Sleep Medicine 16 (2015) 107–112

Contents lists available at ScienceDirect

Sleep Medicine

journal homepage: www.elsevier.com/locate/sleep

Original Article

Polygraphic respiratory events during sleep in children treated with home continuous positive airway pressure: description and clinical consequences

Alessandro Amaddeo [a,b], Valeria Caldarelli [c], Marta Fernandez-Bolanos [a], Johan Moreau [a,d,e], Adriana Ramirez [a,f], Sonia Khirani [a,g], Brigitte Fauroux [a,h,i,*]

[a] AP-HP, Hôpital Necker Enfants-Malades, Pediatric Noninvasive Ventilation and Sleep Unit, Paris, France
[b] Pediatric Department, Institute for Maternal and Child Health, IRCCS Burlo Garofolo, Trieste, Italy
[c] Department of Paediatrics, Azienda Ospedaliera Santa Maria Nuova, IRCCS, Reggio Emilia, Italy
[d] Physiological Department, University of Montpellier I, Montpellier, France
[e] INSERM U1046, University of Montpellier I, Montpellier, France
[f] ADEP ASSISTANCE, Suresnes, France
[g] ASV Santé, Gennevilliers, France
[h] Paris Descartes University, Paris, France
[i] INSERM U 955, Equipe 13, Créteil, France

ARTICLE INFO

Article history:
Received 10 April 2014
Received in revised form 25 July 2014
Accepted 26 July 2014
Available online 18 November 2014

Keywords:
Polygraphy
Sleep
Continuous positive airway pressure (CPAP)
Child
Arousal
Desaturation

ABSTRACT

Objective: Data are scarce on respiratory events during sleep for children treated at home with continuous positive airway pressure (CPAP). The present study aimed to characterize the respiratory events with CPAP during sleep and to analyze their clinical consequences.
Patients/Methods: Consecutive polygraphies (PG) performed on stable children treated with CPAP were analyzed and scored using SomnoNIV Group definitions. For every respiratory event, the presence of a 3% oxygen desaturation and/or an autonomic arousal was systematically searched. Nocturnal gas exchange was assessed using summary data of oximetry and transcutaneous carbon dioxide pressure recordings.
Results: Twenty-nine consecutive polygraphies, performed on 26 children (mean age 7.8 ± 6.2 years, mean CPAP use 10.6 ± 14.4 months), were analyzed. The index of total respiratory events was low (median value 1.4/h, range 0–34). The mean number of different types of respiratory events per PG was 2 ± 1 (range 0–4), with always a predominant event. Partial or total upper airway obstruction without a decrease in ventilatory drive was the most frequent event and was the most frequently associated with an oxygen desaturation (in 30% of the events) and an autonomic arousal (in 55% of the events). Weak correlations were observed between nocturnal oximetry and PG results.
Conclusions: The index of respiratory events during CPAP treatment for stable children is low. As these events may be associated with an oxygen desaturation or an autonomic arousal, and as nocturnal gas exchange cannot predict PG results, a systematic sleep study seems justified for the routine follow-up of children treated with CPAP.

1. Introduction

Obstructive sleep apnea syndrome (OSAS) in children is a relatively common disease, with a reported prevalence that varies between 1 and 5% of the pediatric population [1]. Since adenotonsillar hypertrophy constitutes the most common cause of OSAS, adenotonsillectomy represents the first-line and most efficient treatment in children [1]. However, residual OSAS is common in children with underlying disorders such as Down syndrome, craniofacial abnormalities, or obesity. In these cases, continuous positive airway pressure (CPAP) represents an effective treatment [2–7].

In children with OSAS, manual titration of CPAP during attended laboratory polysomnography (PSG) is recommended [8], but such a procedure is time consuming and not feasible in all pediatric centers. Therefore, CPAP is usually set up during the day, according to the clinician's experience and the patient's characteristics. The optimal CPAP level is then adjusted according to nocturnal tolerance to treatment, normalization of nocturnal gas exchange,

* Corresponding author. Pediatric noninvasive ventilation and sleep unit, AP-HP, Hôpital Necker, 149 rue de Sèvres, Paris, F-75015, France. Tel.: +33 1 71 19 60 92; fax: +33 1 71 19 57 70.
E-mail address: brigitte.fauroux@nck.aphp.fr (B. Fauroux).

http://dx.doi.org/10.1016/j.sleep.2014.07.030
1389-9457/

and the disappearance of OSAS symptoms. However, once CPAP is successfully instituted, validated follow-up guidelines are lacking. Current guidelines recommend a periodic reassessment of CPAP pressure [9]; a large adult series has shown the need for an active re-evaluation of pressure therapy, even after accurate titration studies [10,11]. This may be even more relevant for children whose condition may improve with age due to a physiological increase in upper airway caliber and patency, or worsen because of weight gain or upper respiratory infections or allergy. However, very few studies have assessed the need for pressure changes over time in children having CPAP, and little is known about the type and incidence of the different residual respiratory events [2,12,13]. Furthermore, the current definitions of respiratory events during noninvasive ventilation (NIV) and CPAP derive from those in spontaneous breathing and do not accurately take into account the complex interaction between the patient and the response or reaction of a ventilator [14].

Recently, the SomnoNIV Group proposed a systematic scoring analysis of respiratory events observed with polygraphy (PG) during NIV [15]. These criteria were originally set up for NIV, taking into account the events generated by the patient, the ventilator, or the patient–ventilator interaction. However, CPAP differs from NIV, as it delivers a positive pressure during the whole respiratory cycle without actively assisted inspiration [16]; therefore, it is not considered to be a ventilatory mode per se. However, except for patient–ventilator interaction, all of the other SomnoNIV respiratory events may occur during CPAP, such as: unintentional leaks, partial or total upper airway obstruction (UAO) without or with decrease in ventilatory drive (DVD), DVD, and mixed events.

The aim of the present study was to characterize respiratory events in infants and children having CPAP treatment at home, according to the SomnoNIV Group definitions, and to examine the clinical consequences of these events (ie, the occurrence of an oxygen desaturation or an autonomic arousal). Whether oximetry and transcutaneous carbon dioxide tension ($PtcCO_2$) were associated with the occurrence of respiratory events during CPAP therapy was also explored.

2. Materials and methods

2.1. Patients

All PGs performed between October 2011 and February 2014 in consecutive children who were treated with noninvasive CPAP at home were analyzed. All sleep studies were performed in a dedicated NIV and sleep unit in a tertiary pediatric university hospital. Polygraphies were retained for analysis when: (1) patients were clinically stable (ie, with no infection, unscheduled medical visit or hospitalization in the previous month); and (2) patients were using CPAP for at least one month. The study was conducted in agreement with the French regulations and received appropriate legal and ethical approval from the Institutional Review Board of the French Society for Respiratory Medicine (Société de Pneumologie de Langue Française).

2.2. CPAP therapy

All patients received standard care for the treatable causes of their disease. Patients with persistent OSAS after surgical and/or medical treatment, or with non-treatable causes of OSAS, were eligible for CPAP. Criteria to initiate CPAP were chosen individually for every patient and were based on an apnea-hypopnea index (AHI) >10 events/h, and/or a pulse oximetry (SpO_2) <90% for >2% of sleep time and/or a $PtcCO_2$ >50 mmHg for >2% of sleep time.

Children and families were instructed about the CPAP device and the interface. The devices used were: VPAP IV and S9 series (ResMed™, North Ryde, NSW, Australia); Remstar Plus (Philips Respironics™, Murrysville, PA, USA); and ICON (Fisher & Paykel™, Auckland, New Zealand). Interfaces were chosen to obtain the best tolerance and comfort [16]. Therapy was started in the hospital by experienced staff during practical daytime sessions, and then adjusted during consecutive nights in order to achieve an at least 6 h/night use of CPAP, a normalization of nocturnal gas exchange (defined by a SpO_2 >90% and a maximal $PtcCO_2$ <50 mmHg during sleep with CPAP), and the disappearance of sleep disordered breathing-related symptoms. Routine CPAP titration with PG as well as a control PG with CPAP before discharge was not feasible. Patients were discharged after careful education was given to them and their parents. A home-care provider trained in pediatric CPAP/NIV performed a home visit on the day of discharge, after one week and then every 1–3 months.

A systematic overnight PG with CPAP was performed in the hospital 1 month after treatment initiation and then every 2–6 months, according to the child's age and underlying disease. When possible, objective adherence to treatment was downloaded from the built-in software of the device at every hospital and home-care provider visit [17].

2.3. Nocturnal ventilatory polygraphy

Polygraphy was performed using the SOMNOscreen device (SOMNOscreen™ plus PSG+, SOMNOmedics GmbH, Germany) or CID 102* (Cidelec, Angers, France). The recorded data included: airflow, using a pneumotachograph; airway pressure in the CPAP line; body position; body movements; thoracic and abdominal movements, assessed with piezoelectric belts for the SOMNOscreen (SleepSense, Multiple use Inductive Plethysmography Band, S.L.P. Ltd., Israel) or with inductance belts for the CID 102* (Cidelec, Saint Gemme sur Loire, France); SpO_2; and photoplethysmographic pulse-wave amplitude. The pneumotachograph was inserted between the interface and the circuit. Polygraphy analysis was started at sleep onset. Periods with artefacts were removed from analysis. A minimum of 4 h of recording during sleep with CPAP was required for inclusion in the present study.

An autonomic arousal was identified as a reduction in pulse-wave amplitude greater than 30% of the baseline amplitude [18,19]. Mean and minimal nocturnal SpO_2 as well as the percentage of nighttime spent with a SpO_2 <90% were recorded. An oxygen desaturation was defined as a fall in SpO_2 of at least 3% and the oxygen desaturation index was defined as the number of desaturations/h of PG recording. For the present study, nocturnal hypoxemia was defined as the presence of a SpO_2 ≤90% for at least 2% of nighttime PG recording [20], and the oxygen desaturation index was considered as abnormal when >1.4/h of PG recording [21].

2.4. Respiratory events

Respiratory events (see online supplement) were scored according to the consensus opinion definitions of the SomnoNIV Group [15]. In contrast to NIV [22], only five types of events were analyzed during CPAP: unintentional leaks, UAO without or with DVD, DVD, and mixed events (Table 1); the analysis of patient–ventilator asynchrony was not applicable for this spontaneous breathing mode. As no scoring algorithm for respiratory events during CPAP has been validated in children, the index of respiratory events was arbitrarily defined as the number of total respiratory events/h of PG recording. This index was then stratified into four categories of severity: <1.5 events/h (considered as a normal CPAP-PG); 1.5–4.9 events/h; 5–10 events/h; and >10 events/h, by extrapolation from the AHI [1].