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Original article

Risk factors for children requiring adenotonsillectomy and their impact on postoperative complications: a retrospective analysis of 2000 patients

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Summary

Adenotonsillectomies are commonly performed procedures and sleep-disordered breathing is becoming increasingly important as an indication for surgery. Because of the higher risks in patients with obstructive sleep apnoea, the required level of postoperative care for these patients is currently under discussion, and better identification of patients at risk may reduce unnecessary postoperative monitoring. To evaluate the influence of obstructive sleep apnoea, and other risk factors, on peri-operative complications in children requiring adenotonsillectomy, we performed a retrospective case-control study that included 1995 patients treated between January 2009 and June 2017. In our analysis, young age (OR 3.8, 95%CI 2.1–7.1), low body weight (OR 2.6, 95%CI 1.5–4.4), obstructive sleep apnoea (OR 2.4, 95%CI 1.5–3.8), pre-existing craniofacial or syndromal disorders (OR 2.3, 95%CI 1.4–3.8) and adenotonsillectomy, compared with adenoidectomy alone, (OR 7.9, 95% CI 4.7–13.1) were identified as risk factors for complications during or after surgery, $p < 0.001$. All 13 patients suffering from complications more than 3 h postoperatively had obstructive sleep apnoea plus at least one more of these risk factors. Patients at risk of postoperative complications can therefore be identified by several criteria pre-operatively, and should be monitored postoperatively using pulse oximetry overnight. For all other patients, postoperative observation on a surgical ward without extra monitoring is sufficient. Admission to paediatric intensive care should be reserved for patients suffering serious intra-operative complications.

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Introduction

Obstructive sleep apnoea (OSA) is a chronic sleep-related breathing disorder, characterised by recurrent upper airway obstruction during sleep [1]. Its prevalence ranges from 5.4% to 45.7% in adults [2]; in children, however, the prevalence is reported to be as low as 1–5% [3]. Unlike adults, where obesity plays an important role, the vast majority of OSA in children is caused by hypertrophic lymphatic tissue of the tonsils and adenoids [4, 5]. Therefore, the first line therapy is surgical removal of the hypertrophic lymphatic tissue by performing adenotonsillectomy [6] or, if the tonsils are small and the adenoids clearly the reason for obstruction, by performing adenoidectomy alone [7, 8]. These procedures are reported to be effective in up to 82% of patients [6, 9] and reduce their risk of developing sequelae such as hypertension or attention deficit hyperactivity disorder [10].

Although OSA is the leading indication for adenotonsillectomy in many countries [11], it is also recognised as a risk factor for postoperative complications

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such as oxygen desaturation. In many hospitals, including our own, anaesthetists therefore request postoperative monitoring of all children with OSA, preferably in a paediatric intensive care unit (PICU). As this is both an organisational issue and expensive, there is an ongoing debate regarding the level of observation required for children with OSA following adenotonsillectomy. Although some support day-case surgery even for children with OSA [11], others recommend elective postoperative admission to PICU [12] or at least better identification of those patients requiring postoperative care on PICU [13, 14]. It has been shown that polysomnography (PSG), although considered the gold standard for diagnosing OSA in many countries, cannot reliably identify those children who might suffer from postoperative complications [14]. The aim of the present study was to help identify patients at risk of complications and thus allocate them to an appropriate level of postoperative care.

Methods

Following local research ethics committee approval, we reviewed the medical records and electronic documentation of all children who underwent adenoidectomy or adenotonsillectomy at our institution between January 2009 and June 2017. Baseline patient characteristics, previous medical history, including suspected OSA, ASA physical status, use of tracheal tube or supraglottic airway device (SAD), surgical procedure and duration were all recorded. Children with OSA were identified by asking their parents whether they had phases of apnoea longer than 10 s, and how often. Additionally, parents were asked to film the phases of apnoea with a camera or smartphone in order for medical staff to verify the diagnosis.

Anaesthetic techniques were left to the discretion of the individual anaesthetist, and surgical techniques included curette adenoidectomy, electrocautery tonsillotomy and extracapsular tonsillectomy with scissors or a wire loop. All children were observed in the recovery room for 3 h postoperatively in case a complication occurred and they needed unplanned admission to PICU. Children with OSA, as well as children with syndromal disorders, were monitored with continuous postoperative pulse oximetry on a paediatric ward overnight, regardless of other risk factors, whereas all the other children were observed without pulse oximetry on a paediatric surgical ward. All children were hospitalised for 24 h. Follow-up was conducted at 10–14 days and 3 months postoperatively.

Complications were analysed regarding the type (laryngospasm, oxygen desaturation, secondary haemorrhage), the time-point (intra-operative to 3 h postoperatively and 3–24 h postoperatively) and need for intervention (such as supplementary oxygen or tracheal re-intubation).

Data collected were transferred to standard spreadsheets and statistically analysed using GraphPad Prism software (version 6.0e; GraphPad Software Inc., San Diego, CA, USA). Normal distribution was tested using the D'Agostino-Pearson omnibus normality test. If data were normally distributed, Students t-test was applied, otherwise the non-parametric Wilcoxon–Mann–Whitney test was used. Categorical data were analysed with Chi-squared test. When testing multiple comparisons, a Bonferroni correction was applied to each group of tests. For OR analysis, the continuous variables of age, weight, body mass index (BMI) and surgical duration were converted into binaries. A value of $p < 0.05$ was considered statistically significant.

Results

A total of 2723 children were identified. All patients who received additional surgical or diagnostic procedures, such as brainstem-evoked response audiometry or tympanoplasty at the same time, were excluded. This left 1995 patients for inclusion in the analysis. Table 1 shows the baseline and clinical characteristics of children with OSA (n = 528) compared with controls (n = 1467). Children with OSA had lower median (IQR [range]) body weight; 15.0 (13.0–18.8 [7.0–65.0]) kg vs. 16.0 (13.4–20.0 [4.0–130.0]) kg, $p < 0.001$ and lower BMI; 15.3 (14.1–16.5 [8.3–25.8]) $kg.m^{-2}$ vs. 16.6 (14.6–17.1 [7.7–40.1]) $kg.m^{-2}$, $p < 0.001$ compared with the control group, respectively. The OSA group also had higher rates of additional tonsillectomy; 73.3% vs. 5.0%, $p < 0.001$, and this correlated with a longer duration of surgery; 36 (24–49 [3–131]) min vs. 31 (21–42 [4–130]) min, $p < 0.001$. Due to a policy of inserting tracheal tubes when performing tonsillectomies at our institution, this group had higher rates of tracheal tube placement; 83% vs. 43%, $p < 0.001$ rather than a SAD. In addition, children with OSA were more likely to have a pre-existing medical disorder or syndrome; 26% vs. 18%, $p < 0.001$ and ASA physical status scores of 2 or 3 52.7% and 1.2% vs. 39.1% and 0.8% respectively, $p < 0.001$, than children without OSA. Complications occurred more often in patients with OSA, both in the period up to 3 h postoperatively; 4.8% vs. 2.7%, $p < 0.001$ and during the later observation period; 2.3% vs. 0.1%, $p < 0.001$. There was a higher rate of secondary haemorrhage in the OSA group; 1.9% vs. 0.6%, $p = 0.016$.

Table 2 shows the patient characteristics and clinical features that were associated with complications. For the time-period from the start of anaesthesia until 3 h

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Table 1 Baseline patient characteristics, intra-operative data and postoperative complications in patients with obstructive sleep apnoea compared with a control group. Values are number (proportion) or median (IQR [range]).

	Obstructive sleep apnoea group n = 528	**Control group n = 1467**	**p value**
Sex; male patients	307 (58%)	912 (62%)	0.130
Age; years	3.8 (2.9–5.0 [0.7–14.5])	3.9 (2.7–5.5 [0.4–17.0])	0.254
Weight; kg	15.0 (13.0–18.8 [7.0–65.0])	16.0 (13.4–20.0 [4.0–130.0])	< 0.001
BMI; $kg.m^{-2}$	15.3 (14.1–16.5 [8.3–25.8])	16.6 (14.6–17.1 [7.7–40.1])	< 0.001
ASA physical status;			< 0.001
1	46.1%	60.2%	
2	52.7%	39.1%	
3	1.2%	0.8%	
Previous medical history (coagulation disorder, syndromal disease, cardiopulmonary disease, etc.)	139 (26.3%)	256 (17.5%)	< 0.001
Intra-operative airway device			
Tracheal tube	439 (83.1%)	627 (42.7%)	< 0.001
Supraglottic airway	87 (16.8%)	838 (57.3%)	
Surgical procedure;			< 0.001
Adenoidectomy alone	141 (27%)	1394 (95%)	
Adenotonsillectomy	387 (73%)	73 (5%)	
Duration of surgery; min	36 (24–49 [3–131])	31 (21–42 [4–130])	< 0.001
Complications (laryngospasm, oxygen desaturation < 92%, tracheal re-intubation, aspiration);			
< 3 h postoperatively	26 (4.8%)	39 (2.7%)	< 0.001
> 3 h postoperatively	12 (2.3%)	1 (0.1%)	< 0.001
Secondary haemorrhage	10 (1.9%)	11 (0.8%)	0.019

postoperatively, complications were significantly correlated with OSA ($p < 0.001$), age < 3 y ($p < 0.001$), low body weight ($p < 0.001$), previous medical history ($p = 0.001$) and additional tonsillectomy ($p < 0.001$). No influence on the rate of complications was found for BMI ($p = 0.529$), ASA physical status ($p = 0.205$) or duration of surgery ($p = 0.085$). Within the overnight observation period complications were significantly correlated with low body weight ($p < 0.001$), presence of OSA ($p < 0.001$), previous medical history ($p = 0.002$) and additional tonsillectomy ($p < 0.001$). No correlation was found for age < 3 y ($p = 0.180$), BMI ($p = 0.610$), ASA physical status ($p = 0.384$) or duration of surgery ($p = 0.178$).

Table 3 shows the overall complications, as well as the known risk factors the patients had. In both groups, most patients either had oxygen desaturation alone or secondary haemorrhage. Major respiratory complications such as laryngospasm, bronchospasm or the need for tracheal re-intubation were rare in both groups. The types of complication were similar in both groups. All except one patient in the OSA group had at least one other risk factor in addition to OSA, and this one patient suffered from aspiration intra-operatively following an airway change from SAD to tracheal tube. In the control group, 80% of patients suffering from a complication had at least one risk factor such as young age, low body weight or a previous medical history. Of the 528 patients in the OSA group, 338 patients had OSA alone and one of these had a complication, whereas 190 had OSA and at least one other risk factor, and 37 suffered a complication. For OSA and at least one other risk factor, the likelihood of a complication had a sensitivity of 97% and a specificity of 69%, with a positive predictive value of 19% and a negative predictive value of 99%. Of the 1467 children in the control group, 1083 patients had one risk factor, of which 14 had a complication, whereas 384 had more than one risk factor, of which 26 suffered a complication. If a patient in the control group had two or more risk factors, the likelihood of a complication had a sensitivity of 65% and a specificity of 75%, with a positive predictive value of 6% and a negative predictive value of 99%.

Table 4 provides details of the 13 patients who suffered a complication more than 3 h postoperatively, for example, during overnight observation. All had a decrease in oxygen saturation, with the lowest recorded being between 78% and 90%; in one patient this was following aspiration that

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Table 2 Risk factors for complications from the start of anaesthesia until 3 h postoperatively and 3–24 h postoperatively.

	3 h postoperatively		3–24 h postoperatively	
	p value	OR (95%CI)	p value	OR (95%CI)
Young age (< 3 y)	< 0.001	3.8 (2.1–7.1)	0.180	2.3 (0.7–7.6)
Low body weight (< 13.2 kg)	< 0.001	2.6 (1.5–4.4)	< 0.001	32.1 (1.9–538.4)
Low BMI (< 14.2 $kg.m^{-2}$)	0.529	1.2 (0.7–2.0)	0.610	1.5 (0.5–4.4)
Obstructive sleep apnoea	< 0.001	2.4 (1.5–3.8)	< 0.001	37.6 (4.9–287.6)
ASA physical status 1 or 2	0.205	1.5 (0.9–2.5)	0.384	1.8 (0.6–5.8)
Previous medical history	0.001	2.3 (1.4–3.8)	0.002	5.5 (1.9–15.8)
Adenotonsillectomy	< 0.001	7.9 (4.7–13.1)	< 0.001	6.2 (2.1–18.0)
Long surgical duration (> 42 min)	0.085	1.6 (1.0–2.5)	0.178	2.5 (0.8–8.0)

BMI, body mass index.

Table 3 Overall complications and risk factors in patients included in the study. Values are number (proportion).

Obstructive sleep apnoea group n = 528		Control group n = 1467	
Total complications	38 (7.1%)	Total complications	40 (2.7%)
Oxygen desaturation	18 (3.4%)	Oxygen desaturation	17 (1.2%)
Tracheal re-intubation	4 (0.8%)	Tracheal re-intubation	4 (0.3%)
Laryngospasm	5 (1.0%)	Laryngospasm	6 (0.4%)
Secondary haemorrhage	10 (1.9%)	Secondary haemorrhage	11 (0.8%)
Aspiration	1 (0.2%)	Aspiration	2 (0.1%)
Risk factors present		Risk factors present (no OSA)	
Two or more, including OSA	9 (23.7%)	Two or more	9 (22.5%)
OSA and previous medical history	16 (42.1%)	Previous medical history	8 (20.0%)
OSA and low body weight	9 (23.7%)	Low body weight	8 (20.0%)
OSA and young age	3 (7.9%)	Young age	7 (17.5%)
OSA alone	1 (2.6%)	None	8 (20.0%)

OSA, obstructive sleep apnoea.

occurred intra-operatively and in another because they were developing pneumonia. In eight children no specific treatment or intervention was necessary. Five patients required supplementary oxygen for a few hours on the first night, two required antibiotic therapy due to aspiration or pneumonia, and one patient required tracheal re-intubation for 12 h due to respiratory fatigue. No patient had postoperative respiratory problems at 48 h. Of the 13 patients who suffered a complication more than 3 h postoperatively, eight had syndromal disorders; trisomy 21 (3), Crouzon's disease (2), Franceschetti syndrome (1), Chiari malformation (1), Pierre Robin sequence (1) and four had low body weight.

Discussion

Obstructive sleep apnoea occurs in approximately 1–5% of the paediatric population and in the vast majority of these it is due to hypertrophic tissue of the adenoids and/or the tonsils [3, 15–18]. Therefore, in contrast to the adult population, adenoidectomy or adenotonsillectomy are widely recognised to be the treatment of choice for children with OSA [19–21]. Although adenotonsillectomy is not without risk [22], it is a commonly performed procedure which, in a number of countries, is performed as a day case [11, 23]. Children with OSA, however, are more likely to suffer from respiratory complications after this type of surgery [22], possibly due to increased nasal secretions and postoperative oedema in the adenoidal and tonsillar beds [24]. Therefore there is still much debate regarding the level of postoperative observation that is necessary for these children.

Our study showed that children with OSA had significantly different baseline and clinical characteristics compared with children having adenotonsillectomy for other

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Table 4 Individual characteristics of the 13 patients who suffered a complication 3–24 h postoperatively.

No.	Sex	Age (y)	Weight (kg)	BMI ($kg.m^{-2}$)	ASA	OSA	Medical history	T&A	Lowest recorded S_pO_2%	Intervention
1	Male	4.3	12.2	12.4	1	Yes	Crouzon's disease	Yes	78% in first 24 h	Not necessary
2	Male	1.7	10.8	25.8	2	Yes	Franceschetti syndrome	Yes	80% in first 48 h	Not necessary
3	Male	3.9	12.0	13.3	1	Yes		Yes	83% in first 24 h	Not necessary
4	Female	5.2	13.1	13.3	2	Yes	Chiari malformation	Yes	85% in first 24 h	Tracheal re-intubation for 12 h
5	Female	3.5	13.0	13.5	2	Yes		Yes	88% in first 24 h	Not necessary
6	Male	2.2	11.8	13.7	1	Yes	Pierre Robin syndrome	Yes	88% in first 24 h	Not necessary
7	Female	2.2	12.5	13.4	1	Yes		Yes	89% in first 24 h	Not necessary
8	Male	4.4	14.0	12.7	3	Yes	Crouzon's disease	Yes	89% in first 24 h	Supplementary oxygen
9	Male	1.7	8.0	13.9	1	Yes		Yes	90% in first 24 h	Not necessary
10	Male	2.1	14.5	18.7	1	Yes		Yes	Aspiration intra-operatively 88% in first 24 h	Supplementary oxygen, antibiotic treatment
11	Male	3.3	15.0	18.5	2	Yes	Trisomy 21	Yes	90% in first 24 h	Supplementary oxygen
12	Female	1.7	7.2	13.5	2	Yes	Trisomy 21	Yes	88% in first 24 h	Not necessary
13	Male	4.5	15.5	17.2	2	No	Trisomy 21	No	84% in first 24 h, pneumonia	Supplementary oxygen, antibiotic treatment

BMI, body mass index; ASA, ASA physical status; OSA, obstructive sleep apnoea; T&A, adenotonsillectomy.

reasons. They were lighter and had a lower BMI compared with controls. Some studies have reported higher weights and higher BMI's in patients with OSA, which might indicate that the reason for OSA in these children was more related to obesity than to adenotonsillar hypertrophy [17, 25, 26]. Others have reported lower age, weight and BMI at the time of surgery in children with OSA, possibly because the children were failing to thrive or the symptoms and signs were being noticed earlier due to their severity [27].

Children with OSA required tonsillectomies more often than the control group. Although there are several studies demonstrating that, for many children with OSA, an adenoidectomy is sufficient [7, 8], others argue that all children with OSA should also receive a tonsillectomy because adenoidectomy alone is not sufficient [4, 5, 28]. The dual procedure of adenotonsillectomy resulted in an increase in the duration of surgery for patients with OSA compared with controls.

Children with OSA were more likely to have co-existing medical conditions, resulting in an increase in their ASA physical status. This is in agreement with previous studies demonstrating a higher prevalence of OSA in children with syndromal disorders such as trisomy 21 or craniofacial abnormalities [12–14].

Having demonstrated that children with OSA show many differences in clinical and baseline characteristics compared with controls, we analysed which of these items, independently or in combination, were a risk factor for complications during or after surgery. As well as OSA, low body weight at the time of surgery, known syndromal disorders, or having tonsillectomy in addition to adenoidectomy were identified as risk factors for complications in both the time periods analysed. Young age only seemed to increase the risk during, or immediately following, surgery rather than during the overnight observation period. As early as 1993, Rosen et al. reported higher rates of complications in children with OSA undergoing adenotonsillectomy, noting that these patients were younger, were of extremes in weight or had craniofacial abnormalities, although a low number of patients was included [29]. Age < 2 y [12, 13, 29] or 3 y [14, 30, 31] has frequently been shown to increase the risk of complications, although it is not clear whether complications arose in the immediate peri-operative setting or during an observation period overnight. In agreement with our data, the majority of studies note a medical history of craniofacial abnormalities or other syndromal disorders among the risk factors for children with OSA [12, 32–34],

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whereas others have offered inconclusive results [14]. Very low body weight, a sign of failure to thrive, as well as obesity, have been identified as risk factors [12, 13]. For very obese children, however, it has to be noted that adenotonsillectomy often does not resolve the sleep-related disorder in these patients [8], therefore bringing into question the indication for adenotonsillectomies in obese children.

Other possible pre-operative risk factors have been described. Among these are several items derived from pre-operative PSG or pulse oximetry, such as the apnoea-hypopnoea-Index (AHI) [13, 35], capillary oxygen saturation (S_pO_2) [36, 37], respiratory disturbance index (RHI) [12] or a significant central component in PSG [12].

Although several researchers suggest that adenotonsillectomy may be performed as a day-case procedure with minimal postoperative observation times of between 3 h [38] and 6 h [18, 32], observation overnight seems justified, in our opinion, especially when transport to and from the hospital may take a relatively long time in rural areas [38]. This is because postoperative pain can be managed better and oral intake can be more closely monitored. Postoperative care may be on a general surgical ward, a ward with access to pulse oximetry, or a PICU. In the present study, we have demonstrated that almost all patients with OSA suffering a complication had at least one other risk factor as well as OSA (e.g. low body weight, young age, previous medical history), and in the control group the majority of patients with a complication also had at least one of these. This is in agreement with previous studies that showed these three items (four if OSA is included) are highly reliable at predicting complications in patients undergoing surgery. We excluded tonsillectomy itself as a risk factor as it is not a patient characteristic but a consequence of the indication in patients with OSA. Although in the OSA group the sensitivity (97%) for these criteria was excellent, the specificity (69%) was not. In the control group, the sensitivity was lower (65%) and the specificity was comparable (75%). In both groups, however, the negative predictive value was 99%, which demonstrates that almost all children at risk can be appropriately identified.

An analysis of complications that occurred after discharge from the recovery room 3 h postoperatively showed that only 13 out of 1995 patients suffering from oxygen desaturation or another complication. If the presence of two or more of the following risk factors were identified pre-operatively; OSA, low body weight, a syndromal disorder; or young age, then all but one patient would have been identified as being at risk of a complication. The one patient who would not have been identified pre-operatively suffered from aspiration intra-operatively. Only one patient needed a major intervention (tracheal re-intubation), whereas all other children required supplementary oxygen and/or antibiotic therapy, and this is consistent with data from Rieder et al. [14], who found that the majority of respiratory complications did not require intervention. The 3 h period of postoperative observation in the recovery room, which has previously been proposed by Rhodes et al. [13], helped to identify nearly all the patients who were at risk of a postoperative complication. Walker et al. have previously found that the vast majority of patients with late postoperative complications already had problems during surgery or in the immediate postoperative recovery period [12].

One advantage of the present study is the large number of patients included, the completeness of data and the standardisation of patient management. A limitation of the study is its retrospective design. In addition, there was no matching of the groups, but this would have been difficult due to the many different characteristics that children with OSA have, compared with the controls (age, weight, previous medical history, adenotonsillectomy rather than adenoidectomy, etc.). In our study, the diagnosis of OSA was based on questioning the parents, video documentation and clinical findings. Although sleep studies are considered the gold standard for diagnosis of OSA in adults [13], its use in children is questionable due to cost implications and limited information obtained [14, 39, 40]. The diagnosis of OSA in children is based on a variety of tests, including sleep studies [18, 32], pulse oximetry [18, 33], history from a carer and clinical observation [34, 40].

We conclude that OSA, low body weight, young age or a previous medical history can be identified as risk factors for complications after adenotonsillectomy in children. When two or more of these risk factors are present, postoperative observation on a general surgical ward with access to pulse oximetry overnight is adequate, whereas all other children can be observed on a surgical ward without additional monitoring. The presence of OSA alone does not justify routine postoperative pulse oximetry monitoring. Only in the situation when major intra-operative complications occur is admission to PICU necessary and, due to its rarity, an unplanned admission to PICU appears to be manageable in usual clinical practice.

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