

# Upper Airway Stimulation in Patients with Profound Sleep Apnea

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## Abstract

**Objective:** Evaluate the effectiveness of upper airway stimulation (UAS) in patients with profound obstructive sleep apnea (OSA), and compare outcomes to patients with lower apnea-hypopnea index (AHI).

**Methods:** Retrospective chart review of all patients undergoing UAS between 2014 and 2018 at a tertiary medical center. Profound OSA was defined as AHI > 65. Variables evaluated included demographics, nadir saturation, ideal voltage, device adherence, and follow-up. AHI at UAS titration was compared to preoperative polysomnography.

**Results:** 171 patients underwent UAS, of which 11 had a profound preoperative AHI. While the profound group was noted to have higher body mass index (0.026) and a trend towards lower oxygen nadir ( $p=0.12$ ), there was no statistically significant difference in treatment success (AHI < 20 with > 50% reduction) between the two groups ( $p=0.320$ ). However, the profound group had a statistically significantly elevated AHI at ideal UAS voltage,  $16.1 \pm 13.2$ , as compared to the non-profound group,  $5.6 \pm 8.1$  ( $p=0.025$ ). The profound group was more likely to have residual moderate OSA (AHI > 15) with treatment than the non-profound group ( $p=0.007$ ).

**Conclusion:** Patients with profound obstructive sleep apnea (AHI > 65) experience comparable treatment success with UAS, but are more likely to have residual AHI elevation during use.

## Background

Obstructive sleep apnea (OSA) is an extremely common disorder in the United States. An estimated 17% of males age 50-70 and 9% of females age 50-70 suffer from this disease, and the prevalence has been increasing.<sup>1-4</sup> Left untreated, the consequences of OSA can be severe, especially within the cardiovascular system, including as hypertension, arrhythmias, and heart failure.<sup>5,6</sup> OSA has also been associated with impaired glucose tolerance, metabolic syndrome, and poorly controlled mood disorder, among other comorbidities.<sup>5</sup> Continuous positive airway pressure (CPAP) has been established as the gold standard of OSA treatment. However, even with an extremely low definition of compliance, 4 hours of use per night, a significant proportion of the OSA population cannot tolerate the device and achieve this rate of use.<sup>7</sup>

Multiple surgical modalities have been developed to help alleviate airway obstruction in OSA patients who are unable to tolerate CPAP therapy. Most recently, upper airway stimulation (UAS) has gained popularity as a novel approach OSA treatment. With this technique, selective stimulation of the hypoglossal nerve is used to improve muscle tone and airway patency, thus reducing apneas and hypopneas. In properly selected patients, UAS has been shown to cause dramatic improvement in apnea-hypopnea index (AHI), with a reduction of median AHI from 34 events/hr to 7 events/hr.<sup>8</sup> In order to better manage patient and provider expectations, we sought to elucidate whether these impressive results persisted in the subset of patients with profound sleep apnea, which we defined as an AHI > 65.

## Methods

A retrospective chart review was performed at Thomas Jefferson University Hospital of all patients undergoing UAS placement between 2014 and 2018. Institutional Review Board approval by the Thomas Jefferson University Division of Human Subjects Protection was obtained to create a database including both demographic and clinical data, including drug induced sleep endoscopy findings, implantation records, pre- and post-operative polysomnography results, and medical comorbidities. Patients were divided based on AHI above or below 65, and statistical analysis was performed using SAS (Statistical Analysis System) software.

Value	AHI > 65 pts	AHI < 65 pts	Statistical Significance
Patient number	11	160	
Age	62.5±12.6	61.7±11.7	$p=0.91$
Preop ESS <sup>a</sup>	13±4	10±5	$p=0.18$
BMI	31.3±2.7	29.0±4.0	$p=0.026$
Preop AHI	80.6±12.8	31.6±14.3	$p=0.00$
Preop O2 nadir	76.8±7.4	80.4±7.5	$p=0.12$
Postop AHI	27.7±36.8	9.3±17.8	$p=0.02$
Postop O2 nadir	86.9±3.9	87.1±6.4	$p=0.44$
Ideal Voltage	2.5±1.1	2.4±0.8	$p=0.91$
Treatment Success	78%	84%	$p=0.32$
Compliance <sup>(hr/wk)</sup>	42.5±13	39.3±17.6	$p=0.66$

**Table 1: Patient characteristics and outcomes with upper airway stimulator implantation.**

Values are mean ± standard deviation, except for where otherwise documented as a percentage. a. ESS: epworth sleepiness scale.

## Results

171 patients underwent UAS, of which 11 had a profound preoperative AHI. The mean preoperative AHI of the profound group was  $80.6 \pm 12.8$ , as opposed to  $31.6 \pm 14.3$  in the non-profound OSA patients.

**Demographics and Preoperative Characteristics:** There was no statistical difference between the age or gender between the two groups. The profound group was noted to have a statistically significant higher body mass index (BMI) of  $31.3 \pm 2.7$ , as compared to  $29.0 \pm 4.0$  ( $p=0.026$ ). The profound apnea group also had a trend towards lower oxygen nadir 76% vs 80%, however this did not reach statistical significance ( $p=0.12$ ).

**Stimulation Outcomes:** There was no statistically significant difference in treatment success (AHI < 20 with > 50% reduction) between the two groups, 84% for AHI < 65, as opposed to 78% for AHI > 65 ( $p=0.320$ ). Oxygen nadir remained comparable between the two groups, both mean 87%. However, the profound group had a statistically significantly elevated AHI at ideal UAS voltage,  $16.1 \pm 13.2$  events/hr, as compared to the non-profound group,  $5.6 \pm 8.1$  ( $p=0.025$ ). The profound group was more likely to have residual moderate OSA (AHI > 15) with treatment than the non-profound group ( $p=0.007$ ). Ideal stimulation voltage was similar between the two groups,  $2.5 \pm 1.1$  for profound apnea, as opposed to  $2.4 \pm 0.8$  for other patients.

## Discussion

An extremely important characteristic of successful upper airway stimulation is appropriate patient selection. Drug induced sleep endoscopy findings that portend favorable UAS implantation results have been established,<sup>9</sup> but the effect of extreme preoperative apnea on these results has not yet been elucidated in the literature. Our research shows that patients with extremely elevated AHIs achieve treatment success rates similar to individuals with more typical levels of sleep apnea - 84% success for AHI < 65, compared to 78% for AHI > 65 ( $p=0.320$ ). In keeping with the literature, treatment success with UAS was defined as a posttreatment AHI < 20, with a > 50% reduction.

Other than the level of preoperative apnea, patients were characteristically similar between the two groups. This included age, Epworth sleepiness score, and gender. Those with profound apnea were noted to have a statistically significantly higher BMI. Given the known association of BMI and OSA severity, this finding is not unexpected. While the absolute magnitude of BMI difference between these two groups was relatively small, only 2.3 (31.3 vs 29.0), the ADHERE study showed that for each 1-point increase in BMI there was a 9% decrease in the odds of treatment success.<sup>8</sup> Therefore, the ability to achieve comparable treatment success between the two groups is especially notable.

Inability to tolerate CPAP therapy is what leads to UAS evaluation, thus tolerance of UAS an important aspect to consider. One may have concern that profound sleep apnea patients require higher levels of stimulation, which could be more difficult to tolerate. However, this did not prove to be the case. Ideal voltage was 2.5V in the profound group, compared to 2.4V in all other patients.

This study is limited by the small number of people with profound OSA, only 11 individuals, preventing the statistical power necessary to perform multivariate analysis. However, we feel that these promising early results encourage continued implantation in profound apnea patients. As the number of profound apnea patients with UAS increases, further analysis of their outcomes should continue.

## Conclusion

Patients with profound obstructive sleep apnea (AHI > 65) are appropriate UAS candidates and experience similar treatment success rates with UAS, compared to those with more common levels of apnea. Voltages needed to achieve success are similar in both groups. However, preoperative expectations should be appropriately managed, as these patients are likely to have moderate residual AHI elevation with use.

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