Novel Surgical Approaches for the Treatment of Obstructive Sleep Apnea

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KEYWORDS

• Sleep apnea • Sleep surgery • Palate surgery • Expansion pharyngoplasty
• Upper airway stimulation • Hypoglossal nerve stimulation • Drug-induced sleep endoscopy

KEY POINTS

- Drug-induced sedation endoscopy provides diagnostic information about the anatomic structures, locations, and patterns of collapse under conditions that more closely resemble sleep rather than wakefulness.
- Improved phenotyping of the muscular and skeletal anatomy allows for integration of this anatomy into a customized medical and/or surgical treatment plan.
- Advanced palatal surgery techniques are now available that use more reconstructive and physiologically sound (rather than excisional) techniques to improve effectiveness and reduce morbidity.
- Upper airway neurostimulation therapy via an implantable hypoglossal nerve stimulation system has been shown to provide sustainable multilevel treatment of selected patients with moderate to severe obstructive sleep apnea with low morbidity and good adherence.

INTRODUCTION: THE ROLE OF SURGICAL THERAPY

Surgical therapy for obstructive sleep apnea (OSA) has traditionally been synonymous with uvulopalatopharyngoplasty (UPPP) from the perspective of many practicing sleep specialists as well as their patients. However, sleep-disordered breathing surgery encompasses dozens of surgical procedures and approaches for a wide variety of clinical applications:

- First-line surgical therapy to address intraluminal obstructing lesions, such as adenotonsillectomy in pediatric OSA
- Minimally invasive outpatient procedures for nonapneic snoring or upper airway resistance syndrome
- Nasal surgery to lower nasal airway resistance and augment the effectiveness of positive pressure or oral appliance therapy
- Hypoglossal nerve stimulation (HNS) therapy to augment the neuromuscular activity of the pharynx
- Multilevel upper airway reconstructive pharyngeal surgery as salvage after failure of medical device treatments
- Skeletal advancement surgery for patients with maxillomandibular deficiency or as salvage treatment
- Bariatric surgery to facilitate substantial weight loss
- Tracheotomy to bypass upper airway obstruction

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For the millions of patients who will not accept or are unable to adhere to positive pressure therapy (continuous positive airway pressure [CPAP]), surgical therapy can provide a method of symptom and quality-of-life improvement in addition to a reduction in cardiovascular risk. Surgical treatment of OSA has evolved rapidly over the last decade. Improved understanding of the pathophysiology of OSA and improved methods of airway evaluation, endoscopically and radiographically, have resulted in better phenotyping the various anatomic patterns of collapse and subsequent customization of novel surgical approaches.

Numerous modifications and advances in pharyngeal and skeletal surgical techniques have been reported around the world in the last decade. In addition, new implantable device technologies that use novel approaches to stabilize the airway continue to be developed every year. A comprehensive review of all such procedures and devices is beyond the scope of this article. The goal of this article, rather, is to highlight a few select novel diagnostic and therapeutic surgical approaches.

Novel Diagnostic Evaluation Approach

Drug-induced sedation endoscopy

Background By definition, almost all patients with OSA have some form of anatomic vulnerability of the upper airway. Successful OSA surgical therapy depends critically on proper knowledge and phenotyping of the upper airway structure and subsequently integrating that anatomy into surgical decision-making. Physical examination, lateral cephalometric radiograph, computed tomography scan, MRI, awake flexible nasolaryngoscopy, acoustic analysis, manometry, and drug-induced sedation endoscopy (DISE) represent some of the options available to better phenotype the structural anatomy of the upper airway.[1] One of the major limitations of most airway assessment techniques is that the information is usually obtained while patients are awake and upright, not in a sleep-disordered breathing state.

DISE allows for dynamic examination of the airway during conditions that more closely resemble the reduced upper airway dilator muscle activity and loss of control of breathing that occurs during sleep.[2] When performed under specific conditions and guidelines, propofol-induced sedation correlates most closely with deeper levels (stage N2) of non–rapid eye movement (NREM) sleep and maintains a similar AHI as compared with physiologic sleep.[3,4] Studies of sleep endoscopy have demonstrated validity, test-retest reliability, and interrater reliability.[5,6] Recent data suggest that utilization of DISE can improve treatment outcomes with oral appliances.[7–9] Evidence is emerging that certain DISE findings are related to treatment outcome and that DISE is a valuable selection tool in treatment decision-making.[10–15] Approximately 100 articles have been published on DISE just in the last 5 years. The recently published European position paper provides a comprehensive review and starting point for the reader interested in more in-depth analysis of the data and controversies surrounding DISE.[16]

Technique The goal of sedated endoscopy is to examine and phenotype the upper airway structure under conditions that more closely resemble sleep rather than wakefulness. Although the procedure was first described by Croft and Pringle in 199,[17] the foundation for the current procedure was established by Hillman and others[2] a decade or two later. Using the bispectral index score (BIS) monitor and a slow gradual propofol infusion (no benzodiazepine, no bolus), they demonstrated a nonlinear increase in upper airway collapsibility (pharyngeal critical pressure [Pcrit]) and decrease in genioglossus muscle activity occurring in a relatively narrow BIS range.[2]

The procedure is commonly performed in an outpatient surgery setting or bronchoscopy suite with standard anesthesia monitoring, including oxygen saturation, electrocardiogram, and blood pressure. In the author's medical center, patients receive an intravenous catheter in the preoperative area and glycopyrrolate to reduce secretions. Once in the surgical suite, patients remain on the same mobile bed where a BIS monitor and the standard anesthesia monitors are placed. One side of the nose is anesthetized and decongested with topical lidocaine and oxymetazoline. A slow gradual propofol infusion is initiated with a standardized protocol to titrate to clinical signs of sedation and sleep-disordered breathing as well as to a BIS level between 50 and 70.

The flexible endoscope is then inserted to examine both sides of the nose and the pharynx and larynx under the conditions that mimic sleep. When the steady state of snoring and obstructive sleep-disordered breathing is achieved (usually 5–10 minutes), the anatomic locations and pattern of collapse are recorded at baseline and again during other iterations as dictated by patients' clinical history (eg, with jaw advancement, with patients' own mandibular repositioning device in place, with changes in neck position). In patients with persistent AHI elevation on CPAP or other symptoms concerning for inadequate effectiveness of CPAP despite