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POLYSOMNOGRAPHIC FINDINGS ON FAR-EAST ASIAN CHILD PATIENTS WITH SLEEP DISORDERED BREATHING

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Summary

Many issues on sleep disordered breathing (SDB) in children remain to be elucidated. This study summarized polysomnographic data on far-east Asian child patients with suspected SDB. We analyzed labor breathing index (LBI), the desaturation time (DT), SaO_2 nadir, and obstructive apnea index (OAI) on a single night polysomnography.

Eighty-four initial recordings obtained in 84 children (mean age, 64.3 months; rang, 5-196) before adenotonsillectomy were divided into two groups according to their age at 40 months; the younger (n=17) and older (n=67) groups. OAI in the older group showed moderately elevated coefficients of correlation in absolute values with DT, SaO_2 nadir, and LBIs. In contrast, OAI in the younger group showed high absolute values of correlation coefficients with SaO_2 nadir, and LBIs, and revealed a very low correlation coefficient with DT. SaO_2 nadir was often recorded during REMS, and a median OAI value was higher during rapid eye movement sleep (REMS) than during non-REMS. In eight pairs of records obtained before and after the adenotonsillectomy, not all parameters were changed into better values, although clinical improvement was obvious in all patients after the surgery.

Forty months of age is a key age to consider the pathophysiology of SDB in children. SDB in children is a REMS-related disease. We have to pay more attention to SDB in children and have to treat them in order to secure their healthy lives in future.

Key Words: Sleep disordered breathing, Children, Rapid eye movement sleep, Labor breathing index

Introduction

Obstructive sleep apnea is a common problem among middle aged obese snores, and is probably serious when severe (He et al. 1988). In adults, the close association among diabetes, hypertension, obesity, and sleep apnea has been well-known, and this association is considered to be involved in fatal cardiovascular risk factors (Wilcox et al. 1998). Sleep disordered breathing (SDB) including obstructive sleep apnea also occurs with a high prevalence rate of 1 to 3% in children (Ali et al. 1993; Gislason and Benediktsdottir 1995; Lofstrand-Tidestrom et al. 1999). Although severe sequelae of childhood SDB such as failure to thrive, cor pulmonale, and mental retardation (Brouillette et al. 1982) are less common now, neurocognitive deficits, systemic hypertension, and an affection on endocrine systems have been reported (Marcus 2001). At the present time, as with adults, the gold standard for diagnosing childhood obstructive sleep apnea is polysomnography. However, because of the shortage of pediatric sleep centers, especially in far-east Asia, many issues on SDB in children remain to be elucidated. For example, it is not clear whether obstructive sleep apnea in children is the same condition as in adults, or whether these are two distinct disease. Although the role of obesity in SDB occurrence is now known to be different among races (Li et al. 2000), no data has been available on polysomnographic differences among races in child SDB patients. It must be surprising that one of the most basic issues - what degree of polysomnographic abnormalities requires treatment - has still been inconclusive for SDB children (Marcus 2001). The current study summarized polysomnographic data on far-east Asian child patients with suspected SDB.

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Methods

Patients referred to the Pediatric Clinic at Tokyo Medical and Dental University for evaluation of SDB between August in 1998 to February in 2001 were recruited sequentially to this study. Each patient underwent at least one all-night polysomnographic recording. Informed consent was obtained from the guardians of each patient, and consent was obtained from the child if older than 5 years of age.

All recordings were performed in an isolated semi-soundproof recording room with an air conditioner (temperature range, 22-24°C). No sedation or sleep deprivation was used for sleep studies. Children were accompanied by a guardian throughout the night. Each polysomno-graphic session included an electroencephalograph, electrooculograph, electromyography of the chin and trunk muscles, oxygen saturation (SaO_2) monitoring (Ohmeda Biox 3740; averaging time, 6 sec), respiratory monitoring through respiratory inductive plethysmography (RIP), and video monitoring (Kohyama et al. 2001). Oxygen desaturation measurements obtained when the averaging time was set to 6 sec on this equipment was found to show no significant difference from that obtained with the control oximeter (Farre et al. 1998). Neither the end-tidal nor transcutaneous level of carbon dioxide was measured. Sleep stages were determined according to the standard criteria (Rechtschaffen and Kales 1968; Anders et al. 1971; Guilleminault and Souquet 1979).

A 5-minute qualitative diagnostic calibration (QDC) was performed before each RIP recording. One episode of apnea was defined as 10 seconds or more of respiratory suppression that did not exceed 25% of the baseline tidal volume measured during QDC (Krieger 1989). According to the movements of the chest and abdominal portions during the respiratory suppression, a pause on RIP was determined as obstructive or central (Krieger 1989).

We calculated the average labored breathing index (LBI) every 5 minutes. LBI is a global measurement of chest wall motion that reflects both the phasic relationship of ribcage and abdomen movement, and the volume displacement due to that movement. LBI is the sum of the integrals of the absolute values of the derivatives of the inspiratory limbs of the rib cage and abdomen divided by the corresponding integral of the derivative of the inspiratory limb of the tidal volume (Warren et al. 1997). LBI equals 1.0 when the chest and abdominal motions are in perfect synchrony. Any desynchrony between their motions will increase LBI. The QDC performed before each RIP recording allowed determination of the absolute tidal volume value by RIP (Krieger 1989; Chadha et al. 1982; Sackner et al. 1989). After QDC, LBI has been reported to be stable regardless of a change in body position (Chadha et al. 1982; Krieger 1989; Sackner et al. 1989; Warren et al. 1994). The QDC was assessed by means of the quality control factor (Sackner 1986). We calculated the average whole night LBI value during rapid eye movement sleep (REMS) (LBI-R) and non-REMS (LBI-NR), respectively. Five-minute periods during which changes in the sleep stage (REMS and non-REMS) or massive body movements occurred were excluded from the calculation.

In addition to LBIs, the desaturation time [DT; the percentage of the time with SaO_2 <90% against the total sleep time], minimum SaO_2 level (SaO_2 nadir), and obstructive apnea index (OAI; incidence of obstructive apnea per one 1 hour) were calculated. The body mass index (BMI) was defined as the weight (kilograms) divided by the square of the height (meters).

Results

Study population

A total of 104 recordings were obtained. Seven recordings were insufficient for evaluation, and then the other 97 recordings were analyzed. Sleep studies were performed twice in 11 children, and once for 75 children. Among 11 children who had two sleep recordings, 8 had each sleep study before and after adenotonsillectomy, 2* had both recordings before the surgery, and one underwent each sleep study after the surgery. Among 75 children who had a single sleep study, one child had her recording after the surgery. Thus, we had 86 (= (75-1) + 8 + (2*x2)) sleep recordings that were conducted before adenotonsillectomy. However, two of them were follow-up recordings obtained from the same children*. Then we analyzed the 84 initial sleep recordings obtained in 84 children. Also, we compared eight pairs of records obtained before and after adenotonsillectomy. All patients were healthy other than SDB secondary to adenotonsillar hypertrophy.

Eighty-four initial sleep records

Mean age of these 84 children was 64.3±35.6 months, ranging from 5 to 196.

In children who showed no desaturation of less than 90% and had no obstructive apnea of 10 seconds or more, LBI-NR was found to reveal no change with age, while LBI-R decreased significantly with age, reaching an adult level (1.11) at 39.6 months of age (Kohyama et al. 2001). Then, we divided our 84 patients into two groups; the younger group of aged less than 40 months (n=17), and the older group of aged 40 months or more (n=67). In both groups, we calculated the coefficients of correlation among obtained parameters.

Coefficients of correlation among obtained parameters (Table 1)

Table 1. Correlation coefficients among obtained parameters.

	AGE(MONTH)	BMI	OAI	DT	SAO_2 NADIR	LBI-R	LBI-NR
	Correlation coefficients in the older group (n=67)						
Age	-	0.36	-0.12	-0.14	0.15	-0.11	-0.22
BMI	-0.26	-	-0.06	0.28	-0.18	-0.09	-0.24
OAI	0.48	-0.20	-	0.27	-0.41	0.21	0.26
DT	0.56	-0.37	0.08	-	-0.79	0.36	0.31
SaO_2 nadir	-0.45	0.30	-0.62	-0.51	-	-0.32	-0.35
LBI-R	0.44	-0.30	0.63	0.39	-0.66	-	0.84
LBI-NR	0.56	-0.24	0.66	0.42	-0.69	0.92	-
	Correlation coefficients in the younger group (n=17)						

In both groups, the absolute values of the coefficient of correlation between DT and minimum SaO_2 level as well as LBI-R and LBI-NR exceeded 0.5.

In the older group, the correlation coefficients of age and BMI showed low absolute values (less than 0.30) with LBIs, DT, SaO_2 nadir, and OAI, respectively. OAI showed relatively low coefficients of correlation (between 0.2 and 0.5 in absolute values) with DT, SaO_2 nadir, and LBIs. Similarly, between LBIs and DT or SaO_2 nadir, coefficients of correlation did not exceed 0.5 in absolute values.

In the younger group, however, the absolute values of the correlation coefficients of age and BMI showed higher values with LBIs, DT, SaO_2 nadir, and OAI than in the older group (0.20-0.56). Especially, the correlation coefficients of age and DT as well as of age and LBI-R exceeded 0.50, respectively. In contrast to the older group, OAI in the younger group showed high coefficients of correlation with SaO_2 nadir (-0.62), and LBIs (LBI-R;0.66; LBI-NR; 0.63), while had a very low correlation coefficient (0.08) with DT.

Sleep stages and parameters

SaO_2 nadir was often recorded during REMS. In the younger group, only one among 17 records experienced his minimum SaO_2 value only during NREMS. Three records revealed their SaO_2 nadir both during REMS and non-REMS. In the older group, fifteen records experienced their minimum SaO_2 value only during non-REMS. Four records had their SaO_2 nadir both during REMS and non-REMS.

A median OAI was 7.1 (range, 0-82.0) during REMS and 2.7 (0-31.6) during non-REMS in the older group (t test; p=0.002), and was 2.7 (0-49.1) and 1.2 (0-15.3) in the younger group (p=0.09), respectively.

Eight pairs of records before and after the surgery

We obtained only eight pairs of polysomnographic records before and after the adenotonnsillectomy (Table 2). All of these patients showed clinical improvements. However, not all parameters related with SDB were changed into better values.

Discussion

We divided our patients into two groups according to our previous study at age 40 months. Surprisingly, in the younger group, age showed high correlation coefficients with DT and LBI-R. Furthermore, in contrast to the older group, OAI in the younger group showed high coefficients of correlation with SaO_2 nadir, and LBIs, while OAI had a very low correlation coefficient with DT. We have to be cautious to generalize this finding because of the small sample size in our study. Suffice it to say that the age of 40 months is likely to be a key age to consider the pathophysiology of SDB in children. According to Marcus (2001), many children, particularly those younger than 3 years of age, have a pattern of persistent, partial upper airway obstruction associated with hypercapnia and/or hypoxemia, rather than cyclic discrete obstructive apneas.

Goh et al. (2000) showed a median apnea index of 56/h in REMS versus 9/h in non-REMS (n=20; age, 2-12 years). This finding has been known to indicate that obstructive sleep apnea syndrome in children is very much a REMS-related disease. Similarly, we had higher OAI values in REMS than in non-REMS in both groups, although no statistically significant difference was obtained in the younger group. In addition, most records had SaO_2 nadir during REMS. For evaluating child patients with SDB, we have to be careful not to miss recordings during REMS.

Table 2. Polysomnographic data before and after adenoronsillectomy.

GENDER	AGE (MONTH)		OAI		DT		SAO_2 NADIR		LBI-R	
	before	after	before	after	before	after	before	after	before	after
M	42	49	4.7	1.6	0.5	0.0	79	92	2.14	1.04
M	43	53	3.0	0.4	1.1	0.1	78	82	2.30	1.03
F	52	57	6.3	0.1	11.9	0.0	59	90	2.78	1.12
F	55	56	5.6	0.1	66.8	10.3	29	75	∞	1.69
F	56	61	3.0	4.4	0.6	0.4	74	89	1.57	1.73
M	63	68	1.0	1.2	23.1	0.1	79	86	1.72	2.00
F	80	86	3.9	0.0	0.1	0.4	89	87	1.28	1.04
M	123	128	19.2	0.4	10.8	0.0	79	92	1.11	1.04

It is very difficult to select child SDB patients who need adenotonsillectomy, since it is not known what level of abnormality in polysomnographic data is clinically significant. In our institution, the criteria proposed for adults in Japan (DT, 1.0% or more; SaO_2 nadir, less than 85%) (Ohta 1995) are used to select clinically significant patients. In normal children, the frequency of obstructive apneas of any length is considered to be less than one per hour (Marcus et al. 1992). Taken this finding into consideration, we took OAI (an incidence of obstructive apnea per one 1 hour) of or more as an additional criterion to evaluate clinical significance of child patients. In general, if these 3 parameters exceed (DT and OAI) or lower (SaO_2 nadir) cutoff values, we recommend patients to take adenotonsillectomy. However, these parameters do not always reflect clinical significance. Indeed, among eight presented patients (Table 2) whose data obtained before and after adenotonsillectomy, two patients met the two criteria, and another one patient fulfilled only one criterion for OAI (3.9) (DT =0.1, SaO_2 nadir =89).

The current study revealed that each of the coefficients of correlation among OAI, SaO_2, and LBIs did not exceed 0.5 in absolute values in the older group. Then, we interpreted that OAI, SaO_2, and LBIs reflected different aspects of SDB in children. In adults, an apnea index is the parameter used most often to characterized SDB. However, children often desaturate with short apneas, as they have a lower functional residual capacity and a faster respiratory rate than adults (Marcus 2001). Not only OAI but also SaO_2, and LBIs are all necessary for evaluating children with SDB. It should also be mentioned that these parameters were independent of age and BMI in the older group. Taken LBI-R (cutoff value: 1.11) into consideration, all eight patients in Table 2 fulfilled at least two of four criteria. In SDB patients of more than 3 years of age, we propose a necessity to pay more attention to a new parameter -LBI-R- in addition to classic parameters (DT, SaO_2 nadir, and OAI) (Kohyama et al 2001). We hope this proposal to contribute to elucidating a fundamental question what degree of polysomnographic as well as clinical abnormalities requires treatment.

We preliminarily obtained an observation that blood pressure and glycated haemoglobin showed higher values in severe child SDB patients than in mild patients, although even the severe patients were essentially healthy other than for SDB. In addition, these patients were all non obese. The close association among diabetes, hypertension, and sleep apnea (Wilcox et al. 1998) might also be present in children. Child patients with SDB might suffer from elevated blood pressure and impaired glucose control for years even before severe complications (respiratory failure, heart failure, or coma) arise if they do not receive treatment for SDB. We have to pay more attention to SDB in children in order to secure their healthy lives in future.

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