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FOLLOW-UP FOR PATIENTS WITH OBSTRUCTIVE SLEEP APNEA SYNDROME USING A PORTABLE RECORDING DEVICE

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ABSTRACT

A home screening device, LT-200, can record data on both breathing conditions and body positions during sleep for up to 3 consecutive days in patients with obstructive sleep apnea (OSAS). We investigated the usefulness of the LT-200 device for follow-up of OSAS.

Eighteen patients (age 51.0±10.8 years, mean±SD) were enrolled in this study. Standard polysomnography (PSG) was performed on all patients. The number of apnea/hypopnea episodes per hour (apnea/hypopnea index: AHI), the total time that nocturnal oxygen saturation was <90% (oxygen desaturation time: ODT), and the minimum oxygen saturation during sleep (lowest Spo_2) were calculated. We used the LT-200 and PSG to evaluate any improvement in the data obtained after auto-continuous positive airway pressure (auto-CPAP) therapy. AHI was also measured using the LT-200 in three sleep positions to evaluate the efficacy of the lateral position.

AHI, ODT, and lowest Spo_2 values did not differ significantly between the PSG and LT-200 recordings on the control and therapy nights. The LT-200 recordings showed that AHI, ODT, and lowest Spo_2 tended to be better on the second night of auto-CPAP therapy than on the first. AHI was significantly lower in the right and left lateral sleep positions than that in the supine position.

Our findings suggest that since the LT-200 device provides important information about the severity of OSAS, the efficacy of auto-CPAP therapy, and body position under unattended conditions in the home. It may prove to be a useful tool for following up patients.

Key Words: Obstructive sleep apnea, Body position, Continuous positive airway pressure, Portable monitoring, Polysomnography

INTRODUCTION

Obstructive sleep apnea syndrome (OSAS) is characterized by repeated episodes of apnea or hypopnea accompanied with arterial oxygen desaturation and arousal during sleep.[1)] OSAS results in excessive daytime sleepiness, which not only can impair the quality of life but also cause serious accidents at work and in the home.[2,3)] Continuous positive airway pressure (CPAP) therapy

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has been accepted as the primary method of treating OSAS. Successful CPAP therapy dramatically reduces excessive daytime sleepiness, thereby improving the quality of life in patients with OSAS.[4,5] However, the rate of compliance with CPAP therapy is reported to be approximately 60–80%, and may be limited by complications such as mouth dryness, nasal obstruction, and air leaking from the nasal mask.[6,7] The compliance of CPAP therapy and outcomes can be improved by a conscientious close follow-up.[8]

Diagnostic assessments of OSAS have been based on standard polysomnography (PSG) during an overnight stay in a hospital,[9] and hence are time consuming and labor intensive. The long waiting time for undergoing PSG contributes to the incidence of undiagnosed and untreated OSAS. Although several more practical and less time- consuming devices have been validated in the home under unattended conditions and have been accepted for OSAS screening, they have exhibited limited only efficacy in diagnosing OSAS.[10,11] However, the usefulness of the LT-200 device as a follow-up tool for therapy is unknown.

Accordingly, we examined the device, that can record data for up to 3 consecutive days, for evaluating OSAS severity and for follow-up of therapy for OSAS patients an unattended in the home.

METHODS

Patients

We studied 18 male OSAS patients who were consecutively diagnosed by PSG (age 51.0±10.8 years, mean±SD; body mass index 25.1±3.7 kg/m^2). Fifteen of the 18 underwent auto-CPAP therapy (Virtuoso LX, Respironics, Murrysville, PA, USA) while the other 3 slept in the lateral position. All patients were screened at home with the LT-200 (Fukudadenshi, Tokyo, Japan) for 2 nights: a control night and a therapy night after being diagnosed by PSG as OSAS. Two examinations were performed within 1 week. Three months after initiating therapy, the patients underwent home screening with the LT-200 for 3 consecutive nights: control night (natural sleep), and a first and second night of auto-CPAP therapy. This study was approved by the Ethics Committee of Nagoya University. All subjects provided written informed consent prior to the study after being informed of objectives and the conditions of the experiment.

Polysomnography

Standard PSG (ALICE3, Respironics, Murrysville, PA, USA) with pulse oximetry was performed on all patients from 9:00 p.m. to 6:00 a.m. Electroencephalograms (C3-A2, C4-A1, O1-A2, and O2-A1), electrooculograms, electromyograms (mentalis, legs, and intercostale), and electrocardiograms (bipolar CM5 and standard V5 lead positions) were recorded, and respiration was monitored with an oronasal thermistor and a thoracoabdominal piezo sensor on PSG. Sleep stage was scored according to the criteria of Rechtshaffen and Kales by visual analysis,[12] and the percentages of stage 1, stage 2, stage 3+4, and REM (rapid eye movement) sleep were calculated. Apnea was defined as the cessation of airflow through the mouth and nose for more than 10 s, and hypopnea as a reduction in airflow associated with either an oxygen desaturation of more than 3% or arousal from sleep, also for more than 10 s.[9] The number of apnea/hypopnea episodes per hour (apnea/hypopnea index: AHI), the total time that nocturnal oxygen saturation was less than 90% (oxygen desaturation time: ODT), and the minimum oxygen saturation during sleep (Spo_2) were also calculated. The patients with an AHI of ≥5/h were diagnosed as OSAS, and those with an AHI of >20/h were given CPAP therapy in this study.[9]

Home screening test

Patients in the present study were not receiving auto-CPAP therapy or other treatments prior to the home screening, which was performed on 3 consecutive nights: the first night during natural sleep (control night), and the second and third nights during therapy (the first and second therapy nights, respectively). The starting time and duration of recording were set by a technician at the hospital, and patients were sufficiently trained in the use of sensors by knowledgeable technicians. The following parameters were monitored using the LT-200[13] during sleep: oronasal airflow (using a thermistor), thoracoabdominal movement (detected by an air-bag pressure sensor), oxygen saturation (by pulse oximetry), snoring, and body position. AHI, lowest Spo_2, and ODT as determined by pulse oximetry were measured. We investigated the relations between the severity of OSAS obtained by PSG and that obtained using the LT-200, and any improvement in OSAS severity by treatment. Furthermore, AHI at each body position obtained using the LT-200 was calculated to evaluate the efficacy of the lateral sleep position.

Statistical analysis

Paired *t*-tests were used to compare AHI, ODT and lowest Spo_2 obtained using PSG between the control and therapy nights, and to compare AHI, ODT, and lowest Spo_2 between PSG and LT-200 recordings. We used two-way analysis of variance (ANOVA) with Scheffe's test to compare AHI and ODT data obtained using the LT-200 between the control night and the 2 nights of auto-CPAP therapy. In addition, ANOVA was used to compare AHI recordings obtained using the LT-200 among sleep positions. AHI, ODT, and lowest Spo_2 values obtained by PSG and the LT-200 were compared using Pearson correlation analysis and the method described by Bland and Altman[14]; for each recordings we calculated the mean of the difference [bias, (AHI on PSG – AHI on LT-200)/n and (lowest Spo_2 on PSG – lowest Spo_2 on LT-200)/n] and SD of the differences [precision (n-1), SD of (AHI on PSG – AHI on LT-200) and SD of (lowest Spo_2 on PSG – lowest Spo_2 on LT-200)] between PSG and LT-200 in AHI and lowest Spo_2. A probability value of $p<0.05$ was considered statistically significant.

RESULTS

AHI, ODT, and lowest Spo_2 did not differ significantly between PSG and the LT-200 on the control and therapy nights (Table 1). The AHI and lowest Spo_2 obtained by LT-200 significantly correlated with those obtained by PSG (AHI: r=0.94, p<0.0001, lowest Spo_2: r=0.69, p<0.005) (Fig. 1b & d). The mean difference between the AHI values obtained by PSG and the LT-200 was 4.3/h, and ranged from –4.4/h to 13.1/h (Fig. 1a). The mean difference between the lowest Spo_2 values obtained by PSG and the LT-200 was –0.7%, and ranged from –9.1% to 7.6% (Fig. 1c). Both mean differences on AHI and lowest Spo_2 were small, and the SD of the difference was narrow. The correlation coefficient analysis and Bland and Altman plots of AHI and lowest Spo_2 between PSG and LT-200 indicated good concordance.

In patients undergoing auto-CPAP therapy (n=15), the LT-200 gave a significantly lower AHI on the first and second nights of auto-CPAP therapy than on the control night (control night: 29.5±20.9/h; vs the first and second therapy nights: 11.8±11.2/h and 3.3±3.7/h, respectively; $p<0.05$) (Table 2). ODT with the LT-200 was significantly lower on the second night of therapy night than on the control night (43.7±62.1 min vs 4.2±10.2 min, $p<0.05$) (Table 2). Although there were no significant differences in lowest Spo_2 as measured with the LT-200 among the control night and the first and second therapy nights, it tended to improve on therapy nights compared with the control night (Table 2). AHI and ODT tended to be lower on the second

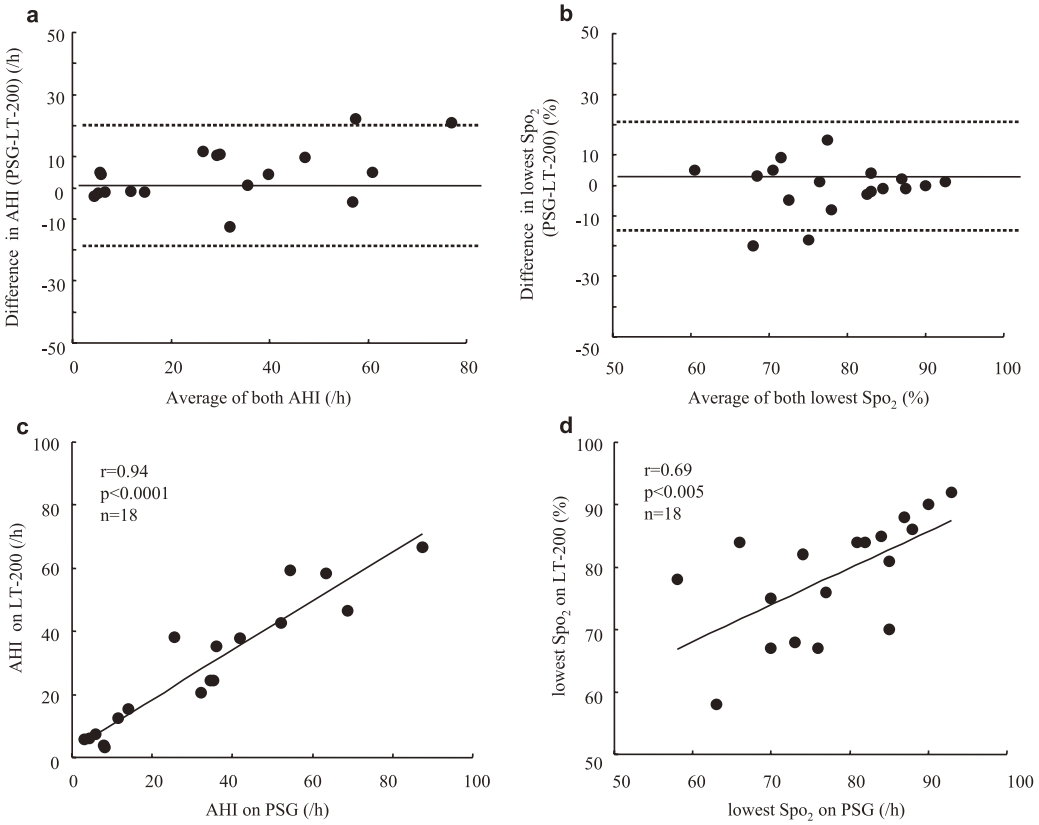

Fig. 1 Comparison of AHI and lowest Spo2 between PSG and LT-200. (a, b) Graphic representation of PSG versus LT-200 relationship for AHI (a) and lowest Spo_2 (b). Each data point plotted PSG – LT-200 differences against arithmetic mean of the two measurements. Bold lines represent mean differences between PSG and LT-200 and dashed lines represent 95% confidence interval (bias±2SD). (a) The mean difference between AHI obtained by PSG and LT-200 was 4.3/h, and ranged from –4.4/h to 13.1/h. (b) The mean difference between lowest Spo_2 obtained by PSG and LT-200 was –0.7%, and ranged from –9.1% to 7.6%. (c, d) Graphic representation of Pearson correlation between PSG and LT-200 for AHI (c) and lowest Spo_2 (d). Solid lines represent regression lines for all data points. AHI: number of apnea/hypopnea episodes per hour (apnea/hypopnea index), lowest Spo_2: lowest oxygen desaturation, PSG polysomnography.

Table 1 Comparison of results between polysomnography (PSG) and LT-200.

n=18	Natural sleep			Therapy night		
	PSG	LT-200	*p* value	PSG	LT-200	*p* value
AHI (/h)	33.0±25.7	28.1±20.6	ns	8.4±7.6	9.5±8.0	ns
ODT (min)	50.1±95.6	40.5±56.9	ns	6.5±14.8	7.5±14.8	ns
lowest Spo_2 (%)	77.4±9.9	78.6±9.3	ns	86.5±9.9	84.3±8.8	ns

AHI, number of apnea/hypopnea episodes per hour (apnea/hypopnea index); ODT, the total time of 90% oxygen desaturation (oxygen desaturation time); Spo_2, oxygen saturation during sleep; ns, not significant. Paired *t*-tests compared to PSG.

Table 2 Comparison of sleep disordered breathing indices among control night and first and second treatment nights as measured with LT-200.

n=15	AHI (/h)	ODT (min)	lowest Spo_2 (%)
Natural sleep	29.5±20.9	43.7±62.1	78.2±9.8
Auto-CPAP therapy night			
first night	11.8±11.2*	16.1±23.4	81.1±9.6
second night	3.3±3.7*	4.2±10.2*	86.0±8.1

CPAP, continuous positive airway pressure.
*: $p<0.05$. Analysis of variance with repeated measures compared to control night.

Table 3 Comparison of AHI among the supine, right, and left lateral positions as measured with LT-200.

n=18	AHI (/h)
Supine position	34.2±15.0
Right lateral position	5.7±7.6*
Left lateral position	9.8±9.4*

*: $p<0.05$. Analysis of variance with repeated measures compared to supine position.

night of therapy than on the first.

AHI was lower in the lateral sleep position than in the supine position (right lateral position: 5.7±7.6/h, left lateral position: 9.8±9.4/h; vs supine position: 34.2±15.0/h, $p<0.05$) (Table 3).

DISCUSSION

AHI, ODT, and lowest Spo_2 values did not differ significantly between PSG and the LT-200 on the control and therapy nights. AHI, ODT, and lowest Spo_2 recorded with the LT-200 tended to improve on the second night of therapy compared with the first night. AHI and lowest Spo_2 values obtained using the LT-200 showed a high level of agreement with those obtained by PSG. AHI values were significantly lower in the right and left lateral sleep positions than that in the supine position. Our findings suggest that the LT-200 can be used to assess the severity of OSAS as well as the efficacy of auto-CPAP therapy or body position.

In patients suspected of having sleep breathing disorders, previous studies have focused on the screening method instead of the full PSG in sleep laboratories.[10,11] The utility of home sleep recording for the follow-up of CPAP therapy has not yet been systematically studied. Sleep apnea recurs soon after the cessation of CPAP in many patients, indicating that CPAP does not provide a cure. Among those patients who can be successfully weaned from CPAP, the most likely reason is weight loss.[15] Accordingly, it is important to reevaluate OSAS severity and the efficacy of CPAP therapy during the follow-up. However, recording and analyzing PSG data involve considerable time and expense, which limits the application of PSG. In this study, we found that the LT-200 could be used to appraise the severity of OSAS and also the efficacy of auto-CPAP therapy, and hence may prove clinically useful for both home screening and the reassessment of OSAS severity during follow-up of CPAP therapy.

Body position shifting during sleep is recognized as a simple treatment for OSAS,[16,17] especially for nonobese sleep apnea patients.[16] Additionally, body position shifting is effective for patients with a narrow site or those with mild upper-airway obstruction.[16] Body shifting during sleep is an alternative treatment for patients who cannot tolerate CPAP. This study showed that AHI was significantly lower in the right and left lateral positions than in the supine position. We therefore suggest that evaluating the body position during sleep is important even after the initiation of treatment in patients with OSAS.

The LT-200 has been recognized as a useful tool in the diagnosis of OSAS.[13] In this study, we did not simultaneously perform PSG and screening using the LT-200 on either the night of the diagnosis or on the follow-up night, since this would have affected the quality of sleep and the severity of OSAS due to the large number of attached electrodes.

Portable monitoring cannot provide information on total sleep time and sleep structure, which results in an underestimation of AHI.[18] Furthermore, it is impossible to simultaneously evaluate the use of auto-CPAP and respiratory events obtained by LT-200.

In summary, we found that the LT-200 provides reliable and important information about the severity of OSAS as well as the efficacy of auto-CPAP therapy or body position during unattended conditions in the home. The LT-200 may be of practical use for home screening and for monitoring variations in OSAS severity during follow-up of CPAP therapy in OSAS patients.

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