Roles of Surgery in OSA
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## Conflict of Interest Disclosure

**Kathleen Yaremchuk MD**

1. I do not have any relationships with any entities **producing, marketing, re-selling, or distributing** health care goods or services consumed by, or used on, patients, **OR**

2. I have the following relationships with entities **producing, marketing, re-selling, or distributing** health care goods or services consumed by, or used on, patients.

<table>
<thead>
<tr>
<th>Type of Potential Conflict</th>
<th>Details of Potential Conflict</th>
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<tbody>
<tr>
<td>Grant/Research Support</td>
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<td>Consultant</td>
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<td>Speakers’ Bureaus</td>
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<td>Financial support</td>
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3. The material presented in this lecture has no relationship with any of these potential conflicts, **OR**

4. This talk presents material that is related to one or more of these potential conflicts, and the following objective references are provided as support for this lecture:

1. 
2. 
3.
Types of Surgery for OSA

- Anatomy Altering
  - UPPP
  - UPPP/Tonsillectomy
  - Tonsillectomy
  - TORS (Trans oral robotic surgery)
  - Tracheostomy

- Physiologic
  - Hypoglossal Nerve Stimulator
Surgery Staging
Level of Collapse

- Drug Induced Sleep Endoscopy
  - Propofol drip
    - 75 mcg and then increase
    - Quiet room, lights down
    - No stimulus
    - When snoring, endoscopy
    - Evaluate VOTE
Surgery Staging  Level of Collapse

- **Velum**
  - Airway closure related to the velum can occur with collapse in an anteroposterior or concentric configuration

- **Oropharyngeal lateral walls**
  - The tonsils and other lateral pharyngeal tissues all collapse in a lateral configuration.

- **Tongue base**
  - Anteroposterior tongue base prolapse is common during DISE

- **Epiglottis**
  - Anteroposterior prolapse can result apparent posterior displacement of the entire epiglottis against the posterior pharyngeal wall
  - lateral folding or involution, is consistent with a central vertically oriented crease of decreased rigidity that enables this folding to occur in the same location.
Surgery Staging  Level of Collapse

- Degree of obstruction has one number for each structure:
  - 0, No obstruction (no vibration);
  - 1, Partial obstruction (vibration);
  - 2, Complete obstruction (collapse);
  - X, Not visualized
Drug Induced Sleep Endoscopy

- Propothol
- Dexmedetomidine
- A comparison of dexmedetomidine versus propofol during drug-induced sleep endoscopy in sleep apnea patients.
  - Yoon BW1, Hong JM2, Hong SL1, Koo SK3, Roh HJ4, Cho KS1.

- The % of patients with a >20% change in blood pressure and heart rate compared to baseline was significantly higher in response to propofol than to dexmedetomidine (P = 0.003 and P < 0.001, respectively).
- Minimal oxygen saturation was significantly lower in DISE with propofol than with dexmedetomidine (P = 0.004).
- The percentage of patients with oxygen saturation less than 90% or 80% during DISE was significantly higher in response to propofol than to dexmedetomidine (P = 0.032 and P < 0.001, respectively).
DISE

- VOTE-25%, 50%, 75%, 100%
  - Velum
  - Oropharynx
  - Tongue
  - Epiglottis
DISE

- Oropharynx
DISE

- Tongue
DISE

- Epiglottis
Does it help?

- Interrater reliability
  - Interrater Reliability of Drug-Induced Sleep Endoscopy
    - Eric J. Kezirian, MD, MPH; David P. White, MD; Atul Malhotra, MD;

- It may change surgery being done
  - Thirty-eight patients (22 M, 16 F) underwent preoperative assessment with awake and drug-induced sleep endoscopy.
  - The surgical plan was changed after drug-induced sleep endoscopy in 23 (62%) cases and unchanged in 14 (38%). The majority (73%) had multi-segmental airway collapse with fewer having single-level palatal (16%) or tongue base (11%) collapse.

- No change in outcomes
Nasal Surgery

a. Septum
b. Turbinate
   i. Partial resection
   ii. Tissue reduction (radiofrequency, cold ablation, etc.)
c. Nasal valve

• May decrease AHI 1-5%
• May increase CPAP compliance
• May decrease CPAP pressure
T & A for OSA

- Tonsillectomy
  - Pediatric
  - Hypertrophic tonsils
  - OSA by PSG
  - AHI>2
  - IPD
  - No narcotics for post op
- Pediatric-obligate nasal breathers
  - Nasal Obstruction
  - Adenoid hypertrophy
  - Choanal atresia
  - Nasal Mass
The CHAT study was a multicenter, single-blinded, RCT conducted at 6 academic sleep centers.

Baseline data from 453 children from the Childhood Adenotonsillectomy (CHAT) study were analyzed.

Children 5.0 to 9.9 years of age with PSG-diagnosed OSAS, who were considered candidates for AT, were included.
Eligible children were 5 to 9 years of age, had the obstructive sleep apnea syndrome without prolonged oxyhemoglobin desaturation, and were considered to be suitable candidates for adenotonsillectomy.

The obstructive sleep apnea syndrome was defined as an obstructive apnea–hypopnea index (AHI) score of 2 or more events per hour or an obstructive apnea index (OAI) score of 1 or more events per hour.

Children with an AHI score of more than 30 events per hour, an OAI score of more than 20 events per hour, or arterial oxyhemoglobin saturation of less than 90% for 2% or more of the total sleep time were not eligible.

Children were randomly assigned to early adenotonsillectomy (surgery within 4 weeks after randomization) or a strategy of watchful waiting.
The primary study outcome was the change in the attention and executive-function score on the Developmental Neuropsychological Assessment.

Caregiver and teacher ratings of behavior (Conners' Rating Scale Revised: Long Version Global Index, comprising Restless–Impulsive and Emotional Lability factor sets).

Pediatric Sleep Questionnaire sleep-related breathing disorder scale.

Sleepiness, as assessed with the use of the Epworth Sleepiness Scale modified for children.

Generalized intellectual functioning.

Polysomnographic indexes.
PSG Results

**Figure 2. Normalization of Polysomnographic Findings.**
Adverse Events

<table>
<thead>
<tr>
<th>Event</th>
<th>Watchful Waiting (N=203)</th>
<th>Early Adenotonsillectomy (N=194)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>225</td>
<td>160</td>
</tr>
<tr>
<td>Tonsillar hemorrhage</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Postoperative pain</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Asthma</td>
<td>18</td>
<td>3</td>
</tr>
<tr>
<td>Lower respiratory tract illness</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Upper respiratory tract or ear illness</td>
<td>90</td>
<td>67</td>
</tr>
<tr>
<td>Cough</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>Gastrointestinal tract illness</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>Dehydration</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>ADHD</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Other infection</td>
<td>40</td>
<td>17</td>
</tr>
<tr>
<td>Hypersomnolence</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Exacerbation of sleep-apnea symptoms</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>34</td>
<td>27</td>
</tr>
</tbody>
</table>

* Serious adverse events included tonsillar hemorrhage in three children randomly assigned to early adenotonsillectomy and in one child randomly assigned to watchful waiting who crossed over to early adenotonsillectomy; see Table S3 in the Supplementary Appendix for details. ADHD denotes attention deficit–hyperactivity disorder.
Tonsillectomy In Adults for OSA

Table 1. Outcomes After Tonsillectomy in Adults with Tonsillar Hypertrophy and Obstructive Sleep Apnea.

<table>
<thead>
<tr>
<th>Outcome Variable: BMI Group</th>
<th>Subjects, n</th>
<th>Pretreatment</th>
<th>Posttreatment</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AHI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>18</td>
<td>31.57 ± 25.88</td>
<td>8.12 ± 8.94</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>25-29.9</td>
<td>4</td>
<td>26.28 ± 15.54</td>
<td>9.38 ± 15.11</td>
<td>.125</td>
</tr>
<tr>
<td>30-34.9</td>
<td>5</td>
<td>30.2 ± 18.35</td>
<td>4.0 ± 2.35</td>
<td>.063</td>
</tr>
<tr>
<td>35-39.9</td>
<td>9</td>
<td>34.68 ± 33.74</td>
<td>10.41 ± 7.65</td>
<td>.074</td>
</tr>
<tr>
<td><strong>ESS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>34</td>
<td>10.94 ± 4.43</td>
<td>5 ± 4.61</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>25-29.9</td>
<td>7</td>
<td>10.86 ± 2.54</td>
<td>4.14 ± 3.53</td>
<td>.016</td>
</tr>
<tr>
<td>30-34.9</td>
<td>8</td>
<td>7.88 ± 3.14</td>
<td>4 ± 4.24</td>
<td>.016</td>
</tr>
<tr>
<td>35-39.9</td>
<td>19</td>
<td>12.26 ± 4.90</td>
<td>5.73 ± 5.15</td>
<td>.001</td>
</tr>
<tr>
<td><strong>ISI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>34</td>
<td>16.64 ± 5.54</td>
<td>6.15 ± 3.47</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>25-29.9</td>
<td>7</td>
<td>17.14 ± 5.24</td>
<td>5.43 ± 2.76</td>
<td>.016</td>
</tr>
<tr>
<td>30-34.9</td>
<td>8</td>
<td>15.38 ± 6.55</td>
<td>4.75 ± 2.12</td>
<td>.008</td>
</tr>
<tr>
<td>35-39.9</td>
<td>19</td>
<td>17 ± 5.44</td>
<td>7 ± 3.99</td>
<td>.001</td>
</tr>
<tr>
<td><strong>FOSQ-10</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>34</td>
<td>9.91 ± 3.1</td>
<td>14.26 ± 1.94</td>
<td>.001</td>
</tr>
<tr>
<td>25-29.9</td>
<td>7</td>
<td>9 ± 2.92</td>
<td>14.57 ± 1.24</td>
<td>.016</td>
</tr>
<tr>
<td>30-34.9</td>
<td>8</td>
<td>10.94 ± 2.24</td>
<td>14.69 ± 0.92</td>
<td>.008</td>
</tr>
<tr>
<td>35-39.9</td>
<td>19</td>
<td>9.82 ± 3.46</td>
<td>13.97 ± 2.42</td>
<td>.001</td>
</tr>
</tbody>
</table>

Abbreviations: AHI, apnea-hypopnea index; BMI, body mass index; ESS, Epworth Sleepiness Scale; ISI, Insomnia Severity Index; FOSQ-10, Functional Outcomes of Sleep Questionnaire-10.
<table>
<thead>
<tr>
<th>Mechanism of Action</th>
<th>Locus of Primary Action</th>
<th>Procedure</th>
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<tbody>
<tr>
<td>Soft tissue ablation</td>
<td>Retropalatal</td>
<td>Uvulopalatopharyngoplasty (UPPP)</td>
</tr>
<tr>
<td></td>
<td>Retropalatal</td>
<td>Laser assisted uvulopalatoplasty (LAUP)</td>
</tr>
<tr>
<td></td>
<td>Retrolingual</td>
<td>Laser midline glossectomy/lingualplasty (LMG)</td>
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<td></td>
<td>Retropalatal and retrolingual</td>
<td>Radiofrequency tongue base ablation (RFTBA)</td>
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<td></td>
<td>Retropalatal</td>
<td>Tongue base reduction with hyoepiglottoplasty (TBRHE)</td>
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<td>Skeletal modification</td>
<td>Retropalatal</td>
<td>Uvulopalatopharyngoglossoplasty (UPPGP)</td>
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<td>(soft tissue repositioning)</td>
<td>Retrolingual</td>
<td>Transpalatal advancement pharyngoplasty (TPAP)</td>
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<td></td>
<td>Retropalatal and retrolingual</td>
<td>Mandibular advancement (MA)</td>
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<td></td>
<td></td>
<td>Genioglossal advancement (GA)</td>
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<td>Hyoid myotomy and suspension of hyoid from mandible (HM-1)</td>
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<td></td>
<td></td>
<td>Hyoid myotomy and attachment of hyoid to thyroid cartilage (HM-2)</td>
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<td>By-pass upper airway</td>
<td></td>
<td>Maxillomandibular advancement (MMA)</td>
</tr>
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<td></td>
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<td>Tracheotomy</td>
</tr>
<tr>
<td>Criterion</td>
<td>Definition</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td>1A</td>
<td>Postop RDI/Preop RDI (\leq 50%)</td>
<td></td>
</tr>
<tr>
<td>1B</td>
<td>Postop AI/Preop AI (\leq 50%)</td>
<td></td>
</tr>
<tr>
<td>2A</td>
<td>Postop RDI/Preop RDI (\leq 50%) and Postop RDI (\leq 20) apneas and hypopneas per h</td>
<td></td>
</tr>
<tr>
<td>2B</td>
<td>Postop RDI/Preop RDI (\leq 50%) and Postop RDI (\leq 15) apneas and hypopneas per h</td>
<td></td>
</tr>
<tr>
<td>2C</td>
<td>Postop RDI/Preop RDI (\leq 50%) and Postop RDI (\leq 10) apneas and hypopneas per h</td>
<td></td>
</tr>
<tr>
<td>2D</td>
<td>Postop AI/Preop AI (\leq 50%) and Postop AI (\leq 10) apneas per h</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Postop RDI/Preop RDI (\leq 40%) and Postop AI/Preop AI (\leq 40%) and/or Postop AI (\leq 10) apneas per h and Postop RDI (\leq 15) apneas and hypopneas per h</td>
<td></td>
</tr>
</tbody>
</table>
Palate Surgery

- Palate surgery
  A. Uvulopalatopharyngoplasty
    i. Multiple modifications
  B. Tissue reduction (radiofrequency, etc.)
  C. Stiffening procedures
    i. Radiofrequency
    ii. Pillar Implants
    iii. CAPSO
Surgical correction of anatomic abnormalities of OSA-UPPP

- 12 patients
  - 11 men
  - 10 were obese with short and thick neck
- Each patient had a history of EDS (8.8 years) and loud, habitual snoring for many years (9 since childhood)
- 8 patients reported nasal obstruction
  - Otolaryngol Head Neck Surg 1981;89; 923-934.
Degree of OSA

- Average AHI 60
- Average lowest SaO2 46%
- Min SaO2 (<85% of TST) 20%
- Mean apneas duration 25 sec
- Waking SaO2 93%
Responders vs Non responders

- 8 patients required no further treatment
  - AI 50→10

- 2 patients showed a mild decrease in AI
  - 76→61

- 2 patients showed an increase in AI
  - 48→64
Responders vs. Non-responders

“Since there is a variable response to UPPP, it is important to determine what subgroup of the sleep apnea patients would benefit from this procedure or whether another factor might influence the surgical results.”

Fujita, Oto/HNS 1981,89; 923-934
The Efficacy of Surgical Modifications of the Upper Airway in Adults With Obstructive Sleep Apnea Syndrome*

- Meta-analysis of articles from January 1966 through April 1993
- Nasal, UPPP, laser midline glossectomy, lingualplasty, inferior sagittal mandibular osteotomy and genioglossal advancement, tracheotomy, maxillomandibular osteotomy and advancement
  - Sher, Sleep 19(2):156-177
Analysis of the UPPP papers revealed that this procedure is effective in treating less than 50% of patients with OSA.

The studies to support the use of the surgical treatment of obstructive sleep apnea contain biases related to small sample size, limited follow-up and patient selection.
Efficacy of UPPP in unselected patients with mild OSA

- 37 patients with mild (REI > 5 and < 25) OSA
- Follow up PSG in 68%
  - 10 patients (40%) had a >50% decrease in REI
  - 60% had an increase in REI
- Responders vs. Non Responders
- Proves that severity of OSA is independent of surgical success
  - Senior et al, Oto/HNS2000, 123(3);179-182
Clinical Staging for Sleep Disordered Breathing*

- Identify prognostic indicators that would lead to stratification of patients likely to have successful surgery for SDB
- Retrospective study of 134 patients to correlate palate position and tonsil size to the success of the UPPP
- Success defined as 50% decrease in preop AHI AND AHI<20
  - Friedman, Otolaryngology HNS 2002;127,13-21
Oral Cavity - Mallampati

- I - Posterior pharyngeal wall + soft palate + uvula + hard palate
- II - Posterior pharyngeal wall + soft palate + part of uvula
- III - Soft palate + hard palate
- IV - Hard palate
Tonsils

- Zero or 1-can’t see
- 2+ evident on exam
- 3+large
- 4+ Kissing tonsil
- *If patient gags while you are examining- ALL TONSILS WILL BE 4+

*Figure 1 – Grading of palatine tonsils hypertrophy proposed by L. Brodsky.*
Modified Friedman Staging System for Patients with OSA

<table>
<thead>
<tr>
<th>Stage</th>
<th>Friedman Palate Position</th>
<th>Tonsil Size</th>
<th>BMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage I</td>
<td>1</td>
<td>3,4</td>
<td>&lt;40</td>
</tr>
<tr>
<td>Stage II</td>
<td>1,2</td>
<td>1,2</td>
<td>&lt;40</td>
</tr>
<tr>
<td></td>
<td>3,4</td>
<td>3,4</td>
<td>&lt;40</td>
</tr>
<tr>
<td>Stage III</td>
<td>3</td>
<td>0,1,2</td>
<td>&lt;40</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0,1,2</td>
<td>&lt;40</td>
</tr>
<tr>
<td>Stage IV</td>
<td>1,2,3,4</td>
<td>0,1,2,3,4</td>
<td>&gt;40</td>
</tr>
</tbody>
</table>
Success Rate of UPPP in the treatment of sleep disordered breathing

<table>
<thead>
<tr>
<th>Stage</th>
<th>Successful</th>
<th>Failure</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>80.6% (n=25)</td>
<td>19.4% (n=6)</td>
<td>100% (n=31)</td>
</tr>
<tr>
<td>II</td>
<td>37.9% (n=18)</td>
<td>62.1% N=18</td>
<td>100% (n=29)</td>
</tr>
<tr>
<td>III</td>
<td>8.1% (n=68)</td>
<td>91.9% (n=68)</td>
<td>100% (n=74)</td>
</tr>
</tbody>
</table>
Conclusion: A clinical staging system for SDB based on palate position, tonsil size, and body mass index is presented. It appears to be a valuable predictor of the success of UPPP.

Laser-assisted uvulopalatoplasty (LAUP)

- PSG success rate ranging from 0-87%
  - (criterion 1A)
- PSG success rate 0-48%
  - Criterion 1B
- Insurances do not authorize LAUP
- Exacerbation in immediate post op period
- Dimensions before and after UPPP and LAUP of 10 patients before and after
  - Photography, nasopharyngoscopy of the velopharyngeal region and lateral and frontal cephalometry with contrast enhancement
  - UPPP results in ↑ velopharyngeal space but LAUP results in ↓ velopharyngeal space
Tongue Reduction

- a. Volume reduction
  - Coblation
  - TORS
  - Cautery
  - SMILE

- b. Tongue suspension
  - i. Suture
  - ii. Genioglossus advancement
Laser Midline Glossectomy

- UPPP failures
  - MLG salvage (criterion 1) 42%
  - UPPP & MLG is 77% (criterion 2A)
RF BOT in 56 patients without palate or nasal obstruction
  – RDI 41
Response rate of 20% (2A) or 33% (2D)

TORS

- Trans Oral Robotic Surgery
  - Base of Tongue
  - Lingual Tonsils
  - Epiglottis
    - Floppy
    - Loss of elasticity
A retrospective cohort review was performed comparing 40 patients who had previously undergone UPPP ± T with 64 patients who had DISE, UPPP ± T, and possible TORS base-of-tongue resection and/or partial epiglottectomy.

Apnea-hypopnea index (AHI), Epworth Sleepiness Scale (ESS), body mass index, sex, hospital length of stay, hospital charges, hospital readmissions, emergency department visits, and major complications were compared for both groups.

The 40 patients who underwent UPPP ± T without DISE showed a significant reduction in AHI of $-20.1 \ (P = 0.001)$ and a complication rate of 3% ($P = 0.001$). There was no significant change in ESS ($-2.2; \ P = 0.734$). The 64 patients who underwent DISE and subsequent procedures showed a significant reduction in AHI of $-21.4 \ (P = 0.001)$ and a complication rate of 34.7% ($P = 0.001$).

There was no significant difference in the ESS (+0.1; $P = 0.734$) or AHI ($P = 0.092$) between the two groups.
Conclusion

- Patients who underwent UPPP ± T without DISE did not show a statistically significant difference in outcomes compared to the patients who underwent DISE with other procedures, including TORS.

- The TORS patients had increased total costs and length of stay that were statistically significant and had increased complications that were not statistically significant.
Trachostomy

- First surgical procedure for OSA
- Patient dissatisfaction
- Risks of crusts, loss of airway, etc.
- 100% effective
Upper Airway Stimulator

- Pacemaker and Cochlear Implant Hybrid
  - Works inside the body - fully implanted
  - Monitors breathing patterns during sleep
  - Delivers mild stimulation to key airway muscles to keep airway open during sleep
    - Tongue and Palate
  - Turned on and off with a handheld sleep remote
Multi-level Mechanism of Action

- Therapeutic effect is evident at both the palate and tongue-base
- More prominent response with increasing stimulation energy – within therapeutic range
Sleep Study Illustration
Upper-Airway Stimulation for Obstructive Sleep Apnea

Patrick J. Strollo, Jr., M.D., Ryan J. Soose, M.D., Joachim T. Maurer, M.D., Nico de Vries, M.D., Jason Cornelius, M.D., Oleg Froymovich, M.D., Ronald D. Hanson, M.D., Tapan A. Padhya, M.D., David L. Steward, M.D., M. Boyd Gillespie, M.D., B. Tucker Woodson, M.D., Paul H. Van de Heyning, M.D., Ph.D., Mark G. Goetting, M.D., Oliver M. Vanderveken, M.D., Ph.D., Neil Feldman, M.D., Lennart Knaack, M.D., and Kingman P. Strohl, M.D., for the STAR Trial Group*

ABSTRACT

BACKGROUND
Obstructive sleep apnea is associated with considerable health risks. Although continuous positive airway pressure (CPAP) can mitigate these risks, effectiveness can be reduced by inadequate adherence to treatment. We evaluated the clinical safety and effectiveness of upper-airway stimulation at 12 months for the treatment of moderate-to-severe obstructive sleep apnea.
Conclusion

- Anatomy altering surgery staging based on anatomy can be used to determine success
  - It is not about the severity of the AHI, it is about the anatomy
- Hypoglossal nerve stimulation has 5 year sustainable outcomes
  - 90% adherence