Predictors of Hypoglossal Nerve Stimulation Treatment Response for Obstructive Sleep Apnea Patients

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Introduction

- Obstructive sleep apnea (OSA) is characterized by recurrent upper airway collapse during sleep and is associated with daytime somnolence, reduced quality of life, and cardiovascular morbidity.
- Continuous positive airway pressure (CPAP): gold standard; effective but limited by poor adherence/intolerance
- Hypoglossal nerve stimulation (HGNS): FDA-approved alternative for moderate–severe OSA
  - Stimulates tongue protrusors to maintain airway patency
- Current patient selection criteria are largely based on the STAR trial and feasibility studies, including BMI <35 kg/m², AHI 15–65 events/hour, and <25% central apneas.
- Drug-induced sleep endoscopy (DISE) is also integral in preoperative evaluation, with complete concentric collapse (CCC) at the velum serving as the primary FDA exclusion.
  - More recently, lateral wall collapse (LWC) has been identified as a potential additional negative predictor.
- Despite these criteria, variability in HGNS outcomes persists, underscoring the need for reliable predictors of treatment success.
- ***In this study, we evaluated baseline characteristics, sleep study data, and DISE findings—including DISE-PAP opening pressure (PhOP)—to identify predictors of HGNS outcomes.***

Methods

- Study design: Retrospective review of 628 consecutive HGNS patients at Thomas Jefferson University Hospital (2014–2024)
- Patients with missing sleep study data or without oropharyngeal LWC data on DISE findings were excluded, leaving **475** for analysis
  - Baseline characteristics are summarized in **Table 1**
- Preoperative testing included polysomnography (PSG) and home sleep apnea testing (HSAT)
  - Hypopneas were scored using AASM criteria 1A (≥3% desaturation or arousal) and 1B (≥4% desaturation)
  - Postoperative scoring used 1B criteria
- Predictive factors extracted from the medical record included **age, sex, BMI, preoperative AHI, LWC (present vs absent)**, and **PhOP**
- HGNS outcomes were measured by **postoperative AHI**, **change in AHI**, and **Sher15 success** (≥50% reduction to <15 events/hr)
- Multivariate generalized linear models were used to evaluate predictors of surgical success
  - Postoperative AHI was modeled with Poisson regression
  - AHI change and Sher15 success were analyzed with ordinary least squares regression
- Sex was coded as binary, while age, BMI, AHI, and PhOP were continuous variables. LWC was coded as binary (absent vs partial/complete).
- PhOP was available for 44 patients; missing values were imputed with the mean (7.0 cm H_2O).

Table 1. Baseline Patient Characteristics

Characteristics	HGNS cohort (n=475)[1]
Age	62.9 (11.4)
Sex	
Male	309 (65.1%)
Female	166 (34.9%)
Race/Ethnicity	
White/Caucasian	437 (92.0%)
Black/African American	14 (2.9%)
Hispanic/Latino/a	12 (2.5%)
Asian	6 (1.3%)
Other	1 (0.2%)
Unreported	5 (1.1%)

[1]Mean (SD); n (%)

Results

Figure 1. Univariate and Bivariate Distributions in the Dataset

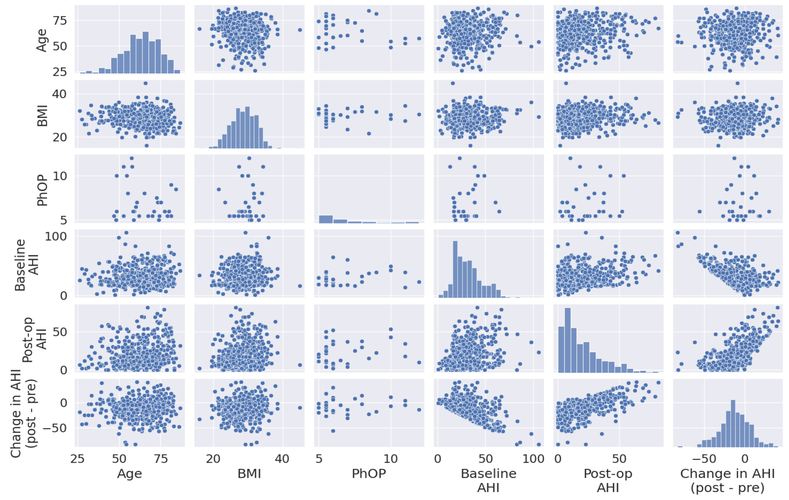

Table 2. Multivariate Prediction of Postoperative AHI

Predictor	Coefficient (β)	Incidence Ratio (e^{β})	Std. Err.	Z	p	95% CI
Intercept	0.2025	1.224	0.176	1.152	0.249	[-0.142, 0.547]
Sex (F vs M)	-0.1871	0.829	0.024	-7.959	**< 0.001**	[-0.233, -0.141]
LWC	0.1646	1.179	0.022	7.645	**< 0.001**	[0.122, 0.207]
Age	0.0137	1.014	0.001	13.776	**< 0.001**	[0.012, 0.016]
BMI	0.0356	1.036	0.003	11.821	**< 0.001**	[0.030, 0.041]
PhOP	0.0661	1.068	0.020	3.337	**< 0.001**	[0.027, 0.105]
Baseline AHI	0.0115	1.012	0.001	18.282	**< 0.001**	[0.010, 0.013]

Multivariate Prediction of Postoperative AHI

Since Postoperative AHI is a count of discrete events per unit time, we modeled it using Poisson regression. All factors were significantly predictive of post-op AHI ($p<0.001$) (**Table 2**).

Expected postoperative AHI:

- for a Female is 82.9% (i.e., 17.1% lower than) that of a Male
- is 17.9% higher for patients with partial or complete LWC
- increases by 1.4% for each year of age
- increases by 3.6% for each unit of BMI
- increases by 6.8% for each unit of PhOP
- increases by 1.2% for each unit of preop AHI

Table 3. Multivariate Prediction of Change in AHI

Predictor	Coefficient (β)	Std. Err.	t	p	95% CI
Intercept	-33.8704	12.163	-2.785	**0.006**	[-57.772, -9.969]
Sex (F vs M)	-3.2772	1.524	-2.150	**0.032**	[-6.272, -0.282]
LWC	3.1298	1.473	2.124	**0.034**	[0.235, 6.025]
Age	0.2679	0.064	4.166	**<0.001**	[0.142, 0.394]
BMI	0.6431	0.197	3.270	**0.001**	[0.257, 1.029]
PhOP	1.4070	1.376	1.022	0.307	[-1.298, 4.112]
Baseline AHI	-0.7492	0.046	-16.230	**<0.001**	[-0.840, -0.659]

Multivariate Prediction of AHI Change

- All factors, except PhOP, were significant ($p<0.05$) predictors of AHI change (**Table 3**)
- Results aligned with post-op AHI outcomes with the exception of baseline AHI.

Table 4. Multivariate Prediction of Sher15 Success

Predictor	Coefficient (β)	Std. Err.	Z	p	95% CI
Intercept	3.0748	1.656	1.856	0.063	[-0.172, 6.321]
Sex (F vs M)	0.2678	0.204	1.312	0.189	[-0.132, 0.668]
LWC	-0.0571	0.198	-0.288	0.773	[-0.446, 0.332]
Age	-0.0240	0.009	-2.747	**0.006**	[-0.041, -0.007]
BMI	-0.0581	0.027	-2.160	**0.031**	[-0.111, -0.005]
PhOP	-0.0434	0.186	-0.233	0.816	[-0.408, 0.322]
Baseline AHI	0.0018	0.006	0.290	0.772	[-0.010, 0.014]

Multivariate Prediction of Sher15 Success

- **Overall Sher15 success rate** = 205/475 ≈ **43.2%**
- While all coefficients were directionally consistent with AHI change predictions**, only Age and BMI were significant ($p<0.05$) predictors of Sher15 success** (**Table 4**)
- Each year of age and unit of BMI reduced success odds by 2.4% and 5.8%, respectively.

Discussion

Our study findings reinforce established predictors of HGNS treatment outcomes, including age, sex, BMI, and baseline AHI, and evaluate previously less-explored characteristics such as LWC and PhOP.

- Higher **BMI** was consistently associated with poorer HGNS outcomes, with each unit increase linked to higher postop AHI and lower Sher success odds.
  - This aligns with prior literature, though strict BMI cutoffs likely excluded patients with very high BMI.
  - While many studies confirm worse outcomes with BMI >32-35, some specialized centers report good results in carefully selected higher-BMI patients. BMI remains a key but nuanced factor in patient selection.
- Advancing **age** was associated with higher postop AHI and reduced success odds. Prior studies have been mixed.
  - Physiologic changes with aging—including increased collapsibility, altered sleep architecture, and neuromuscular decline—may reduce HGNS responsiveness. Our findings support a modest detrimental effect of age on treatment outcomes.
- **Female** patients demonstrated significantly better outcomes, with lower postop AHI compared to males.
  - Prior literature has been inconsistent but generally favors females, potentially due to anatomical or hormonal differences, lower baseline BMI, or higher device utilization.
- **Baseline AHI** showed complex associations. Higher baseline severity correlated with greater absolute AHI reduction and increased likelihood of Sher15 success, but also with higher postop AHI overall.
  - Prior studies similarly report that patients with severe OSA can still experience meaningful improvement, even if predefined success thresholds are harder to meet.
- Patients with **LWC** had significantly higher postop AHI, supporting its role as a negative predictor. This finding mirrors prior reports linking LWC to poorer HGNS outcomes.
  - The mechanism may relate to physiological similarities with palatal CCC or weaker indirect HGNS effects on lateral walls.
- Lower **PhOP** was associated with better HGNS outcomes, consistent with prior studies.
  - PhOP likely reflects overall airway collapsibility, with lower pressures indicating anatomy more amenable to stimulation. While our analysis was limited by missing data and imputation, results suggest PhOP may be a useful additional metric in patient selection.

Conclusions

Our study findings underscore the importance of considering multiple pathophysiological parameters to effectively assess and accurately predict HGNS treatment success and enhance clinical decision-making for HGNS therapy by identifying optimal candidates.

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Poster Handout

References