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Original Article

Combined hyoid suspension with Repose system, uvulopalatopharyngoplasty and radiofrequency ablation in treatment of moderate and severe obstructive sleep apnea hypopnea syndrome

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Abstract: *Background:* Obstructive sleep apnea hypopnea syndrome (OSAHS) is the sleep respiratory disease. Uvulopalatopharyngoplasty (UPPP) and radiofrequency ablation are commonly used for OSAHS, but the efficacy is not very good for moderate and severe OSAHS. This study aimed to investigate the outcomes of combined hyoid suspension with Repose system, UPPP and radiofrequency ablation in treatment of moderate and severe OSAHS. *Methods:* Ninety patients with moderate and severe OSAHS were divided into group A and B, 45 cases in each group, in which the combined hyoid suspension with Repose system, UPPP and tongue base radiofrequency ablation and the combined UPPP and tongue base radiofrequency ablation were performed, respectively. After 6 months from the surgery, the total treatment efficacy was evaluated, and the apnea hypopnea index (AHI), lowest arterial oxygen saturation ($LSaO_2$), Visual Analogue Scale (VAS) score and Epworth Sleepiness Scale (ESS) score were measured. *Results:* The treatment effective rate in group A was 95.55%, which was significantly higher than 82.22% in group B ($P<0.05$). After treatment, the AHI in group A was significantly lower than that in group B ($P<0.01$), the $LSaO_2$ in group A was significantly higher than that in group B ($P<0.01$), and the VAS and ESS scores in group A were significantly lower than those in group B, respectively ($P<0.01$). The severe complications rarely occurred in each group. *Conclusion:* Combined hyoid suspension with Repose system, UPPP and tongue base radiofrequency ablation is safe and effective in the treatment of moderate and severe OSAHS, and has good clinical application prospect.

Keywords: OSAHS, hyoid suspension, Repose system, uvulopalatopharyngoplasty, radiofrequency ablation

Introduction

Obstructive sleep apnea hypopnea syndrome (OSAHS) is the sleep respiratory disease with unknown causes. The manifestations of OSAHS are the daytime sleepiness and nocturnal snoring and apnea. The nocturnal snoring and apnea can lead to hypoxia and hypercapnia which induce the cardiovascular diseases, diabetes, and even sudden death. Therefore, OSAHS is considered as a serious sleep respiratory disease with potential lethality [1]. The majority of OSAHS patients are accompanied by the obstruction and stenosis of multiple planes of upper airway in nasopharynx, oropharynx and hypopharynx, especially for severe OSAHS who are often with obesity, nasal septum deviation, tonsil hypertrophy, long soft palate, and turbinate hypertrophy [2]. Therefore, the nasal factors are the main causes for the onset of OSAHS. The occlusions of velopharyngeal plane and glossopharyngeal plane are the most common in OSAHS patients [3]. Uvulopalatopharyngoplasty (UPPP) is a common used surgery for OSAHS. However, it can only relieve the obstruction of the velopharyngeal plane, and has poor effect on the occlusions of glossopharyngeal plane [4]. In order to seek more effective methods for treatment of airway stenosis in OSAHS, the partial resection of tongue base [5], submaxillary hyoid suspension [6], maxillary and mandibular advancement are often performed [7]. The combination of these surgeries with UPPP can greatly increase the effective rate of treatment. The hyoid suspension with endoscopic assisted

Table 1. Comparison of general information between two groups

Group	A (n=45)	B (n=45)	P
Age (years)	37.26±4.36	41.71±3.82	>0.05
Gender (male/female, n)	39/6	40/5	>0.05
Disease course (years)	4.13±1.15	6.43±1.27	>0.05
BMI (kg/m^2)	20.20±2.01	23.40±1.9	>0.05
OSAHS severity of (moderate/severe)	34/8	33/15	>0.05
Friedman type (I/II/III)	16/26/2	18/24/4	>0.05
Hypertension complication	15	12	>0.05
Hypertension complication	6	8	>0.05

BMI, body mass index.

bone screw system (Repose system) is an effective surgical treatment for patients with OSAHS [8, 9]. This study investigated the outcomes of combined hyoid suspension with Repose system, UPPP and tongue base radiofrequency ablation in the treatment of moderate and severe OSAHS. The objective was to provide a basis for the further clinical application of this strategy.

Subjects and methods

Subjects

Ninety patients with moderate and severe OSAHS treated in The Central Hospital of Wenzhou City (Wenzhou, China) form October 2009 to June 2016 were enrolled in this study. There were 79 males and 11 females. The age of patients was 18-56 years, with mean of 38.95±4.55 years. The body weight of patients was 59-89 kg, with mean of 76.24±8.49 kg. The mean body mass index (BMI) was 16.56-24.67 kg/m^2, with mean of 21.22±4.04 kg/m^2. All patients had the complete data of preoperative polysomnography monitoring and upper airway obstruction positioning system monitoring (Apnea, Graph, AG 200; JC Medical Inc., CA, USA). According to the diagnosis and surgical treatment guidelines for OSAHS in 2009, the severity of OSAHS was determined based on the apnea hypopnea index (AHI) as follows: AHI 5-15 times/h, mild; AHI 15-30 times/h, moderate; AHI >30 times/h, severe. There were 67 and 23 cases with moderate and severe OSAHS, respectively. According to Friedman typing [10], there were 23, 33 and 4 cases with type II, III and IV, respectively. The course of disease was 1-9 years, 5.31±1.55 years. Twenty cases had different degrees of hypertension, and 9 cases were accompanied by hyperglycemia. This study was conducted with approval from the Ethics Committee of the Central Hospital of Wenzhou City. Written informed consent was obtained from all participants.

Inclusion and exclusion criteria

The inclusion criteria were follows: AHI >15 times/h; severe snoring and apnea; tongue and tongue hypertrophy; velopharyngeal and retrolingual stenosis showed by upper airway CT, lateral cephalometric radiograph or Muller scanning. The exclusion criteria were follows: AHI <15 times/h; severe deformity of maxillofacial region.

Grouping and treatment

All patients were treated with preoperative continuous positive pressure ventilation for 3-5 days. For patients with hypertension and hyperglycemia, the glucose-lowering and lipid-lowering treatment was performed, respectively, until the blood pressure or blood sugar was adjusted to normal levels. All patients underwent the surgery under general anesthesia by tracheal intubation, without tracheotomy. Ninety patients were randomized into group A and B, 45 cases in each group. In group A, the combined hyoid suspension with Repose system, UPPP and tongue base radiofrequency ablation were performed. In group B, only the combined UPPP and tongue base radiofrequency ablation were performed. The general information of two groups was shown in **Table 1.** There was no significant difference of age, gender, disease course, BMI, OSAHS severity, Friedman type hypertension complication, or hyperglycemia complication between two groups (P>0.05).

Hyoid suspension with Repose system

The patient was in supine position. After general anesthesia, the shoulders were padded, followed by the conventional disinfection of surgical site. A 3.0-4.0 cm arc incision was made at the cervical hyoid plane. The skin, subcutaneous tissue and platysma myoides were cut open. The flap was separated from the deep

platysma surface to the lower margin of mandible. The hyoid was exposed. The infrahyoid muscles were cut off. For cases with excessive fat accumulation in front of the neck, the excess fat was removed. The periosteum of the lower border of mandible was separated. The bone screw with 2 polypropylene sutures was inserted into the median medial surface of mandible (1.0 cm from the median line of mandible) using the Repose bone screw implant. One polypropylene suture was pierced from the deep surface of hyoid, and the hyoid bone was clamped using tissue forceps so that it could be lifted as far as possible. Two polypropylene sutures were knotted and fixed. After surgery, the patients were moved in ICU for 24-48 h to reduce the incidence of respiratory accidents. After 2 days, the drainage strip was removed, and the polypropylene sutures were taken out after 7 days.

UPPP

The bilateral tonsils and excess mucous membranes were removed. The palatal arch and palatine arch were contrapuntally sutured to extend the effective cross sectional area of oral cavity. An inverted "U" shape incision was made on both sides of the uvula. The excess submucosal fat was removed, protecting the palatosalpingeus and levator veli palatini. The soft palate pharyngeal mucosa was pulled forward to be sutureed with the palate oral mucosa. If the uvula was too long, it could be appropriately truncated. For retaining the full-length uvula, the upper end of the velopharyngeal muscle was cut off to eliminate the pulling of uvula by velopharyngeal muscle and increase the soft palate pharyngeal space.

Tongue base radiofrequency ablation

The tongue body was towed using 7# suture. After identifying the circumvallate papillae, 6-8 points were designed from the both sides of central line in posterior middle part of tongue to the front of the tongue. The distance from each point to the central tongue line was more than 0.5 cm, with depth of about 2.0 cm. Two points were designed at the inside site <1.0 cm from margo linguae, with distance more than 1.5 cm from the palatoglossal arch. ENT-Cobiator cryogenic plasma radiofrequency operating system (ArthroCare Corp., CA, USA) was used for ablation. The power was set at the grade 6. The one-time Refex55 plasma radiofrequency cutter head was used to ablate the tongue body, 15 s for each point.

Observation indexes

Before and after 6 months from the surgery, the AHI [11], lowest arterial oxygen saturation ($LSaO_2$) [12], Visual Analogue Scale (VAS) score [13] and Epworth Sleepiness Scale (ESS) score [14] were measured.

Evaluation of total treatment efficacy

The patients were reexamined 6 months after the surgery. According to the diagnosis and surgical treatment guidelines for OSAHS in 2009, the treatment outcome was divided into cured (AHI <5 times/h), markedly effective (AHI <20 times/h; AHI decrease ≥50%), effective (AHI decrease ≥50%), and ineffective (AHI decrease <50%). The effective rate was calculated based on the total effective number (cure + markedly effective + effective).

Statistical analysis

All statistical analysis was carried out using SPSS 22.0 software (SPSS Inc., Chicago, IL, USA). The enumeration data were presented as number and rate, and were compared using χ^2 test. The measurement data were presented as mean ± SD, and were compared using t test. $P<0.05$ was considered as statistically significant.

Results

Comparison of total treatment efficacy between two groups

In all 90 OSAHS patients, after 6 months from treatment, the nocturnal snoring almost disappeared. The mental status of patients and polysomnography outcome were improved significantly, compared with before treatment. There were 5, 33, 5 and 2 cases with cured, remarkably effective, effective and ineffective treatment outcome in group A, with 5, 24, 8 and 8 cases with cured, remarkably effective, effective and ineffective treatment outcome in group B. The effective rate in group A was 95.55%, which was significantly higher than 82.22% in group B ($P<0.05$) (**Table 2**).

Comparison of AHI and $LSaO_2$ between two groups

Before treatment, there was no significant difference of AHI or $LSaO_2$ between two groups ($P>0.05$). After 6 months from treatment, the AHI in two groups was significantly lower than

Table 2. Comparison of total treatment efficacy between two groups

Group	Total (n)	Cured (n)	Remarkably effective (n)	Effective (n)	Ineffective (n)	Effective rate (%)
A	45	5	33	5	2	95.55[a]
B	45	5	24	8	8	82.22
χ^2						4.050
P						0.044

[a]*P*<0.05 compared with B group.

Table 3. Comparison of AHI between two groups

Group	n	Before treatment	After treatment	t	P
A	45	52.34±6.29	14.87±2.17	37.776	<0.001
B	45	49.67±7.43	27.03±4.01	17.988	<0.001
t		1.840	-17.891		
P		0.069	<0.001		

AHI, apnea hypopnea index.

Table 4. Comparison of LSaO2 between two groups (%)

Group	n	Before treatment	After treatment	t	P
A	45	58.67±8.33	86.03±5.44	-18.448	<0.001
B	45	60.26±7.25	76.88±4.02	-13.449	<0.001
t		-0.966	9.074		
P		0.337	<0.001		

$LSaO_2$, lowest arterial oxygen saturation.

that before treatment (*P*<0.01), and $LSaO_2$ in two groups was significantly higher than that before treatment (*P*<0.01). In addition, after treatment, the AHI in group A was significantly lower than that in group B (*P*<0.01), and the $LSaO_2$ in group A was significantly higher than that in group B (*P*<0.01) (**Tables 3** and **4**).

Comparison of VAS and ESS score between two groups

As shown in **Tables 5** and **6**, before surgery, the VAS and ESS score had no significant difference between two groups, respectively (*P*>0.05). After 6 months from treatment, the VAS and ESS scores in two groups were significantly decreased, respectively, compared with before treatment (*P*<0.01). In addition, the VAS and ESS scores in group A after treatment were significantly lower than those in group B, respectively (*P*<0.01).

Complications

In ninety OSAHS patients, there were 6 cases with postoperative severe hemorrhage, and the amount of bleeding was more than 200 ml. In group A, there were 4 cases of postoperative severe hemorrhage. The wound pseudo membrane at lower tonsil shed, and were sutured intermittently. In group B, there were 2 cases with postoperative severe hemorrhage, which was due to the pharyngeal venous plexus injury of lower tonsil. This was treated by iodoform gauze packing for 48 h. In group A, there were 1 case with dysphonia and dysphagia after 2 years from surgery. In two groups, there was occurrence of other complications included eating nasal reflux, lower jaw swelling, fat liquefaction of neck wound, choking at drinking water, etc. All were cured by conservative treatment.

Discussion

In moderate and severe OSAHS patients, the multi-plane obstructions often exist in the upper airway, and the stenosis in posterior soft palate region, palatal region and tongue root region is the most common [15]. The simple UPPP surgery can only deal with the stenosis in soft palate plane, with no effect on the stenosis in tongue base plane [16]. In order to investigate the effect of UPPP surgery, Friedman et al [10] have developed a four-grade staging system based on the patient's BMI, tonsil size and tongue height. It is found that, the multi-plane upper airway obstruction often exists in OSAHS patients with grade III-IV, and the simple UPPP surgery can only relieve the oropharyngeal obstruction. Only the combination with treatment of tongue base plane can achieve a good therapeutic result.

Hyoid suspension surgery was firstly reported by scholar DeRowe et al [17], which was applied in tongue traction for treating OSAHS. The advantages of this model include minimal invasion, easy mastering, short operation procedure, little complication and easy acceptance by patients [18]. In this study, the Repose system was used in Hyoid suspension surgery. The hyoid was suspended in the direction of the mandible to enlarge the space of the hypopharyngeal space. At the same time, the UPPP and tongue base radiofrequency ablation were performed. Results found that, after 6 months from treatment, both the group A and group B could obtain satisfactory therapeutic effect. In

Table 5. Comparison of VAS score between two groups

Group	n	Before treatment	After treatment	t	P
A	45	7.05±1.33	2.05±0.56	23.242	<0.001
B	45	7.34±2.01	4.56±1.89	3.8061	<0.001
t		-0.807	-8.542		
P		0.422	<0.001		

VAS, Visual Analogue Scale.

Table 6. Comparison of ESS score between two groups

Group	n	Before treatment	After treatment	t	P
A	45	12.76±2.24	6.01±1.27	17.585	<0.001
B	45	13.01±2.59	8.49±2.02	9.231	<0.001
t		-0.490	-6.972		
P		0.626	< 0.001		

ESS, Epworth Sleepiness Scale.

addition, the effective rate in group A was significantly higher than that in group B (P<0.01); the AHI in group A was significantly lower than that in group B (P<0.01); the $LSaO_2$ in group A was significantly higher than that in group B (P<0.01); the VAS and ESS scores in group A were significantly lower than that in group B, respectively (P<0.01). This indicates that, compared with combined UPPP and tongue base radiofrequency ablation, the combined hyoid suspension with Repose system, UPPP and tongue base radiofrequency ablation can obtain better treatment outcome.

In the present study, there were 6 cases (group A, 4 cases; group B, 2 cases) with postoperative severe hemorrhage. No other serious complication such as breathing difficulty occurred, and no tracheotomy was performed. In group A, there was only 1 case with dysphonia and dysphagia after 2 years from surgery. This indicates that, the combined hyoid suspension with Repose system, UPPP and tongue base radiofrequency ablation is relatively safe in treatment of OSAHS. However, for severe OSAHS patients, the staged oropharyngeal and retrolingual surgeries are safer. For obese OSAHS patients with BMI > 34 kg/m^2 which are the high-risk group of cardiovascular and cerebrovascular accidents during perioperative period, it is suggested to conduct the weight-reducing treatment firstly.

In the combined hyoid suspension with Repose system, UPPP and tongue base radiofrequency ablation, avoiding the postoperative complications is very important, The following points should be given great importance: i) special care should be taken for the lower polar suture of the tonsil, and the suture must be tightly packed to stop bleeding thoroughly. If the bleeding point is deep, and cannot be touched, the aseptic iodoform gauze can be used for hemostasis; ii) the extubation should be performed after the patient is completely awake; in order to determine whether the catheter can be pulled out, the air sac is relaxed firstly; if the air sac size does not change, which shows that the airway pressure is large, the extubation cannot be conducted; iii) the oxygen equipment, rescue equipment, emergency medicine, thyrocricoid puncture bag and tracheotomy bag should be in-bed equipped after surgery. Our experience is that, the extubation is performed after more than 3 h from stopping anaesthesia. Before extubation, the secretion obstruction in the trachea cannula should be paid attention, especially for preventing the respiratory complications. In addition, the patient can be asked to cough, to prevent the sudden asphyxia. If asphyxia occurs, the secondary trachea intubation should be performed immediately.

There are two main points in hyoid suspension with Repose system as follows: i) before the bone screw inserting into the mandible, the periosteum of the implant should be completely stripped, and the surrounding soft tissue should be removed, otherwise the bone screw cannot be implanted or is easily loosened after implantation; ii) during surgery, the operator should avoid clamping polypropylene suture by vessel forceps or folding the suture, otherwise the suture is easy to break and is difficult to fix the tongue.

In conclusion, the combined hyoid suspension with Repose system, UPPP and tongue base radiofrequency ablation is safe and effective in the treatment of moderate and severe OSAHS, and has good clinical application prospect. This study still has some limitations. The sample size of this study is relatively small. Larger sample size will make the results more convincing.

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Disclosure of conflict of interest

None.

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