LITERATURE REVIEW

Obstructive sleep apnea syndrome surgical treatment

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ABSTRACT

Obstructive sleep apnea (OSA) is characterized by a complete or partial collapse of the upper airways during sleep, with consequent cessation of breathing, despite ongoing respiratory effort. The treatment of choice is continuous positive airway pressure (CPAP) to expand the pharyngo-laryngeal lumen. For the patients who either fail or are unwilling to pursue CPAP, surgery offers a chance of improvement or success. In our experience, in moderate to severe OSA, the multilevel surgery is always associated with improved outcomes.
KEYWORDS: obstructive sleep apnea, CPAP, nasal surgery, pharyngeal surgery, laryngeal surgery

INTRODUCTION

Obstructive sleep apnea (OSA) is characterized by a complete or partial collapse of the upper airways during sleep, with consequent cessation of breathing, despite ongoing respiratory effort. The treatment of choice is continuous positive airway pressure (CPAP) to expand the pharyngo-laryngeal lumen. In cases of poor compliance in CPAP (especially in mild OSAS) or when other conservative therapies failed (i.e., mandibular retaining device), surgery represents a possible treatment option. The goal of surgery is obviously to remove the cause of the obstruction by acting on the involved sites. Surgical options depend on severity of the sleep disorder breathing (SDB).

While most patients undergo surgery because of CPAP intolerance, it is imperative that they use their CPAP for at least two weeks prior to and after surgery. This is so they do not accumulate a sleep debt. Hypertension should be treated aggressively in the perioperative period. After surgery, admission with pulse-oximetry and pain management with narcotics is required. Patients need to demonstrate the ability to tolerate a liquid diet, have adequate pain control, and have a safe airway prior to discharge.

SURGICAL TECHNIQUES

Nasal surgery

Multilevel anatomic obstruction is often present in snoring and obstructive sleep apnea. As the nose is the first anatomical boundary of the upper airway, nasal obstruction theoretically may contribute to sleep-disordered breathing (SDB). The nose accounts for more than 50% of the total resistance of the upper airway and nasal breathing serves important physiological functions, including humidification, heating and filtration. Nasal obstruction leads to various breathing disturbances, including a modified architecture and quality of sleep and a reduced nocturnal SpO_2[1,2]. Although the primary site of obstruction in OSAS patients is believed to be the oro-hypopharyngeal region, several lines of evidence suggest that experimental reduction of nasal patency and flow has a significant effect on breathing during sleep. The upper airway comparable to a Starling resistor predicts that a further obstruction upstream (nose) will generate a suction force (negative intraluminal pressure) downstream (oropharynx), resulting in oropharyngeal collapse in predisposed individuals[3]. This effect is exacerbated by the

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supine position, when the nasal resistance tends to increase both actively, due to postural reflex mechanisms, as well as passively, as a result of the reduced hydrostatic pressure on nasal venous circulation. Mouth opening, independent of the breathing route, is believed to increase the collapsibility of the upper airways as a result of a decrease in the contractility of the upper airway muscles. Oral breathing by nasal obstruction causes a negative pressure as well as vibration due to the Bernoulli effect at the narrowed oral airway: this mechanism may therefore aggravate the symptoms of OSA[4].

Various observational and cross-sectional studies have documented a relationship between chronic nasal obstruction and OSA[5]. The major nasal pathologies that can cause sleeping disorder are: allergic and non-allergic rhinitis, nasal polyps, nasal septal deviation and inferior turbinate hypertrophy. In general, rhinitis constitutes a pathologic condition characterized by an increase in nasal airway resistance due to mucosal swelling and therefore, theoretically, it may represent a risk factor for OSA. Several studies correlate the nasal congestion by allergic and non-allergic rhinitis as a risk factor for OSAS with different results. Epidemiological data have shown that chronic rhinitis symptoms and increased nasal resistance measured by rhinomanometry are associated with habitual snoring, but a similar association is not documented for OSAS.

Kohler et al[5] reviewed the Literature about the role of the nose in the pathogenesis of OSA. From the currently available data, the authors concluded that nasal congestion may contribute to the pathogenesis of OSA. Architecture and quality of sleep could be improved by treating nasal congestion, but clinical relevance remains to be proven. Nasal surgery may be helpful in patients who are unable to tolerate CPAP because of nasal obstruction, but this has never been proven in randomized controlled trials. Although there is no role for nasal surgery as single treatment for OSA, it is quite useful in improving symptoms in simple snorers and potentially useful as part of multilevel surgery in many patients with sleep related breathing disorders (SRBD). In CPAP failures, if upper airway evaluation demonstrates an obstructive nasal passage, then treating this certainly improves CPAP compliance and adherence. Nakata et al[6] suggest that nasal surgery is useful for lowering nasal resistance, ameliorating sleep-disordered breathing and improving sleep quality and daytime sleepiness in OSAS.

ERS task force[7] concludes that nasal surgery as a single intervention is not recommended for treatment of OSAS (grade of recommendation C), but is recommended for reducing high therapeutic CPAP pressure due to nasal obstruction.

Velo-palatal and pharyngeal surgery

The tonsils and retropalatal areas clearly represent common sites of obstruction in OSA.

Palatal stiffening by pillar implant technique may be useful only for a limited number of patients with mild to moderate OSA, who refused other conservative approaches. Palatal implants are expensive and a partial extrusion occurs in 10.3% of the patients[7]. The overall success rate is limited.

Laser-assisted uvulopalatoplasty (LAUP) is an office-based surgical procedure that progressively shortens and tightens the uvula and palate through a series of carbon dioxide laser incisions and vaporisations. This technique is affected by moderate or severe pain immediately after the procedure and it is weighed against the risk of scar contracture, which can reduce the effectiveness of surgery and lead to complications. In mild OSAS LAUP is not recommended (recommendation B)[7].

Radiofrequency (RF) surgery of the soft palate is applied by inserting the electrodes submucosally, usually into five sites of the soft palate, with a power setting of 10 W. This procedure represents a good treatment option in habitual snorers, but it is not recommended as a single-stage approach in mild OSAS, since the result is not superior to placebo[8].

Other procedures for soft palate stabilization have been proposed, such as using nasal septum cartilage or concha cartilage[9].

Uvulopalatopharyngoplasty[10] (UP3) is the single most common surgical procedure performed for the correction of retropalatal obstruction causing or contributing to OSAS. This basic procedure only corrects obstruction of the palate and tonsils. First, Fujita himself recognized that half of the patients submitted to UP3 were non-responders. For those with a component of hypopharyngeal obstruction (Types II and III in Fujita and Simmons classification[11]), the response rate is only 5.3%[12]. Actually, for patients with morbid obesity and pan-airway involvement, UP3 treatment is unsuccessful. Velopharyngeal insufficiency, dry throat and abnormal swallowing are the most frequent long-term side effects, especially if the surgical procedure is not performed properly. The UP3 failure may be also correlated with a persistent retropalatal obstruction due to the different experience of the surgeon and to the different anatomy. In patients who have failed UP3, a Z-palatoplasty (ZPP) may be brought. As described by Friedman et al[13], this surgical technique provides the removal of mucosa only, the splitting of the soft palate in the midline to create 2 Z-plasty flaps for reconstruction and a very meticulous 2-layered closure.

Anterior palatoplasty (modified cautery-assisted palatoplasty) was proposed by Pang[14] in the management of patients with mild-moderate OSA. This procedure is very simple and safe and, if associated to UP3, gives excellent results in patients type I Fujita.

Tucker Woodson[15] described a method of reconstructing the upper pharynx by performing a posterior maxillary osteotomy and advancing the soft palate anteriorly (posterior palatal osteotomy and palatal advancement flap). A 67% successful response rate was observed in patients who only underwent transpalatal advancement. This procedure enlarges only the upper oropharyngeal airway and can be indicated in UP3 failures.

Lateral pharyngoplasty has been proposed by Cahali[16] in 2003 for patients with moderate to severe OSA, in order to enlarge the collapsed lateral pharyngeal wall: the results seemed promising initially, but many patients had dysphagia postoperatively. The expansion sphincter pharyngoplasty basically consists of a tonsillectomy, expansion pharyngoplasty with or without superolateral incision on the soft palate, horizontal section and superolateral rotation of the palatopharyngeus muscle, a partial uvulectomy, and a closure of the anterior and posterior tonsillar pillars. The key of this procedure is to not completely isolate the muscle and rotate it. This procedure is simple to perform, but significant pain and swallowing problems may occur.

Tongue surgery

Isolated retrolingual obstruction is present in only 25% or less of patients with OSAS.

A variety of approaches have been described for lingual tonsillectomy and to advance the tongue base. Exposure of the tongue base is optimized via suspension laryngoscopy with endoscopy.

Radiofrequency tongue base ablation (RFA) is performed by a two-pronged insulated probe inserted into the tongue base around the level of the foramen cecum. Radiofrequency is delivered at a frequency of 465 KHz to ablate the tongue tissue and causes scar contracture, thus reducing the tongue volume. This can also be done in the office under local anaesthesia, or can be performed in the operating room under general anaesthesia. The best results have been seen when delivering a total of 12kJ in 8-12 locations, over a four-week period. This may also be done as a onetime procedure, but there is more risk of mucosal ulceration. Success rates are higher according to the subjects' posture with a rate of 87.5% for the supine position and 56.6% in non-supine positions[17].

Lingual tonsillectomy can be done with laser, diathermy, cryotherapy, ultrasonic coagulating dissector, microdebrider. The surgical technique should be always performed under visualization with telescope, and care should be taken to avoid damage to the lingual neurovascular bundle[18].

Laser midline glossectomy[19] enlarges the retrolingual airway by reducing the base of tongue by approximately 2.5 x 5 cm through an intraoral approach. Lingual tonsillectomy, epiglottectomy and aryepiglottic fold reduction may be performed at the same setting. More aggressive resection is associated with more frequent complications, such as lingual and airway edema necessitating tracheotomy.

The submucosal minimally invasive lingual excision (SMILE)[20] is a modified version of the description by Robinson et al of tongue base reduction using coblation through a suprahyoid neck approach. It provides a mucosal sparing approach while allowing aggressive tissue removal using a plasma-mediated radiofrequency device (coblation) under ultrasonic and endoscopic guidance. This procedure is performed under general anaesthesia and the course of the lingual arteries bilaterally is marked using intraoperative ultrasound for the guidance. An incision is made approximately 2 cm from the tongue tip, in the midline of the tongue, and the coblator is used to ablate tissue at the tongue base. Ablation is performed medially to the marked lingual arteries. The incision is left open and heals by secondary intention. This allows for a greater degree of tongue base reduction than radiofrequency tongue base ablation, with less morbidity than the midline glossectomy.

In 1999, Chabolle[21] proposed the tongue base reduction with hyoepiglottoplasty (TBRHE) through a cervical approach. The lingual neurovascular bundle must be carefully identified and a subtotal tongue base resection is performed. Then, the hyoid bone is suspended at the lower border of the mandible and finally a temporary tracheotomy is carried out. The authors reserve such treatment for obese patients with severe OSA (mean, RDI 70) in whom marked anomalies of hyolingual complex are present. Chabolle et al report that the infection is the most frequent complication: this can be attributed to the use of non-absorbable sutures for hyoid suspension. Non-severe abnormalities in the oral and pharyngeal phases of deglutition with videofluorographic examination are documented.

Also, in cases of anteroposterior collapse of the retrolingual airway, the genioglossus muscle advancement using the genioglossus bone advancement technique (GBAT) has been proposed[22]. It allows the opening of the retrolingual space by pulling the tongue base forward. The procedure is performed through a gingivobuccal incision. The midline of the mandible in the lingual cortex is the site of insertion of the genioglossus muscle. Osteotomies are made to mobilize the genial tubercle, with care not to cut the tooth roots. The gingival cortex is then drilled away and the segment is advanced and rotated. It is secured in place with 1 or 2 screws, and the wound is closed. In the case of inexperienced surgeons, detachment of the advanced genioglossus muscle, mandible fracture, or aesthetic changes of the chin may occur. Medium to long-term results are disappointing.

The tongue-base suspension can be obtained also by means of Repose system[23]. In our opinion, this procedure belongs to the past and should be forgotten.

Recently, in Literature, some reports about the partial glossectomy using of transoral robotic surgery (TORS) have been reported[24]. This procedure can be performed without the need for tracheotomy, but it has an increased morbidity compared with the other techniques as RFA or SMILE[25].

Hyoid advancement

Riley et al. first described in 1986 a hyoid suspension, although with an osteotomy of the mandible and the fixation of the hyoid bone to the mandible[26].

According to Hörmann and Baish[27], the modified hyoid suspension may provide a good benefit for a successful surgical therapy of OSA. Baish et al[28] believe that the hyoid suspension, as part of a multilevel surgery, has a success rate of 60%. In 2007, Lewis[29] proposed a modified technique of inferior hyoid advancement using 4 sutures between just below the superior border of the thyroid cartilage and the hyoid bone pulled completely over the anterior surface of the thyroid cartilage.

Maxillo-mandibular osteotomy (MMO)

Maxillo-mandibular advancement is clearly a very valid option for OSAS failures. This procedure is usually performed after the above surgeries have failed to improve obstructive sleep apnea and it is considered a phase II surgery. It requires extensive preoperative measurements and planning in order to achieve surgical success. Cephalometric analysis with aid of MRI can assist in evaluating the hypopharyngeal airway. The important landmarks are the sella (S), nasion (N), anterior nasal spine (ANS), gnathion (Gn), gonion (Go), A point (A), B point (B), posterior airway space (PAS) and the hyoid (H). The normal angle for SNA is 82 and the normal for SNB is 80. Splints need to be made with preoperative occlusion and intermediate occlusion. Advancement is performed by at least 10 mm for optimal results. A Lefort I osteotomy is performed with plating of the fractured segment after appropriate advancement. Bone grafts may need to be placed. The bilateral sagittal split osteotomy is then performed. The patient is kept in maxilla-mandibular fixation.

Most of these patients had undergone a staged surgery, often with UP3 and genioglossal advancement as part of a multilevel surgical program. The success rate of this group varies from 65.2% to 97.5%[30]. This kind of surgery is perceived as an unattractive treatment modality because of the possibility of a significant facial profile change. MMO is particularly indicated in presence of craniofacial abnormalities.

Laryngeal surgery

The larynx can also be a possible site of obstruction in OSA. First, Rubinstein et al[31] reported in 1989 that sleep-disordered breathing is associated with diffuse upper airway narrowing, including glottic and tracheal areas, and that obesity contributes to this narrowing. According to a Japanese study[32], a lower position of the larynx may be a risk factor for OSA. It is documented that an increase in the concavity of the posterior surface of the epiglottis can be correlated with the increase in BMI[33]. In the Literature, occasional cases in which the cause of OSA was laryngocele secondary to partial laryngectomy and epiglottic cyst have been reported[34]. An elongated, flaccid and lax epiglottis, displacing posteriorly during inspiration, can obstruct the airway in OSA, as well as in laryngomalacia. Epiglottis prolapse during inspiration is an unusual cause of OSA: it was founded in 11.5 per cent of patients who failed the UP3 procedure[35]. In these cases, a partial epiglottectomy with a CO_2 laser is indicated. In 85% of the adult patients, polysomnographic studies demonstrated a statistically significant improvement[36]. The epiglottis reshaping with CO_2 laser irradiation also gives a significant improvement in children with laryngomalacia and obstructive sleep apnea. The data suggest that this form of airway distress, characterized by prolapse of supraglottic structures into the glottic airway during inspiration, are an important contributor to OSA and that its correction can significantly improve sleep in children.

Skin-lined tracheostomy

Tracheostomy still represents the definitive surgery for upper airway obstruction, showing to be an effective single intervention to correct OSA. It is not a benign procedure and the toll on both the patient and family can be devastating, and it is not recommended as a primary therapy. This procedure bypasses the laryngeal airway and it is reserved for use in patients with severe OSA, who have failed to improve with other medical and surgical treatments, and in special cases in which these modalities are contraindicated or not tolerated. In OSA patients submitted to tracheostomy, a severe reduction in blood pressure and hypoglycemia were observed[37]. Tracheostomy is preferably carried out with the skin-lined technique[38] to guarantee greater stability, less risk of granulation tissue and wider opening than tracheotomy.

CONCLUSIONS

For the patients who either fail or are unwilling to pursue CPAP, surgery offers a chance of improvement or success. Few studies exist about randomized, controlled trials and in some cases the benefits of surgery are more subjective (improvement of daytime somnolence, quality of life and vigilance) than documented by polysomnography.

The choice among surgical procedures includes the consideration of risks as well as outcomes. According to Kezirian et al[39], the consideration of procedural risk is a central issue in surgical decision making. When examining an OSA patient, the assessment is critical in regarding the patient himself and in determining the different sites of obstruction. According to Riley et al[40] and Friedman et al[41], in 75% to 93.3% of OSAS patients, a multilevel obstruction is present. In our experience, in moderate to severe OSA, the multilevel surgery is always associated with improved outcomes.

REFERENCES

1. Zwillich C.W., Pickett C., Hanson F.N., et al. - Disturbed sleep and prolonged apnea during nasal obstruction in normal men. Am Rev Respir Dis., 1981;124:158-160.
2. Lavie P., Fishel N., Zomer J., et al. - The effects of partial and complete mechanical occlusion of the nasal passages on sleep structure and breating in sleep. Acta Otolaryngol., 1983;95:161-166.
3. Smith P.L., Wise R.A., Gold A.R., et al. - Upper airway pressure-flow relationships in obstructive sleep apnea. J Appl Physiol., 1988;64:789-795.
4. Olsen K.D., Kern E.B., Westbrook P.R. - Sleep and breathing disturbance secondary to nasal obstruction. Otolaryngol Head Neck Surg., 1981;89:804-810.
5. Kohler M., Bloch K.E., Stradling J.R. - The role of the nose in the pathogenesis of obstructive sleep apnea. Curr Opin Otolaryngol Head Neck Surg., 2009;17:33-37.
6. Nakata S., Noda A., Yasuma F., Morinaga M., et al. - Effects of nasal surgery on sleep quality in obstructive sleep apnea syndrome with nasal obstruction. Am J Rhinol., 2008;22:59-63.
7. Randerath W.J., Verbraecken J., Andreas S., et al. - Non-CPAP therapies in obstructive sleep apnoea. Eur Resp J, 2011;37:1000-1023.
8. Bäck L.J., Liukko T., Rantanen I., et al. - Radiofrequency surgery of the soft palate in the treatment of mild obstructive sleep apnea is not effective as a single-stage procedure: A randomized single-blinded placebo-controlled trial. Laryngoscope, 2009;119:1621-7.
9. Tolsdorff P., Honnef B. - Gaumen-Knorpel-Stabilisierung bei Schnarchen und mildem bis mittelschwerem obstruktivem Schlaf-Apnoe-Syndrom. Laryngorhinootologie, 2009;88:696-698.
10. Fujita S., Conway W., Zorick F. et al. - Surgical correction of anatomic abnormalities in obstructive sleep apnea syndrome: uvulopalatopharyngoplasty. Otolaryngol Head Neck Surg., 1981;89:923-934.
11. Fujita S., Simmons F.B. - Pharyngeal surgery for obstructive sleep apnea and snoring. In: Fairbanks D.N.F., Fujita S., Ikematsu T., et al, eds. - Snoring and Obstructive Sleep Apnea. NY Raven Press, 1987;p.101-128.
12. Sher A.E., Schectman K.B., Piccirillo J.F. - The efficacy of surgical modifications of the upper airway in adults with obstructive sleep apnea syndrome. Sleep, 1996;19:156-177.
13. Friedman M., Duggal P., Joseph N.J. - Revision uvulopalatoplasty by Z-palatoplasty. Otolaryngol Head Neck Surg., 2007;136:638-643.
14. Pang K.P., Tan R., Puraviappan P., et al. - Anterior palatoplasty for the treatment of OSA: three-year results. Otolaryngol Head Neck Surg., 2009;141:253-256.
15. Woodson B.T. - Transpalatal advancement pharyngoplasty. Operative Techniques in Otolaryngology - Head and Neck Surgery, 2007;18:11-16.
16. Cahali M.B. - Lateral pharyngoplasty: a new treatment for obstructive sleep apnea hypopnea syndrome. Laryngoscope, 2003 Nov;113(11):1961-8.
17. Babademez M.A., Ciftci B., Acar B., et al. - Low-temperature bipolar radiofrequency ablation (coblation) of the tongue base for supine-position-associated obstructive sleep apnea. ORL J Otorhinolaryngol Relat Spec., 2010;72:51-55.
18. Barakate M., Havas T. - Lingual tonsillectomy: A review of 5 years experience and evolution of surgical technique. Otolaryngol Head Neck Surg., 2008;139:222-227.
19. Fujita S., Woodson B.T., Clark J.L., et al. - Laser midline glossectomy as a treatment for obstructive sleep apnea. Laryngoscope, 1991;101:805-809.
20. Maturo S.C., Mair E.A. - Submucosal minimally invasive lingual excision (SMILE): Technique for tonguebase reduction. Operative Techniques in Otolaryngology – Head and Neck Surgery, 2007;18:29-32.
21. Chabolle F., Wagner I., Blumen M., et al. - Tongue base reduction with hyoepiglottoplasty: A treatment for severe obstructive sleep apnea. Laryngoscope, 1999;109:1273-1280.
22. Lewis M.R., Ducic Y. - Genioglossus muscle advancement with the genioglossus bone advancement technique for base of tongue obstruction. J Otolaryngol., 2003;32:168-173.
23. Fibbi A., Peirano M., Bertino G. - Mini-invasive surgical approach for obstructive sleep apnea syndrome (OSAS). A case report. Acta Otorhinolaryngol Ital., 2000;20:129-33.
24. Vicini C., Dallan I., Canzi P., et al. - Transoral robotic surgery of the tongue base in obstructive sleep Apnea-Hypopnea syndrome: anatomic considerations and clinical experience. Head Neck, 2012;34:15-22.
25. Friedman M., Hamilton C., Samuelson G.C., et al. - Transoral robotic glossectomy for the treatment of obstructive sleep apnea-hypopnea syndrome. Otolaryngol Head Neck Surg., 2012;146:854-862.
26. Riley R.W., Powell N.B., Guilleminault C. - Inferior sagittal osteotomy of the mandible with hyoid myotomy-suspension: A new procedure for obstructive sleep apnea. Otolaryngol Head Neck Surg., 1986;94:589-593.
27. Hörmann K., Baisch A. - How I do it: The hyoid suspension. Laryngoscope, 2004;114:1677-1679.
28. Baisch A., Maurer J.T., Hörmann K. - The effect of hyoid suspension in a multilevel surgery concept for obstructive sleep apnea. Otolaryngology Head Neck Surg., 2006;134:856-861.
29. Lewis R. - A modified technique of hyoid advancement. Operative Techniques in Otolaryngology – Head and Neck Surgery, 2007;18:17-19.
30. Lin H.C., Friedman M., Chang H.W., et al. - The Efficacy of Multilevel Surgery of the Upper Airway in Adults With Obstructive Sleep Apnea/Hypopnea Syndrome. Laryngoscope, 2008;118:902-908.
31. Rubinstein I., Bradley T.D., Zamel N., et al. - Glottic and cervical tracheal narrowing in patients with obstructive sleep apnea. J Appl Physiol., 1989;67:2427-2431.

32. Yamashiro Y., Kryger M. - Is laryngeal descent associated with increased risk for obstructive sleep apnea? Chest, 2012;141:1407-1413.
33. Gazayerli M., Bleibel W., Elhorr A., et al. - A correlation between the shape of the epiglottis and obstructive sleep apnea. Surg Endosc., 2006;20:836-837.
34. Araz O., Turan A., Yoruk O., et al. - Laryngocele and epiglottic cyst as rare causes of obstructive sleep apnea. Sleep Breath, 2009;13:285-287.
35. Catalfumo F.J., Golz A., Westerman S.T., et al. - The epiglottis and obstructive sleep apnoea syndrome. J Laryngol Otol., 1998;112:940-943.
36. Golz A., Goldenberg D., Westerman S.T., et al. - Laser partial epiglottectomy as a treatment for obstructive sleep apnea and laryngomalacia. Ann Otol Rhinol Laryngol., 2000;109:1140-1145.
37. Bhimaraj A., Havaligi N., Ramachandran S. - Rapid reduction of antihypertensive medications and insulin requirements after tracheostomy in a patient with severe obstructive sleep apnea syndrome. J Clin Sleep Med., 2007;3:297-279.
38. Campanini A., De Vito A., Frassineti S., et al. - Role of skin-lined tracheotomy in obstructive sleep apnea sindrome: personal experience. Acta Otorhinolaryngol Ital., 2004;24:68-74.
39. Kezirian E.J., Goldberg A.N. - Hypopharyngeal Surgery in Obstructive Sleep Apnea. An Evidence-Based Medicine Review. Arch Otolaryngol Head Neck Surg., 2006;132:206-213.
40. Riley R.W., Powell N.B., Guilleminault C. - Obstructive sleep apnea syndrome: a review of 306 consecutively treated surgical patients. Otolaryngol Head Neck Surg., 1993;108:117-125.
41. Friedman M., Ibrahim H., Bass L. - Clinical staging for sleep-disordered breathing. Otolaryngol Head Neck Surg., 2002;127:13-21.