Surgical Treatment of OSA

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Disclosure

- None
Treatment of OSA

- PAP
- Oral appliance
- Surgery
OSA and Mortality
Surgical Treatment of OSA

- **Surgery to Cure**
  - Surgical success is usually defined as AHI <20 with 50% reduction in AHI

- **Surgery to improve PAP use**
  - Surgery not intended to cure patient of OSA but allow improved compliance of PAP
  - Meta-Analysis: 89.1% of patients who were not using CPAP prior to nasal surgery subsequently accepted, adhered to, or tolerated it after nasal surgery.
Why Consider Surgery for OSA

- Reduction in AHI
- Eliminate snoring
- Improve quality of life
- Decrease ESS
- Some improvement is better than no treatment
Is Surgery Really That Bad Compared to CPAP?
Mean AHI

- Ravesloot et al. Sleep 2011; 34(1);105-110
- Reliable Calculation of Efficacy of Non-Surgical and Surgical Treatment of OSA revisited
- Mean AHI
- Mean AHI is more realistic when taking into account for compliance
- Take a pt with AHI 34 - Wearing CPAP reduces AHI 2
- Uses CPAP 7 night per week but only 4 hours a night (TST 8 hours)
- AHI 2 during 4 hours of CPAP use and 34 when not used
- Mean AHI 18 – brings it down to moderate OSA
The minimum percentage of TST during which CPAP must be used to reach a mean AHI < 5. To be cured of OSAS, the mean AHI must be < 5.
The minimum percentage of TST during which CPAP must be used to reduce the initial AHI by a certain percentage (when the AHI is reduced to 5 while using CPAP)
Role of Otolaryngologist

- Positive Airway Pressure, not surgery, is the first line of treatment for OSA for adults
  - Safe and effective

- Rejection rate of CPAP
  - 5-50% reject CPAP before or soon after trying
  - 12-25% abandon treatment within 3 years

- Compliance rate for CPAP
  - No set criteria of defining compliance
  - Compliance = > 4 hour/night on > 70% of nights

<table>
<thead>
<tr>
<th>Paper</th>
<th>Sample size</th>
<th>Rejection rate</th>
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<tbody>
<tr>
<td>Mc Ardle 1999 [1]</td>
<td>1211</td>
<td>5%</td>
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<tr>
<td>Lacassagne 2000 [4]</td>
<td>248</td>
<td>9%</td>
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<td>Waldhorn 1990 [6]</td>
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<td>Rauscher 1991 [7]</td>
<td>95</td>
<td>50%</td>
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<td>Meurice 1994 [8]</td>
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<td>Fleury 1994 [9]</td>
<td>27</td>
<td>26%</td>
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</table>
Role of Otolaryngologist

- Options for OSA patients who are noncompliant to PAP
  - Improve PAP compliance
    - Offer medical and surgical treatments to alleviate physical discomfort such as nasal obstruction
    - Offer surgical treatments, such as tonsillectomy for pts with obstructing tonsils, to decreased positive pressure required & increase comfort
  - Provide surgical alternatives by offer multi-level surgical procedures based on the level of airway obstruction
    - Surgical Success (↓ AHI >50% and AHI<20)
    - Improved tolerance and compliance with PAP
    - Improved daytime symptoms
History of Surgical Treatment

- **Tracheotomy**
  - Sole treatment available in 1960’s and 1970’s
  - 100% effective but associated with some morbidity
  - Not well accepted by patients

- **Uvulopharyngopalatoplasty (UPPP)**
  - Ikematsu in Japan in 1964
  - Fujita in the US in 1981
  - Meta-analysis by Sher et al. in 1996 indicated effectiveness of **40.7%**
    - > 50% reduction in AHI with AHI < 20
  - Became discredited among many physicians as well as general public
History of Surgical Treatment

- **Multi-Level Airway Surgery**
  - OSA involves multiple levels of airway, not limited to the velopharynx level
  - Fujita Classification System
    - Type I Palatal obstruction only
    - Type II Both palate and BOT obstruction
    - Type III BOT obstruction only
  - Riley and Powell
    - Introduced genioglossus advancement and hyoid myotomy to address the BOT in 1986
    - Developed the Stanford Powell Riley Protocol that involves a graduated surgical approach for Tx of OSA
    - Reported response rate of **76.5%**
  - Basis of modern surgical management of OSA
Fujita Classification
Powell Riley 2-Phase Surgical Protocol

Presurgical Evaluation
(Physical Examination, Cephalometric Analysis, Fiberoptic Pharyngoscopy)

Phase I
(Site of Obstruction)

UPPP
(Type 1 Oropharynx)

UPPP+GAHM
(Type 2 Oropharynx - Hypopharynx)

GAHM
(Type 3 Hypopharynx)

Post-Operative Polysomnogram (6 Mos)
(Failure)

Phase II
MMO
Powell-Riley 2-Phase Surgical Protocol:

- Phase 1 success 60-70%
- Phase 2 success over 90%
- Problem: Identification of Level of Obstruction is Subjective
- Factors predicting less successful outcome include:
  - RDI > 60
  - Lowest O2 sat < 70%
  - BMI > 35
  - Severe mandibular deficiency
Multi-Level Airway Surgery: Determine Level of Obstruction

- Riley et al. reported that 87% of pts had multi-level obstruction.
- Failure to recognize the multi-level nature of airway obstruction may account for the poor surgical outcome following UPPP.

- UPPP alone (type I-III) Response rate = 40.7%
- UPPP + BOT (type I-III) Response rate = 61 – 86%
- UPPP alone (type I) Response rate = 70 – 80%
Multi-Level Airway Surgery: Determine Level of Obstruction

- PAP effective in relieving obstruction at all levels. Airway stent via pressure
- Surgical treatments, such as UPPP and BOT procedures, treat only specific segment of the upper airway
- The precise determination of the site of airway obstruction allows the site-specific surgical approach to address the problem areas
  - Maximize effectiveness and minimize complications
Multi-Level Airway Surgery: Determine Level of Obstruction

Many older diagnostic modalities are imperfect
  ▪ May account for the less than perfect results after phase I surgery (61 – 86%)
  ▪ All on awake patients

Limited by lack of accuracy & high cost
  ▪ Head & Neck Exam
    ▪ Assess size of tongue, tonsil, soft palate, OP airway
    ▪ Modified Muller’s Maneuver
  ▪ Lateral Cephalometric Analysis
  ▪ Pharyngeal Pressure Measure
  ▪ Sine-CT Scan and MRI

Drug Induced Sleep Endoscopy

[Utley, 1997 #515] [Terris, 2000 #246] [Yao, 1998 #456] [Sher, 1985 #1020]
Friedman Scale
Grading Lingual Tonsillar Hypertrophy

Grade 1: Lymphoid tissue scattered over the tongue

Grade 2: Lymphoid tissue covering the tongue but with limited vertical thickness

Grade 3: Between 25% and 75% of the height of the epiglottis

Grade 4: Vertical thickness rising above the tip of the epiglottis
Drug Induced Sleep Endoscopy (DISE)

- Drug Induced Sleep Endoscopy
  - Determine the site of airway obstruction/collapse during simulated natural sleep state (induced w/ low dose propofol)
  - Objective measurement of airway can be obtained by the use of quantitative computer assisted digital imaging
    - Validated by comparison w/ MRI data
    - Airway during simulated natural sleep state
- Type and extent of surgical procedures based on this exam
## Multi-Level Airway Surgery: Determine Level of Obstruction

<table>
<thead>
<tr>
<th></th>
<th>Velopharynx</th>
<th>Oropharynx</th>
<th>Base of Tongue</th>
<th>Epiglottis</th>
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<td><strong>AP Collapse</strong></td>
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<td><strong>Concentric</strong></td>
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<td><img src="image11.jpg" alt="Image" /></td>
<td><img src="image12.jpg" alt="Image" /></td>
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Multi-Level Airway Surgery: Selection of Surgical Procedures

- **Nose**
  - Septoplasty
  - Turbinate reduction
  - Nasal valve reconstruction

- **Velopharynx**
  - UPPP, lateral pharyngoplasty
  - Tonsillectomy & Adenoidectomy
  - Pillar implant

- **Oropharynx**
  - Mandibular osteotomy w/ Genioglossus advancement
  - Hyoid myotomy and advancement
  - Tongue and hyoid suspension
  - Radiofrequency BOT reduction
  - Robotic-assisted Partial Glossectomy / Lingual Tonsillectomy
  - Hypoglossal Nerve Implant

- **Others**
  - Maxillo-mandibular advancement
  - Distraction osteogenesis
  - Tracheostomy
Nasal Surgery: Turbinate Reduction
Nasal Surgery:
Septoplasty/Turbinate Reduction
Surgical Treatment – Level of Velopharynx

-Z-plasty (Friedman)
-Changes the scar contracture tension line to pull laterally and anteriorly
-Aggressive, temporary VPI expected
-Select based on sleep endoscopy: Circumferential collapse
-Ideal for pts with h/o tonsillectomy
Surgical Treatment –
Level of Velopharynx

- Palatal Advancement Pharyngoplasty (Woodson)
  - Ideal for pts w/ h/o UPPP
  - Similar to a V-Y advancement flap
  - Degree of advancement determined by
    - Mobilization
    - Bone removal
    - Placement of palatal drill holes
Palatal Advancement Pharyngoplasty
Palatal Advancement Pharyngoplasty
Lateral Pharyngoplasty
Surgical Tx – Oropharynx

Genioglossus Advancement

- GBAT System
  - Genial Bone Advancement Trephine System
  - Reiley and Powell
  - Horizontal mandibulotomy
  - Advance mentum and its attached genioglossus muscle 12-15mm anteriorly

- Disadvantages:
  - Takes too long
  - Dental complications
Anatomy-Genioglossus Muscle
Surgical Tx – Oropharynx
Genioglossus Advancement
Surgical Tx – Oropharynx
Genioglossus Advancement
Surgical Tx – Oropharynx
Genioglossus Advancement
Surgical Tx – Oropharynx
Hyoid Suspension

- First reported by Riley et al. in 1986
  - Suspend hyoid bone to ant mandibular arch using fascia lata
- Later simplified in 1994
  - Suspension of hyoid to thyroid cartilage
  - Hyoid released from inferior attachments
  - Hyoid advanced ant & inf over thyroid cartilage
  - Apply tension to hyoepiglottic ligament, pulling epiglottis forward
  - Pull hypoglossus m and thus BOT inf & ant

[Riley, 1986 #1009] [Riley, 1994 #675]
Surgical Tx – Oropharynx

Hyoid Suspension
Surgical Tx – Oropharynx

Hyoid Suspension
Surgical Tx – Oropharynx
Hyoid Suspension
Epiglottis Collapse
Surgical Tx – Oropharynx Tongue Suspension

- AlRvance Procedure
  - Suspend tongue base to mandible w/ suture
  - Prevent BOT from prolapsing when supine
  - Minimally invasive
  - Require only 15-30 min to perform

- Caution to prevent tissue ischemia, pain, and edema

- Correct suture tightening should advance the tongue base 3-7 mm towards the mandible.

- Tightness of tongue suspension is determined by palpation
Surgical Tx – Oropharynx
AIRvance System

Drill driver device

4mm screw attached to double polypropylene #1 suture

Suture passer
Surgical Tx – Oropharynx
AIRvance Tongue Suspension
Surgical Tx – Oropharynx
AIRvance Tongue Suspension
AIRvance Base of Tongue and Hyoid Suspension
AIRLIFT Procedure (Encore system) BOT and Hyoid Suspension
Surgical Tx – Oropharynx
Transoral Robotic Surgery (TORS)
Surgical Robotics: Advantage

- Excellent Depth Perception (3-D vision)
- Amazing Visualization (High Definition and Magnification)
- Steady Visual Field
Surgical Robotics: Advantage

- Improved precision of movement
  - Motion scaling
  - Tremor filtering
Surgical Robotics: Advantage

- Enhanced Surgical Dexterity
  - Wide variety of instruments w/ articulating wrist
  - Endowrist w/ 7 degrees of freedom that mimic dexterity of human hand and wrist
Surgical Tx – Oropharynx
Robotic Assisted Lingual Tonsillectomy/Partial Glossectomy
Lingual Tonsil Hypertrophy Preop
Postop After TORS
TORS Outcomes

- Mean AHI reduction of 50.9%

- Statistical significant reduction in daytime somnolence, as measured by Epworth Sleepiness Scale (15.6 ± 5.4 preoperatively vs. 5.7 ± 4.3 postoperatively; P < 0.001)

- Surgical response, as defined by > 50% reduction in AHI and final AHI < 15 with resolution of daytime somnolence, was achieved in 21 patients (53.8%).

- Clinical characteristics found to be significantly different between the responders and nonresponders were BMI, AHI, and lateral velopharyngeal collapse. Patients with BMI < 30, AHI < 60, or absence of lateral velopharyngeal collapse have excellent surgical response rate of 88.2%, 67.9%, or 66.7%, respectively

Lin et al Laryngoscope 2015
Pioneers in Transoral Robotic Surgery (TORS)
TORS with UPPP

- Patients who had **no** prior surgery achieved an average AHI reduction from 58.4 to 19.5 (67%, $P < .0001$)
- Surgical success rate of 56%

- Patients with **prior** pharyngeal surgery achieved an AHI reduction from 55.0 to 45 (24%, $P = .19$), a surgical success rate of 30%

- ESS improved for all patients combined from 12.8 to 5.8 ($P < .0001$)

- Outcomes for the combined approach of OSA TORS and UPPP provide strong evidence in favor of this multilevel approach for the surgical management of OSA. The benefit of the current surgical approach is most significant for previously unoperated patients

*Thaler et al Laryngoscope 2016*
Maxillomandibular Advancement

Before

Narrow airway at base of tongue prior to jaw surgery

After

Airway enlarged after jaw advancement
Meta-analysis Maxillomandibular Advancement

- Forty-five studies with individual data from 518 unique patients/interventions were included
- 197 of 268 (73.5%) had undergone prior surgery for OSA.
- Mean postoperative changes in the AHI and RDI after MMA were \(-47.8\) (25.0) and \(-44.4\) (33.0), respectively;
- Mean reductions of AHI and RDI outcomes were 80.1% and 64.6%, respectively;
- 512 of 518 patients (98.8%) showed improvement
- Significant improvements were seen in the mean postoperative oxygen saturation nadir (70.1% to 87.0%; \(P < .001\))
- Epworth Sleepiness Scale score (13.5 to 3.2; \(P < .001\)).
- Rates of surgical success and cure were 389 (85.5%) and 175 (38.5%), respectively.
- Preoperative AHI of fewer than 60 events/h was the factor most strongly associated with the highest incidence of surgical cure. Nevertheless, patients with a preoperative AHI of more than 60 events/h experienced large and substantial net improvements despite modest surgical cure rates.

Zaghi et al JAMA Otolaryngology 2016
Problem with OSA Surgery

- Static surgery
- Difficult to adjust after surgery
- Soft tissue component – OSA recurs

- Nerve stimulation - dynamic
Inspire Hypoglossal Nerve Stimulation

Inspire Upper Airway Stimulation (UAS) Therapy

Stimulation of the upper airway prevents airway collapse during breathing.

Sensor detects each time patient breathes.

Airway maintained open during therapy.

Pulse generator processes breathing data and provides stimulation.
Inspire Hypoglossal Nerve Stimulation
Hypoglossal Nerve Stimulator

- Phase 3 trial from ImThera Medical – THN sleep therapy
Conclusion

- Airway obstruction occurs at multiple levels
- Surgery for OSA is evolving and improving
- Diagnostic tools are evolving and improving
- Positive Airway Pressure is the first line of treatment for OSA
- However, in patients noncompliant with PAP, surgery is better than no treatment