TONGUE BASE PROCEDURES FOR OBSTRUCTIVE SLEEP APNEA
OVERVIEW

- Sleep physiology and testing
- Adult obstructive sleep apnea
  + Pathophysiology
  + Evaluation
- Medical Management
- Surgical Management
- Tongue base procedures
- Conclusions
PHYSIOLOGY OF SLEEP

- Sleep stages (wake, non REM, REM)
- Sleep latency
- Sleep onset
- Sleep cycle
- Aberrant sleep patterns
  - Insomnia, narcolepsy, Sleep related breathing disorders (Obstructive sleep apnea, central sleep apnea, upper airway resistance syndrome)
The gold standard for evaluating sleep

- EEG, EOG, EMG (chin)
- Airflow (nasal airway pressure sensor or thermister)
- Respiratory effort (abdominal and rib cage EMG)
- Oxygenation (pulse oximetry)
- Cardiac rhythm (EKG)
- Leg movements
American Academy of Sleep Medicine (2007) classifies 4 stages of sleep (N1, N2, N3, and R)

- W – wake stage, is not considered stage of sleep, characterized by alpha waves (8-13 Hz)
- N1 – low amplitude, mixed frequency (4-7 Hz) activity and slow eye movement
- N2 – K complexes and sleep spindles
- N3 – delta waves, 20% of epoch has slow wave activity (0.5-2 Hz) (Previously N3 and N4)
- R – rapid eye movement sleep, saw tooth theta waves
## EEG OF SLEEP STAGES

<table>
<thead>
<tr>
<th>REM Stage</th>
<th>EEG characteristics</th>
<th>EOG</th>
<th>EMG muscle activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>Predominant alpha activity (more than 50% of the epoch) mixed with EEG beta</td>
<td>Slow &amp; rapid</td>
<td>High</td>
</tr>
<tr>
<td>1</td>
<td>Alpha activity is replaced by low voltage, predominant low voltage, mixed-frequency background activity sometimes with vertex sharp waves</td>
<td>Slow</td>
<td>Decreased from awake</td>
</tr>
<tr>
<td>2</td>
<td>Sleep spindles and K-complexes in a background EEG that has less than 20% delta activity</td>
<td>None</td>
<td>Decreased from awake</td>
</tr>
<tr>
<td>3</td>
<td>Slow wave (EEG delta activity) comprises 20%–50% of the epoch; sleep spindles usually are present</td>
<td>None</td>
<td>Decreased from awake</td>
</tr>
<tr>
<td>4</td>
<td>More than 50% of the epoch has EEG delta activity</td>
<td>None</td>
<td>Decreased from awake</td>
</tr>
<tr>
<td>REM</td>
<td>Low voltage, mixed frequency background activity; saw-tooth theta waves may be present</td>
<td>Rapid</td>
<td>Nearly absent</td>
</tr>
</tbody>
</table>
RESPIRATORY EVENTS

- Epoch – each 30 seconds of sleep study
- Apnea – cessation of oral or nasal airflow 10 seconds or longer
  - Obstructive, central or mixed
- Hypopnea – 30% reduction in thoracoabdominal excursion and 4% drop in saturation
- Respiratory effort-related arousal – events like hypopneas, with less than 4% drop in saturation
- Snoring
- Leg Movement
PSG INTERPRETATION

- Apnea Index
  + Apneas/hour

- Apnea/hypopnea index
  + Apneas + hypopneas/hour

- Respiratory disturbance index
  + Apneas + hypopneas + RERA’s/hour

- Minimum Oxygen saturation

- Total time below 85% oxygen saturation

- Snore arousal index
Upper airway resistance syndrome (no desaturations, and continuous respiratory effort)

Snoring

RDI > 5 is considered OSA

RDI 5 – 20, mild

RDI 20 – 40, moderate

RDI > 40, severe
PREVALENCE OF OSA

- Young et al found the prevalence of Sleep disordered breathing (SDB) in 30-60 year olds to be 9% in women and 24% in men.
- More prevalent in men (8-10 fold more), and post-menopausal women.
- 70% of patients are obese.
- OSA prevalence is 4% of males and 2% of females.
Airway narrowing and collapse at multiple sites
- Fujita I, retropalatal
- Fujita II, retropalatal/retrolingual
- Fujita III, retrolingual

Hypoxia

Hypercapnia
Corrected hypoxia

Hypercapnia

Patent Airway

Regained pharyngeal muscle tone

Sleep arousal

Increased ventilatory effort

Hypoxia and hypercapnia

Obstructive apnea

Airway obstruction and collapse

Pharyngeal dilator hypotonia

Sleep
DIAGNOSIS OF OSA

- **History**
  - Sleep questionnaire (GBI, ESS)

- **Physical**
  - Muller’s manoeuvre

- **Diagnostic tests**
  - Polysomnography (PSG), attended
  - Multiple sleep latency test (MSLT)
  - Home PSG
  - Sleep endoscopy
  - Fluoroscopy
  - Cephalometrics
BEARS

- Bedtime
- Excessive sleepiness
- Night and early morning Awakenings
- Regularity and duration of sleep
- Snoring
SIGNS AND SYMPTOMS

- Snoring
- Unrefreshing sleep
- Witnessed apnea
- Waking up choking or gasping for air
- Nocturnal reflux
- Nocturia
- Nocturnal sweating
- Sleep talking
- Morning dry mouth
- Morning headache
- Unexpected sleep onset
- Falling asleep while driving
- Routine napping
- Unrefreshing naps
EPWORTH SLEEPINESS SCALE

- 8 question survey that determines the chance that a person will fall asleep in certain situations.
  + Sitting and reading
  + watching TV
  + sitting inactive in a public place
  + as a passenger in a car for longer than 1 hour
  + sitting and talking to someone
  + sitting quietly after lunch
  + lying down in the afternoon
  + while stopped at a traffic light

- A score greater than 11, is correlated with OSA
CLINICAL FINDINGS

- Patient falling asleep during history
- Nasal obstruction (septal deviation, turbinate hypertrophy)
- Elongated uvula
- Large tongue
- Large tonsils (palatine or lingual)
- Large/floppy epiglottis
- Redundant pharyngeal tissue
- Retrognathia
- High arching hard palate
- Retro-displaced hyoid complex
- Increased neck circumference
FRIEDMAN’S CLASSIFICATION
MULLER’S MANEUVER

- Nasopharyngoscopy is performed in the awake patient in either the seated or supine position.
- Patient inhales against a closed glottis with the nose and mouth sealed.
- Can show anterior/posterior compression or lateral compression of pharyngeal walls.
- A better test for determining who will fail palate procedures.
Drug induced sleep endoscopy (DISE)
First described in 1991
Pharmacological sedation and fiberoptic telescope evaluation of upper airway (Propofol only)
Not routinely used in the US
Rodriguez-Bruno et al performed prospective cohort study on 32 adults with OSA. All patients underwent diagnostic DISE, followed by preoperative DISE. These were recorded and reviewed by the surgeon (unblinded observer), and a blinded observer. Total of 8 reviews, two reviews of the preoperative DISE and postoperative DISE done 2 days to 6 weeks apart, done by both observers.
- Analysis I – global analysis of obstruction at the palate and hypopharynx
- Analysis II – degree of palatal and hypopharyngeal obstruction
- Analysis III – assessment of individual regions of the pharynx and specific structures
  - Palate
    - Palatine tonsils
    - Lateral pharyngeal wall at the level of velopharynx
  - Hypopharynx
    - Tongue
    - Epiglottis
    - Lateral pharyngeal wall at the level of the hypopharynx
Found good inter-tester reliability and test-retest reliability for analysis I

This was especially true for hypopharyngeal obstruction

Limitations of study
- Experienced sleep surgeons
- Unnatural sleep
- Cost of procedure, and risks of performing
- Needs larger numbers of patients
S sella
N nasion
ANS anterior nasal spine
A subnasale
B supramentale
PAS posterior airway space
Go gonion
Gn gnathion
Sequelea of Untreated OSA

- Neuropsychological
  - Impaired cognition, decreased attentiveness

- Metabolic
  - Insulin resistance

- Cardiovascular
  - HTN, myocardial infarction

- Pulmonary
  - Pulmonary HTN, cor pulmonale
After a patient is diagnosed with OSA, there is behavioral modification that should be recommended:

- Avoidance of alcohol and sedatives
- Smoking cessation
- Weight loss
MEDICAL DEVICES

- CPAP
- BiPAP
- Chin supports
- Nasal Cones/Breathe rite strips
- Dental Devices
CPAP/BiPAP

- These treatments have known efficacy and can treat OSA as long as the optimal pressure can be achieved.
- Titration study is needed to determine the optimal pressure.
CPAP/BIPAP COMPLIANCE

- Must wear mask for at least 5 hours/night and 5 nights/week
- Over 50% of people are non-compliant
- Noncompliance due to
  - Excessive pressure required
  - Patient discomfort
  - CPAP is cumbersome
  - Noise
  - Claustrophobia
  - Air leakage
Robinson et al (2009) performed cohort study of consecutively treated patients with OSA.
- 77 underwent staged UARS and 89 underwent CPAP therapy
- Looked at ESS, Glasgow benefit inventory, and snoring
- No difference between groups in GBI, ESS, snoring
- Postoperative reduction of RDI by 50% (44 down to 22)
- RDI correlated with decreased ESS and snoring, but not GBI
- Snoring control and GBI correlated with CPAP compliance
- Found that 26% of patients had side effects, and a total of 45% of patients were either non-compliant or had side
- Concluded that patients who are non-compliant or have side effects from CPAP should be evaluated for UARS
Surgical Management of OSA

- OSA is caused by obstruction at various sites along the upper airway.
- Surgery can be performed to decrease collapsibility at any of these sites.
- Nasal procedures
- Oropharyngeal procedures
  - Palate
  - Base of tongue
- Maxillomandibular advancement (MMA)
- Tracheostomy
STAGED SURGICAL PROTOCOL

- Developed by Riley and Powell
- Perform phase I surgery
  - Nasal, palatal, tongue base
- 6 month postoperative PSG
- If failure, then perform phase II surgery (MMA)
NASAL PROCEDURES

- Septoplasty
- Turbinoplasty
- Removal of concha bullosa
  - As well as treatment of associated inflammatory nasal disease (allergic rhinitis, rhinitis medicamentosa)
PALATAL PROCEDURES

- Classically, uvulopalatopharyngoplasty
  - Developed to address the proposed cause of obstruction in OSA
  - Involves performing tonsillectomy, repositioning the anterior and posterior tonsillar pillars
  - Trimming the excess mucosa overlying the muscularis uvula, and creating a neo-uvula
Kahn et al (2009) from Mayo Clinic performed RCT of patients undergoing UPPP over an 18 year period.

They found 63 patients that underwent preoperative PSG, and a postoperative PSG

Used AHI of < 5 as endpoint for cure

Found a cure rate of 23.8%

All patients had a reduction in the amount of pressure needed for CPAP
Cures were achieved in patients with lower BMI, less severe OSA, and a higher minimum O2 saturation on initial PSG.

BMI remained unchanged from preop/postop.

For those where cure was not obtained, there was a reduced CPAP pressure postoperatively, and increased CPAP compliance.
OTHER PALATAL PROCEDURES

- Laser assisted uvulopalatoplasty (LAUP)
- Pillar implants
- Soft Palate tightening
  - Radiofrequency procedures
  - Injection snoreplasty
  - Cautery-assisted palatal stiffening operation (CAPSO)
- Lateral pharyngoplasty
- Transpalatal advancement pharyngoplasty
PALATAL PROCEDURES

- These procedures may decrease snoring, but usually fall short of providing a cure for OSA.
- They are effective in selected individuals
- Often times, this is the first-line procedure
- Nasal procedures and tongue base procedures may be done concurrently
TONGUE BASE PROCEDURES

- Radiofrequency base of tongue ablation
- Lingual tonsillectomy
- Submucosal minimally invasive lingual excision
- Geniotubercle advancement
- Hyoid suspension/Repose
- Maxillomandibular advancement
TONGUE BASE PROCEDURES

- These are rarely done alone
- Part of multilevel surgery
- Knowledge of anatomy and important structures is critical
- Address the tongue base by three mechanisms
  - Tissue reduction
  - Improved tension
  - Increased airway space
PERIOPERATIVE MANAGEMENT

- Medical optimization of comorbidities
- Patient should use CPAP for at least 2 weeks prior to surgery
  - Reduces sleep debt and prevents REM rebound in postoperative period
- Anesthesia and induction performed with surgeon present
- 24 hour ICU stay with nasal CPAP or humidified O2 via face mask
- Aggressive treatment of hypertension
- Narcotic pain control
- Discharge criteria include
  - Stable airway
  - Adequate PO intake of fluids
  - Pain control
TONGUE BASE ANATOMY

- Hypoglossal nerve, lingual artery neurovascular bundle
- Foramen cecum and sulcus terminalis
- Retromolar trigone
- Lingual tonsil
- Epiglottis
- Hyoid
1997 Lauretauno et al. performed cadaver study to determine the position of the HNLANVB Bundle is midway between midline of tongue and lateral border of tongue

- 2.7 cm inferior and 1.6 cm lateral to the foramen cecum
- 2.77 cm inferior and 1.1 cm medial to the lateral tongue margin at the level of the foramen cecum
- Within 1.5 cm superior to the hyoid bone (mean 0.9 cm)
Can be performed in the operating room, or in the office setting

Ablation in the central portion of the tongue at the level of the foramen cecum

Does not exceed 12,000 J total (750 J to each site)

10-12 spots are targeted

- Rapid lesion technique
- Classic technique
Meta analysis of efficacy of RFA (soft palate, base of tongue, both) over 16 published studies.

Overall reduction of RDI of 31% and ESS of 31% in short-term follow-up. There was no change to minimum O2 sat.

To obtain these results, need to perform RFBOT over 4 sessions with approximately 12,000 J total.

Complications (3.5%)

- Mucosal ulceration (0.6), floor of mouth hematoma (0.7), tongue cellulitis (0.6), tongue base abscess (0.3), hypoglossal paresis (0.3), lingual nerve hypesthesia (0.2), prolonged dysphagia (0.1), and vasovagal syncope (0.1)
Advantages

- Relatively safe (3.5% overall complication rate)
- Can be performed on outpatient basis
- Can be performed in as little as one sitting

Disadvantages

- Can only ablate a small amount of tissue
LINGUAL TONSILECTOMY

- Can be performed under visualization using a telescope
- Use coblator or microdebrider to remove tissue
- Increases posterior airway space
- Lingual tonsils may regrow
- Traditionally a high morbidity procedure, but with the advent of coblation, it is safer.
Lingual arteries found and marked using doppler

Midline of tongue one centimeter anterior to the circumvallate papillae an incision is made using 15 blade

Coblator wand to ablate tissue to vallecula

Stay within 1 cm of midline, and medial to the markings for artery

Leave open for drainage
FRIEDMAN ET AL 2009

- Retrospective chart review comparing SMILE (48) to RFBOT (48)
- Friedman stage II or III, intolerant to CPAP, preop abnormal PSG
- Surgical success rate 64.6 vs 41.7
SMILE COMPLICATIONS

- Infection
- Hematoma
- Airway edema
- Hypoglossal nerve injury
- Risk of lingual artery damage, may require neck exploration to control bleeding
REPOSE (SUTURE SUSPENSION OF TONGUE)

- Intraoral incision is made in the frenulum and a titanium screw is placed in the lingual cortex of the geniotubercle.
- Permanent suture is passed through the paramedian tongue musculature to the tongue base and then back through:
  - 1 cm lateral to midline, and 1 cm below foramen cecum
- Pulls the tongue base anteriorly
- Increase tension, and posterior airway space
COMPLICATIONS

- Dysphagia
- Dysarthria
- Submandibular sialadenitis
- Pain
- Infection of suture
- Swelling in the floor of mouth
FERNANDEZ-JULIAN ET AL, REPOSE VS RFBOT

Patients with AIH ≥ 15, who failed to tolerate or refused CPAP, assessed for eligibility (n=83)

Comprehensive history, Epworth Sleepiness Scale, Static and dynamic Nasopharyngoscopy, Lateral cephalometric.

Excluded (n=26)
- Failed inclusion criteria (n=11)
  (only retropalatal obstruction)
- Presented exclusion criteria (n=9)
  (BMI ≥ 35 kg/m², nasal pathology)
- Refused to participate (n=6)

Randomized (n=57)

Allocated to UPPP+TBRF (n=29)
- Received allocated intervention (n=29)
- Did not receive allocated intervention (n=0)

Allocated to UPPP+TBS (n=28)
- Received allocated intervention (n=28)
- Did not receive allocated intervention (n=0)

Follow-up
Lost to follow-up (n=0)
Discontinued intervention (n=0)

Analysis
Analyzed (n=29)
Excluded from analysis (n=0)

Analyzed (n=28)
Excluded from analysis (n=0)
**FINDINGS**

- Similar success rate (57.1 vs 51.7)
- Worse success in obese patients (12.5 vs. 10)
- Higher morbidity with tongue base suspension
  - 21.4 vs 3.4 rate of complications
  - Longer duration of pain
  - Longer duration of dysphagia and dysarthria
MIDLINE GLOSSECTOMY

- Intraoral procedure using laser
- 2.5 x 5cm of midline tongue tissue excised
- May need to perform lingual tonsillectomy, reduction of AE folds, and partial epiglottectomy
- Usually need tracheotomy for airway protection
COMPLICATIONS

- High morbidity surgery
- Hematoma
- Seroma
- Abscess formation
- Hypoglossal nerve injury
- Lingual artery injury requiring neck exploration for control
- Airway edema, necessitating tracheostomy
GENIOTUBERCLE ADVANCEMENT

- Intraoral approach that enlarges the retrolingual area.
- Fixes the major dilators of the pharyngeal airway forward
- Genial tubercle is mobilized with osteotomies. It is advanced and rotated
- Fixed at the inferior aspect with titanium screw
COMPLICATIONS

- Infection 2-5%
- Need for root canal 4%
- Permanent anesthesia (6%)
- Seroma 2%
- Mandibular fracture
HYOID MYOTOMY AND SUSPENSION

- Addresses the retrolingual area
- Alleviates obstruction caused by redundant lateral pharyngeal tissue or retrodisplaced epiglottis
- Horizontal cervical incision over the hyoid, dissect down to the suprahyoid muscles
- Midline hyoid is advanced over the thyroid ala and secured with two medial and lateral permanent sutures
- Usually done in conjunction with GTA, of little benefit when performed alone
Lin et al (2008) performed meta-analysis

49 multilevel surgery articles with 1,978 pts.

Overall success rate 59.2% (without MMA groups)

Complication rate 14.6%

Goal is cure, but if a cure cannot be achieved, then reduce the number and severity of obstructive events
Friedman et al (2009) RCR with 52 pt. meeting criteria

All had tried CPAP and could not tolerate

After surgery

- increase in the usage of CPAP from 0.2 ± 0.14 hrs/night to 3.2 ± 2.6 hrs/night
- decrease in optimal CPAP pressure from 10.6 ± 2.1 cm H2O to 9.8 ± 2.1 cm H2O
- ESS was decreased in all postoperative patients and when comparing those that used CPAP versus those that did not, the ESS was 3.9 ± 1.4 for users and 6.9 ± 3.5 for non-users
MAXILLOMANDIBULAR ADVANCEMENT

- Improves retropalatal collapse and retrolingual obstruction
- Performed after stage I procedures when there continues to be significant OSA
- Maxillary advancement by LeFort I osteotomy
- Bilateral sagittal split osteotomy
- 80-97% success rate
Need preoperative Cephalometrics
Intermediate splint needs to be made
Advancements of greater than 10 mm are most effective
Need to be comfortable with osteotomies, and bone grafting
4 weeks of MMF
Will likely cause a change in appearance
A. Lefort I osteotomy
B. Sagittal split osteotomy
MMA COMPLICATIONS

- Malocclusion
- Parasthesia (inferior alveolar, lingual or infraorbital)
- Nonunion or malunion
- Relapse of advancement
- Significant bleeding
- TMJ complaints
Retrospective Chart review of 59 patients that underwent MMA as initial treatment for OSA. Total of 50 in there analysis. “Cure” rate of 80%, with 52% reaching AHI<10. 12% failure rate, 4 of these patients went on to have soft tissue procedures with lowering of AHI (8-16) Complications
- Parasthesia (94%), declined to 52% at 18 months postop
- Change in appearance (89%)
  - 13.1% dissapointed and 5.2% unsatisfied with change
- TMJ complaints (21%)
- Trismus (39.4%)
Randomized prospective trials are needed to compare the efficacy of the newer tongue base procedures.

Redefine the definition of cure, currently 50% reduction in RDI and RDI<20.

Sleep endoscopy is not widely used in the US, and needs more study.

Sleep imaging (sleep MRI) is being investigated to preoperatively determine sites of obstruction.

The role of Bariatric surgery in the treatment of OSA is still being determined.
Summary

- Obstructive sleep apnea affects millions of people causing poor quality of life, decreased productivity at work, and potentially exacerbates medical comorbidities.
- First line therapy is CPAP or BiPAP, and behavioral modification.
- To be effective, CPAP must be used for at least 4 hrs/night and 5 nights per week.
- If this can not be achieved, then Otolaryngologic referral is warranted.
Indications for surgical treatment of OSA include:

- CPAP noncompliance
- Altered daytime performance
- RDI > 20 (moderate to severe disease)
- Minimum O2 saturation < 90
- Arrhythmias and hemodynamic changes associated with obstruction
SUMMARY

- There are many surgeries available that address obstruction at various sites within the upper airway.
- Using a stepwise approach, multiple levels of the airway can be addressed.
- In appropriately selected patients, these procedures can cure OSA.
- These surgeries can reduce the severity of OSA, and make CPAP use more tolerable.
Tongue base procedures are an integral part of multilevel surgery for the treatment of OSA.
Thorough knowledge of the hypoglossal nerve and lingual artery neurovascular bundle is essential to avoid complications.
BIBLIOGRAPHY

- Friedman, NR. PSG should not be required both before and after adenotonsillectomy for childhood sleep disordered breathing. Journal of Clinical Sleep Medicine (2007) Vol. 3:7