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Research Article

Diagnosing Lingual Airway Obstruction Using Nasopharyngeal Tube in OSAHS: Natural Sleep vs Induced Sleep

Abstract

Objective: The goal of this study was to use the results from nasopharyngeal tube polysomnography (NPT-PSG) to detect glossopharyngeal airway obstruction in patients with obstructive sleep apnea hypopnea syndrome (OSAHS) and to compare the results with those obtained by observing sleep apnea/hypopnea after nasopharyngeal tube insertion during drug-induced sleep.

Methods: Fifty-three patients with OSAHS underwent NPT-PSG. In addition, during drug-induced sleep before surgical anesthesia, NPT was inserted, and the incidence of sleep apnea/hypopnea was observed. The observed results were compared with the NPT-PSG results. Both NPT-PSG data and observed data during drug-induced sleep were used to determine whether glossopharyngeal airway obstruction was present, and the two results were compared.

Results: Among the 53 patients, NPT-PSG was successfully completed in 50 and unsuccessfully in 3. All 53 patients completed the examination after NPT insertion during induced sleep successfully. The correlation coefficients of apnea-hypopnea index (AHI) and lowest oxygen saturation (LaSO₂) between the results obtained from the two methods were 0.367 and 0.375, respectively, and *P* values were less than 0.001 in both cases. When using the two methods to detect the presence of glossopharyngeal airway obstruction, the coincidence rate was 80%.

Conclusion: NPT-PSG results are highly consistent with the results obtained after NPT insertion during induced sleep. For patients in whom NPT-PSG fails to be performed or produces uncertain results, the complementary observation after NPT placement during induced sleep can further clarify the condition of glossopharyngeal airway obstruction.

Introduction

Obstructive sleep apnea hypopnea syndrome (OSAHS) is apnea and hypoventilation caused by upper airway collapse during sleep, accompanied by snoring, disrupted sleep structure, frequent occurrence of oxygen desaturation and daytime sleepiness [1,2]. OSAHS has a rather high prevalence and can cause systemic and multi-system damages. Hence, it has received increasing attention in recent years. The anatomical stenosis or obstruction of the upper respiratory tract is one of the main reasons for the pathogenesis of OSAHS [3,4], and accurate determination of the location and extent of upper airway obstruction is the key for choosing the proper surgical approach and improving the therapeutic effect [5-7].

Previous studies have shown that in addition to the most common oropharyngeal area, the glossopharyngeal area is another common site of obstruction [6,7]. Currently, a number

of methods are used to diagnose glossopharyngeal obstruction. In addition to a series of commonly applied examinations while awake [8,9], examinations performed during natural or induced sleep are relatively accurate [4,5,10]. Nasopharyngeal tube (NPT) insertion can guarantee the responsibility of excluding the obstruction of the nasal cavity, nasopharyngeal and oropharyngeal airways. If nasopharyngeal tube polysomnography (NPT-PSG) still detects obstructive sleep apnea after NPT insertion, it suggests that the obstruction site should be located at the glossopharyngeal area [11,12]. Our previous work has demonstrated that good efficacy can be achieved by guiding the choice of surgical approach based on NPT-PSG findings, suggesting that NPT-PSG examination is an effective diagnostic tool for diagnosing glossopharyngeal obstruction [12,13]. However, some patients do not tolerate NPT insertion, which prevents proper examination [12]. In a small number of patients, the NPT-PSG results were more severe than the results of the first polysomnography (PSG), so the

examination results were uncertain. To solve these problems, we performed both NPT-PSG and examination after NPT insertion during induced sleep on the same group of OSAHS patients to compare the advantages and disadvantages of the two methods and to determine the coincidence rate between these two methods.

Materials and Methods

Participants

All OSAHS patients, who underwent surgical treatment in our hospital from September 2014 to March 2015 and met the inclusion criteria, were included in this study. The inclusion criteria were as follows: 1) first PSG examination confirmed the diagnosis of OSAHS; 2) apnea-hypopnea index (AHI) > 15 times/h; 3) nasal endoscopy and/or CT scan confirmed no significant obstruction of the nasal cavity or nasopharynx; 4) no micrognathia or other craniofacial structural abnormalities; 5) signed informed consent.

PSG before and after NPT insertion

The Alice 5 PSG sleep system (Respironics, U.S.) was used for sleep monitoring of all patients. We used the sleep monitoring standards and the diagnostic criteria for OSAHS described by the American Sleep Association [14]. Namely, AHI and lowest oxygen saturation (LSO₂) were the main monitoring indicators. If AHI reached or exceeded 15 times/h, the condition was diagnosed as moderate or severe OSAHS. Patients who were scheduled to undergo surgical treatment and met the inclusion criteria were examined after NPT insertion.

The methods for the selection and insertion of NPT were the same as that described in a previous study [11]. Briefly, silicone NPTs with different types and specifications were selected according to the condition of the nasal cavity and were trimmed to the appropriate length. The relatively wide nasal cavity was chosen for the procedure. To contract the nasal cavity, 1% ephedrine was applied, and 1% tetracaine was applied topically to anesthetize the nasal cavity and nasopharynx. After the surface of the NPT had been lubricated with liquid paraffin, the NPT was inserted through the anterior nostril and was properly secured. The distal end of the NPT was slightly beyond the free edge of the soft palate.

After successful placement of NPT, PSG examination was repeated. The examination procedure and indicators measured were the same as those in the first PSG. AHI and LSO₂ decided by NPT-PSG during overnight sleep were recorded. AHI decided by NPT-PSG greater than or equal to 15 times/h was used as the diagnostic criterion for glossopharyngeal obstruction [11-13]. For all patients, whether there was glossopharyngeal airway obstruction was observed.

Examination after NPT placement during induced sleep

This examination was performed before the patient received surgical anesthesia in all cases. After entering the operating room, the patient was placed in a supine position, and intravenous access was established. The patient was connected to a physiological monitoring system (Datex-Ohmeda, Finland) and a bispectral index system (BIS Vista,

U.S.). The monitoring indicators included electrocardiography (ECG), blood pressure, oxygen saturation, carbon dioxide partial pressure in the respiratory tract, and BIS value. First, 1% ephedrine was applied to contract the nasal cavity, and 1% tetracaine was applied topically to anesthetize nasal cavity, nasopharynx and oropharynx. A 6.5 cm endotracheal tube was inserted through the wider nasal cavity, and when the distal end of the tube was slightly beyond the free end of the soft palate, the tube was secured. A probe for carbon dioxide partial pressure measurement was placed inside the rear end of the tube. Dexmedetomidine Hydrochloride was administered intravenously at 1 ug/kg bodyweight in 15 minutes and continuously pumped at 0.5ug/kg.h, and the patient gradually was transitioned to the sleeping state. When the BIS value dropped below 70 [15-17], we started to observe. Video recordings of the monitor, the BIS screen and the patient were obtained simultaneously for five consecutive minutes. If no obstructive apnea/hypopnea occurred during the five minutes, we determined that there was no glossopharyngeal airway obstruction. If obstructive apnea/hypopnea occurred once or more during the five minutes, we determined that there was glossopharyngeal airway obstruction. For patients in whom apnea/hypopnea was observed, the endotracheal tube was advanced by 1 cm and observations were continued for another five minutes. If there was still obstructive apnea/hypopnea, the endotracheal tube was advanced by another 1cm and the observation was continued for five minutes. On the contrary, if there was not still apnea/hypopnea, the observation was ended. Finally, the endotracheal tube was advanced into the trachea, and general anesthesia was applied to perform the surgery.

Criteria used to determine apnea/hypopnea in the operating room environment were as follows. A BIS value of less than 70 indicated that the patient entered the sleeping state. Changes in the capnography waveform at the end of exhalation were used to monitor the respiratory airflow in the airway. The digital oxygen saturation monitor was used to monitor blood oxygen saturation. Thoracoabdominal breathing movement was monitored visually with the naked eyes. In the presence of thoracoabdominal breathing movement, if airflow stopped or decreased by more than 50% for over 10 seconds, accompanied by a decrease in oxygen saturation by over 4%, it was considered as obstructive apnea or hypopnea. The LSO₂ data during this time were recorded.

Statistical analysis

The medical statistics software SPSS 17.0 was used for data analysis. Correlation analysis between NPT-PSG examination results and examination results after NPT placement during induced sleep was performed. The numbers of cases of glossopharyngeal airway obstruction determined by two examination methods were compared, and a contingency table was drawn to calculate the coincidence rate.

Results

Patient information

Fifty-three eligible participants were enrolled in this study, including 49 males and 4 females. There were 11 cases of moderate OSAHS and 42 cases of severe OSAHS. The age ranged

from 20 to 59 years, with a mean age of 37.8 years. The AHI ranged between 17.8 and 91.0 times/h, with a mean AHI of 53.4 times/h. The LSO_2 ranged from 41% to 85%, with a mean LSO_2 of 62%; The body mass index (BMI) ranged from 23.5 to 35.7 kg/m^2 , with a mean BMI of 28.9 kg/m^2 . The Epworth sleepiness scale (ESS) score ranged from 2 to 24 points, with a mean ESS score of 12.1 points. All patients showed substantial nighttime snoring, daytime sleepiness of varying severity, fatigue and other symptoms.

First PSG and NPT-PSG

All 53 patients successfully completed the first PSG and were scheduled for the subsequent NPT-PSG examination. Three patients could not tolerate sleeping with NPT insertion as they experienced notable discomfort in the nasal cavity and nasopharynx, and had difficulty in falling asleep, thereby causing NPT-PSG to fail. For the remaining 50 patients, comparison of PSG indicators before and after NPT insertion revealed that AHI significantly decreased and LSO_2 significantly increased after NPT insertion (Table 1). However, among these 50 patients, 3 showed increased AHI in NPT-PSG compared to the first PSG. According to the criterion for glossopharyngeal airway obstruction, namely AHI greater than or equal to 15 times/h, 23 had glossopharyngeal airway obstruction among the 50 patients.

Clinical observation after NPT insertion during drug-induced sleep

Before surgical anesthesia, all 53 patients entered a drug-induced sleeping state. In all cases, before NPT insertion, typical obstructive sleep apnea was observed. The distal end of the endotracheal tube was placed slightly beyond the level of the free edge of the soft palate, and the tube was secured. During the five minutes of continuous observation after the BIS value dropped below 70, 29 patients showed no notable apnea/hypopnea, and clear apnea/hypopnea was observed in the remaining 24 cases. The numbers of cases that had 1-6 apnea/hypopnea within five minutes were 10, 5, 3, 3, 1 and 2. Subsequently, the distal end of the endotracheal tube was advanced by 1 cm, and notable apnea/hypopnea was observed on 13 patients. After advancing the tube by another 1 cm, clear apnea/hypopnea was still observed on two patients. Endoscopic examination confirmed that for these two patients, the cause of apnea was that curled epiglottis covered the glottis during sleep.

Correlation analysis between NPT-PSG results and observation results during induced sleep

We performed correlation analysis between the NPT-PSG results and the observation results during induced sleep collected from 50 patients. The correlation coefficient between the numbers of sleep apnea observed during five minutes of induced sleep and AHI decided by NPT-PSG was 0.367, $P = 0.009$, and the correlation coefficient between the LSO_2 observed during induced sleep and LSO_2 decided by NPT-PSG was 0.375, $P = 0.007$, which were both statistically significant.

Comparison of two methods in determining glossopharyngeal airway stenosis

Among the 53 patients, NPT-PSG failed in 3, but was successfully completed in the remaining 50 patients. NPT-PSG examination revealed that 23 patients still had an AHI greater than 15 times/h, and these patients were considered to have glossopharyngeal airway obstruction. The positive rate was 46%. All 53 patients entered a drug-induced sleeping state, and when the tip of the endotracheal tube slightly exceeded the level of the free edge of the soft palate, significant apnea was observed in 24 cases, resulting in a positive rate of 45.3%. The results obtained according to the two methods are shown in Table 2. The number of cases that were determined to have glossopharyngeal airway obstruction and those that did not have glossopharyngeal airway obstruction by both methods were 18 and 22, respectively. Therefore, the results on the determination of glossopharyngeal airway obstruction obtained according to the two methods were consistent in a total of 40 cases. In the remaining 10 cases, the results obtained according to the two methods differed. The overall coincidence rate between the two methods was 80%. Among the three cases in which NPT-PSG revealed higher AHI than that in the first PSG, only one patient showed clear apnea during induced sleep, whereas the other two did not. And among the three patients with failed NPT-PSG two patient showed notable apnea during induced sleep, whereas the other one did not.

Discussion

The direct pathogenesis of OSAHS is stenosis or obstruction of the upper airway during sleep. In addition to the most common oropharyngeal area, the glossopharyngeal area is a common site of obstruction [4,5]. Currently, there are many methods for diagnosing glossopharyngeal obstruction. In addition to a series of commonly used tests while the patient is awake [3,8,9], examinations about localizing the site of obstruction during natural or induced sleep are relatively reliable [4,5,10]. In recent years, studies have shown that during natural sleep good efficacy can be achieved by diagnosing obstruction in the

Table 1: Changes in PSG monitoring indicators after NPT insertion compared to before in 50 OSAHS patients (Mean \pm Std. Deviation).

| | AHI | LSO_2 |
|----------------------|-------------------|-----------------|
| Before NPT insertion | 53.37 \pm 21.22 | 0.62 \pm 0.12 |
| After NPT insertion | 18.17 \pm 14.86 | 0.74 \pm 0.12 |
| <i>t</i> value | 9.793 | 5.013 |
| <i>P</i> value | <0.001 | <0.001 |

Table 2: Comparison between the two methods in determining the status of the glossopharyngeal airway.

| | NPT insertion during induced sleep | | Total | |
|----------------|------------------------------------|----------------|-------|----|
| | Obstruction | No Obstruction | | |
| NPT-PSG | Obstruction | 18 | 6 | 24 |
| | No Obstruction | 4 | 22 | 26 |
| Failed NPT-PSG | 2 | 1 | 3 | |
| Total | 24 | 29 | 53 | |

glossopharyngeal area with PSG after NPT insertion and using the diagnostic result to guide the treatment [11-13]. However, we have also found that NPT-PSG examination failed to be performed in some patients because they could not tolerate NPT insertion in practice. In addition, in a small number of patients, NPT-PSG revealed more severe apnea than the first PSG. In theory, NPT insertion should substantially reduce the severity of OSAHS. Hence, in these cases the NPT-PSG results were questionable.

To solve these problems, we performed both NPT-PSG and examination after NPT insertion during induced sleep on the same group of OSAHS patients who received surgical treatment in our hospital. Among the 53 patients included, NPT-PSG failed in 3 patients, and was successful in 50 patients. NPT-PSG results showed that after NPT insertion overall OSAHS was improved in the 47 patients. The AHI significantly decreased, and LSO_2 significantly increased, which is consistent with our previous reports [11-13]. However, in three cases, the NPT-PSG results showed more severe OSAHS symptom than the results of the first PSG.

Because it was inconvenient to use PSG equipment in an operating room to perform observations during induced sleep, we used common equipment in the operating room as much as possible. Endotracheal tubes had sufficient length, thereby enabling observation of apnea when the tip of the endotracheal tube was at different sites of the airway. In addition, it was convenient to perform subsequent endotracheal intubation after the observation stage ended. Therefore, we used endotracheal tubes to replace the regular NPT for insertion and observation. To ensure that the observation was made when the patients were truly asleep, we used the BIS system to monitor electroencephalogram (EEG), and did not start to observe until the BIS value reduced below 70 [15-17]. A fingertip pulse oximeter was used to monitor the level of oxygen saturation. In addition, carbon dioxide monitoring was used to determine airflow in the endotracheal tube and video recording was obtained to determine whether airflow in the airway stopped or the reduced extent according to quantifiable standards, thereby confirming the events of apnea or hypopnea.

Under these conditions, observation after endotracheal intubation and induced sleep was successfully completely in all 53 patients. When the tip of the endotracheal tubes slightly exceeded the free edge of the soft palate, clear sleep apnea was observed in 24 patients, suggesting the existence of glossopharyngeal airway obstruction. In addition, with the gradual advancement of the endotracheal tube, apnea gradually decreased in frequency or disappeared. For all 3 patients in whom NPT-PSG failed, observation during induced sleep was successfully conducted. In 2 cases, clear glossopharyngeal airway obstruction was observed, and in the remaining cases, no notable obstruction was observed. Among the 3 patients in whom NPT-PSG results showed more severe OSAHS symptom than the first PSG, we observed apparent glossopharyngeal airway obstruction in only one case, and no clear obstruction in the other two cases. These results suggested that the observation after endotracheal intubation during induced sleep could be applied to patients in whom NPT-PSG fail. In addition,

for patients in whom NPT-PSG results revealed more severe OSAHS symptom than the first PSG, the possibility of inaccurate examination result should be considered. The causes of such inaccuracy might be related to changes in the NPT position, NPT bending, NPT blockage by secretions, and other factors.

Under the constraints of a variety of factors, the time duration of the observation under NPT insertion in induced sleep was only a short period of five minutes. We concerned about the reliability of the results obtained in this way. The correlation coefficient between the apnea times/5 minutes induced sleep and AHI in NPT-PSG reached 0.367 ($P < 0.001$). Correspondingly, the correlation coefficient between LSO_2 decided by NPT-PSG and LSO_2 observed during induced sleep was 0.375 ($P < 0.001$). After excluding the 3 patients in whom NPT-PSG failed, we determined the presence of glossopharyngeal airway obstruction using both observations during induced sleep and NPT-PSG on all remaining 50 patients, and compared the results. The numbers of cases diagnosed as having and not having glossopharyngeal airway obstruction were 18 and 22, respectively. Namely, the assessment results which were the same using the two approaches were 40 cases, giving an overall coincidence rate of 80%. These findings indicated that results obtained from NPT-PSG and observation after NPT insertion and induced sleep were in good agreement.

Given that NPT-PSG examination is performed while the patient is in a natural sleep state overnight, in theory its accuracy should be higher than examination performed during a short period of induced sleep. Thus, NPT-PSG has an irreplaceable role as a routine diagnostic method for localizing the site of glossopharyngeal airway obstruction in clinical practice. However, for OSAHS patients in whom NPT-PSG fails or produces questionable result, observation after NPT insertion during induced sleep can serve as a useful complementary diagnostic tool.

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