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Long term noninvasive ventilation in children with OSA-I and OSA-II

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Abstract

Objective

The aim of the study was to describe the characteristics of otherwise healthy children with obstructive sleep apnea (OSA; OSA-I) and children with OSA and obesity (OSA-II) treated with long term continuous positive airway pressure (CPAP) or noninvasive ventilation (NIV) in 2019 in France. Design National cross-sectional survey.

Patients

Children with OSA-I and OSA-II.

Main outcome measures

Initiation criteria, age, adherence, equipment and settings

Results

Patients with OSA-I and OSA-II represented 6% (n=84, 71% males) and 10% (n=144, 72% males) of the national cohort, respectively. The apnea- hypopnea index (63% vs 76%), alone or combined with nocturnal gas exchange (25% vs 21%, for OSA-II and OSA-I patients respectively) were used as initiation criteria of CPAP/NIV. OSA-II patients were older at CPAP/NIV initiation (mean age 11.0 ± 4.0 vs 6.8 ± 4.5 years, $p<0.001$) and were treated for a longer time (2.3 ± 2.6 vs 1.3 ± 1.5 years, $p=0.008$) than OSA-I patients. NIV was used in 6% of OSA-I patients and 13% of OSA-II patients ($p=0.142$). Nasal mask was the most used interface in both groups. Mean CPAP level was higher in OSA-II patients as compared to OSA-I patients (8.7 ± 2.0 vs 7.7 ± 2.4 cmH₂O, $p=0.02$). Objective compliance was comparable (mean use 6.8 ± 2.6 vs 5.9 ± 3.0 hours/night in OSA-I and OSA-II, respectively, $p=0.054$).

Conclusion

Six and 10% of children treated with long term CPAP/NIV in France in 2019 had OSA-I and OSA-II, respectively. Both groups were preferentially treated with CPAP and were comparable except for age, with OSA-II patients being older.

Keywords:

obstructive sleep apnea, noninvasive ventilation, obesity

Introduction

Obstructive sleep apnea (OSA) is defined as repeated partial or complete obstructions of the upper airways during sleep. Hypertrophy of the adenoids and/or the tonsils is the main cause of OSA in otherwise healthy children (also called OSA-I) with a prevalence ranging from 0% to 5.7% (1, 2). OSA-I is generally mild to moderate, with the majority of children having a spontaneous favorable evolution over time or after adenotonsillectomy (3). However, a minority of children may present severe residual OSA after upper airway surgery. These children require other therapeutic options in order to avoid the deleterious neurocognitive and behavioral consequences of persistent OSA (4, 5). Continuous positive airway pressure (CPAP), by maintaining airway patency during the entire breathing cycle has shown its efficacy in these children (5, 6).

The escalating global obesity epidemic represents one of the most serious public health challenges, not only in adults but also in children (7). Overweight and obese children have an increased risk of OSA (also called OSA-II), with OSA being in general more severe than in lean children, and associated with a greater risk of residual OSA after adeno-tonsillectomy (8). If weight loss cannot be obtained, CPAP has shown to be an efficient treatment for severe persistent OSA (5). As adults, children with OSA-II are also at risk of obesity hypoventilation syndrome (OHS), which may require noninvasive ventilation (NIV) if CPAP is insufficient to correct nocturnal hypoventilation.

In France, children treated with long term NIV/CPAP at home are followed within the French national paediatric NIV network. A survey performed by the network showed that 1449 patients aged less than 20 years were treated with NIV/CPAP for at least 3 months on June 2019 (9). The mean age of the patients was 9.8 +- 5.8 years and the most frequent underlying disorders were upper airway obstruction (46%), neuromuscular disease (28%), and central nervous system disorder (13%). Within the context of a growing number of children with obesity, we analysed the characteristics of the subgroups of patients of the 2019 national survey with OSA-II and compared them to patients with OSA-I.

Material and methods

This study was a sub-analysis of a national cross-sectional survey performed in 2019 among all the centres of the French national paediatric NIV/CPAP network, which gathers 28 paediatric university centres distributed among 24 cities (9). This sub-analysis focused on patients treated with CPAP or NIV for OSA-I or OSA-II, without any other comorbid condition. The detailed methodology of the survey has been published (9).

In summary, all the centres filled in an anonymous questionnaire for every child aged [?] 18 years treated since at least 3 months with CPAP or NIV on June the 1st, 2019. Some young adults aged 18-22 years who were still followed in these centres since childhood were also included. The questionnaire comprised the following information : date of birth, gender, primary and secondary diagnosis, investigations performed before CPAP/NIV initiation, parameters that led to the decision of CPAP/NIV treatment, CPAP/NIV duration, mean objective adherence to treatment during the last month obtained from the device built-in

software, type of interface, and CPAP/NIV device. The study was approved by the local institutional board (Comite d'Ethique de Necker Enfants Malades, CENEM, ndeg CENEM19-5-BF) on March the 7th 2019, and all the patients aged > 6 years and all the parents gave their informed consent.

Comparisons between the patients with OSA-I and OSA-II were done using the t-test, or the Mann-Whitney test in case of non-parametric data. Comparisons of quantitative data were done using the chi-square test. Statistically significant difference was considered for a p value < 0.05.

Results

Patients with OSA-I and OSA-II represented 6% (n=84, 71% males) and 10% (n=144, 72% males) of the national cohort (n=1449) respectively. OSA-II patients were older at CPAP/NIV initiation (mean age 11.0 \pm 4.0 vs 6.8 \pm 4.5 years, $p < 0.001$) (Table 1). OSA-II patients were treated with CPAP/NIV for a longer time than OSA-I patients (mean duration 2.3 \pm 2.6 vs 1.3 \pm 1.5 years, $p = 0.008$). A minority of patients were treated with NIV as compared to CPAP, with no difference between patients with OSA-I and OSA-II (6% of OSA-I vs 13% of OSA-II patients, $p = 0.142$). For both groups, the overall duration of ventilatory support was greater for patients treated with NIV as compared to patients treated with CPAP (4.0 \pm 3.0 vs 1.7 \pm 2.1 years, $p < 0.001$) (Table 1). The objective adherence was similar for both groups (mean adherence 6.8 \pm 2.6 hours/night and 5.9 \pm 3.0 hours/night for OSA-I and OSA-II patients, respectively, $p = 0.054$). However, in both groups, the objective adherence was greater with NIV as compared to CPAP (Table 1). The 5 OSA-I patients treated with NIV were younger at NIV initiation as compared to those treated with CPAP, they were treated with NIV for a longer time, and were also more adherent to treatment as compared to patients treated with CPAP. The 19 OSA-II patients treated with NIV were also treated for a longer time than those treated with CPAP.

Table 1 : Age, type and duration of the ventilatory support, and objective adherence in patients with OSA-I and OSA-II.

	Patients with OSA-I (n=84)		Patients with OSA-I (n=84) Total	Patients with OSA-II (n=144)		Patients with OSA-II (n=144) Total	p value between total populations
	CPAP	NIV		CPAP	NIV		
Ventilatory mode							
Number of patients, n	79 (94%)	5 (6%)	84	125 (87%)	19 (13%)	144	< 0.001
(%) Mean	8.4 \pm 4.8	\pm 4.5	6.8 \pm 4.8	13.2 \pm 3.7	14.2 \pm 2.9	11.0 \pm 3.6	< 0.001
age (years)	7.2 \pm 4.5	\pm 2.3*	6.8 \pm 4.5	11.2 \pm 3.9	9.8 \pm 3.9	10.5 \pm 4.0	0.008
Mean age at CPAP/NIV initiation (years)	1.2 \pm 1.5	\pm 2.8*	1.5 \pm 1.5	2.0 \pm 2.4	4.4 \pm 3.0§	2.6 \pm 5.9	0.054
Mean duration of CPAP/NIV (years)	6.6 \pm 2.6	\pm 1.3*	6.8 \pm 2.6	5.7 \pm 3.1	7.4 \pm 2.9*	6.5 \pm 3.0	0.088
Mean objective adherence (hours/night)	12 (15%)		12 (14%)	33 (26%)	3 (16%)	36 (25%)	
Number of patients with a mean objective adherence < 4 hours/night, n (%)							

Data are given as mean \pm standard deviation or numbers (percentage of patients).

* Significantly different between CPAP and NIV ($p < 0.05$); § significantly different between CPAP and NIV ($p < 0.001$)

Abbreviations: OSA-I: obstructive sleep apnea type I, OSA-II: obstructive sleep apnea type II, CPAP: continuous positive airway pressure, NIV: noninvasive ventilation.

Nearly all the patients had a polysomnography (PSG) or a respiratory polygraphy (PG) prior to CPAP/NIV initiation (Table 2), with approximately half of the patients having a simultaneous recording of transcutaneous carbon dioxide pressure (PtcCO₂), with no difference between patients with OSA-I and OSA-II. Only a minority of patients (4%) had only a nocturnal recording of pulse oximetry (SpO₂) and PtcCO₂ without a PSG or a PG.

Table 2 . Investigations performed prior to CPAP/NIV initiation and CPAP/NIV initiation criteria.

Investigations prior to CPAP/NIV initiation, n (%) PG/PSG + nocturnal PtcCO₂ recording PG/PSG Nocturnal SpO₂ +

Data are presented as numbers (percentage of patients).

Abbreviations: CPAP: continuous positive airway pressure, NIV: noninvasive ventilation, OSA-I: obstructive sleep apnea type I, OSA-II: obstructive sleep apnea type II, PG: polygraphy, PSG: polysomnography, AHI: apnea-hypopnea index, PtcCO₂: transcutaneous carbon dioxide pressure, SpO₂: pulse oximetry.

*2 missing data.

CPAP/NIV was initiated on a high AHI in 68% of the patients, and on a high AHI with an abnormal SpO₂ and PtcCO₂ value in 24% of the patients, with no difference between patients with OSA-I and OSA-II (Table 2). CPAP/NIV was initiated on an abnormal SpO₂ and PtcCO₂ alone in only 4% of the patients. On note, the 5 patients with OSA-I who were treated with NIV had all a PtcCO₂ recording, whereas the 44 patients who did not have a PtcCO₂ recording were all treated with CPAP. Of the 19 patients with OSA-II who were treated with NIV, only 2 had no PtcCO₂ recording.

Table 3 . CPAP/NIV equipment.

Type of device#, n (%) Standard Intermediate Life support *Type of interface**, n (%) Nasal mask Nasobuccal mask Nasal p

Missing data: 6 OSA-I; 6 OSA-II.

* Missing data: 1 OSA-I.

Standard device: use at night, no alarms, no battery; Intermediate device: use between 8-16 hours/24, basic alarms, internal battery [?] 2 hours; Life support ventilator: for use [?] 16 hours/24, full range of alarms, internal + external batteries [?] 8 hours and allows patient's mobility.

Abbreviations: OSA-I: obstructive sleep apnea type I, OSA-II: obstructive sleep apnea type II, CPAP: continuous positive airway pressure, NIV: noninvasive ventilation.

Patients with OSA-II were treated more often with a standard device, and less often with an intermediate and life support device, as compared to patients with OSA-I (Table 3). Patients treated with a standard device were older than those treated with an intermediate or life support device, with a greater age difference for patients with OSA-I as compared to patients with OSA-II (Table 4). The mean age of the patients treated with an auto-titrated CPAP was 11.4 +- 3.6 and 14.4 +- 3.3 years for patients with OSA-I and OSA-II, respectively. Both groups used most often a nasal interface with around 20% of patients in both groups using a nasobuccal interface. Patients with OSA-II were treated with a higher CPAP level in case of CPAP, while the inspiratory and expiratory pressures were not different between sub-groups in case of NIV even though they tended to be higher in patients with OSA-II (Table 5).

Table 4. Type of device according to age (years).

Type of device	Patients with OSA-I (n=84)	Patients with OSA-II (n=144)
Standard	9.7 ± 4.3	13.5 ± 3.2
Intermediate	4.7 ± 3.5	12.8 ± 4.8
Life support	1.5 ± 1.0	10.6 ± 6.4

Abbreviation : OSA-I: obstructive sleep apnea type I, OSA-II: obstructive sleep apnea type II

Table 5 . CPAP/NIV settings.

	Patients with OSA-I (n=83)	Patients with OSA-II (n=144)	p
<i>Constant CPAP</i>	64 7.7 ± 2.4 14 7.9 ±	83 8.7 ± 2.0 42 7.1 ±	0.003 0.184 0.209
Number of patients	2.5 13.1 ± 2.5 5 13.0 ±	1.6 13.4 ± 2.2 19 16.0	
Mean CPAP level (cmH ₂ O)	2.8 5.8 ± 1.5 20 ± 8	± 4.6 7.1 ± 2.0 15 ± 3	
<i>Auto-titrating CPAP</i>			
Number of patients			
Mean CPAP min (cmH ₂ O)			
Mean CPAP max (cmH ₂ O)			
<i>NIV</i>			
Number of patients			
Mean IPAP (cmH ₂ O)			
Mean EPAP (cmH ₂ O)			
Mean back up rate (breaths/minute)			

Data are given as mean ± standard deviation and numbers (percentage of patients).

Abbreviations: OSA-I: obstructive sleep apnea type I, OSA-II: obstructive sleep apnea type II, CPAP: continuous positive airway pressure, NIV: noninvasive ventilation, IPAP: inspiratory pressure, EPAP: expiratory positive airway pressure.

Discussion

This study is the first to describe the number and characteristics of children with OSA-I and OSA-II treated with long term CPAP/NIV in France. Our results show that 6% and 10% of children had OSA-I and OSA-II, respectively, with the majority being treated with CPAP. Both groups were comparable except for age with OSA-II patients being older.

CPAP/NIV is not a first line treatment for severe OSA-I and OSA II. Indeed, these treatments are reserved for patients who have severe persistent OSA after failure of all other therapeutic options (4, 5, 10). Drug-induced sleep endoscopy (DISE) is recommended in case of residual OSA after adeno-tonsillectomy in children with OSA-I to identify other persistent obstructive sites that may be cured by a complementary, targeted upper airway surgery (11, 12). Orthodontic treatment may be an option for selected patients (4, 5). In children with OSA-II, weight loss represents the first line treatment, even if a sufficient weight loss to correct or improve OSA is difficult to obtain. DISE is also indicated in these patients, mainly because of the high prevalence of hypertrophy of the lingual tonsils, beside the hypertrophy of the tonsils (4, 5). In any case, the decision of CPAP/NIV should be taken by a pediatric multidisciplinary team, after having explored all other alternative therapeutic options (10).

Six and 10% of children treated with long term CPAP/NIV in France on June 2019 had OSA-I and OSA-II, respectively. The majority of epidemiological studies worldwide which analyzed the characteristics of children treated with long term CPAP/NIV showed that nearly all children had an underlying disease (10). Some studies gave no information on patients with OSA-I or OSA-II (13-16), whereas other studies gave information on patients with obesity without specifying if these patients had OSA-II or syndromic obesity (17-19). Obese children represented 19% of the cohort in the studies by Castro-Codezal et al. (17) in Canada and Tsang et al. (19) in Hong-Kong, and 7.4% in a survey by Leske et al. (18) in Argentina. A recent study in Finland identified 5 children out of 93 who were treated with long term CPAP/NIV for OSA-II (20). The only study which reported long term CPAP/NIV in children with OSA-I was the study by Tsang et al. (19) in Hong Kong with 45% of 114 children having OSA-I. However, no information was available on the selection of the patients and the initiation criteria. Our data are thus one of the first nation-based data focusing on the prevalence and characteristics of patients with OSA-I and OSA-II treated with long term CPAP/NIV. As standardized protocols are used in France for the management of children with OSA-I and OSA-II, the prevalence of 6% for OSA-I and 10% for OSA-II seems realistic (21-23).

The fact that the patients with OSA-I were younger than those with OSA-II may be explained by the pathophysiology of OSA-I and OSA-II. Indeed, OSA-I is related to adeno-tonsillar hypertrophy which peaks between the age of 3 to 6 years (24), whereas obesity predominates during pre-adolescence and adolescence. Patients with OSA-I have a tendency to improve with age, while a sufficient weight loss is rarely obtained in obese children with severe OSA to be weaned from CPAP (25). Consequently, patients with OSA-II were treated for a longer time than patients with OSA-I probably because they are less prone to be weaned from CPAP/NIV. The objective adherence was quite good, with a higher adherence in patients treated by NIV, and comparable between both groups. This is in contradiction with the literature with numerous studies showing a low CPAP/NIV adherence in obese patients as compared to non-obese patients (26, 27). This may be explained by the close follow-up and systematic therapeutic education of the children treated with CPAP/NIV in France (9).

Concerning the investigations performed before the CPAP/NIV initiation, only half of the patients had an overnight PtcCO₂ recording. PtcCO₂ recording is highly recommended in children with a suspicion of OSA but not always available in every center (28). Like adults, children with obesity are at risk of nocturnal hypoventilation and should thus ideally have a PtcCO₂ recording. Indeed, the persistence of nocturnal alveolar hypoventilation despite optimal CPAP treatment is an indication to switch for NIV (10, 28). Of note, all the obese patients who had no PtcCO₂ recording were treated with CPAP. It is thus possible that some patients with OSA-II had non-diagnosed alveolar hypoventilation and were thus consequently not treated optimally.

The majority of patients were treated with a standard device. The proportion of patients treated with a standard device was higher in patients with OSA-II as compared to patients with OSA-I. This may be explained by the older age and thus the greater weight in patients with OSA-II as compared to patients with OSA-I. Indeed, in order to adequately detect the patient's airflow, a device corresponding to the patient's weight should be used, with thus younger children requiring more often a level II or level III device (10, 29). The majority of the patients used a nasal interface. Very few OSA-II patients used nasal prongs (n=6), which may be explained in part by the young age of the patients.

The mean CPAP level was slightly but significantly higher in patients with OSA-II as compared to patients with OSA-I. Mean inspiratory and expiratory pressures tended to be higher in patients with OSA-II treated by NIV. This may be explained by the older age but also the presence of obesity requiring a higher positive airway pressure to maintain airway patency.

The main limitation of this study is the lack of information on the body mass index and the AHI and nocturnal gas exchange values. As this study is a sub-analysis of a national study, this information is unfortunately not available.

In conclusion, this study is the first to provide clinical data on an important and potentially increasing population of children treated with long term CPAP or NIV. Patients with OSA-I and OSA-II represented 6% and 10% of a French national cohort, respectively. Patients were mainly initiated on CPAP/NIV on a high AHI and treated with CPAP. Objective compliance was quite good and comparable between the two groups. A prospective study, taking in account the body mass index but also other clinical data such as waist circumference, the initiation criteria, and the duration and weaning of CPAP/NIV is worth to be performed in the future.

What is already known on this topic

- Continuous positive airway pressure (CPAP) or noninvasive ventilation (NIV) may be indicated in children with severe persistent obstructive sleep apnea (OSA).
- Most of these children have an underlying condition, such as a malformation of the upper airways.
- Information on otherwise healthy children with obstructive sleep apnea (OSA-I) and children with obstructive sleep apnea and obesity (OSA-II) is scarce.

What this study adds

- Children with OSA-I and OSA-II represented 6% and 10% of children treated with long term CPAP or NIV in France in 2019
 - Both groups were preferentially treated with CPAP and a nasal mask.
 - Patients with OSA-II were older and treated for a longer time than patients with OSA-I.
- Summary box
- Children with OSA-I and OSA-II represented 6% and 10% of children treated with long term CPAP or NIV in France in 2019
 - Both groups were preferentially treated with CPAP and a nasal mask.
 - Patients with OSA-II were older and treated for a longer time than patients with OSA-I.

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