Use of Phenotyping to Improve Sleep Surgery Outcomes

Roger H. Lehman, MD, Lecture
Medical College of Wisconsin
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Disclosures

Consulting  
Cook, Invicta

Scientific Advisory Board  
(CryOSA, Zelegent)

(Stock Options)

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Olympus, LivaNova, 
Cook, Inspire Medical
OSA: The Public Health Issue
Untreated OSA Affects Mortality

Young, et al. SLEEP 2008, Figure 1
CPAP Adherence

CPAP is the gold standard therapy, but with limitations

- 46-83% of patients reported to be non-adherent to CPAP, usage < 4 hours per night
- Despite improvements in the therapy, adherence rates remain unchanged
- Efficacious therapy that a large segment of patient population rejects.
OSA: The Sleep Surgeon Dilemma
20-year-old with Down Syndrome

60 year old with loud snoring
OSA and Sleep Surgery
Defining the Problems

- Multi-level nature of airway collapse
- Interaction between anatomic sites
- Multi-factor etiology of OSA
  - Sleep stability (loop gain)
  - Passive airway collapsibility (stiffness/elasticity)
  - Active airway dilation (neuromuscular integrity)
  - Soft tissue hypertrophy (obesity; fat neck; large tongue)
  - Craniofacial structure (small box)
- Need for an individualized treatment plan
OSA and Sleep Surgery
The Central Question

- What surgical approach will maximize outcomes for a given OSA patient?
In order to answer this question, we need:
- Need prospective sleep surgery studies
- Need large number of patients (multi-center)
- Record validated factors (variables) acquired during routine patient care
<table>
<thead>
<tr>
<th>Variables</th>
<th>Timing of Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Op</td>
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<tr>
<td><strong>Patient Demographics</strong></td>
<td></td>
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<tr>
<td>Age</td>
<td>X</td>
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<tr>
<td>Gender</td>
<td>X</td>
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<tr>
<td>Race</td>
<td>X</td>
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<tr>
<td><strong>Anatomic Phenotype</strong></td>
<td></td>
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<tr>
<td>BMI (kg/m²)</td>
<td>X</td>
</tr>
<tr>
<td>Tonsil Size (1, 2, 3, 4 +)</td>
<td>X</td>
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<tr>
<td>Nasal Obstruction (Yes or No)</td>
<td>X</td>
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<tr>
<td>Modified Mallampati (1, 2, 3, 4)</td>
<td>X</td>
</tr>
<tr>
<td>Small jaw/Craniofacial Structure (Yes or No)</td>
<td>X</td>
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<tr>
<td><strong>Sleep Study Parameters</strong></td>
<td></td>
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<tr>
<td>Apnea-hypopnea Index</td>
<td>X</td>
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<tr>
<td>Lowest Oxygen Saturation</td>
<td>X</td>
</tr>
<tr>
<td>% Sleep time with $O_2 &lt; 90%$</td>
<td>X</td>
</tr>
<tr>
<td><strong>Surgical Procedures Performed</strong></td>
<td></td>
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<td></td>
<td>X</td>
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<tr>
<td><strong>Surgical Complications</strong></td>
<td></td>
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<td></td>
<td>X</td>
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<tr>
<td><strong>Patient-Based Clinical Outcome Measures</strong></td>
<td></td>
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<tr>
<td>Epworth Sleepiness Scale</td>
<td>X</td>
</tr>
<tr>
<td>Snoring VAS (0=None; 10= sleep apart)</td>
<td>X</td>
</tr>
<tr>
<td>Global Sleep-related QOL VAS (0= No difficulty; 10= Totally disabled)</td>
<td>X</td>
</tr>
<tr>
<td>Dysphagia VAS (0= No difficulty; 10= Severe)</td>
<td>X</td>
</tr>
</tbody>
</table>
Phenotype
- Composite of an organism’s observable characteristics or traits
- Includes morphology, behavior
- Determined by expression of genetic code in interaction with external “environmental” influences
Decisions based on visual observation alone, can be close... but wrong
"I always measure the crania of those going out there... Ever any madness in your family?"

Marlowe’s doctor in Joseph Conrad’s *Heart of Darkness*
Moral hazard of decision-making based on physical characteristics...
Initial Application of Phenotyping in Sleep Surgery
Tongue position

Tonsil size

Body mass index

Large (3,4+) tonsils, normal tongue: 80% cure rate with soft palate surgery

Normal (0, 1, 2+) tonsils, normal tongue: 40% cure rate with soft palate surgery

Normal (0,1, 2+) tonsils, large tongue (or BMI > 40) 8% cure rate with soft palate surgery
Phenotyping Tools at Our Disposal

- History
- Physical Examination
- PSG
- Imaging
- Drug-Induced Sleep Endoscopy (?)
Phenotyping Tools at Our Disposal

- **History**
  - Insomnia: problem for PAP and non-PAP alternatives
  - Respiratory Instability (loop gain)
  - Primary nasal complaints

- **Physical Examination (Less Favorable For UPPP)**
  - BMI (worsening non-PAP results >32 kg/m²)
  - Neck girth (>17” males; >16” females)
  - Modified Mallampati Score (score 3, 4)
  - Jaw shape and size (High-arched maxilla; retrognathia; misalignment)
  - Tonsil size (< 0, 1+ less favorable)

- **PSG**
  - Supine: Lateral Ratio 2:1 (Tongue compression)
  - REM/NREM Ratio 2:1 (Neuromuscular collapsibility)

- **Imaging**
  - Primary use to assess jaw abnormalities
Phenotyping Effect on Non-PAP Treatment Selection

(1) Too much tissue? Tissue reductive surgery (UPP; partial glossectomy)/ weight loss (bariatrics)
- BMI >32
- Acquired macroglossia (Mallampati 3,4)/ teeth indentations on lateral tongue
- Adenotonsillar (Lingual Tonsil) Hypertrophy (grade 3,4)

(2) Box to small (craniofacial structure)? Address craniofacial issue (MMA; maxillary distraction)
- BMI < 32
- Relative macroglossia (Mallampati 3,4)
- Narrow mandibular arch; High-arched palate
- Class II/III occlusion; retrognathia
- Open or Cross Bite

(3) Tissue to lax (poor neuromuscular tone)? Tissue stiffening/ repositioning (HMS; RFA)
- BMI <32
- Normal tongue (Mallampati 1,2)
- Supine/Lateral Sleep AHI 2:1
- REM/ NREM Sleep AHI 2:1
What About Drug-Induced Sleep Endoscopy (DISE)?
Awake Supine Endoscopy (Mueller Maneuver)

- East to perform
- Readily accessible in office-setting (cost-effective)
- Identification of inflammatory issues in need of medical management (allergy; polyps; LPR)
- May identify narrowing from tissue hypertrophy (adenoid; palatine tonsil; pharyngeal wall squeeze; lingual tonsil; tongue base hypertrophy)
- Poor predictive power with regards to sleep surgery outcomes
Drug Induced Sleep Endoscopy (DISE)

- Easy to perform
- More costly (OR/ bronchoscopy suite)
- Visualization of all 3 levels- Nasal, OP, HP
- Real-time correlation with oximetry data
- Safe
- Allows visualization of collapsible sites in patients without tissue hypertrophy (tongue laxity; supraglottic structures)
- Characterization of collapse pattern during snoring/apneas
DISE Grading Systems

- **Site (V, O, T, E)**
- **Degree (None, Partial, Complete)**
- **Pattern (AP, Lateral Concentric)**


**But are findings any better than awake endoscopy at predicting surgical outcome?**
Drug-Induced Sleep Endoscopy (DISE) Effect on Sleep Surgery Decisions
DISE Outcomes
Surgical Decision Making

Systematic Review

Awake Examination Versus DISE for Surgical Decision Making in Patients With OSA: A Systematic Review

Victor F. Certal, MD, PhD; Rui Pratas, MD; Lidia Guimaraes, MD; Rodolfo Lugo, MD; Yungan Tsou, MD; Macario Camacho, MD; Robson Capasso, MD

- Meta-analysis of 8 studies (535 patients) comparing Awake Endoscopy to DISE
- Treatment decision changed after DISE 50% of the time
- Decision changed related to how to treat hypopharynx or larynx
- No evidence to support that these changes resulted in better outcome
Inspire UAS Screening

- Anterior-posterior palatal collapse
- Complete concentric palatal collapse

Vanderveken, J Clin Sleep Med 2013
DISE and Upper Airway Stimulation (Inspire) Outcomes

Sub-study (Belgium, Univ Hospital Antwerp)  N = 8

<table>
<thead>
<tr>
<th>AHI (mean ± std)</th>
<th>Baseline</th>
<th>Mon-1</th>
<th>Mon-2</th>
<th>Mon-4</th>
<th>Mon-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Palatal CCC N = 3</td>
<td>24.9±5.7</td>
<td>11.9±5.0</td>
<td>7.7±4.6</td>
<td>11.0±9.5</td>
<td>5.8±4.8</td>
</tr>
<tr>
<td>With Palatal CCC N = 5</td>
<td>40.5±14</td>
<td>33.6±23.7</td>
<td>40.6±15.8</td>
<td>45.0±22.4</td>
<td>45.2±21.8</td>
</tr>
</tbody>
</table>

Mueller vs. DISE (Unpublished Data) on UAS Candidacy

Mueller effect on DISE velopharynx collapse type (CCC vs non-CCC)

Mueller not predictive of CCC on DISE
DISE Influence of Intraoperative Decision Making in Children (UTHSC IRB 17-05657-XP)

- 29 pediatric patients with severe OSA
- DISE performed at time of initial surgical intervention; consented for variety of interventions (pharyngoplasty; lingual tonsillectomy; tongue reduction; supraglottoplasty) in addition to T&A
- 57% showed velopharyngeal collapse; 48% tongue base collapse; 21% supraglottic collapse
- Mean preop AHI 22
- Mean postop AHI 7
Drug-Induced Sleep Endoscopy (DISE) Effect on non-PAP Outcomes
Case-control study of 20 patients (Pre-DISE) recommended for OA after DISE and 20 patients who had OA placed prior to DISE (Post-DISE).

- No difference between groups in gender, age, BMI, AHI, oxygen nadir, ESS
- Significantly lower treatment AHI (7.9 v. 14.7) and significantly more patients reaching AHI<5 (45% v. 15%) in the Pre-DISE group
DISE & UPPP Outcomes

Clinical Analysis of Drug-Induced Sleep Endoscopy for the OSA Patient

Dina Golbin, DO; Brandon Musgrave, MD; Eric Succar, MD; Kathleen Yaremchuk, MD


- Study of 40 patients who underwent UPPP and 64 who underwent DISE, UPPP, ± Hypopharyngeal Surgery
- No difference in mean AHI reduction in UPPP only group (-20.1) versus UPPP-DISE group (-21.4)
- Complication rate in UPPP only group was 3% versus 35% in UPPP-DISE group
- No difference in AHI severity; BMI; age; gender between groups
- Differences between groups- UPPP only (retrospective)/ UPPP-DISE (prospective); therefore unclear if other unaccounted confounding variable were present.
DISE and Upper Airway Surgery

Drug-Induced Sleep Endoscopy and Surgical Outcomes: A Multicenter Cohort Study

Katherine K. Green, MD, MS; David T. Kent, MD; Mark A. D’Agostino, MD; Paul T. Hoff, MS, MD; Ho-Sheng Lin, MD; Ryan J. Soose, MD; M. Boyd Gillespie, MD, MSc; Kathleen L. Yaremchuk, MD; Marina Carrasco-Llatas, Md PhD; B. Tucker Woodson, MD; Ofer Jacobowitz, MD, PhD; Erica R. Thaler, MD; José E. Barrera, MD; Robson Capasso, MD; Stanley Yung Liu, MD, DDS; Jennifer Hsia, MD; Daljit Mann, MD; Taha S. Meraj, MD; Jonathan A. Waxman, MD, PhD; Eric J. Kezirian, MD, MPH

Laryngoscope 2018; 129:761-770.

- Retrospective study of sleep surgery outcomes 275 patients who underwent pre-operative DISE at 14 centers across United States
- Moderate degree of interrater agreement (Cohen’s kappa 0.40-0.55)
- 41% of patients demonstrated surgical response (AHI < by 50% and overall AHI≤ 15)
- Collapse of lateral wall of oropharynx and complete tongue base collapse associated with poorer surgical response.
Does Drug-Induced Sleep Endoscopy Affect Surgical Outcome?
A Multicenter Study of 326 Obstructive Sleep Apnea Patients

Kenny P. Pang, FRCSEd, FRCSI (OTO); Peter M. Baptista, MD, PhD; Ewa Olszewska, MD, PhD;
Itzhak Braverman, MD; Marina Carrasco-Llatas, MD, PhD; Srivinas Kishore, MBBS, MS;
Sudipta Chandra, MBBS, MS; Hyung Chae Yang, MD, PhD; Cybil Mei Zhi Wang, BSc;
Yiong Huak Chan, BSc, PhD; Kathleen A. Pang; Edward B. Pang; Brian Rotenberg, MD, MPH, FRCSC


- Retrospective study of sleep surgery outcomes of 326 patients at 7 international sites
- 170 patients underwent DISE; 156 patients had no DISE
- DISE group showed 48% AHI decrease versus 60% AHI decrease for No DISE group (p<0.001)

Failed to control for different outcomes among study sites; procedural differences among study sites; reasons for DISE among study sites
Upper Airway Stimulation for Obstructive Sleep Apnea: 5-Year Outcomes

B. Tucker Woodson, MD¹, Kingman P. Strohl, MD², Ryan J. Soose, MD³, M. Boyd Gillespie, MD⁴, Joachim T. Maurer, MD⁵, Nico de Vries, MD⁶, Tapan A. Padhya, MD⁷, M. Safwan Badr, MD⁸, Ho-sheng Lin, MD⁹, Olivier M. Vanderveken, MD, PhD⁷, Sam Mickelson, MD¹⁰, and Patrick J. Strollo Jr, MD¹²

UAS: Primary Outcome AHI

- Baseline: 29.3 AHI (N=126)
- 12 Month: 9.0 AHI (N=124)
- 18 Month: 9.7 AHI (N=121)
- 36 Month: 6.0 AHI (N=98)
- 60 Month: 6.2 AHI (N=71)

Health Science Center
UAS: Epworth Sleepiness Scale

<table>
<thead>
<tr>
<th></th>
<th>12 Month</th>
<th>18 Month</th>
<th>36 Month</th>
<th>60 Month</th>
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<tbody>
<tr>
<td>Baseline</td>
<td>6.0</td>
<td>6.0</td>
<td>6.0</td>
<td>6.0</td>
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<tr>
<td>N=126</td>
<td>N=123</td>
<td>N=123</td>
<td>N=110</td>
<td>N=92</td>
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<tr>
<td>ESS Score</td>
<td>11.0</td>
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</table>
Snoring

<table>
<thead>
<tr>
<th>% Soft or no snoring</th>
<th>Baseline</th>
<th>12 Month</th>
<th>18 Month</th>
<th>48 Month</th>
<th>60 Month</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>17%</td>
<td>86%</td>
<td>85%</td>
<td>85%</td>
<td>90%</td>
</tr>
</tbody>
</table>

Snoring outcomes stable at 60 months
Post-approval upper airway stimulation predictors of treatment effectiveness in the ADHERE registry

Clemens Heiser, Armin Steffen, Maurits Boon, Benedikt Hofauer, Karl Doghramji, Joachim T. Maurer, J. Ulrich Sommer, Ryan Soose, Patrick J. Strollo Jr., Richard Schwab, Erica Thaler, Kirk Withrow, Alan Kominsky, Christopher Larsen, Eric J. Kezirian, Jennifer Hsia, Stanley Chia, John Harwick, Kingman Strohl, and Reena Mehra. on behalf of the ADHERE registry investigators

Eur Respir J 2019; 53
Prospective Outcomes of DISE at UTHSC  
(UTHSC Protocol 17-05239-XP)

<table>
<thead>
<tr>
<th>VOTE Scores (22 patients)</th>
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<tbody>
<tr>
<td>Awake Endoscopy</td>
<td>3.59 ± 0.85</td>
</tr>
<tr>
<td>DISE</td>
<td>5.77 ± 1.11</td>
</tr>
<tr>
<td>P value</td>
<td>&lt;0.0001</td>
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<table>
<thead>
<tr>
<th>AHI Outcomes</th>
<th></th>
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<tbody>
<tr>
<td>DISE Group (14 patients)</td>
<td>Pre-op AHI  40</td>
</tr>
<tr>
<td>Non-DISE Group (7 patients)</td>
<td>Pre-op AHI  52</td>
</tr>
<tr>
<td>P Value</td>
<td>0.69</td>
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</table>
Is Drug-Induced Sleep Endoscopy (DISE) Reliable?
Is DISE Reliable for Determining Candidacy for UAS Therapy?

Application of drug-induced sleep endoscopy in patients treated with upper airway stimulation therapy

Adrian A. Ong a, Christopher M. Ayers a, Eric J. Kezirian b, B. Tucker Woodson c, Nico de Vries d,e, Shaun A. Nguyen a, M. Boyd Gillespie f,*
Methods

- Single blinded cross sectional study.
- 64 DISE video clips used in the STAR (Stimulation Therapy for Apnea Reduction) trial were evaluated (2 minute representative clips)
- 10 with velum CCC, 54 without.
- Each video scored using the VOTE scoring system.
- Results compared for agreement amongst STAR’s determination of CCC.
# Inspire UAS Screening

## Reliability of DISE for CCC

<table>
<thead>
<tr>
<th></th>
<th>Complete Agreement (score=5/5)</th>
<th>Partial Agreement, (score=4/5)</th>
<th>Mixed Agreement (score=3/5)</th>
<th>Total #</th>
</tr>
</thead>
<tbody>
<tr>
<td># Videos</td>
<td>42</td>
<td>8</td>
<td>14</td>
<td>64</td>
</tr>
<tr>
<td>Type (based on STAR)</td>
<td>CCC-: 37</td>
<td>CCC-: 5</td>
<td>CCC-: 12</td>
<td>CCC-: 54</td>
</tr>
<tr>
<td>% of total videos</td>
<td>66%</td>
<td>12%</td>
<td>22%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Reviewers agree with each other = 78% of all videos

**DISE remains a qualitative, imperfect study**
Case 1:
Complete Circumferential Collapse? Yes or No
Case 2:
Complete Circumferential Collapse? Yes or No
Case 3:
Complete Circumferential Collapse? Yes or No
DISE for Non-PAP Treatment Selection

- May improve effectiveness of OA fitting
- May *not* help improve outcomes of soft tissue upper airway surgery over awake examination.
- UAS therapy outcomes validates use of DISE for screening UAS eligibility
- May have role in initial surgery for severe pediatric OSA
- *Remains a subjective evaluation* with expected disagreement in 20-25% of cases
- Continued research into other more precise methods (sleep MR?) may be indicated
# Summary of Indications for DISE

<table>
<thead>
<tr>
<th>Sleep-Disordered Breathing Severity</th>
<th>DISE Indication</th>
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</thead>
<tbody>
<tr>
<td>Snoring, UARS, Mild OSA</td>
<td>Selection for outpatient snoring treatments; Jaw Manipulation/ Oral Appliance Fitting</td>
</tr>
<tr>
<td>Any OSA level undergoing nasal surgery</td>
<td>Adjunct at time of nasal surgery</td>
</tr>
<tr>
<td>Moderate-Severe OSA CPAP non-adherent</td>
<td>Candidacy for UAS; Identification of airway sites in need of surgery; Jaw Manipulation/ Oral Appliance Fitting;</td>
</tr>
<tr>
<td>Moderate-Severe OSA Incomplete Surgical Response</td>
<td></td>
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</table>
Sleep-Disordered Breathing in Older Adults: Is It A Different Phenotype?
Bimodal Incidence of Obstructive Sleep Apnea
Changes in OSA Phenotype Over Age Spectrum
(UTHSC Protocol 19-06640-XM)

<table>
<thead>
<tr>
<th>Factors</th>
<th>&lt; 50 year cohort</th>
<th>&gt; 50 cohort</th>
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</thead>
<tbody>
<tr>
<td>OSA Prevalence</td>
<td>Less</td>
<td>More</td>
</tr>
<tr>
<td>OSA Severity</td>
<td>More</td>
<td>Less</td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
<td>Equal</td>
</tr>
<tr>
<td>BMI</td>
<td>Larger</td>
<td>Smaller</td>
</tr>
<tr>
<td>Neck Circumference</td>
<td>Larger</td>
<td>Smaller</td>
</tr>
<tr>
<td>Tonsil Size</td>
<td>Larger</td>
<td>Smaller</td>
</tr>
<tr>
<td>OSA Effects</td>
<td>CV morbidity; QOL</td>
<td>QOL</td>
</tr>
<tr>
<td>Pathophysiology</td>
<td>Tissue; Craniofacial</td>
<td>Neuromuscular</td>
</tr>
</tbody>
</table>
Sleep-Disordered Breathing in Older Adults

- More prevalent than general population:
  - AHI >10 62%
  - AHI > 20 44%
  - AHI > 40 24%

- Post-menopausal women have 3.5x risk of AHI>15 than pre-menopausal women (*hormonal predisposition*)

- Loss of muscle tone associated with physiologic aging (*neuromuscular predisposition*)
The influence of aging on pharyngeal collapsibility during sleep.
Eikermann M¹, Jordan AS, Chamberlin NL, Gautam S, Wellman A, Lo YL, White DP, Malhotra A.

- Normal older adults had significantly more collapsible airways
Effects of aging on genioglossus motor units in humans.

Saboisky JP¹, Stashuk DW², Hamilton-Wright A³, Trinder J⁴, Nandedkar S⁵, Malhotra A⁶.

- Slower reaction times of genioglossus dilator in older awake adults
Increased mortality only observed in patients <50 years with AHI≥ 30
Mortality rates in older patients with SDB= mortality rates to those without SDB
Snoring, witnessed apneas, EDS not associated with CV disease in patients ≥ 65 years
SDB not associated with BP change in adults ≥60 years unlike younger adults where association is strong
Increased risk of stroke (2x) in older patients with sleep hypoxemia (≥10% sleep O2 sat <90%)

Explanations?
Younger SDB- Increased CO2 responsiveness and ventilatory control (higher loop gain)
(greater pressure swings, heart rate changes, unstable breathing patterns, catecholamine release)
Older SDB-Predominance of airway collapsibility; neuromuscular decline;
loss of CO2 responsiveness and lower loop gain
Sleep-Disordered Breathing in Older Adults: Which Therapy to Address Airway Collapsibility and Neuromuscular Decline?
CPAP Still Treatment of Choice For Moderate-to-Severe OSA

- CPAP has similar adherence rates in older adults compared to your adults (66%)
- Best adherence seen in older patients with more severe disorder
- Older adults who adhere to CPAP realize similar benefits- reduced snoring and reduced sleepiness (cardiovascular improvement unclear)
- CPAP adherent patients show significant improvement in tests of mental agility and memory.
- Reduced need for daytime napping, and reduced nap duration.
Non-CPAP Options for Older Adults

Procedure Selection- Guiding Themes:
- Cost effective (outpatient/office-based)
- Minimally invasive
- Low pain and morbidity with rapid recovery
- Multi-level treatment

Key:
Match Severity of Intervention = Severity of Disease (cure should not be worse) = Outcomes of Interest (snoring level, daytime sleepiness, sleep quality)
Low-Morbidity Methods to Address Increased Upper Airway Collapsibility and Neuromuscular Decline:

- Nasal Valve Collapsibility (Latera)
- Soft Palate Collapsibility- Tissue Stiffening Procedures (Barbed Suture; Radiofrequency; Pillar; Elevoplasty)
- Oropharynx Collapsibility-Soft Tissue Advancement - Pharyngosling (static)
- Hypopharynx Collapsibility-Soft Tissue Advancement - Hyoid Myotomy and Suspension (static)
- Oropharynx and Hypopharynx Collapsibility- Soft Tissue Advancement - Oral Appliance (static)
- Oropharynx and Hypopharynx Neuromuscular Dilation - Upper Airway Stimulation (dynamic)
Soft-Palate Collapsibility: Tissue Stiffening
Soft Palate Tissue Stiffening

- Radiofrequency Ablation
- Pillar Implants
- Elevoplasty
- 0 Quill Barbed Suture/ Ethicon

Health Science Center
Soft Palate Tissue Stiffening

- No single technique predictably cures snoring
- All reduce snoring volume by 30-50% based on bed partner VAS
- All reduce daytime sleepiness by 30-50% based on patient assessed Epworth
- All show trend toward reduced effectiveness over time; best effect < 24 months
- All cause minimal levels of pain (average 24 hour VAS pain scale 2 to 3) not requiring narcotics
- All are safe with few complications (device extrusion; tissue ulceration)
- All can be used as first-line option for snoring; upper airway resistance syndrome (UARS); mild OSA (AHI<15)
- All can be combined with multi-level procedures (Nasal surgery; BOT RFA; OA) to further reduce snoring and improve treatment outcomes
## Soft Palate Tissue Stiffening Differences

<table>
<thead>
<tr>
<th>Technique</th>
<th>Evidence</th>
<th>Multi-level</th>
<th>Resorbable</th>
<th>Repeatable</th>
<th>Reusable</th>
<th>Shelf-Life</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barbed Suture</td>
<td>Limited</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Long</td>
<td>30</td>
</tr>
<tr>
<td>Radiofrequency</td>
<td>Good</td>
<td>Yes</td>
<td>NA</td>
<td>Yes</td>
<td>Yes</td>
<td>Long</td>
<td>300</td>
</tr>
<tr>
<td>Pillar (3 implants)</td>
<td>Good</td>
<td>No</td>
<td>No</td>
<td>Yes/No</td>
<td>No</td>
<td>Long</td>
<td>675</td>
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<tr>
<td>Elevoplasty</td>
<td>Limited</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Short</td>
<td>1250</td>
</tr>
</tbody>
</table>
Soft Palate Tissue Stiffening

First-line trial of resorbable Quill suture
Soft Palate Tissue Stiffening
Tongue-tissue Stiffening
Soft Tissue Stiffening - Tongue

- Topical benzocaine/pontocaine; 6-7 cc of 1% lidocaine
- 6 lesions in 2 locations
- Must be repeated in 2 to 3 sessions
Soft Tissue Stiffening-Tongue
Oropharynx Soft-tissue Advancement (Static)
Oropharynx Soft Tissue Advancement (Static)

Pharyngosling (Under FDA Protocol)
Hypopharynx Soft-tissue Advancement (Static)
Hypopharynx Anatomy

OSA: Associated with Inferior Hyoid Position

- Elongates upper airway creating longer collapsible segment.
- Positions the tongue more posteriorly.
- More commonly observed in males.
Hypopharynx Soft Tissue Advancement (Static)

Hyoid Swayspension (AirLift)-retroepiglottic collapse
Drug-Induced Sleep Endoscopy (DISE):
Hyoid Traction
Hyoid Myotomy and Suspension (HMS)

- Thyrohyoidopexy technique of Riley & Powell most commonly performed (mid-1990’s).
- Immobilizes base of tongue reducing posterior collapsibility.
- Reported mean success rate of 50% (range, 17-78%)
- Low rate of complications
- Used alone or in combination with other techniques
Thyrohyoidopexy

Lifts Thyroid Cartilage but Hyoid Stays In Position
Hyomandibular Suspension

- Prevents epiglottic prolapse by placing tension on hyoepiglottic ligament opening retroepiglottic airspace.
- Prevents collapse of lower lateral pharyngeal wall by placing tension on stylohyoid muscles.
- Provides modest lift of tongue base.
Hypopharyngeal Soft Tissue Advancement (Static)

Hyoid Traction Intraoperative Fluoroscopy

*Courtesy of Michael Abidin, MD*
Research Paper

Hyoid myotomy and suspension without simultaneous palate or tongue base surgery for obstructive sleep apnea

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Siesta Encore Device

Health Science Center
Fig. 1  Concurrent procedures performed with hyoid myotomy and suspension.

<table>
<thead>
<tr>
<th>Patient variable</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>6 (29)</td>
</tr>
<tr>
<td>Male</td>
<td>15 (71)</td>
</tr>
<tr>
<td>Mean age, y (range)</td>
<td>55.3 (31–76)</td>
</tr>
<tr>
<td>Mean BMI (range)</td>
<td>29.2 (22.8–43.4)</td>
</tr>
<tr>
<td>Mild apnea (AHI &lt;15 events/h), No. (%)</td>
<td>2 (11)</td>
</tr>
<tr>
<td>Moderate apnea (AHI 16–30 events/h), No. (%)</td>
<td>4 (21)</td>
</tr>
<tr>
<td>Severe apnea (AHI &gt;30 events/h), No. (%)</td>
<td>13 (68)</td>
</tr>
<tr>
<td>Complications</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

Table 1  Description of patients undergoing hyoid myotomy and suspension.

Table 2  Outcomes before and after hyoid myotomy and suspension (n = 19).

<table>
<thead>
<tr>
<th>Outcome variable</th>
<th>Pre</th>
<th>Post</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI, mean (SD)</td>
<td>29.2 (5.7)</td>
<td>28.9 (6.1)</td>
<td>0.172</td>
</tr>
<tr>
<td>AH1, mean (SD)</td>
<td>39.7 (21.2)</td>
<td>22.6 (22.7)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Lowest O₂ saturation, mean (SD)</td>
<td>82.2 (9.9)</td>
<td>86.6 (6.2)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Epworth Sleepiness Scale, mean (SD)</td>
<td>8.2 (4.4)</td>
<td>8.3 (5.2)</td>
<td>0.904</td>
</tr>
<tr>
<td>Surgical success (&gt;50% reduction in AH1 and postoperative AH1 &lt;20 events/h), No. (%)</td>
<td>9/19 (47.4)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Final AH1 &lt;10 events/h, No. (%)</td>
<td>8/19 (42.1)</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>
Hypopharynx Soft Tissue Advancement (Static)

Submental Edema:
Triacsinolone Cream Massage
BID 3-4 weeks
Hypopharynx Soft Tissue Advancement (Static)
Hypopharynx Soft Tissue Advancement (Static)

Hyoid Myotomy and Suspension 21685
- Among better coded procedures in sleep surgery
- Work RVU 15.26
- Total Facility/non-facility RVU 28.59
- Global 90 days
Oropharynx and Hypopharynx
Soft-tissue Advancement
(Static)
Oropharynx and Hypopharynx Soft Tissue Advancement (Static)

Oral Appliance -
Most forms of retroglottic and retropalatal collapse;
Must have supportive Dentition
Selection of Best OA Advancement with DISE
Oropharynx and Hypopharynx
Neuromuscular Dilation
(Dynamic)
Neuromuscular Dilation (Dynamic)-Upper Airway Stimulation

- Stimulation Lead
- Respiratory Sensing Lead
- Implantable Pulse Generator
- Physician Programmer
- Patient Sleep Remote
Upper Airway Stimulation: Geniohyoid Stimulation
Efficacy of Upper Airway Stimulation on Collapse Patterns Observed during Drug-Induced Sedation Endoscopy

Adrian A. Ong, MD¹, Alexander W. Murphey, MD¹, Shaun A. Nguyen, MD¹, Ryan J. Soose, MD², B. Tucker Woodson, MD³, Olivier M. Vanderveken, MD, PhD⁴,⁵, Nico de Vries, MD, PhD⁵,⁶, and M. Boyd Gillespie, MD, MSc¹

- 222 patients screened with DISE for STAR Trial
- 52 (23%) with CCC
- 170 (77%) without CCC
Younger Age, Higher VOTE Score, Complete Palatal And Complete Epiglottis Collapse Predictive of Nonresponse

Table 5. Predictors of UAS Nonresponse at 12 Months Postoperatively.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Response (n = 84)</th>
<th>Nonresponse (n = 40)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>55.6 ± 10.3</td>
<td>51.6 ± 9.4</td>
<td>.04</td>
</tr>
<tr>
<td>Male, No.</td>
<td>69</td>
<td>35</td>
<td>.45</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>28.3 ± 2.7</td>
<td>28.7 ± 2.4</td>
<td>.42</td>
</tr>
<tr>
<td>Neck size, cm</td>
<td>41.1 ± 3.4</td>
<td>41.6 ± 2.9</td>
<td>.47</td>
</tr>
<tr>
<td>Baseline AHI, events/h</td>
<td>30.7 ± 10.8</td>
<td>33.7 ± 13.0</td>
<td>.21</td>
</tr>
<tr>
<td>VOTE score</td>
<td>5.0 ± 1.4</td>
<td>5.7 ± 1.2</td>
<td>.02</td>
</tr>
<tr>
<td>Complete collapse, No. (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velum</td>
<td>49 (58)</td>
<td>33 (83)</td>
<td>.01</td>
</tr>
<tr>
<td>Oropharynx</td>
<td>17 (20)</td>
<td>7 (17)</td>
<td>.91</td>
</tr>
<tr>
<td>Tongue base</td>
<td>53 (63)</td>
<td>28 (70)</td>
<td>.58</td>
</tr>
<tr>
<td>Epiglottis</td>
<td>26 (31)</td>
<td>24 (60)</td>
<td>&lt;.01</td>
</tr>
</tbody>
</table>

Abbreviations: AHI, apnea-hypopnea index; BMI, body mass index.

*Values are presented as mean ± SD unless otherwise indicated.
Comparison of younger (N=365) and older (N=235) adults who underwent UAS therapy

Older adults (>65 years) had 30% better response on AHI (-28 versus -22); greater normalization of Epworth Sleepiness Scores (mean 6.3 versus 7.1); and higher nightly usage rates on average (6 hours versus 5.4 hours)
Conclusions

- Sleep surgery outcomes will improve with better patient phenotyping.
- Older patients with OSA (including snoring) may be a unique phenotype characterized by both increased tissue collapsibility and neuromuscular decline.
- Newer surgical techniques can address these underlying issues for older patients with less morbidity.
- Outcomes for older adults go beyond AHI:
  - Snoring
  - Sleepiness
  - Function
  - Memory and Concentration
Don’t delay...
Get Treated Now!
Advanced Surgical Techniques for

OBSTRUCTIVE SLEEP APNEA & SNORING

October 10th, 2019
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Course Directors:
Brandon Boyd, MPAS, PA-C
Mai X. Yang, DNP, FNP-BC, APNP

Honored Guest
Rudolfo Lugo-Saldaña, MD

October 11-12th, 2019
PHYSICIAN WORKSHOP
Course Directors:
M. Boyd Gillespie, MD, MSc
Tod C. Huntley, MD, FACS

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