International Journal of Pediatric Otorhinolaryngology 110 (2018) 53–56

Contents lists available at ScienceDirect

International Journal of Pediatric Otorhinolaryngology

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

The characteristics and clinical significance of REM < 10% in children with sleep-disordered breathing

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ARTICLE INFO

Keywords:
REM sleep deficit
Sleep-disordered breathing
Children

ABSTRACT

Objective: Fractional time in REM sleep < 20% ('little REM sleep') is indicative of more severe sleep-disordered breathing (SDB) in adults. We examined if other REM% is predictive of more severe SDB in children.
Methods: In this retrospective study of 616 pediatric SDB patients, age, sex ratio, BMI, sleep efficiency, awakening frequency, sleep latency, apnea-hypopnea index (AHI), obstructive apnea index (OAI), and lowest oxygen pulse saturation ($LSpO_2$) were compared among groups stratified according to REM%: REM ≥ 20%, REM < 20%, 15% ≤ REM < 20%, 10% ≤ REM < 15%, and REM < 10%. Correlations with AHI, OAI, $LSpO_2$, sleep efficiency, and awakening frequency were examined in REM < 20% and REM < 10% groups. Associations of these parameters with REM < 10% were examined by single- and multifactor regression.
Results: Pediatric SDB patients with little REM sleep demonstrated poorer sleep quality than patients with REM ≥ 20%, while patients with REM < 10% also exhibited more severe SDB. Specifically, the REM < 20% group exhibited higher number of awakenings and lower sleep efficiency than the REM ≥ 20% group (both P ≤ 0.001), as did each REM% < 20% subgroup (lower sleep efficiency: all P < 0.05; higher awakening frequency: all P < 0.001). Moreover, compared to the REM ≥ 20% group, the REM < 10% also exhibited higher AHI (P = 0.025) and lower $LSpO_2$ (P = 0.019). In the REM < 10% group, individual REM% was negatively correlated with AHI (r = −0.216, P = 0.031) and positively with $LSpO_2$ (r = 0.2, P = 0.046). Multifactor logistic regression correcting for age and BMI identified AHI as an independent predictor of REM < 10% (P = 0.012, OR = 1.016, 95% CI [1.004,1.029]).
Conclusion: REM% < 10% is associated with poor sleep quality and SDB severity in children, suggesting that this threshold should define "little REM sleep" in pediatric patients.

1. Introduction

Sleep-disordered breathing (SDB) is a spectrum of disorders ranging in severity from primary snoring, upper airway resistance syndrome, obstructive hypoventilation, and obstructive sleep apnea-hypopnea syndrome (OSAHS). OSAHS refers to the repeated occurrence of complete or incomplete obstruction in the upper airway [1], and the prevalence rate in children is 1%–3% [2]. The main causes of OSAHS include tonsillar hypertrophy and/or adenoid hypertrophy. Due to intermittent hypopnea and obstructive apnea, OSAHS in children often leads to delayed growth and development as well as abnormal behaviors [3]. A complete sleep architecture is required for normal neural development, and the high frequency of awakenings and apnea episodes in OSAHS children cause fragmentation of sleep, mainly manifested as an increase in light sleep (sleep phase I) and decreases in moderate (phase II), deep (slow wave), and rapid eye movement (REM) sleep [4]. REM sleep is characterized by accelerated heart rate, elevated blood pressure, muscular relaxation, and penile erection as well as rapid eye movements. REM sleep is vital for brain development, and the absolute value of REM sleep time is associated with cognitive development. People with an intellectual delay exhibit shorter REM sleep time, and deprivation of REM sleep leads to behavioral deviation, insomnia, and brain shrinkage, as well as abnormally high rates of neural cell death [5,6]. A recent study reported that little REM sleep (REM < 20%) in adult OSAHS patients was associated with more serious apnea-hypopnea index (AHI), obstructive apnea index (OAI), and nocturnal lowest oxygen pulse saturation ($LSpO_{2)}$ compared to patients with normal REM sleep (20% ≤ REM < 25%) or excessive REM sleep (REM ≥ 25%), while there were no differences in most sleep parameters between patients with normal or excessive REM sleep [7]. These results suggest that little REM sleep is predictive of OSAHS severity and so should be considered in diagnostic evaluation and the

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https://doi.org/10.1016/j.ijporl.2018.04.015
Received 23 February 2018; Received in revised form 13 April 2018; Accepted 14 April 2018
Available online 18 April 2018
0165-5876/

development of better therapeutic regimens.

Pediatric sleep architecture differs markedly from adult sleep architecture, so it is uncertain whether the little REM sleep observed in severe adult OSAHS patients is also present in pediatric SDB patients. In the current investigation, we compared clinical features of SDB among pediatric patients with different levels of REM% to seek out a more special REM% so that clinicians could pay attention to the pediatric SDB patients with the REM%, because the kind of patients are easier to appear complications.

2. Materials and methods

2.1. Subjects

This is a retrospective study. 616 pediatric SDB patients (3–15 years old) who visited our hospital from February 2013 to November 2016 with chief complaints of snoring and/or mouth breathing during sleep were brought into. Inclusion criteria was that the subjects aged 3–15 with AHI > 1 were selected. Detail medical, pregnancy, and family histories were obtained. Exclusion criteria were other diseases that may impact REM sleep, such as acute sinusitis, allergic rhinitis, neuromuscular disorders, narcolepsy, recurrence after tonsil and/or adenoid operation, continuous positive airway pressure (CPAP) treatment, total PSG monitoring time of less than 7 h, upper respiratory tract infection within 2 weeks before the PSG examination, and ingestion of sleeping pills, tea, or coffee within 24 h before the examination.

2.2. Research methods

2.2.1. Grouping

Based on PSG results (detailed below), patients were first divided into two groups according to the proportion of total sleep in REM phase (REM%): REM < 20% and REM ≥ 20%. Based on the analysis of above results, the REM < 20% group was further divided into REM < 10%, 10% ≤ REM < 15%, and 15% ≤ REM < 20% groups. OSAHS-related parameters were compared among groups.

2.2.2. PSG monitoring

All enrolled children were monitored using the USA Polysmith 36-lead sleep system (4.0 version) for ≥7 h in total. Electroencephalogram (EEG), electromyogram (EMG), eye movement, oro-nasal flow (pressure transducer and thermistor were used), thoracic and abdominal respiratory movements, electrocardiogram (ECG), and SaO_2 were monitored continuously and then analyzed off-line. The sleep parameters monitored were based on American Association of Sleep Medicine (AASM) accreditation (2014) [8]. An obstructive apnea even was defined as either (i) a reduction in airflow signal peak value ≥ 90% of baseline for ≥ 2 breath cycles with respiratory effort and hypopnea or (ii) a reduction in airflow amplitude ≥ 30% from baseline for ≥ 2 breath cycles and saturation oxygen decrease of ≥3% from pre-event baseline and (or) arousal. Apnea-hypopnea index (AHI) was defined as the number of apnea and hypopnea events per hour of sleep and obstructive apnea index (OAI) as the total number of obstructive apnea events per hour of sleep. Lowest oxygen pulse saturation ($LSpO_2$) was defined as the lowest oxygen pulse saturation during sleep. Sleep efficiency was defined as total sleep time divided by total recording time. Awakening was defined as a single epoch of wake. Sleep latency was defined as lights out to first epoch of any sleep in min. The diagnosis of SDB was defined as AHI at least one per hour during sleep [9]. All the data were analyzed by two physicians simultaneously.

2.2.3. Statistical methods

All continuous data sets were first tested for normality using the Kolmogorov-Smirnov test. As all were non-normally distributed, group values are expressed by median (interquartile range). Groups in Table 1 are compared by Wilcoxon rank sums test. For Table 2, within-group changes were tested for significance using the nonparametric signed rank test between-group differences.

In these changes were tested using the Wilcoxon rank sums test. Sex ratios were compared by chi-square test. Associations between variables were examined by Spearman correlation analysis. Single- and multifactor logistic regression analyses were conducted to identify factors influencing the probability of REM < 10%. P < 0.05 is defined as significant. SPSS13.0 software was used for all statistical calculations.

Table 1
Comparison of demographic and OSAHS-related clinical parameters between REM < 20% and REM ≥ 20% groups.

Parameter	REM < 20% (n = 471)	REM ≥ 20% (n = 145)	P-value[a]
Age (Y)	5 (4,7)	5 (4,6)	0.637
Male: female	372:99	119:26	0.419
BMI (kg/m^2)	15.44 (14.24, 17.64)	15.42 (14.13, 16.67)	0.383
Sleep efficiency (%)	91.3 (81.3, 96.4)	94 (86, 98)	0.001
Number of awakenings	2 (1, 3)	1 (0, 2)	< 0.001
Sleep latency (min)	5.5 (0, 20.5)	6.5 (0, 24.5)	0.761
AHI (times/h)	4.2 (1.9, 10.7)	3.3 (1.7, 8.3)	0.077
OAI (times/h)	1.0 (0.4, 2.1)	0.7 (0.4, 1.5)	0.069
$LSpO_2$ (%)	88 (84, 91)	90 (85, 92)	0.057

[a] Wilcoxon rank sums test, 2-sided, using normal approximation.

3. Results

A total of 616 pediatric SDB patients (3–15 years old, 491 males, 79.7%) were examined by PSG and stratified into REM < 20% group and REM ≥ 20% group. While there were no differences in age, sex ratio, and BMI between groups (Table 1), the REM < 20% group exhibited poorer sleep quality as evidenced by a higher awakening frequency (P < 0.001) and lower sleep efficiency (P = 0.001) compared to the REM ≥ 20% group. These differences remained significant for all three low REM% subgroups (REM < 10% group: P = 0.009 and P < 0.001; 10% ≤ REM < 15% group: P = 0.022; P < 0.001; 15% ≤ REM < 20% group: P < 0.001 for both sleep efficiency and awakening frequency), despite no significant differences in age, sex ratio, or BMI.

In addition to more fragmented sleep, children with REM < 10% group also exhibited more severe SDB than the REM ≥ 20% group as evidence by higher AHI (P = 0.025) and lower $LSpO_2$ (P = 0.019) (Table 2).

Furthermore, individual REM% in the REM < 10% group was negatively correlated with AHI (r = −0.216, P = 0.031) and positively correlated with $LSpO_2$ (r = 0.2, p = 0.046), but not significantly correlated with OAI, sleep efficiency, or number of awakenings. Individual REM% in the REM < 20% group was not correlated with OAI, sleep efficiency, number of awakenings, AHI, or $LSpO_2$ (Table 3).

Single-factor logistic regression analysis indicated a significant association of AHI with REM < 10% (P = 0.014) but not with any other demographic or SDB-related parameter (Table 4). This association with REM < 10% remained significant in multivariant logistic regression analysis correcting for confounding factors (including age and BMI) (P = 0.012). Thus, high AHI is a risk factor for the occurrence of REM < 10% (OR = 1.016, 95%CI [1.004, 1.029]) (Table 5).

4. Discussion

Sleep architecture in children differs in several respects from that in adults. For instance, the REM stage normally accounts for 20%–25% of the total sleep time in adults but only 17%–21% in children (1–18 years) [10]. In this study, 76.5% of children with SDB exhibited REM < 20%. Although the REM < 20% group had a lower sleep