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Outcome of drug-induced sleep endoscopy-directed surgery for persistent obstructive sleep apnea after adenotonsillar surgery

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ABSTRACT

Purpose: Drug-induced sleep endoscopy (DISE) is suitable for evaluating persistent obstructive sleep apnea syndrome (OSAS) after adenotonsillar surgery as a means to guide surgical intervention, yet few studies demonstrate its usefulness in resolving the syndrome. We describe our experience of DISE-directed surgery in children with persistent OSAS by analysing objective and subjective outcomes of this treatment.

Methods: Prospective study of 20 otherwise healthy 2–12 year-old children with OSAS persisting after adenotonsillar surgery. All patients underwent DISE-directed surgery and were followed up clinically and with a polysomnogram at 12 ± 3 months.

Results: All 20 children had an apnea-hypopnea index (AHI) score ≥ 1 (mean: 6.1 ± 4.9) and 75% had AHI > 3 before surgery. We performed a total of 14 total tonsillectomies (70%), 7 with associated pharyngoplasties; 5 radiofrequency turbinate reductions (25%); 7 radiofrequency lingual tonsil reductions (35%); and 10 revision adenoidectomies (50%). No surgery-related complications were observed. AHI scores at follow-up were significantly lower than AHI scores before surgery (1.895 ± 1.11 vs 6.143 ± 4.88 ; $p < 0.05$) and, in 85% ($n = 17$) of patients, AHI was below 3. There was a significant reduction in the number of children with AHI > 3 in follow-up at 12 ± 3 months (15%; $n = 3$) compared to before surgery (75%; $n = 15$) ($p < 0.005$).

Conclusion: DISE-directed surgery for otherwise healthy children with persistent OSAS is a useful and safe technique to decide a therapeutic strategy and to obtain good objective and subjective results regarding resolution of the syndrome.

1. Introduction

Hypertrophy of adenotonsillar tissue is a major contributor to the development of obstructive sleep apnea syndrome (OSAS) in otherwise healthy children [1–3]. Accordingly, the practice guidelines of the American Academy of Pediatrics recommend adenotonsillar surgery as the first-line treatment for childhood OSAS [4,5], as it typically resolves symptoms in most affected children, improves respiratory sleep parameters and enhances quality of life [3,6].

However, several studies and recent meta-analyses indicate a 20%–75% likelihood, depending on the population, of OSAS persisting after adenotonsillar surgery [7–10]. The different factors that have been shown to predict residual disease include severe sleep apnea in the

initial polysomnogram (PSG), obesity, craniofacial anomalies, hypotonia and Down syndrome [7,11–16], and also OSAS in children with small tonsils and whose adenoids are not obstructive [17].

While night-time PSG remains the gold standard for diagnosis of OSAS both before and after adenotonsillar surgery [18], it does not provide information on the obstruction site, guidance regarding further therapies or predict which children would benefit from surgical and/or medical interventions [2]. Evaluation of symptomatic patients with persistent OSAS after adenotonsillar surgery could include an examination (in order to detect the site or sites responsible for upper airway obstruction), a naso- and oropharyngeal examination and an in-office fiberoptic endoscopy [3,19]. However, these do not allow evaluation of airways during sleep or sedation or easy identification of

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multiple sites of obstruction. These limitations can be overcome by diagnostic modalities such as cine-magnetic resonance imaging (MRI) and drug-induced sleep endoscopy (DISE) [3].

Indications for DISE in children are still evolving. Some authors argue for DISE use for all children with OSAS [20,21], whereas others consider that DISE should be restricted to patients at risk of persistence [1,22]. Most practitioners agree that DISE is appropriate for patients with persistent OSAS after adenotonsillar surgery in order to guide surgical intervention [2]. Friedman et al. [23] published a multi-institutional survey that confirmed that DISE is not generally performed in children who still have their tonsils, suggesting that the predominant indication for DISE is persistent OSAS after adenotonsillar surgery.

DISE has not yet been clearly linked to outcomes [3], with few studies demonstrating its usefulness in resolving persistent OSAS [19,24] and few of those having conducted PSG testing [24].

Our aim was to describe our experience of DISE-directed surgery in otherwise healthy children with persistent OSAS by analysing the objective (PSG) and subjective outcomes of this treatment.

2. Methods

2.1. Study design and population

Children were recruited from a database that included patients with suspected OSAS who had undergone night-time PSG. This database was designed as a cohort study to assess the negative consequences of OSAS and post-treatment results. The study was approved by the clinical research ethics committee of our hospital.

Our prospective study was based on a population of consecutively recruited otherwise healthy patients aged 2–12 years who presented to the otorhinolaryngology department with suspected persistent OSAS after adenotonsillar surgery. Exclusion criteria were lack of clinical data, non-performance of a PSG and/or absence of signed informed consent.

Anthropometric measurements [25] were made for these patients who also underwent an ear-nose-throat examination and PSG and completed a Chervin paediatric sleep questionnaire (PSQ) [26]. Diagnosis of persistent OSAS was based on a combination of clinical signs, symptoms of upper airway obstruction, all-night PSG and an apnea-hypopnea index (AHI) score of 1 or more (number of events per hour of sleep). Palatine tonsil size was assessed in the clinic using the Friedman grading system: surgically naive patients were scored between 1 and 4 depending on obstruction status and post-tonsillectomy patients were scored 0 [27]. Snoring intensity was evaluated using a visual analogue scale (VAS) scored from 0 to 10 (where 0 indicated complete silence and 10 indicated snoring loud enough to be easily heard through a closed door) [28]. Night-time PSG was performed in the sleep clinic and manually scored by certified technicians according to international guidelines [29]. OSAS was classified as mild (AHI > 1 and < 5), moderate (AHI 5–10) or severe (AHI > 10) [30].

Finally, parents or legal guardians of the patients were asked to complete a consent form that explained the purposes of the study, DISE and the related procedures. They were also informed that DISE could change the initial indication or the final surgical plan, and with their permission, this surgery would be performed immediately (unless the change was substantial, in which case surgery would be performed at another time).

All clinical examinations and PSG recordings were repeated 12 ± 3 months after DISE-directed surgery. Applying the criteria of the Spanish Consensus Document on Paediatric OSAS, a post-treatment score of AHI < 3 was considered as treatment success [30].

2.2. DISE procedure

DISE was performed on all 20 patients by the same endoscopist (EE) [22,31]. Sedation was induced by inhaled sevoflurane followed by

intravenous propofol. In our experience the best window of observation was obtained with bispectral index (BIS) values from 60 to 70, as reported in a previous study [22].

A 3.4-mm flexible fiberoptic endoscope was inserted through the nasal cavity after the first cycle of obstruction, considered to be a complete and stable sequence of snoring-obstructing hypo/apnea-oxygen desaturation-breathing. The upper airway was then observed at six levels (nasal cavity, nasopharynx, velum, oropharynx, tongue base and supraglottis), assessed exhaustively for at least two cycles, and scored according to the Chan four-point scale (minimum 0 to maximum 3) [32]. In this approach, in which obstruction is evaluated in five sites of the upper aerodigestive tract – adenoid, velum, lateral pharyngeal wall, tongue base, supraglottis – inferior turbinates were also included. When there was collapse, considered to be significant when the Chan score for tongue base was 2 or more [31], jaw thrust was performed. Disappearance, reduction or persistence of the anterior-posterior collapse was assessed, as this is helpful in differentiating tongue base hypertrophy from tongue base collapse due to hypotonia or craniofacial anomalies.

All findings, complications and limitations were recorded directly in a database during the DISE procedure.

2.3. Surgical treatment

Immediately after the DISE procedure, all patients with positive findings underwent orotracheal intubation and surgical treatment.

Children with significant nasopharyngeal obstruction due to adenoidal regrowth underwent cold adenoidectomy. Children with lateral oropharyngeal wall collapse due to palatine tonsil hypertrophy underwent total tonsillectomy with or without pharyngoplasty. Children with significant oropharyngeal obstruction (due not only to tonsillar hypertrophy) underwent pharyngoplasty [33,34]. Hypertrophic lingual tonsils and inferior turbinates were all reduced using radiofrequency (Olympus-Celonlab® radiofrequency generator with Celon Prosleep® terminal) when the Chan score was 3 or more.

2.4. Statistical analysis

Descriptive statistics are reported as frequencies for the categorical variables and as means and standard deviations for the continuous variables. To compare pre- and postoperative measurements, the McNemar test was used for categorical variables and the dependent *t*-test for continuous variables (when normally distributed). The Kolmogorov-Smirnov test was used to determine whether variables were normally distributed. All statistical analyses were performed, for a significance level of $p < 0.05$, using SPSS V.21.

3. RESULTS

3.1. Preoperative data

The study group consisted of 20 consecutively recruited otherwise healthy paediatric patients aged 2–12 years with persistent OSAS. Of the 29 initial recruits, 9 patients were excluded due to follow-up failure or a lack of PSG after DISE.

Table 1 shows the most important clinical features for the 20 children. Mean age was 78 ± 34 months (27–144 months) and 70% were boys. Parent-reported snoring at 6 or higher on the VAS was 80%, and over 75% of parents reported sleep apneas in their children some nights, in some cases on more than half of the nights. A quarter (25%) of the children had Friedman tonsil size ≥ 3 . The mean body mass index (BMI) percentile was 55 ± 34 ; 6 children (30%) were overweight and 2 children (10%) were obese (percentiles > 85 and > 95, respectively).

All the children had an AHI ≥ 1 (mean: 6.1 ± 4.9) and 75% had an AHI > 3. The distribution by levels of AHI severity was as follows: < 5

Table 1
Preoperative data.

		Mean	SD	n	%
Age (months)		78	34		
Sex	Girls			6	30.0%
	Boys			14	70.0%
BMI		16.7	2.5		
Weight		23.5	11.8		
Height		115.1	20.1		
BMI percentile		55	34		
BMI percentile > 85	No			14	70.0%
	Yes			6	30.0%
BMI percentile > 95	No			18	90.0%
	Yes			2	10.0%
Friedman scale	0			3	15.0%
	1			4	20.0%
	2			8	40.0%
	3			5	25.0%
AHI		6.1	4.9		
VAS snoring		6.7	2.3		
Apnea	No			4	20.0%
	With upper airway tract infection			7	35.0%
	< 50% of nights			6	30.0%
	Every night			2	10.0%
	Don't know			1	5.0%
Open mouth asleep	No			2	10.0%
	Occasionally			1	5.0%
	Yes			17	85.0%
Open mouth awake	No			1	5.0%
	Occasionally			5	25.0%
	Yes			14	70.0%

AHI: apnea-hypopnea index; BMI: body mass index; VAS: visual analogue scale.

(mild), 11 children (55%); 5-10 (moderate), 6 children (30%); and > 10 (severe), 3 children (15%).

Previous OSAS surgery was as follows: 3 total adenotonsillectomies, 5 bipolar-assisted tonsillectomies with adenoidectomy, 11 monopolar-assisted tonsillectomies with adenoidectomy, and 1 adenoidectomy without tonsillar surgery.

3.2. DISE findings and DISE-directed surgery

All 20 DISE evaluations were performed by the same surgeon (EE).

Table 2
DISE findings, DISE-directed surgery and pre- and postoperative AHI.

Case	Age (mo)	IT	AD	VE	LPW	TB	SG	DISE surgery	Pre AHI	Post AHI
1	68	3	1	1	1	0	1	RF-T	3.8	1.8
2	100	3	2	1	1	3	0	RF-T + RF-LT	3.8	0.9
3	109	3	0	1	1	3	0	RF-T + RF-LT	1.2	2.1
4	132	3	3	1	0	2	0	RF-T + Re-A	1	0
5	80	2	0	2	3	0	0	TT	12.86	2.3
6	42	1	0	2	3	1	0	TT	4	0.9
7	38	0	1	0	3	0	0	TT	6.9	1.6
8	90	1	1	2	3	3	0	TT + RF-LT	20.1	2.1
9	127	3	0	1	3	0	0	TT + RF-T	13.1	1.8
10	42	1	0	1	3	0	0	TT + PP	3.7	1.4
11	144	2	1	1	3	3	0	TT + PP + RF-LT	8.6	0.4
12	59	2	2	1	2	0	0	TT + Re-A	4.3	3.3
13	27	1	1	2	3	1	0	TT + Re-A	7.1	2
14	94	2	1	1	2	3	0	TT + PP + Re-A + RF-LT	9.75	2.4
15	42	2	1	1	2	1	0	TT + PP + Re-A	3.3	2.5
16	96	2	2	2	2	1	0	TT + PP + Re-A	1.8	3.1
17	53	2	3	2	2	1	0	TT + PP + Re-A	8.1	4.69
18	43	2	1	2	2	3	0	TT + PP + Re-A + RF-LT	2.4	2.9
19	84	2	3	1	1	1	0	Re-A	1.3	0.6
20	85	0	3	2	1	3	0	Re-A + RF-LT	5.76	1.1

DISE: drug-induced sleep endoscopy; AHI: apnea-hypopnea index.

IT: inferior turbinate; AD: adenoids; VE: velum; LPW: lateral pharyngeal wall; TB: tonsil base; SG: supraglottis; RF-T: turbinate radiofrequency; RF-LT: lingual tonsil radiofrequency; Re-A: revision adenoidectomy; TT: total tonsillectomy; PP: pharyngoplasty.

All patients tolerated DISE and there were no complications. DISE findings (Table 2) indicate multilevel obstruction in 17 subjects and, in 3 subjects, inferior turbinate obstruction (case 1) or lateral pharyngeal wall obstruction (cases 7 and 9).

Inferior turbinate hypertrophy (70%) and lateral pharyngeal wall obstruction (70%) were the most common causes of collapse, followed by tongue base obstruction (40%), velum obstruction (40%) and adenoid regrowth (35%).

In accordance with the DISE findings, the patients underwent surgical intervention under the same anaesthetic as for the DISE: 14 total tonsillectomies (70%), 7 with associated pharyngoplasties; 5 radiofrequency turbinate reductions (25%); 7 radiofrequency lingual tonsil reductions (35%); and 10 revision adenoidectomies (50%).

3.3. Postoperative data

The mean BMI percentile at follow-up at 12 ± 3 months was 62 ± 31; 7 children (35%) were overweight and 1 child (5%) was obese (percentiles > 85 and > 95, respectively). No significant differences were found either in BMI percentiles as measured before (54.60 ± 34.33) and after (62.15 ± 31.13) DISE-directed surgery or in the proportions of overweight children or obese children.

Regarding the effectiveness of the surgical intervention, there was a significant decrease in the VAS score for snoring after (1.55 ± 1.701) compared to before (6.75 ± 2.337) DISE-directed surgery (p < 0.05). After surgery, no child had a VAS score of 6 or more; although 3 children continued to present with apneas, this only occurred when they had upper respiratory tract infection, and all 3 had AHI < 3 in follow-up at 12 ± 3 months. The proportion of children with parent-reported apneas in the follow-up period at 12 ± 3 months was, at 16.7% (n = 3), significantly lower than in the preoperative period, at 78.9% (n = 15) (p < 0.005).

There was a decrease in the AHI after (1.895 ± 1.11) compared to before (6.143 ± 4.88) DISE-directed surgery (p < 0.05). The postoperative distribution for levels of severity was as follows: no OSAS (AHI < 1), 5 children (25%); and mild OSAS (AHI ≥ 1 and < 5), 15 children (75%). No child had AHI ≥ 5. In 17 of the 20 cases (85%) the score was AHI < 3. There was a significant reduction in the number of children with AHI > 3 (15%; n = 3) in follow-up at 12 ± 3 months compared to before surgery (75%; n = 15) (p < 0.005).

4. Discussion

Our study suggests that DISE-directed surgery for otherwise healthy paediatric patients with persistent OSAS is safe and effective in resolving OSAS.

Our series consisted of 20 consecutively recruited otherwise healthy children, all of whom underwent both pre- and postoperative PSG, treated with DISE-directed surgery for persistent OSAS. At follow-up 12 ± 3 months later, only 3 children (15%) had an AHI > 3 and no child had AHI ≥ 5 . All cases had a VAS < 6 for snoring at follow-up, and only in 3 cases did parents report apneas during sleep, but only when the children had upper respiratory tract infection. There were no complications associated with the DISE-directed surgery.

OSAS is a common problem in children, with an estimated prevalence of 1%–4% [5,35–37]. It is a recognized cause of significant medical morbidity, including neurocognitive dysfunction, cardiovascular complications and inflammatory and metabolic sequelae [36,38]. Because these comorbid conditions can affect quality of life, early diagnosis and treatment is recommended [30,39]. Adenotonsillar hypertrophy is recognized as the most significant contributor to OSAS, and adenotonsillar surgery is first-line therapy. However, several studies have shown that a significant percentage of children may have some degree of persistent OSAS after adenotonsillar surgery [7–10]. For children with persistent OSAS the treatment recommendations reported in the literature are highly varied [24]. Continuous positive airway pressure (CPAP) ventilation, multilevel operations in the pharynx, craniofacial surgery and tracheotomy are all described, depending on the level of ongoing collapse and other patient factors [40]. Nevertheless, in some children, CPAP compliance can be challenging and the treatment is often poorly tolerated [41,42]. Hence, identifying the site of persistent obstruction is important as it allows options other than CPAP to be explored [2,19].

The evaluation of symptomatic patients with persistent OSAS after adenotonsillar surgery can include a repeat PSG and naso- and oropharyngeal examinations for tonsil regrowth, turbinate hypertrophy and septal deviation. The assessment can also include fiberoptic endoscopy to identify adenoid regrowth, lingual tonsillar hypertrophy, tongue base prolapse and laryngeal causes of obstruction [19,43].

Successful treatment of persistent OSAS after adenotonsillar surgery in the paediatric population is challenging, given the high rates of multilevel disease and the difficulty of conducting a comprehensive airway examination [43]. For this reason, something more is needed in the corresponding evaluation protocol. DISE is potentially useful for children with persistent OSAS after adenotonsillar surgery because it may identify the anatomical structures that contribute to obstruction and enable tailored surgical treatment [3,19,22,24,43]. Very little, however, has been published regarding paediatric DISE-directed surgical outcomes [1–3].

In our study, multilevel obstruction was a characteristic of most of our patients (85%), with collapse most commonly occurring due to inferior turbinate hypertrophy (70%) and lateral oropharyngeal wall obstruction (70%), followed by tongue base obstruction (40%), velum obstruction (40%) and adenoid regrowth (35%). Like us, Durr et al. [43] also found multilevel obstruction in most patients in their series, reporting tongue base obstruction, adenoid regrowth and inferior turbinate hypertrophy as the most common sites of persistent obstruction.

A number of surgical treatments have been reported for persistent OSAS in children, including removal of recurrent adenoid and tonsil tissue, turbinoplasty, septoplasty, lingual tonsillectomy, tongue reduction surgery, maxillary expansion, mandibular advancement and supraglottoplasty [43]. DISE may facilitate selection from among these alternative treatments. A combined approach of DISE followed by surgery for persistent OSAS performed under the same anaesthetic is often preferred by families as a way to avoid further anaesthesia [43].

All 20 patients in our study underwent OSAS surgery after DISE-directed surgery in the same intervention. Parents had previously been

informed of, and accepted, this possibility. Friedman et al. [23], in a recent survey, referred to the issues associated with the staged approach (shared decision making, with families informed regarding expected recovery and results) and the all-in-one approach (uncertainty regarding what procedures will be performed on the day of the intervention). Like other authors [24,44], however, if the surgery is expected to proceed normally with no increased risk for the patient, we prefer to perform both stages at once. When surgery is likely to be complex and risky, we leave open the possibility of a second stage.

In our study the surgery was easily done in the same intervention after the DISE procedure, as the level of complexity was generally low: 14 total tonsillectomies (70%), 7 with associated pharyngoplasties; 5 radiofrequency turbinate reductions (25%); 7 radiofrequency lingual tonsil reductions (35%); and 10 revision adenoidectomies (50%). We had no complex cases, e.g. supraglottoplasty or midline posterior glossectomy, as reported by other authors [24,43,44]. In more complex cases, surgery may need to be done in a second phase, as exemplified in the study by Durr et al. [43]: 8 patients (62%) underwent surgery under the same anaesthetic as for the DISE procedure, while 5 patients (31%) were scheduled for surgery at a later date.

There are few studies on DISE-directed surgery and those that exist did not always test postoperative PSG, yet DISE-directed surgery for persistent OSAS treatment would seem to produce good outcomes. All 20 of our patients underwent both pre- and postoperative PSG. Our findings were a significant decrease in AHI scores between measurements made before (6.143 ± 4.88) and after (1.895 ± 1.11) the intervention ($p < 0.05$), no children with AHI ≥ 5 at follow-up, and AHI < 3 in 85% of the children. There was a significant reduction in the number of children with AHI > 3 at follow-up at 12 ± 3 months ($p < 0.005$). Similar results have been reported by Wootten et al. [24] and He et al. [44]. Wootten et al. [24] retrospectively assessed the impact of DISE-directed surgical intervention in 26 children with persistent OSAS after adenotonsillar surgery, reporting an overall family satisfaction score of 92%, due to decreased symptoms after surgery and a reduced mean AHI. However, while 17 of their patients underwent preoperative PSG, only 11 also underwent postoperative PSG. He et al. [44] reported positive results for DISE-directed surgery in 56 patients with either OSAS or OSAS persisting after adenotonsillar surgery: mean obstructive AHI improved from 14.9 ± 13.5 to 10.3 ± 16.2 events per hour ($p < 0.001$) and OSAS disease severity was significantly reduced ($p < 0.001$). After DISE-directed surgery, 17.9% ($n = 10$) of the children had complete resolution of OSAS, 37.5% ($n = 21$) had mild residual disease (obstructive AHI < 5), while 26.8% ($n = 15$) had persistent severe OSAS.

It should be clarified that it is not possible to judge the actual state and influence of the nasal cycle contributing to the size of the turbinates in a brief endoscopic evaluation of a sedated patient in supine decubitus. However, our interest was to evaluate the possible contribution to OSAS. We consider that complete obstruction (inferior turbinates Chan score 3) during DISE may contribute to the development of OSAS. Resolution of the nasal obstruction and of the OSAS in our five patients who underwent radiofrequency turbinate surgery would support this argument.

Regarding the limitations of our study, one is that ours is a private hospital. Therefore, the complexity of the population is lower and this bias is clearly evident in the OSAS severity levels. The DISE findings and the surgery carried out could also be conditioned by this fact, as our good results may be influenced by the low complexity level of our cases.

Another issue is that we did not differentiate between obstructive and central apnea episodes in recording AHI results. This means that our results may be altered by the fact of our study not being comparable with other series in which this distinction is drawn.

Finally, our sample, with only 20 cases, was small and there was no control group of children with persistent OSAS treated with surgery without DISE. While the study conclusions may have been strengthened if we had had controls, we did not have enough patients with the

necessary characteristics and follow-up data to be able to create a control group.

Nonetheless, we consider that our conclusions are significantly supported by the fact that our study is based on 20 consecutively diagnosed children with OSAS for whom PSG records before and after DISE-directed surgery exist.

DISE-directed surgery for otherwise healthy children with persistent OSAS is a useful and safe technique to decide a therapeutic strategy and to obtain good objective and subjective results regarding resolution of the syndrome.

Conflicts of interest

The authors have no funding, financial relationships, or conflicts of interest to disclose.

Compliance with ethical standards

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

References

- [1] F. Galluzzi, L. Pignataro, R.M. Gaini, W. Garavello, Drug induced sleep endoscopy in the decision-making process of children with obstructive sleep apnea, *Sleep Med.* 16 (3) (2015) 331–335.
- [2] L.I. Wilcox, M. Bergeron, S. Reghunathan, S.L. Ishman, An updated review of pediatric drug-induced sleep endoscopy, *Laryngoscope Invest Otolaryngol.* 2 (6) (2017) 423–431.
- [3] P.V. Manickam, S.R. Shott, E.F. Boss, A.P. Cohen, J.K. Meinzen-Derr, R.S. Amin, S.L. Ishman, Systematic review of site of obstruction identification and non-CPAP treatment options for children with persistent pediatric obstructive sleep apnea, *Laryngoscope* 126 (2) (2016) 491–500.
- [4] C.L. Marcus, L.J. Brooks, K.A. Draper, D. Gozal, A.C. Halbower, J. Jones, M.S. Schechter, et al., Diagnosis and management of childhood obstructive sleep apnea syndrome, *Pediatrics* 130 (2012) 576–584.
- [5] M.S. Schechter, Section on Pediatric Pulmonology, Subcommittee on Obstructive Sleep Apnea Syndrome. Technical report: diagnosis and management of childhood obstructive sleep apnea syndrome, *Pediatrics* 109 (2002) 69.
- [6] S.L. Ishman, Evidence-based practice: pediatric obstructive sleep apnea, *Otolaryngol. Clin.* 45 (2012) 1055–1069.
- [7] R. Bhattacharjee, L. Kheirandish-Gozal, K. Spruyt, R.B. Mitchell, J. Promchiarak, N. Simakajornboon, A.G. Kaditis, et al., Adenotonsillectomy outcomes in treatment of obstructive sleep apnea in children: a multicenter retrospective study, *Am. J. Respir. Crit. Care Med.* 182 (2010) 676–683.
- [8] M. Friedman, M. Wilson, H.C. Lin, H.W. Chang, Updated systematic review of tonsillectomy and adenoidectomy for treatment of pediatric obstructive sleep apnea/hypopnea syndrome, *Otolaryngol. Head Neck Surg.* 140 (2009) 800–808.
- [9] S.E. Brietzke, D. Gallagher, The effectiveness of tonsillectomy and adenoidectomy in the treatment of pediatric obstructive sleep apnea/hypopnea, syndrome: a meta-analysis, *Otolaryngol. Head Neck Surg.* 134 (2006) 979–984.
- [10] E. Esteller, P. Santos, F. Segarra, R. Lopez, E. Matión, J.M. Ademà, E. Estiviil, Persistencia a largo plazo del síndrome de la apnea-hipoapnea obstructiva del sueño infantil tratada con adenoamigdalectomía, análisis de factores pronóstico, *Acta Otorrinolaringol. Esp.* 63 (2) (2012) 85–92.
- [11] D.J. Costa, R. Mitchell, Adenotonsillectomy for obstructive sleep apnea in obese children: a meta-analysis, *Otolaryngol. Head Neck Surg.* 140 (2009) 455–460.
- [12] R.B. Mitchell, J. Kelly, Outcome of adenotonsillectomy for obstructive sleep apnea in obese and normal-weight children, *Otolaryngol. Head Neck Surg.* 137 (2007) 43–48.
- [13] A.L. Tang, A.P. Cohen, J.R. Benke, K.D. Stierer, J. Stanley, S.L. Ishman, Obstructive sleep apnea resolution in hypopnea- versus apnea predominant children after adenotonsillectomy, *Otolaryngol. Head Neck Surg.* 155 (4) (2016) 670–675.
- [14] J.S. Park, D.K. Chan, S.R. Parikh, A.K. Meyer, K.W. Rosbe, Surgical outcomes and sleep endoscopy for children with sleep-disordered breathing and hypotonia, *Int. J. Pediatr. Otorhinolaryngol.* 90 (2016) 99–106.
- [15] A.C. Lin, P.J. Koltai, Sleep endoscopy in the evaluation of pediatric obstructive sleep apnea, *Int. J. Pediatr.* 2012 (2012) 576719.
- [16] M. Maris, S. Verhulst, V. Saldien, P. Van de Heyning, M. Wojciechowski, A. Boudewyns, Drug-induced sedation endoscopy in surgically naive children with Down syndrome and obstructive sleep apnea, *Sleep Med.* 24 (2016) 63–70.
- [17] H.M. Myatt, E.J. Beckenham, The use of diagnostic sleep nasendoscopy in the management of children with complex upper airway obstruction, *Clin. Otolaryngol.* 25 (2000) 200–208.
- [18] P.S. Roland, R.M. Rosenfeld, L.J. Brooks, N.R. Friedman, J. Jones, T.W. Kim, S. Kuhar, et al., Clinical practice guideline: polysomnography for sleep-disordered breathing prior to tonsillectomy in children, *Otolaryngol. Head Neck Surg.* 145 (Suppl 1) (2011) s1–15.
- [19] M.T. Truong, V.G. Woo, P.J. Koltai, Sleep endoscopy as a diagnostic tool in pediatric obstructive sleep apnea, *Int. J. Pediatr. Otorhinolaryngol.* 76 (2012) 722–727.
- [20] A. Boudewyns, V. Saldien, P. Van de Heyning, S. Verhulst, Drug induced sedation endoscopy in surgically naive infants and children with obstructive sleepapnea: impact on treatment decision and outcome, *Sleep Breath.* 22 (2) (2018) 503–510.
- [21] M.J. Gazzaz, A. Isaac, S. Anderson, N. Alsufyani, J. Alrajhi, H. El-Hakim, Does drug-induced sleep endoscopy change the surgical decision in surgically naive non-syndromic children with snoring/sleep disordered breathing from the standard adenotonsillectomy? A retrospective cohort study, *J. Otolaryngol. Head Neck Surg.* 46 (1) (2017) 12.
- [22] M.A. Collu, E. Esteller, F. Lipari, R. Haspert, D. Mulas, M.A. Díaz, R.C. Dwivedi, A case control study of Drug-Induced Sleep Endoscopy (DISE) in pediatric population. A proposal for indications, *Int. J. Pediatr. Otorhinolaryngol.* 108 (2018) 113–119.
- [23] N.R. Friedman, S.R. Parikh, S.L. Ishman, A.G. Ruiz, H. El-Hakim, S.O. Uluualp, C.T. Wooten, et al., The current state of pediatric drug-induced sleep endoscopy, *Laryngoscope* 127 (1) (2017) 266–272.
- [24] C.T. Wooten, S. Chinnadurai, S.L. Goudy, Beyond adenotonsillectomy: outcomes of sleep endoscopy-directed treatments in pediatric obstructive sleep apnea, *Int. J. Pediatr. Otorhinolaryngol.* 78 (7) (2014) 1158–1162.
- [25] E. Esteller, J.C. Villatoro, A. Agüero, R. Lopez, E. Matión, J. Argemi, M. Girabent-Farrés, Obstructive sleep apnea syndrome and growth failure, *Int. J. Pediatr. Otorhinolaryngol.* 108 (2018) 214–218.
- [26] R.D. Chervin, K. Hedger, J.E. Dillon, K.J. Pituch, Pediatric sleep questionnaire (PSQ): validity and reliability of scales for sleep-disordered breathing, snoring, sleepiness, and behavioral problems, *Sleep Med.* 1 (1) (2000) 21–32.
- [27] M. Friedman, H. Ibrahim, L. Bass, Clinical staging for sleep-disordered breathing, *Otolaryngol. Head Neck Surg.* 127 (2002) 13–21.
- [28] E. Esteller, F. Segarra, P. Huerta, A. Enrique, E. Matión, J.M. Ademà, Efectividad clínica y polisomnográfica de la adenomigdalectomía en el tratamiento de los trastornos respiratorios del sueño en los niños, *Acta Otorrinolaringol. Esp.* 59 (2008) 325–333.
- [29] R.B. Berry, R. Budhiraja, D.J. Gottlieb, D. Gozal, C. Iber, V.K. Kapur, C.L. Marcus, et al., American Academy of Sleep M, Rules for scoring respiratory events in sleep: update of the 2007 AASM manual for the scoring of sleep and associated events. Deliberations of the sleep apnea definitions task force of the American Academy of sleep medicine, *J. Clin. Sleep Med. JCSM: Off. Pub. Am. Acad. Sleep Med.* 8 (5) (2012) 597–619.
- [30] M.L. Alonso-Álvarez, T. Canet, M. Cubell-Alarco, E. Estivill, E. Fernández-Julián, D. Gozal, M.J. Jurado-Luque, et al., Documento de consenso del síndrome de apneas-hipopneas durante el sueño en niños, *Arch. Bronconeumol.* 47 (Supl 5) (2011) 2–18.
- [31] E. Esteller, D. Mulas, R. Haspert, E. Matión, R. López, M. Girabent-Farrés, Drug-induced sleep-endoscopy in children's sleep related breathing disorders, *Acta Otorrinolaringol. Esp.* 67 (4) (2016) 212–219.
- [32] D.K. Chan, B.J. Liming, D.L. Horn, S.R. Parikh, A new scoring system for upper airway pediatric sleep endoscopy, *JAMA Otolaryngol. Head Neck Surg.* 140 (7) (2014) 595–602.
- [33] P.H. Chiu, K. Ramar, K.C. Chen, Y.J. Tsai, C.M. Lin, Y.C. Chiang, C.Y. Lu, et al., Can pillar suturing promote efficacy of adenotonsillectomy for pediatric OSAS? a prospective randomized controlled trial, *Laryngoscope* 123 (10) (2013) 2573–2577.
- [34] J. Fherm, P. Nerfeldt, J. Sundman, D. Friberg, Adenopharyngoplasty vs adenotonsillectomy in children with severe obstructive sleep apnea a randomized clinical trial, *JAMA Otolaryngol. Head Neck Surg.* 144/7 (2018) 580–586.
- [35] K. Byars, P. Apiwattanasawee, A. Leejakpai, S. Tangchityongsiva, N. Simakajornboon, Behavioral sleep disturbances in children clinically referred for evaluation of obstructive sleep apnea, *Sleep Med.* 12 (2) (2011) 163–169.
- [36] T. Paiva, Epidemiology of sleep disorders in children and adolescents, in: S. Nevšimalová, O. Bruni (Eds.), *Sleep Disorders in Children*, Springer International Publishing, Switzerland, 2017, pp. 53–67.
- [37] J.C. Lumeng, R.D. Chervin, Epidemiology of pediatric obstructive sleep apnea, *Proc. Am. Thorac. Soc.* 5 (2008) 242–252.
- [38] Y. Nachalon, N. Lowenthal, S. Greenberg-Dotan, A.D. Goldbart, Inflammation and growth in young children with obstructive sleep apnea syndrome before and after adenotonsillectomy, *Mediat. Inflamm.* 14 (2014) 1–7.
- [39] American Academy of Pediatrics, Clinical practice guideline: diagnosis and management of childhood obstructive sleep apnea syndrome, *Sect. Pediatr. Pulmonol. Sub-Comm. Obstruct. Sleep Apnea Syndrome Pediatr.* 109 (4) (2002) 704–712.
- [40] S.R. Shott, Evaluation and management of pediatric obstructive sleep apnea beyond tonsillectomy and adenoidectomy, *Curr. Opin. Otolaryngol. Head Neck Surg.* 19 (2011) 449–454.
- [41] A. Castorena-Maldonado, L. Torre-Bouscoulet, S. Meza-Vargas, J.C. Vazquez-García, E. Lopez-Escarcega, R. Perez-Padilla, Preoperative continuous positive airway pressure compliance in children with obstructive sleep apnea syndrome: assessed by a simplified approach, *Int. J. Pediatr. Otorhinolaryngol.* 72 (2008) 1795–1800.
- [42] S. Hawkins, E. Jensen, N.R. Friedman, Correlates of pediatric CPAP adherence, *J. Clin. Sleep Med.* 12 (6) (2016) 879–884.
- [43] M.L. Durr, A.K. Meyer, E.J. Kezirian, K.W. Rosbe, Drug-induced sleep endoscopy in persistent pediatric sleep-disordered breathing after adenotonsillectomy, *Arch. Otolaryngol. Head Neck Surg.* 138 (2012) 638–643.
- [44] S. He, N.S. Peddireddy, D.F. Smith, A.L. Duggins, C. Heubi, S.R. Shott, S.L. Ishman, Outcomes of drug-induced sleep endoscopy-directed surgery for pediatric obstructive sleep apnea, *Otolaryngology-Head Neck Surg. (Tokyo)* 158 (3) (2018) 559–565.