# Home Monitoring Using Portable Polygraphy for Perioperative Assessment of Pediatric Obstructive Sleep Apnea Syndrome

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(Received June 18, 2012; Accepted July 3, 2012)

**Objective: To overcome very few facilities available for polysomnography, a portable device of polygraphy was introduced into home monitoring for the assessment of obstructive sleep apnea syndrome (OSAS) in children.**
**Methods: Forty-eight children (aged 2–11) presenting with snoring and sleep apnea were subjected to home monitoring. Sleeptester™ (Fukuda Lifetech, Japan) was used for this purpose, which was equipped with 5 channels for oronasal airflow, thoracoabdominal effort, snoring, body position, and oximetry ($SpO_2$). Sensors were placed by guardians, and they were requested to attend their children as long as possible during a night. Results were analyzed manually by sleep technologists. Adenotonsillectomy was performed in all 48 children, and the same monitoring was utilized postoperatively.**
**Results: The mean duration of monitoring was 460 ± 172 min. (Mean ± S.D.) in the preoperative test and 471 ± 126 min. in the postoperative test. The mean apnea-hypopnea index (AHI) was 20.6 ± 16.6 and 4.4 ± 2.1, respectively. There was a statistically significant decrease ($p < 0.001$). The lowest $SpO_2$ value was 76.7 ± 17.1% preoperatively and 80.8 ± 14.6% postoperatively, demonstrating no significant difference ($p = 0.16$)**
**Conclusion: Attended home monitoring by guardians using a portable device can be useful in the perioperative assessment of pediatric OSAS.**

**Key words: polysomnography, apnea hypopnea index, $SpO_2$, adenotonsillectomy**

## INTRODUCTION

Although adenotonsillectomy has been widely accepted as the primary treatment for obstructive sleep apnea syndrome (OSAS) in children [1], diagnosis of this syndrome and indications for surgical intervention remain difficult. Attended overnight polysomnography (PSG) in the laboratory setting has been recommended as the gold standard for OSAS diagnosis in children [1, 2], but very few facilities can accommodate overnight pediatric PSG examinations, especially in infants, toddlers, and preschool children, and few technologists are qualified to perform these examinations. To overcome these problems, a simple portable polygraphic device has been developed for home monitoring of nocturnal breathing in children [3]. This device can be monitored by guardians.

In the present retrospective study, charts were reviewed of children in whom adenotonsillectomy was performed after home monitoring with the portable polygraph. The usefulness of this device was investigated by comparing respiratory parameters between pre- and postoperative examinations.

## SUBJECTS AND METHODS

Forty-eight children aged 2–11 years (34 boys and 14 girls; median age, 5 years) who visited Kochi Medical School Hospital from 2003 through 2007 presenting with snoring, sleep apnea, and restless sleep were subjected to home monitoring of nocturnal breathing. The Sleeptester™ (Fukuda Lifetech Inc., Tokyo, Japan) was used for this purpose. This device is equipped with five channels for oronasal airflow, thoracoabdominal effort, snoring, body position, and oximetry ($SpO_2$) (Fig. 1). This device was installed in the homes of all subjects. Each night, these five sensors were appropriately placed by guardians who were trained in the use of this device. Guardians were also requested to remain with the children as long as possible and to reposition the sensors in the event that they slipped. Monitoring occurred overnight and the device was returned the following day. Home monitoring was deferred at least for 2 weeks, when the patient had an upper respiratory tract infection. Results were manually analyzed by sleep technologists using the attached analysis software (SAS-100) on the basis of the information obtained from the night watch. Adenotonsillectomy was performed in all 48 patients. Home monitoring using the same device was then utilized on all patients 2–3 months postoperatively, when an influence of postoperative pharyngeal edema on nocturnal breathing could be eliminated. Twenty-five children were complicated with nasal allergy, and 14 out of those 25 had episodes of bronchial asthma. Congenital disorders such as craniofacial anomalies and tracheo-laryngomalacia were excluded for this study. Written informed consent was obtained from the guardians of all children. This study conformed to the principles outlined in the Declaration of Helsinki.

The data from monitoring with oximetry plus oronasal airflow and/or thoracoabdominal effort was considered assessable. Duration of monitoring was also

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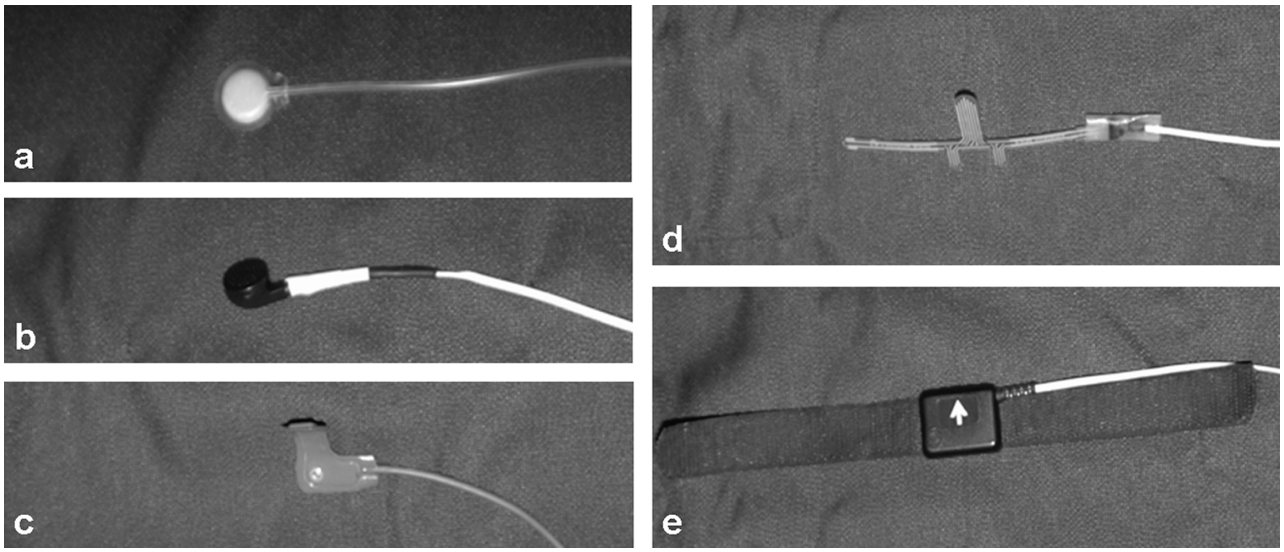


**Fig. 1** Sleeptester™ sensors; a. Respitrase™ for assessment of the thoracoabdominal effort; b. Microphone for assessment of snoring; c. Oximeter; d. Thermistor for assessment of oronasal airflow; e. Belt with body position sensor.

investigated. Apnea–hypopnea index (AHI) values and the lowest value of $SpO_2$ (lowest $SpO_2$) were selected as respiratory parameters indicating OSAS according to the literature [4, 5]. Apnea was defined as cessation (> 90% reduction) of oronasal airflow lasting for more than 2 breaths. Hypopnea was defined as > 50% reduction of oronasal airflow with > 3% desaturation for more than 2 breaths, following the 2007 guidelines of the American Academy of Sleep Medicine (AASM) [6]. These two parameters were analyzed statistically in a comparison between pre- and postoperative data using Student's t-test. The *p*-values less than 0.05 were considered to be statistically significant.

## RESULTS

The mean duration of assessable monitoring was 460 ± 172 min (Mean ± S.D.) (range; 90–642 min) in the preoperative test and 471 ± 126 min (range; 184–660 min) in the postoperative test. The mean AHI values were 20.6 ± 16.6 (range; 3.7–83.6) preoperatively and 4.4 ± 2.1 (range; 1.1–11.2) postoperatively (Fig. 2). A statistically significant decrease in the AHI value due to surgical intervention was observed ($p < 0.001$). The lowest $SpO_2$ values were 76.7 ± 17.1% (range; 20%–95%) preoperatively and 80.8 ± 14.6% (range; 37%–95%) postoperatively. No significant difference was found between the pre- and postoperative values for this parameter ($p = 0.16$) (Fig. 3). The prevalence of OSAS was 93.8% on the basis of the results of preoperative home monitoring when the AHI value of > 5 indicated OSAS [3, 5]. The complete cure rate (AHI value of < 5) obtained by adenotonsillectomy was 75.6%, but a reduction in the AHI value of ≥ 50% was achieved in 39 out of the 48 subjects (81.3%) (Fig. 4). Neither snoring nor subjective sleep apnea was observed in any of the 48 children during the 6-month follow-up.

## DISCUSSION

Adenotonsillectomy is universally approved as a primary treatment for OSAS in children [4, 7, 8]. Overnight PSG is strongly recommended for confirmation of the diagnosis of OSAS preoperatively according to the AASM and American Academy of Pediatrics. Overnight-attended PSG is now the gold standard in Europe and the USA [1, 2]. In Japan and many other countries, however, very few sleep laboratories and technologists are currently available, especially for children. Objective diagnosis of OSAS is therefore difficult. In addition, PSG performance and interpretation has not been standardized [9]. In many cases, otolaryngologists perform surgery with no objective and quantitative assessment based on the high cure rate of adenotonsillectomy [10]. In this study, simple home monitoring using a portable polygraphic device was utilized for preoperative assessment of nocturnal breathing in pediatric subjects in order to facilitate diagnosis and to obtain adequate data for surgical planning.

The AASM has classified portable monitors into four types according to the American Sleep Disorders Association review (1994) [11, 12]. The Sleeptester™ used in this study meets the modified portable sleep apnea testing requirements (Type 3), which include a minimum of four monitored channels, including ventilation or airflow, heart rate or electrocardiograph, and oxygen saturation. In those reviews, Type 3 portable monitoring devices appeared to be usable in an attended setting. The examination parameters are established by sleep technologists, but for the abovementioned reasons, they cannot attend overnight polygraphy. Thus, guardians are requested to monitor their children as long as possible and to reposition sensors in the event of a slip. With the cooperative efforts of the guardians of the children in this study, approximately 8 hours of data were obtained. In some cases, the amount of assessable data was limited, but manual analyses by sleep technologists analyzing the data from overnight polygraphy aided in reaching the correct diagnosis and identifying the severity of OSAS in these children.

Jacob *et al.* [3] first reported the usefulness of home

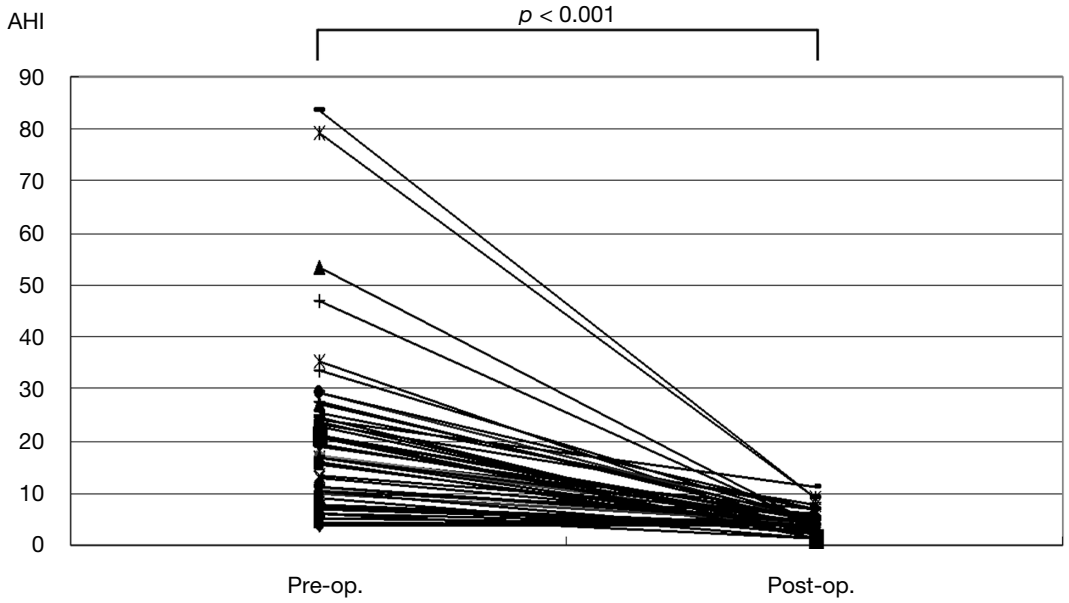


**Fig. 2** Values for apnea–hypopnea indices (AHI) of 48 children obtained in pre- and postoperative examinations. The mean AHI value significantly decreased after adenotonsillectomy.

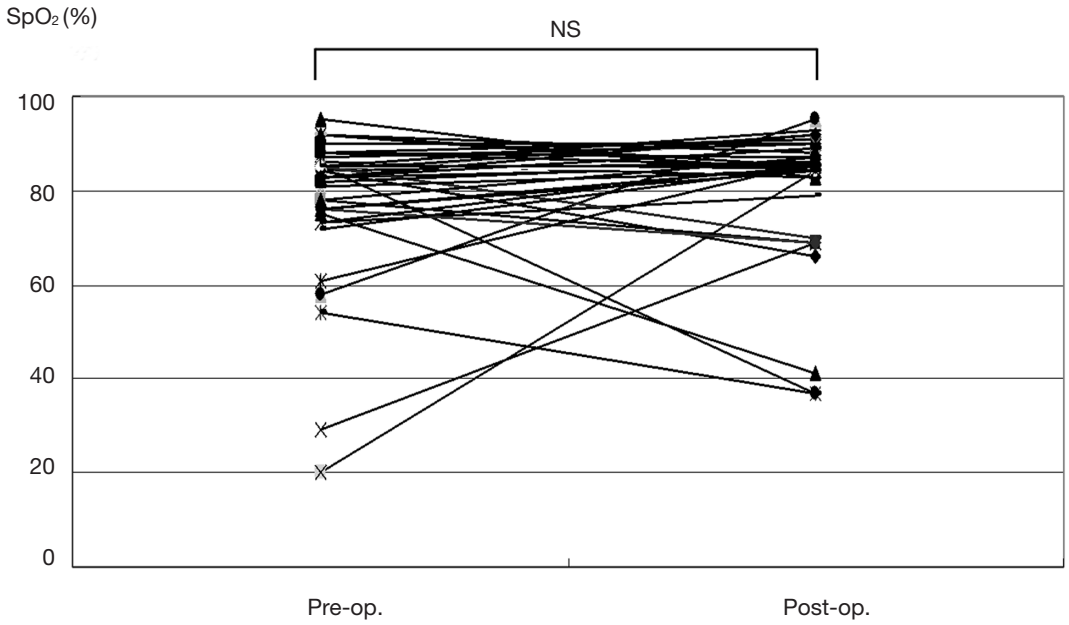


**Fig. 3** The lowest $SpO_2$ value in 48 children in pre- and postoperative examinations was unchanged after surgery.

polygraphy, stating that AHI values of > 5 had better sensitivity and specificity for diagnosis of OSAS. Following their criteria, 45 out of 48 children (93.8%) showed AHI values of > 5 preoperatively and were diagnosed with OSAS in the present study. In the postoperative examinations, AHI values of < 5 were found in 37 children. A complete cure by adenotonsillectomy was achieved in 34 out of 45 children (75.6%) who were diagnosed preoperatively with OSAS. Furthermore, a reduction of ≥ 50% in the AHI value was achieved in 39 out of 48 subjects (81.3%). These results were comparable to those of a series of previous reports [4, 7, 8], and may support a high cure rate of OSAS in children with surgical treatment. In this study, all children had undergone adenotonsillectomy because they all presented with symptomatic snoring and AHI > 2. Snoring is now thought to be a kind of sleep disordered breathing, and can be considered to be a subject to surgery [5]. In addition, there has recently been a controversy on the criteria for diagnosing OSAS, since AHI ≥ 2 was proposed as an indicator of pediatric OSAS by Gozal and his colleagues [13]. Conclusively, snoring and objective sleep apnea were resolved following adenotonsillectomy in all cases of our series. Indications of the surgical intervention for pediatric OSAS may need more argument.

Although the nadir of $SpO_2$ has been widely used to assess the severity of pediatric OSAS [4, 5, 13], the

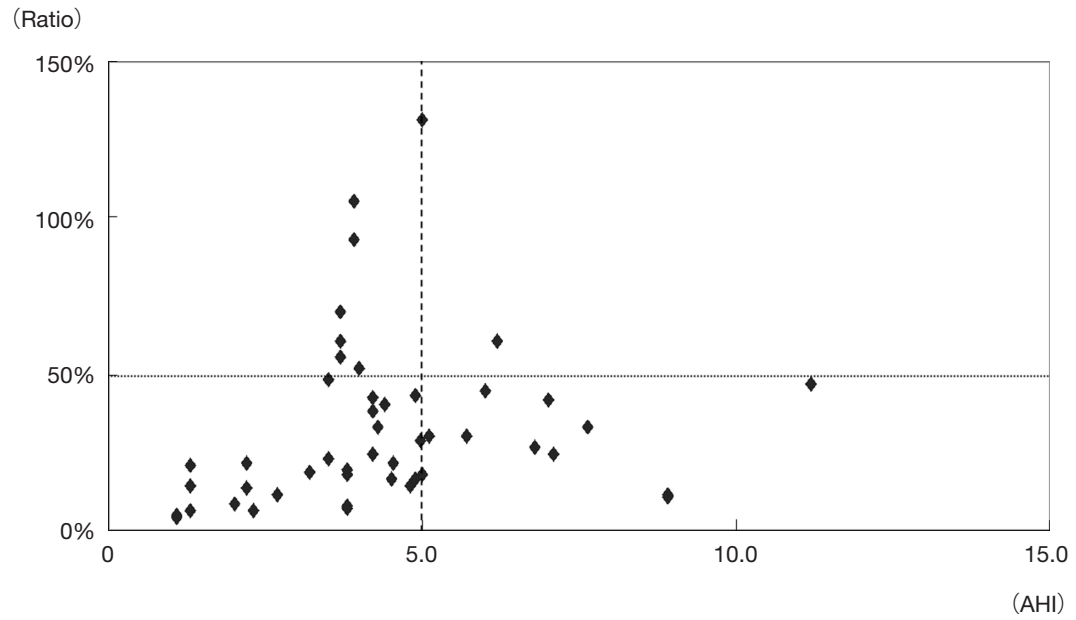


**Fig. 4** Scattergram showing postoperative AHI values and the ratio of postoperative AHI/preoperative AHI in all 48 subjects. The complete cure rate (AHI value of < 5) obtained by adenotonsillectomy was 75.6%, but a reduction in the AHI value of ≥ 50% was achieved in 81.3% of subjects.

lowest $SpO_2$ value was found to be unchanged by adenotonsillectomy in the present study. This result may be more attributable to the unreliability of $SpO_2$ monitoring than to the ineffectiveness of surgery. $SpO_2$ was monitored by oximetry with a roll-up sensor in this study. This sensor is intended mainly for adult use, and pediatric sizes are not available. The sensor used in this study was too large for the subjects, especially the infants. It slipped off the fingertip easily, thereby making the results of $SpO_2$ monitoring less reliable. The results of the lowest $SpO_2$ may have to be excluded for the assessment of pediatric OSAS on the basis of this study, while oximetry itself is thought to have a predictive value in screening for OSAS [14]. Sensors developed for children in future are expected to be more reliable in assessing pediatric OSAS. Alternatively, another parameter such as the percentage of time that $SpO_2$ measured less than 90% may have to be applied to the assessment of hypoxia in children with OSAS.

## CONCLUSION

Attended home monitoring of nocturnal breathing in children by guardians can be useful in the perioperative assessment of pediatric OSAS, especially to assess the change of AHI obtained by the surgery.

## ACKNOWLEDGMENT

The authors greatly appreciate the cooperation of the sleep technologists, Tadafumi Doi and Mutsumi Shimasaki, who showed great dedication in manual analyses of the data from the Sleeptester™. The authors would also like to thank Enago for the English language review.

## CONFLICT OF INTEREST STATEMENT

The authors here disclose no conflicts of interest with the company that produced the monitoring devices.

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