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Strategies in the clinical diagnosis and surgical treatment of OSAHS with multilevel obstruction

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Abstract

Objective: To examine the safety and effectiveness of individualized treatment strategies that include three principles (security, top-down and priority) for patients with obstructive sleep apnoea hypopnea syndrome (OSAHS) and multilevel obstruction who decline therapy with continuous positive airway pressure (CPAP).

Methods: Patients with OSAHS and upper airway obstruction who were diagnosed with multilevel obstruction were included in this retrospective study. Patients were evaluated for the degree of obstruction in each level. Three principles were followed in planning the appropriate intervention level and measures to reduce perioperative risks. Polysomnography indices and Epworth sleepiness scores were used to evaluate the efficacy of surgery and improvement in patients' sleepiness at $\geq$3 months post-surgery.

Results: Among 51 patients with OSAHS and multilevel obstruction, three were treated with CPAP, 41 were treated with nasopharyngeal surgery, and seven were treated with oropharyngeal surgery. No severe complications were reported. Following surgery, apnoea hypopnea index and Epworth sleepiness scores were significantly reduced, and the lowest oxygen saturation level was significantly increased.

Conclusion: The three-principle strategy was safe and effective in planning surgical treatments for patients with OSAHS and multilevel obstruction.

Keywords

OSAHS, apnoea, hypopnea, multilevel obstruction, strategies, diagnosis and treatment

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Introduction

Obstructive sleep apnoea hypopnea syndrome (OSAHS) remains a common public health problem that significantly affects human health, particularly in those with severe OSAHS and continual serious hypoxaemia (author communication). Continuous positive airway pressure (CPAP) therapy is an effective intervention for patients with OSAHS if used as recommended,[1–3] however, with compliance varying from 54–80%,[4,5] the success rate of CPAP therapy is extremely low.[6] Stenosis and collapse of different levels in the upper airway play an important role in the development of OSAHS, thus, surgical intervention to remove upper airway obstruction remains an important option for patients with OSAHS and anatomic abnormalities. Aetiological variations between patients with OSAHS make it impossible to cure all cases via surgical intervention that removes obstruction at a single level. For example, the success rate of uvulopalatopharyngoplasty (UPPP) in the oropharyngeal level is approximately 40–60% for unselected patients with OSAHS, and the long-term outcome is less than satisfactory.[7] In clinical practice, the present authors have encountered many patients with severe OSAHS and coexisting obstructions of the nasopharyngeal and oropharyngeal levels, while obstruction of the hypopharyngeal level was relatively rare. The authors also note that perioperative risks in patients with multilevel obstructions are significantly increased, and epidemiological data show that the incidence of perioperative complications among patients with OSAHS is between 10% and 20%.[5,8] Practitioners should, therefore, strive to improve treatment effectiveness and reduce associated risks.

The present authors aimed to develop a clinical strategy to preoperatively assess the major obstructive level, by employing a variety of measures to ensure perioperative safety and surgical efficacy. In the present retrospective study, the perioperative risks to patients with OSAHS and coexisting obstructions of the nasopharyngeal and oropharyngeal levels were assessed. Diagnoses were made according to the apnoea hypopnea index (AHI) and lowest oxygen saturation ($LSaO_2$). Comprehensive and objective assessments of each upper airway level were performed through a series of clinical examinations, and the position and severity of each obstruction was determined. Thereafter, a basic judgement was made on the major obstructive level in order to more objectively select the level for surgical intervention. Three principles were applied in planning the appropriate level for intervention and measures to reduce perioperative risks: the security principle, the top-down principle, and the priority principle. The safety and effectiveness of the strategy was then investigated by examining data that was collected following treatment.

Patients and methods

Study population

In this retrospective cohort study, all adult patients with OSAHS who were admitted to the Department of Otorhinolaryngology at Jishuitan Hospital, Beijing, China between September 2014 and October 2016 were screened for study eligibility. Inclusion criteria were: (1) diagnosis of OSAHS according to the American Academy of Sleep Medicine (AASM) criteria;[9] (2) willingness to undergo surgical treatment; and (3) complete follow-up records. Exclusion criteria comprised: (1) sleep-disordered breathing due to particular disorders, such as thyroid dysfunction, narcolepsy, myasthenia gravis, recurrent laryngeal nerve paralysis, and central sleep apnoea syndrome; and/or (2) previous systematic treatment for OSAHS

(CPAP treatment for > 1 month, UPPP, maxillomandibular advancement, oral appliance therapy, or other). All patient data regarding preoperative assessments, treatment and follow-up assessments, as outlined below, were collected following treatment and follow-up. The study was approved by the Ethics Committee of Jishuitan Hospital, and all procedures were performed according to ethical standards of the institutional and national research committees and the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Written informed consent was obtained from all study participants.

Polysomnography and comprehensive preoperative assessments

A Conti polysomnography (PSG) system (Compumedics, Victoria, Australia) was used for monitoring sleep in all patients, and PSG was performed according to AASM standards.[10] The main diagnostic indices were AHI and $LSaO_2$ during sleep. An AHI of ≥ 5 times per hour was indicative of OSAHS: AHI values of 5–14, 15–30, or > 30 were considered to indicate mild, moderate or severe OSAHS, respectively. $LaSO_2$ values were used to assess hypoxaemia severity: values of $< 65\%$, 65–<85% or 85–90%, or were graded as severe, moderate or mild hypoxaemia, respectively.

Obstructed levels of the upper airway were evaluated by comprehensive preoperative assessments in all patients. Obstruction at the nasopharyngeal level was assessed by nasal endoscopy, acoustic rhinometry and rhinomanometry, and the nasal obstruction symptom evaluation (NOSE) scale.[11] Obstruction at the oropharyngeal level, which included the retropalatal and retroglossal regions, was comprehensively evaluated by fibronasopharyngoscopy combined with the results from Muller's test,[12] upper airway computed tomography (CT; in some patients only) using a Brilliance CT 64 Channel – DS scanner (Philips, Amsterdam, the Netherlands) and picture archiving and communication system (PACS), tonsil size, Mallampati score,[13] and Friedman stage.[14] Obstruction at the laryngopharyngeal level was assessed mainly by upper airway CT scanning or magnetic resonance imaging (MRI) using a 1.5 T Magnetom Sonata clinical MR scanner (Siemens, Berlin and Munich, Germany) with PACS, and fibronasopharyngoscopy combined with Muller's test. Epworth sleepiness scores[15] and NOSE scale scores were determined for all patients. Body mass index (BMI) was also included in the assessments, because obesity is an important risk factor for OSAHS and surgical treatment is not effective or safe for patients with a BMI > 35 kg/m^2.[9]

Therapy selection, follow-up, and efficacy assessment

Following preoperative assessments and inclusion into the study, patients' perioperative risks were evaluated according to PSG indices, BMI, and comorbidities (including hypertension, coronary heart disease, and chronic obstructive pulmonary disease). Furthermore, a baseline judgement about the major obstructive level was made. For instance, the oropharyngeal level with tonsil Grade III, Mallampati score 4 or Muller's test collapse 75–100% would be regarded as the major obstructed level. Patients were then provided with individualized treatment according to three principles: the security principle, the top-down principle, and the priority principle (all described further in the Discussion section).

All patients who underwent surgery were followed for > 3 months. A follow-up PSG examination was performed 3 months after surgery. The criteria used to evaluate the efficacy of surgical treatment for OSAHS were as follows: a reduction in AHI to < 5 represented a curative effect, and a reduction in AHI by 50% and to ≤20 was considered markedly effective (both were considered to represent treatment success). Outcomes beyond this range were considered to represent treatment failures. Epworth sleepiness scores were also measured to assess any improvement in daytime sleepiness. Improvements in nasal ventilation in patients treated by nasopharyngeal surgery were evaluated using NOSE score, acoustic rhinometry (unilateral nasal volume 0–5 cm [UV5] values), and nasal resistance.

Treatment complications were classified as follows: Severe complications mainly included severe bleeding, choking, or serious complications involving the cardiovascular and respiratory systems; Moderately severe complications regarding nasopharyngeal surgery, mainly included epistaxis of approximately 50–100 ml, and for oropharyngeal surgery, mainly included bleeding or swelling of the oropharyngeal mucosa. Incidence of post-surgical intensive care unit (ICU) stay was also analysed.

Statistical analyses

Data are presented as range, mean ± SD, or *n* (%) prevalence/incidence, and were statistically analysed using SPSS software, version 17.0 (SPSS Inc., Chicago, IL, USA). Epworth sleepiness scores, NOSE score, acoustic rhinometry, rhinomanometry, and PSG monitoring indices before and after surgery were compared. Student's *t*-test or paired *t*-test was used to compare results between different surgical groups or before and after surgical intervention.[16] A two-tailed P value < 0.05 was considered statistically significant.

Table 1. Baseline characteristics of patients with OSAHS and multilevel obstruction.

	Study group (n = 51)	
Characteristic	Range	Mean ± SD
Age, years	18–68	40 ± 11.95
BMI, kg/m^2	21–36	28 ± 3.18
AHI, episodes/h	15–83	46 ± 20.60
$LSaO_2$, %	64–85	75 ± 7.52
Follow-up duration, months	4–41	10 ± 15.47

AHI, apnoea hypopnea index; BMI, body mass index; $LSaO_2$, lowest oxygen saturation; OSAHS, obstructive sleep apnoea hypopnea syndrome.

Results

Baseline characteristics of patients

Following preoperative assessments, a total of 51 patients with OSAHS and multilevel obstruction were included in the study (6 female and 45 male patients; Table 1).

Three patients with a BMI > 35 kg/m^2 and $LSaO_2 < 65\%$ were treated with CPAP at the discretion of Ear/Nose/Throat (ENT) doctors and technicians. All three patients displayed good treatment compliance (duration of CPAP treatment > 4 h per day). The remaining patients were treated with either nasopharyngeal surgery ($n = 41$; including nasal cavity ventilation expansion techniques, and nasal polyp resection), or oropharyngeal surgery ($n = 7$; including tonsillectomy, H-UPPP,[17] glossectomy or H-UPPP plus glossectomy, depending on the anatomic abnormalities of the oropharyngeal level).

Safety of surgical intervention

All 48 surgical patients remained safe during the perioperative period without any cases of severe bleeding, choking, or serious cardiovascular and respiratory complications, and none required prophylactic tracheotomy. All of the patients recovered

Table 2. Epworth sleepiness score (ESS) and polysomnography indices before and after surgery in 48 patients with obstructive sleep apnoea hypopnea syndrome and multilevel obstruction.

	ESS		AHI (episodes/h)		$LSaO_2$ (%)	
	Group		Group		Group	
Time-point	A	B	A	B	A	B
Preoperative	11 ± 5.01	13 ± 4.71	48 ± 18.61	41 ± 20.52	70 ± 7.24	72 ± 6.67
Postoperative	7 ± 3.34	6 ± 4.30	28 ± 20.80	14 ± 16.25	80 ± 7.98	86 ± 10.08
t value	2.70	5.08	8.53	12.97	2.42	7.41
Statistical significance	$P = 0.01$	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P = 0.02$	$P < 0.001$

Data presented as mean ± SD.
Statistically significant differences at $P < 0.05$ (Paired *t*-test).
AHI, apnoea hypopnea index; $LSaO_2$, lowest oxygen saturation; Group A, nasopharyngeal surgery; Group B, oropharyngeal surgery.

without any severe complications during the post-surgical follow-up period.

Efficacy of surgical intervention

All 48 surgical patients were followed for more than 3 months. Daytime sleepiness symptoms caused by long-term intermittent hypoxia was shown to be significantly improved in all patients (Epworth sleepiness scores, $P < 0.05$; Table 2). AHI was also significantly reduced, and $LaSO_2$ was significantly increased, following surgery ($P < 0.05$, Table 2). In the subgroup of patients treated with nasopharyngeal surgery ($n = 41$), the nasal mucosa showed uneventful recovery. Nasal obstruction symptoms and nasal ventilation function were significantly improved: Unilateral nasal volume of 0–5 cm (UV5) was significantly increased, and nasal resistance (NR) and NOSE scores were significantly decreased ($P < 0.001$, Table 3). There was no statistically significant difference in BMI before and after surgery among the 48 patients with OSAHS and multilevel obstruction who underwent surgical treatment ($P > 0.05$).

Patient-centred clinical outcomes, such as cure rate and success rate, complications, and rate of postoperative ICU admission in patients treated with nasopharyngeal or oropharyngeal surgery are summarized in Table 4. The overall success rate (cure plus success) in patients who received nasopharyngeal surgery ($n = 41$) was 83%, with a failure rate of 17%. Moderately severe complications were observed in 6/41 patients (15%) and there was a 10% ICU admission rate. In patients who received oropharyngeal surgery ($n = 7$) there was a 100% success rate, with a moderate complications rate of 29% and one admission to the ICU. There were no severe complications in either group.

Discussion

The increased stress burden resulting from structural abnormalities of the upper airway is one of the most important factors in the pathogenesis of OSAHS,[18,19] and it is essential, therefore, to provide comprehensive therapy to eliminate these structural abnormalities. To date, most attention has been paid to treating oropharyngeal level obstruction and multilevel obstructions in patients with OSAHS have been relatively neglected. Similar to UPPP, which is aimed at the oropharyngeal level, the clinical

Table 3. Nasal obstruction symptom evaluation (NOSE), unilateral nasal volume 0–5 cm (UV5), and nasal resistance (NR) before and after nasopharyngeal surgery in 41 patients with obstructive sleep apnoea hypopnea syndrome and multilevel obstruction.

	Parameter		
Time-point	NOSE	UV5 (cm^3)	NR (kPa.s/L)
Preoperative	10±3.86	5.29±1.6	0.47±0.35
Postoperative	4±2.28	7.10±2.39	0.21±0.09
t value	11.20	4.43	4.30
Statistical significance	$P < 0.001$	$P < 0.001$	$P < 0.001$

Data presented as mean ± SD.
Statistically significant differences at $P < 0.05$ (Paired *t*-test).

Table 4. Cure/success rates, complications and rate intensive care unit (ICU) stay following surgery in 48 patients with obstructive sleep apnoea hypopnea syndrome and multilevel obstruction.

	Surgical efficacy			Complications		
Study group	Cure	Success	Failure	Severe	Moderately severe	ICU stay rate
Nasopharyngeal surgery ($n = 41$)	2 (4.9)	32 (78)	7 (17.1)	0	6 (14.6)	4 (9.8)
Oropharyngeal surgery ($n = 7$)	2 (28.6)	5 (71.4)	0	0	2 (28.6)	1 (14.3)

Data presented as *n* (%) incidence.
Surgical efficacy: Cure, reduction in apnoea hypopnea index (AHI) to < 5; Success, reduction in AHI by 50% and to ≤20; Failure, outcomes beyond this range.
Complications: Severe, mainly includes severe bleeding, choking, or serious cardiovascular and respiratory complications; Moderately severe, mainly includes epistaxis of about 50–100 ml (nasopharyngeal surgery), or bleeding or swelling of oropharyngeal mucosa (oropharyngeal surgery).

outcome following treatment of the oropharyngeal level obstruction is unsatisfactory.[7] Nevertheless, surgical intervention remains important for relieving upper airway obstruction and improving airway ventilation. With increased recognition of the existence of multilevel obstruction in patients with OSAHS, comprehensive therapy for multilevel obstruction has received increasing attention.[20] The upper airway consists of three levels: nasopharyngeal, oropharyngeal and laryngopharyngeal, and each of them plays an important role in the pathogenesis of OSAHS. According to the present authors' clinical observations, the proportion of patients with OSAHS and coexisting nasopharyngeal and oropharyngeal level obstruction requiring surgical intervention is more than 50%, and the percentage of patients with moderate-to-severe OSAHS is as high as 70% (unpublished data). Thus, the present strategies may benefit at least half of patients with OSAHS.

Increased nasal resistance is documented to be one of the underlying pathogenic factors of OSAHS,[21] and is mainly attributed to deviation of the nasal septum, turbinate hypertrophy, nasal polyps, or adenoid hypertrophy. However, in the authors' personal experience, increased nasal resistance is often neglected by patients and doctors, likely due to long-term tolerance of the subjective symptoms of nasal obstruction.

Obstruction at the oropharyngeal level is a common characteristic of upper airway obstruction among patients with OSAHS,[22,23] and obstruction in the retropalatal region is usually caused by soft palate hypertrophy, lateral pharyngeal wall hypertrophy, tonsillar hypertrophy, and so on. Obstruction of the retroglossal region is often attributed to tongue body hypertrophy, lingual tonsil hyperplasia, and micrognathia, all of which may cause glossoptosis. Obstruction of the laryngopharyngeal level rarely occurs, likely due to the supportive hyoid bone and epiglottis. At present, there are several challenging issues when considering the level for intervention and measures to reduce perioperative risks for patients with OSAHS and multilevel obstruction. First, there is no evidence-based clinical strategy for the diagnosis and treatment of patients with OSAHS and multilevel obstruction, thus, treatment approaches are often based on personal clinical experiences. Secondly, the majority of patients with OSAHS and multilevel obstruction have moderate-to-severe hypoxaemia and the perioperative risk is very high. Thirdly, the therapeutic effectiveness of surgery focusing on the oropharyngeal level is limited.[7] Therefore, based on decades of clinical experience, the present authors have summarized below a basis for diagnostic and therapeutic strategies for treating patients with OSAHS and multilevel obstruction:

(1) Security principle: To ensure the safety of patients with OSAHS and to reduce the incidence of serious perioperative complications, the security principle should be considered the most important and a priority when treating patients with OSAHS. The principal includes three aspects: First, CPAP treatment should be considered during the perioperative period, particularly for high-risk patients with OSAHS who have a $LSaO_2$ level $< 65\%$, or a BMI > 35 kg/m^2, or severe comorbidities (hypertension, coronary heart disease, chronic obstructive pulmonary disease, etc). CPAP is necessary prior to surgery in order to increase the $LSaO_2$ to at least 65%. Preoperative CPAP treatment is able to alleviate the airway inflammatory reaction, reduce the incidence of postoperative cardiovascular complications,[24] and make adaptable preparation for postoperative CPAP therapy. Respiratory centre dysregulation is another risk factor for repeated respiratory incidences in patients with OSAHS,[25] and CPAP treatment during the perioperative period can increase tidal volume in patients with OSAHS and gradually improve respiratory centre function. Furthermore, preoperative CPAP treatment can improve patients' tolerance of surgery and anaesthesia,[26] reducing the incidence of perioperative complications such as postoperative bleeding, airway obstruction and tracheotomy need. In 2014, the American Society of Anaesthesiologists named CPAP treatment for the routine perioperative management of high-risk patients with OSAHS.[27] Secondly, intervention at the nasopharyngeal level may be better than other levels in patients with severe OSAHS and multilevel obstruction, as the nasopharyngeal level is supported by cartilage and bone, and is not liable to collapse, unlike the oropharyngeal level, which is formed of muscular lumen. Thus, for patients with severe OSAHS, although obstruction at the oropharyngeal level is sometimes more serious than that of the nasopharyngeal level, it may still be preferable to manage the nasopharyngeal level in order to reduce perioperative risk and gradually improve patients' long-term nightly blood oxygen state. Thirdly, postoperative intensive care unit (ICU) monitoring of patients should be considered, as perioperative risks in patients with severe OSAHS and serious hypoxaemia are increased significantly, particularly in those treated with

oropharyngeal surgery. Postoperative ICU monitoring of high-risk patients with OSAHS should last at least 24 hours to ensure postoperative patient safety.

(2) Top-down principle: In cases of OSAHS with multilevel obstruction, intervention at the nasopharyngeal level should be given priority when patients' perioperative safety can be guaranteed. Thus, if there is no significant difference in the degree of obstruction between the nasopharyngeal and oropharyngeal levels after a series of clinical ENT examinations, the nasopharyngeal level, which is regarded as the source factor for upper airway obstruction, should be preferred for intervention, to break the vicious cycle, and gradually improve ventilation and quality of life.[28] The nasal and oral cavities are both parts of the upper airway and are anatomically continuous, thus, both have a very close relationship with the development of OSAHS. Relieving obstruction at the nasopharyngeal level is important because: (1) as the source of upper airway obstruction,[29] it is helpful to alleviate or decrease the degree of upper airway obstruction, reduce the fore-resistance of upper airway ventilation, correct or improve collapse of the oropharyngeal cavity, and restore normal ventilation function; (2) it is beneficial to reduce mouth breathing caused by nasal obstruction and to further reduce obstruction in the retroglossal region caused by tongue falling; (3) with lower perioperative risks, surgery at the nasopharyngeal level may help to gradually improve symptoms of hypoxaemia, alleviate the airway inflammatory response caused by chronic hypoxaemia, and ensure safety for later surgery at the oropharyngeal level; and (4) surgery aimed at the nasopharyngeal level, such as nasal cavity ventilation techniques[29] would significantly decrease nasal resistance and nasal obstruction, which may increase CPAP therapy compliance among patients with nasal obstruction.[30,31]

(3) Priority principle: If perioperative safety is ensured and the degree of obstruction is significantly different between the nasopharyngeal and oropharyngeal levels, the more seriously obstructed level should be prioritised for intervention. The priority for treatment depends on which approach is likely to most improve the patient's condition. Patient compliance and familial support affect treatment options and subsequent therapy, thus, if a patient will accept only one operation, clinicians should optimise surgical effectiveness by intervening at the more seriously obstructed levels, as much as possible. Obstruction of the upper airway is relatively complicated, and a single examination cannot objectively and completely reflect the condition of the whole upper airway. Thus, a comprehensive and objective judgement must be made regarding the degree of obstruction at different levels via multilevel examinations. There are multiple, scientifically recognized clinical examinations that can be used to assess the degree of airway obstruction at different levels. For example, current clinical examinations aimed to evaluate the degree of nasopharyngeal obstruction usually include nasal endoscopy, acoustic rhinometry, rhinomanometry, and imaging examinations, and subjective nasal obstruction symptoms should also be considered. Additionally, in the present authors' experience, some patients with OSAHS do not feel an apparent nasal obstruction in the daytime but then breathe through the mouth during sleep. This group of patients should receive careful attention, and nasal surgery,[32] such as nasal cavity ventilation expansion techniques, could remove the obstruction at the nasopharyngeal level. Such surgeries may include nasal septum deviation correction, inferior turbinate surgery, middle turbinate surgery and sinus surgery. The main oropharyngeal level assessments include drug-induced sleep endoscopy,[33] tonsil size, Mallampati score,

nasopharyngeal (electronic) fibreoptic laryngoscopy examination with Muller's test, upper airway CT measurements, apnoea graph, and drug-induced sleep endoscopy. Maxillofacial dysplasia, such as mandibular deformity, should also be noted.[34] Furthermore, other procedures such as H-UPPP, transpalatal advancement, hyoid suspension, glossectomy, genioglossus advancement and their modifications are recommended for relieving an obstruction of the retropalatal or retroglossal regions.[35–39] Obstruction at the hypopharyngeal level is mostly caused by organic diseases, such as infant type epiglottis, epiglottis collapse, giant epiglottic cyst or vocal cord polyp, and can be identified by nasopharyngeal (electronic) fibreoptic laryngoscopy, CT, and MRI. Although the retropalatal region is considered the most common site of obstruction in patients with OSAHS,[40] determination of the major obstructed level of the upper airway prior to surgery is often made by clinical experience, and there are no definitive diagnostic methods.

The above three principles formed the treatment strategies in the current study, and were applied comprehensively for patients with OSAHS and multilevel obstruction. The security principle was the first to be applied in planning surgical treatment for patients with OSAHS and multilevel obstruction. The top-down and priority principles were comprehensively used together, rather than in isolation, to help clinicians choose the appropriate intervention level.

The results of the present study may be limited by several factors. Since the study was observational in design, there are inherent limitations to the methodology.[41] For example, confounding factors, which are prevalent in observational studies, may have affected the outcomes of the present approach, and no adjustment for confounding factors was performed in the present analyses. In future, confounding factors will be accounted for using appropriate statistical methods such as a multivariable regression model[42,43] and propensity score analysis.[44] In addition, drug-induced sleep endoscopy will be added to the evaluation of upper airway obstruction level. Secondly, the study is limited by the small sample size. As a result, the possibility of spurious findings cannot be fully excluded, and the present results need to be validated in an external cohort.

In conclusion, the present strategies based on the security principle, top-down principle, and priority principle, ensured patients' perioperative safety, reduced the incidence of serious complications, and significantly alleviated apnoea-hypopnea and daytime sleepiness (which may improve quality of life), in patients with OSAHS and multilevel obstruction. Thus, the present authors believe that these treatment-strategy principles are extremely valuable in planning surgical treatments for patients with OSAHS and multilevel obstruction. For a proportion of patients with OSAHS and multilevel obstruction, surgical intervention at one single obstructed level may not be effective. If necessary, further surgery should be performed to correct structural abnormalities of the upper airway as much as possible, and to gradually reduce the adverse effects caused by chronic night time hypoxia.

Declaration of conflicting interest

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