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# Surgical Criteria for Obstructive Sleep Apnea Syndrome Based on Localization of Upper Airway Collapse during Sleep: A Preliminary Study

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Ikeda, K., Oshima, T., Shimomura, A. and Takasaka, T. *Surgical Criteria for Obstructive Sleep Apnea Syndrome Based on Localization of Upper Airway Collapse during Sleep: A Preliminary Study.* Tohoku J. Exp. Med., 1998, **185** (1), 1-8 —— Obstructive sleep apnea syndrome (OSAS) is defined as intermittent complete or partial upper airway obstruction during sleep, causing mental and physical effects. Localization of obstructions in the upper airways in OSAS patients provides indispensable information for the selection of surgical procedures. We measured the pressure within the upper airways during sleep in 6 patients with OSAS in order to select the surgical procedure. Five patients were found to have the airway collapse in the velopharynx, and in three of them underwent uvulopalatopharyngoplasty (UPPP) with tonsillectomy was performed. The remaining one patient, having an obstruction in both the velopharynx and hypopharynx, underwent laser-assisted midline glossectomy as well as UPPP. The 4 patients receiving the operation showed improvements in the sleep apnea index and the lowest oxygen saturation postoperatively. These findings suggest that pressure measurement may be a reliable tool for localizing obstructions in OSAS patients and may be used for determined the surgical option. ——— obstructive sleep apnea syndrome; uvulopalatopharyngoplasty; midline glossectomy; upper airway collapse 

Obstructive sleep apnea syndrome (OSAS) is defined as intermittent complete or partial upper airway obstruction during sleep, causing mental and physical effects. The main nocturnal symptoms of OSAS include loud and irregular snoring, breathing pauses, restless sleep and daytime sleepiness. Abnormalities of the structure and function of the upper airway have been established as causative factors in OSAS. Patients with OSAS frequently have airway collapse of different localization from the oropharynx to the hypopharynx.

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A variety of treatments have yielded variable success rates and complications. Continuous positive airway pressure (CPAP) has a potential success rate of up to 99% (Sullivan et al. 1981; Phillips et al. 1990). However, several reports have documented a reduction in patient compliance when using CPAP (Hoffstein et al. 1992; Kribbs et al. 1993). Fewer than 50% of the patients using CPAP have been considered regular users. Uvulopalatopharyngoplasty (UPPP) with tonsillectomy is a popular option for surgical management, with a success rate of 26–70% of patients (Ikematsu 1964; Fujita et al. 1981; Anand et al. 1991). The low success rate of UPPP may be due to indiscriminate use of the procedure (Skatvedt 1995). Midline glossectomy (MLG) is used as a second-stage approach following failed UPPP or as a primary procedure in patients with a hypopharyngeal obstruction (Fujita et al. 1991).

Understanding of the upper airway structure and function in OSAS patients is required for insight into the pathogenesis of this disorder and to select the best therapy and/or surgical treatment for OSAS. Localization of obstructions in the upper airways in OSAS patients have been attempted using a variety of methods, including physical examination, simple fiberoptic endoscopy (Guilleminault et al. 1978), fiberoptic endoscopy with the so-called Muller maneuver (Sher et al. 1985), pharyngeal pressure measurements (Issa and Sullivan 1984; Shepard and Thawley 1990; Gleadhill et al. 1991; Shepard et al. 1991), cephalometrics (Riley et al. 1983), computed tomography (Stein et al. 1987; Horner et al. 1989) and fluoroscopy (Smith et al. 1978; Pepin et al. 1992). Presently, measurements of the pressure within the upper airway during sleep is relatively easy. This method allows us to determine whether the upper airway collapse is confined to the oropharyngeal region or extends more caudally. Surgical corrections would be more effective if accurate localization of the airway collapse could be made and a surgical technique employed that is capable of removing it.

Our preliminary study was aimed at assessing the localization of airway collapse using continuous pressure measurements during sleep in OSAS patients, selecting the surgical technique, UPPP with or without MLG, based on the localization of the airway collapse, and evaluating the effect of the operation on respiratory parameters.

## Patients and Methods

Six patients with OSAS were examined. The diagnosis was established by a combination of medical history, clinical examination and standard nocturnal polysomnography. Four patients, given the option of CPAP or surgical treatment, preferred surgery. All patients showed tonsillar hypertrophy of Mackenzie's classification of II degree. Based on the localization of the airway collapse from the pressure measurement, 3 patients underwent UPPP with tonsillectomy and 1 patient UPPP with tonsillectomy and KTP/532 laser assisted MLG under general anesthesia (Ikeda et al. 1995). The patients were re-examined 6

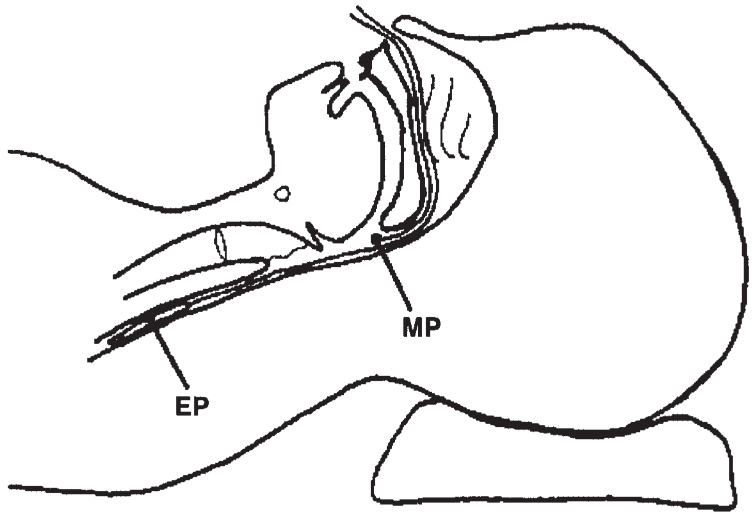


Fig. 1. Schematic drawing of the placement of catheter in the mesopharynx (MP) and esophagus (EP).

months after surgery.

Two pressure transducers (Millar, Houston, TX, USA) were carefully inserted through one nostril into the pharynx and esophagus without the use of any local anesthetic. One transducer was localized in the oropharynx immediately caudal to the posterior border of the soft palate whereas the other one was introduced into the esophagus (Fig. 1). Placement of the transducers was confirmed by fluoroscopy. The data were continuously recorded on a chart-recorder.

Results were expressed as the mean$\pm$s.d. and were compared with paired $t$-test, a $p$ value of less than 0.05 was recognized as significant.

## Results

The patients consisted of 5 men and 1 woman ranging in age from 42 to 63 years (50$\pm$9). The body mass index was from 26.6 to 38.2 kg/m$^2$ (29.1$\pm$4.7). The sleep study showed severe obstructive apnea during sleep in all patients (Table 1).

Obstructive apnea episodes during sleep were characterized by large and

Table 1. *Anthropometric data*

| Patient No. | Age (years) | Sex | Body mass index (kg/m$^2$) | Apnea index | Lowest oxygen saturation (%) |
|---|---|---|---|---|---|
| 1 | 43 | M | 26.6 | 63 | 46 |
| 2 | 60 | M | 26.6 | 50 | 33 |
| 3 | 44 | M | 27.6 | 28 | 57 |
| 4 | 48 | M | 25.5 | 43 | 76 |
| 5 | 63 | F | 38.2 | 55 | 30 |
| 6 | 42 | M | 30.1 | 54 | 60 |

M, male; F, female

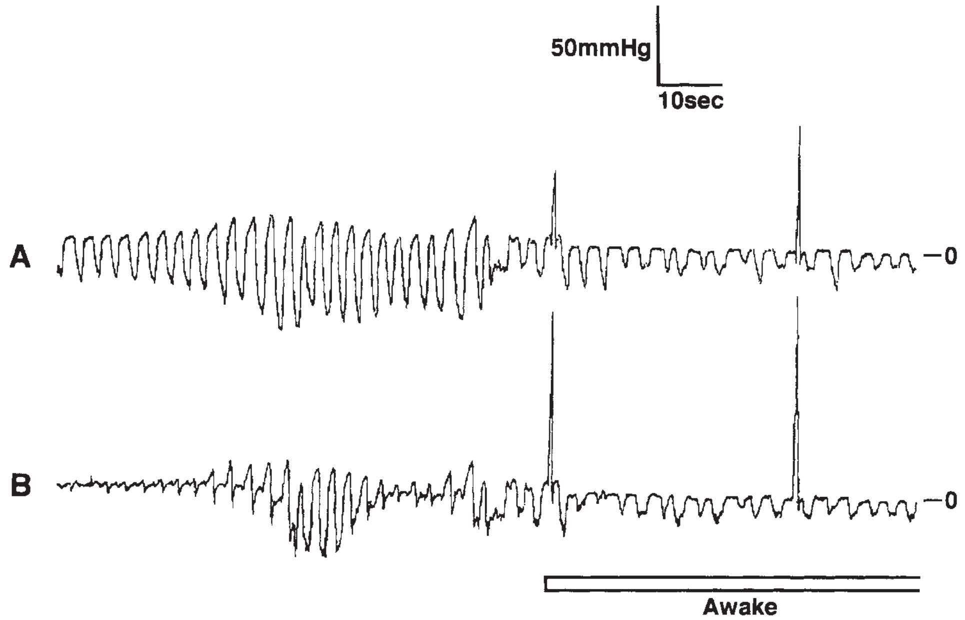


Fig. 2. Pressure recordings from the esophagus (A) and mesopharynx (B) in a representative patient with obstructive sleep apnea syndrome.

mainly negative pressure oscillations in the esophagus and in the pharynx caudal to the obstruction (Fig. 2). The termination of obstructive apnea could be clearly demonstrated by an abrupt pressure change at the opening of the pharynx. Awake conditions produced few pressure fluctuations and tracings from both the pharynx and the esophagus remained flat. The peak values of negative pressure from the recordings of the pharynx and esophagus were calculated and are shown in Table 2. Both recordings obtained from the pharynx and esophagus showed similar changes in negative pressure, indicating that the site of obstruction was the oropharynx (cases 2∼6). On the other hand, case 1 showed a significant difference between the two values of negative pressure, indicating that the airway collapse was in the hypopharynx.

We selected the operation procedure based on the localization of the airway collapse. Namely, both UPPP and MLG were performed in case 1 while cases 2, 3 and 6 underwent UPPP alone. In cases 4 and 5 informed consent for the

Table 2. *Maximal negative pressure values (mmHg) during sleep*

| Patient No. | Mesopharyneal pressure | Esophageal pressure | Pressure difference |
|---|---|---|---|
| 1 | 30 | 60 | 30 |
| 2 | 45 | 50 | 5 |
| 3 | 26 | 30 | 4 |
| 4 | 24 | 30 | 6 |
| 5 | 20 | 25 | 5 |
| 6 | 30 | 40 | 10 |

TABLE 3. *Preoperative and postoperative values of sleep study*

| Patient No. | Apnea index | Lowest oxygen saturation (%) |
|---|---|---|
| 1 | 63[a]/1.5[b] | 46[a]/92[b] |
| 2 | 50[a]/2.5[b] | 33[a]/81[b] |
| 3 | 28[a]/4.9[b] | 57[a]/85[b] |
| 6 | 54[a]/5.2[b] | 60[a]/81[b] |

[a]preoperative data; [b]postoperative data

operation could not be obtained. In all patients the apnea index (AI) was decreased to be within a normal range. The AI average was changed from $49\pm15$ to $3.5\pm1.8$ ($p<0.05$). The lowest oxygen saturation (LSAT) increased from $42\pm26$ to $85\pm5$ ($p<0.05$). The changes of both AI and LSAT were statistically significant. These results are summarized in Table 3.

## DISCUSSION

Previous studies have demonstrated that recordings of pressure could be made at multiple sites along the upper airway collapse during sleep in OSAS (Issa and Sullivan 1984; Shepard and Thawley 1990; Gleadhill et al. 1991; Shepard et al. 1991). In the present study, we also determined the localization of the upper airway collapse using micro-pressure transducers. These transducers were well tolerated, and in no case was recording terminated earlier than planned. No epistaxis or mucosal tears in the nasal cavity appeared as possible complications. Upper airway obstruction in OSAS patients may be localized at different segments from the epipharynx to the hypopharynx. However, both the velopharyngeal and hypopharyngeal segments are the most common sites of airway collapse (Shepard and Thawley 1990; Shepard et al. 1991; Skatvedt 1995). Therefore, two transducers were used in the present study in order to distinguish the obstructive sites in the velopharynx and the hypopharynx. Our present findings showed that the majority of the patients (83%) had obstructions in their velopharyngeal segments, and in the hypopharynx in the remaining patient. Although the number of our subjects was too small to draw firm conclusions regarding the typical sites of obstruction, this variation is consistent with previous studies (Issa and Sullivan 1984; Shepard and Thawley 1990; Gleadhill et al. 1991; Shepard et al. 1991).

Three patients with obstructions solely in the velopharynx underwent UPPP, leading to satisfactory results in the postoperative sleep studies. One patient having the obstruction from the velopharynx to the hypopharynx received KTP/532-assisted MLG as well as UPPP procedure. MLG has variable results (Fujita et al. 1991; Woodson and Fujita 1992; Mickelson and Rosenthal 1997), but is effective in patients demonstrated to have hypopharyngeal narrowing. Furthermore, the MLG has the potential benefit of low rates of complications as compared

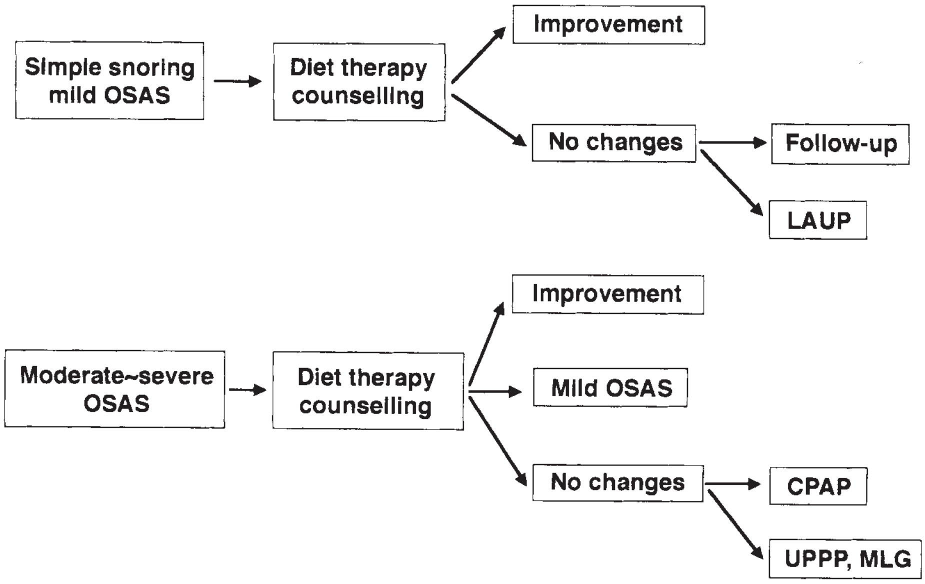


Fig. 3. Treatment algorithm for sleep-related disorders. LAUP, laser-assisted uvulopalatoplasty; UPPP, uvulopalatopharyngoplasty; CPAP, continuous positive airway pressure.

with other procedures for the enlargement of the hypopharyngeal airway, such as maxillary and mandibular advancement (Mickelson and Rosenthal 1997). Our case 1 with the obstruction of the hypopharynx showed a successful reduction of AI and an increase of LSAT following MLG.

Pressure measurement is a reliable tool for localizing obstructions in patients suffering from OSAS. This method is also promising for selection of the appropriate surgery. We think that this method of objective assessment may improve the success rate of surgical treatment for OSAS.

Finally, the approach to evaluating and treating patients with sleep-related disorders used at our clinic is presented in Fig. 3. Laser-assisted uvulopalatoplasty (LAUP), in which the surgical procedure is characterized by bilateral vertical incision through the palate at the base of the uvula using laser, is indicated for simple snorers and mild OSAS patients (Ikeda et al. 1997). Moderate to severe OSAS patients are considered to be candidates for UPPP and MLG on the basis of evaluation of the localization of the upper airway collapse. We emphasize that appropriate selection of the surgical technique needs accurate determination of the localization of airway collapse using objective methods.

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