (the number of the apnoeas and hypopnoeas per hour) more than 26/h, an oximetry recording with three or more clusters of desaturation (4%) and at least three desaturations to < 90%, obesity or low weight and neuromuscular, craniofacial or genetic disorders [11]. The International Otolaryngology Group has recently published a consensus document on the diagnosis and management of paediatric OSA [12]. It declares that postoperative monitoring should be performed in young children (< 2 years old) and in patients with Down syndrome or craniofacial malformation if they present with moderate-to-severe OSA. However, there was no agreement on the location (paediatric intensive care unit, postoperative anaesthesia unit, or ward with oximetry) or the duration (overnight or a shorter period) of postoperative monitoring. Identifying factors leading to PoRCs are therefore of essential clinical value as they can guide decisions regarding postoperative management.

The aim of this study was to assess the effect of the comorbidities and the severity of OSA on the occurrence of PoRCs after adenotonsillectomy in patients with OSA and to determine the duration and level of postoperative care in otherwise healthy children.

Materials and methods

Subjects

We prospectively collected data between 1 January 2015 and 31 December 2018 from 577 children who underwent polysomnography (PSG) followed by adenoid and/or tonsil surgery at Heim Pal National Paediatric Institute, Budapest, Hungary due to symptoms of sleep-related breathing disorders. The indications for surgery were clinical symptoms of OSA and abnormal PSG findings [13]. According to the caregivers' reports, all subjects presented snoring and had other concomitant symptoms including apnoeas, paradoxical breathing, abnormal body position during sleep, frequent awakenings, enuresis, or daytime symptoms (behavioural problems, attention deficit hyperactivity disorder and daytime sleepiness). Details from past medical history, physical status, results of PSG, treatment and postoperative complications were recorded. Obesity was defined as a body mass index (BMI) at or above the 95th percentile for children of the same age and gender. Children born before 37 completed weeks of gestation were considered premature. Patients with laryngeal abnormalities diagnosed with fibreoptic laryngoscopy were excluded.

Polysomnography

Polysomnography was performed with a Somnomedics Somnoscreen plus device (Somnomedics, Randersacker, Germany) according to guidelines [13]. Polysomnographic readings were evaluated by a physician (PB) experienced in sleep medicine. Electroencephalogram (EEG), electrooculogram (EOG) and electromyogram (EMG), thoracic and abdominal respiratory excursions, breath sounds, nasal pressure, electrocardiogram (ECG) and oxygen saturation were recorded. Sleep stages, movements and cardiopulmonary events were scored manually according to the guideline developed by the American Academy of Sleep Medicine and

updated in 2012 [13]. Hypnogram, number of microarousals, apnoea-hypopnoea index (AHI; the number of apnoeas and hypopnoeas per sleeping hour), EEG-confirmed respiratory disturbance index and oxygen desaturation index (DI) were evaluated. Desaturation index (DI) indicates the number of periods with desaturation (min. 3% fall in oxygen saturation) per hour. Obstructive apnoea was defined if there was a drop in the peak signal excursion of the oronasal thermal sensor by ≥ 90% of pre-event baseline that lasted for at least 2 breaths and associated with the presence of respiratory effort [13]. Criterion for hypopnoea was a drop from peak signal excursions ≥ 30% of pre-events baseline lasting for at least 2 breaths with ≥ 3% desaturation from pre-event baseline or associated with an arousal [13]. We analysed our data based on that system developed by Marcus et al. [14]. The severity of OSA was defined by the AHI as mild (1.0-5.0/h), moderate (5.1-10.0/h), or severe (> 10.0/h). Clinical data were analysed with regards to PSG parameters including AHI and DI.

Medical examination and interventions

The ENT examination included examination of the nose (ala nasi, septum nasi, inferior turbinates), nasopharynx, and oropharynx with the size of the tonsils, which was categorised by the Brodsky scale [15]. Flexible fibreoptic laryngoscopy with ER-270 FP video endoscope (FUJINON, Willich, Germany) was performed to evaluate the hypopharynx and larynx to rule out laryngomalacia and other laryngeal abnormalities. During the anaesthesiologic examination, the anaesthetist defined the need for premedication, postoperative observation and treatment required. Tonsil surgery is not a day-care procedure in Hungary, and patients stayed at the hospital overnight after the operation. A monitoring system, which we previously described [16] was used to define the duration of postoperative monitoring (Tab. I). Briefly, if the OSA was mild at 4 hours, and if it was moderate at 24 hours postoperative care with pulse oximetry was used. In severe cases (AHI > 10 events/h), patients were transferred to the ICU for 24 hours after the procedure. Figure 1 shows the selection process of patients during the recruitment period.

Statistical analysis

Data normality was tested (D'Agostino test) and data are shown as mean ± standard deviation or median (interquartile range). Groups were compared with t-test, analysis of variance (ANOVA), Mann-Whitney and Kruskal-Wallis tests. Categorical data were analysed with chi-square or Fisher's exact tests (GraphPad Prism 7.0, GraphPad Software, San Diego, USA). The association between clinical variables and demographics as well as PoRCs was evaluated with multivariate logistic regression. This was investigated separately in patients with and without comorbidities. We calculated the required sample size for Fisher exact test of independence using the G*Power software version 3 (Heinrich Heine University Dusseldorf, Dusseldorf, Germany) [17]. We used the results of a previous study that prospectively evaluated the incidence of postoperative airway-related complications between children with and without comorbidities [18] as input. We expected a difference between the sample sizes of the two groups, so we utilised the findings of another study [19], in which the incidence of craniofacial abnormalities was investigated in children with obstructive sleep apnoea. The calculated minimum total sample size for the study was 131 ($1\text{-}\beta = 0.80$, $\alpha = 0.05$; group with comorbidities N = 21, group without comorbidities N = 110). However, due to the lower prevalence of comorbid conditions than expected initially, we continued to recruit children to reach the minimal sample size in the comorbid group.

Table I. Postoperative monitoring protocol for patients with OSA.

OSA stage	AHI value	Mode of monitoring
Mild OSA	1.0-5.0	4 hours pulse oximetry in a general ward
Moderate OSA	5.1-10	24 hours pulse oximetry in a general ward
Severe OSA	> 10	24 hours monitoring in intensive care unit

Results

Subjects

We recruited 577 patients for the study (Tab. II), 357 boys and 220 girls from the age of 8 months to 18 years. Twenty-four children (4.2%) presented with comorbidities including obesity (13 patients, 4 of whom suffered from Prader Willi syndrome), prematurity with bronchopulmonary dysplasia (3 patients), hypotonic neuromuscular disorder (3 patients), Down syndrome (3 patients), Pfeiffer syndrome (1 patient) and Fragile X syndrome (1 patient) There were no differences in age and gender between patients with and without comorbidities; however, patients with comorbidities suffered from more severe OSA ($p < 0.001$, Tab. II).

Effect of comorbidities on postoperative respiratory complications

The overall postoperative respiratory complication rate in our cohort was 4.3% (25/577). The incidence rate of complications was significantly higher in patients with comorbidities (58.3%, 14/24 *vs* 2%, 11/553; $p < 0.001$). The presence of comorbidity increased the risk for PoRCs with an odds ratio (OR) of 4. (95% confidence interval 3.6-5.2).
Complications in the group without comorbidities were

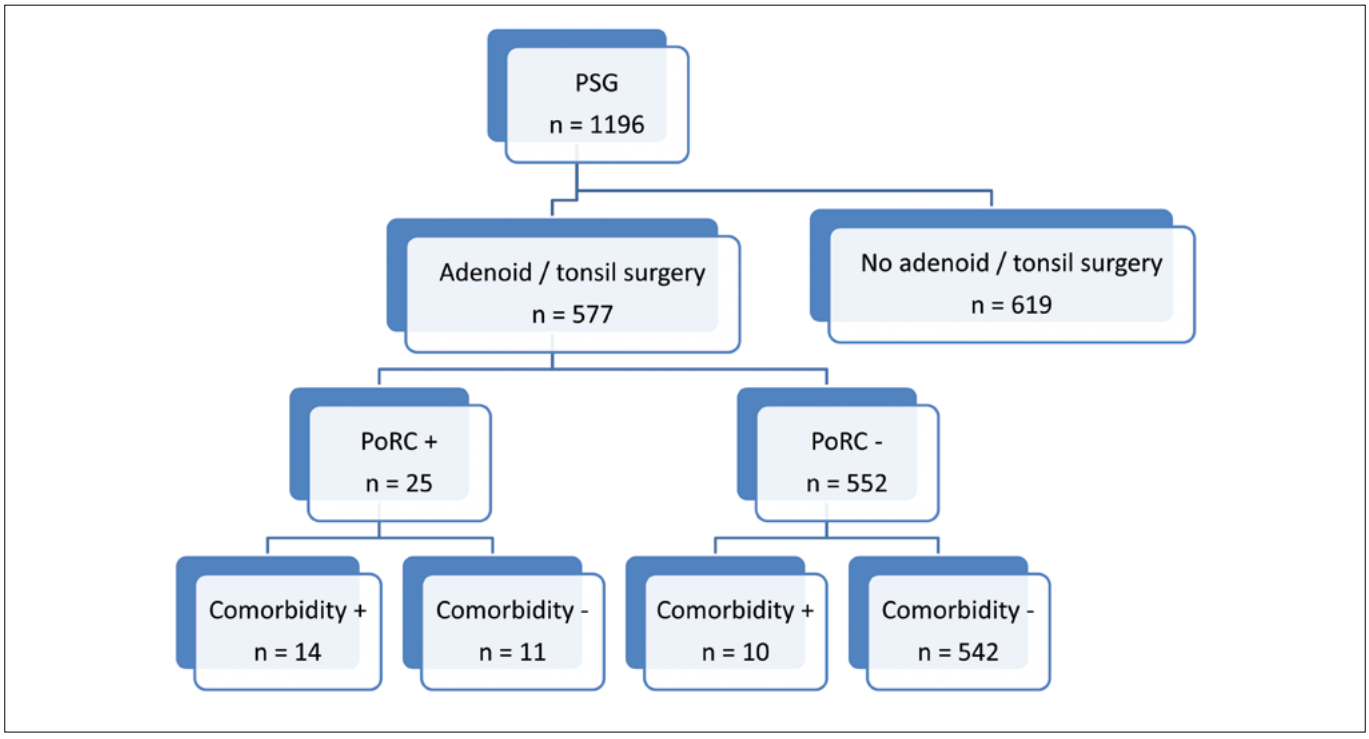

Figure 1. Selection process of patients during the recruitment period. PSG: polysomnography; PoRCs: postoperative respiratory complications.

desaturations (all 11 cases) necessitating supplemental oxygen therapy, apnoeas in 6 cases, and one patient was diagnosed with bronchopneumonia, but no patients needed reintubation. These complications appeared within two hours after the surgical intervention.

In the group of patients with comorbidities, desaturations occurred in all cases, and more severe postoperative nadir oxygen desaturations were noted compared to patients without a comorbidity (72% ± 12% *vs* 83% ± 12%, p = 0.005) (Fig. 2). Specifically, apnoea worsened in 6 cases, while three of these patients suffered only from mild OSA, two being obese and one having a craniofacial malformation. Moreover, 4 patients required reintubation and mechanical ventilation due to laryngospasm, bronchospasm, or pulmonary oedema, showing the more severe nature of complications in this subgroup.

Table II. Clinical characteristics of patients.

	Total	Patients with comorbidities	Patients without comorbidities	p-value
Number	577	24	553	
Boys/girls, N (%)	357/220 (61.9/38.1)	15/9 (62.5/37.5)	342/211 (61.8/38.2)	0.99
Age, years	5.0 ± 2.5	4.5 ± 2.1	5.1 ± 2.5	0.33
AHI, events/hour	4.0 (2.0-8.7)	12.9 (4.9-24.4)	4.0 (2.0-8.2)	< 0.001
OSA severity groups, N (%)				< 0.001
Mild	343	7 (29.2)	336 (60.8)	
Moderate	112	2 (8.3)	110 (19.9)	
Severe	122	15 (62.5)	107 (19.3)	
Postoperative complications, N (%)				< 0.001
Yes	25 (4.3)	14 (58.3)	11 (2.0)	
No	552 (95.7)	10 (51.7)	542 (98.0)	

Data are expressed as mean ± standard deviation or median (interquartile range). AHI: apnoea-hypopnoea index; OSA: obstructive sleep apnoea

Association of PoRCs with clinical parameters

Twenty-five patients had PoRCs, among whom 9 suffered from mild, 1 from moderate and 15 from severe OSA. When all subjects were analysed together, AHI (β = 0.044) and the presence of comorbidities (β = 4.047) were independently associated with PoRCs (both $p < 0.001$). According to stepwise analysis, the presence of a comorbidity was more strongly related to the risk of complications than OSA severity (β = 4.234).

In patients with comorbidities, no significant difference was observed in OSA severity or BMI [AHI values (8.2 (3.8-50.2) events/hour vs. 14.3 (11.7-23.3) events/hour, p = 0.37, Fig. 2], BMI (20.7 ± 4.9 *vs* 18.0 ± 4.6 kg/m^2, p = 0.20), preoperative nadir O_2 saturation (74% ± 18% *vs* 78% ± 15%, p = 0.57) and oxygen desaturation index [5.9 (4.8-41.8) events/hour *vs* 12.5 (7.5-22.8) events/hour, p = 0.67] between cases with and without complications.

In contrast, in patients without comorbidities, AHI was increased in patients with PoRCs [14.7 (3.4-51.3) events/hour *vs* 3.9 (2.0-8.0) events/hour, $p < 0.001$] (Fig. 3). Using stepwise approach, AHI was the most strongly related factor to complications (β = 0.037, p = 0.004). None of the other parameters investigated were associated with the incidence of PoRCs (all $p > 0.05$).

Discussion

OSA is a common medical condition in childhood as well as in adulthood, and can lead to fatal consequences without treatment [1]. Fortunately, these occur only rarely, but in general OSA significantly and adversely affects the child's life. In most cases the symptoms and consequences of OSA are reversible after adenotonsillectomy, which is considered first-line treatment for paediatric OSA. Previous studies have clearly demonstrated an increased risk of PoRCs in patients with OSA, but the incidence was variable in these cohorts. Jaryszak and colleagues found it to be 15.2% in 2011 [9], Kou et al. recorded a 7.4% rate among 30,617 patients [20] and the meta-analysis by Saur et al. reported it to be 5.8% [21]. In our cohort, the respiratory complication rate was 4.3%.

The American Academy of Otolaryngology Head and Neck Surgery Society (AAO-HNS), the American Academy of Pediatrics (AAP) and European Respiratory Society (ERS) all highlight the severity of OSA (AHI) as a risk factor for PoRC [11, 22]. Rhodes and colleagues found that in otherwise healthy patients with OSA the risk for postoperative respiratory complications increases only in extremely severe cases (AHI > 50/h) [23]. In our study population, we found a significant correlation between OSA severity and PoRCs only in patients without comorbidity. Notably, in the group of patients without comorbidity and PoRCs the AHI was 14.7 (3.4-51.3 events/hour), which was substantially lower than in the studies mentioned above. All complications in this group were mild and occurred within the first 2 hours after the intervention.

Our data show that comorbidity plays an important role in the development of postoperative respiratory complications. In our study, the most common comorbidity factors were obesity, craniofacial malformations, prematurity and hypotonic neuromuscular disorder. Beyond the structural factors, decreased neuromuscular tone and regulation disturbances can also lead to the development of OSA. After adenotonsillectomy, oedema and anaesthetic-induced reduction in the pharyngeal muscle tone can cause serious

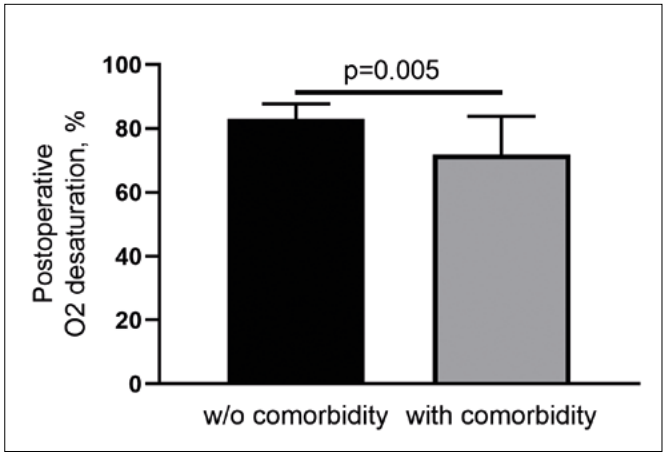

Figure 2. Postoperative oxygen desaturation in patients with PoRCs*. Data are expressed as mean ± standard deviation. *PoRCs: postoperative respiratory complications.

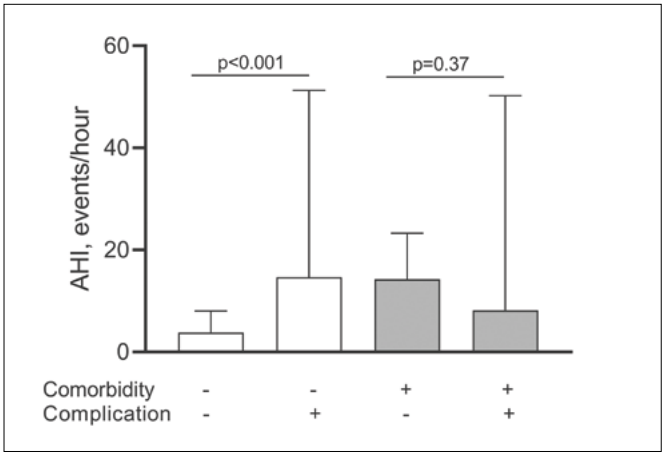

Figure 3. AHI* values in relation to complications and comorbidities. Data are shown as median with interquartile range. *AHI: apnoea-hypopnoea index.

apnoeas and desaturations, which are more severe than in otherwise healthy children [24]. Of note, we did not divide comorbidities into separate groups, as these were composed of relatively low number of subjects individually. To see if different comorbidities pose different amount of risk on PoRCs further studies are warranted.

In our study, PoRCs occurred in 58.3% of patients with comorbidity compared with the otherwise healthy group, where this complication rate was 2%. We did not find a significant difference in AHI values between the complication and non-complication subgroups in patients with comorbidity. Our results clearly demonstrate that these complications are more severe than in patients without comorbidity, with more patients requiring reintubation and mechanical ventilation.

Furthermore, there was a higher incidence of comorbidity among patients who had mild or moderate OSA and suffered from postoperative respiratory complications. This suggests that considering AHI alone is not sufficient to predict complications; other factors such as the presence of comorbidity are also likely to influence complications to varying degrees. These results support our suggestion that all OSA patients with a comorbidity (independent of the severity of the OSA) should be monitored thoroughly in the post-anaesthesia care unit (PACU) or even in a paediatric intensive care unit (PICU) for the first night after surgery. In our study, the most severe complications were found in patients with mild or moderate sleep apnoea and comorbidity.

Analysing data with PoRCs, 40% of these patients had mild and moderate OSA. Among these, 70% were afflicted by comorbidity and 30% were otherwise healthy children. Although most cases with mild/moderate OSA and complications suffered from comorbidity conditions, 30% had no medical issues, yet PoRCs developed in those cases as well. Patients without comorbidity suffered from desaturations and needed supplemental oxygen. All of these complications happened less than 2 hours after surgery. Our results suggest that when PoRCs are observed, it should be recommended to monitor otherwise healthy children for a minimum of 2 hours after surgery independently of OSA severity, but it can be managed at the ward or recovery room with oximetry by a trained nurse.

It is important to optimise the perioperative management of children undergoing tonsillectomy through multidisciplinary evaluation (e.g. anaesthesiology, otolaryngology, paediatrics and sleep medicine) [25]. The limitation of our study was the low event rate in the comorbid group, especially in subgroup analyses, due to the single centre data collection setting. An international, multicentre, observational trial is crucially needed for proper evaluation of the effect of different comorbidities on PoRC and to develop an evidence-based, child-specific, reliable, postoperative monitoring system.

Conclusions

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. In children with comorbidities postoperative complications could also arise in cases of mild/moderate OSA. Therefore, postoperative monitoring protocols should be adjusted to follow different patient groups after adenotonsillectomy.

Conflict of interest statement

Andras Bikov is supported by the NIHR Manchester BRC. The other authors declare no conflict of interest.

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Authors' contributions

All authors have contributed to the concept of the study and they have read, critically reviewed and approved the final version of the manuscript. Additional roles include: PB: designed the study, collected the data, performed the data analyses and wrote the manuscript, ZL: performed the data analyses wrote and revised the manuscript, FK: collected the data, discussed the manuscript, GK (Gabriella Kiss) collected the data, discussed the manuscript, BCS analysed the data, ZB, GK (Gábor Katona), LR, AB: contributed to the concept and design of the investigation and revision of the manuscript.

Ethical consideration

Ethics approval was obtained by the Ethics Committee at Heim Pál National Institute of Paediatrics (6/2015 Heim Pál National Institute of Paediatrics). The study protocol conformed to the ethical guidelines of the Declaration of Helsinki updated in 2013 as reflected in an a priori approval by the institution's human research committee. All caregivers signed a written informed consent.

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