SURGICAL MANAGEMENT OF PEDIATRIC OBSTRUCTIVE SLEEP – RELATED BREATHING DISORDERS

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REPORT OF FINANCIAL RELATIONSHIPS
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None

NOMENCLATURE:
DEFINING THE PROBLEM
Sleep-related Breathing Disorders

Primary Snoring
"Snoring without obstructive apnea, frequent arousals from sleep, or gas exchange abnormalities"

Upper airway resistance syndrome
Obstructive hypopnea without true apnea

Obstructive sleep apnea syndrome (OSAS)
"A disorder of breathing during sleep characterized by prolonged partial upper airway obstruction that disrupts normal ventilation during sleep and normal sleep patterns."*

Clinical characteristics include:
- Habitual (nightly) snoring often with intermittent pauses, snorts or gasps
- Disturbed sleep
- Daytime neurobehavioral problems


EPIDEMIOLOGY

- Prevalence of childhood snoring – 10 to 12%
- Prevalence of childhood obstructive sleep apnea syndrome – 1 to 3%
- Equal prevalence in boys and girls
- Risk populations:
  - Obesity (BMI > 30kg/m2)
  - Trisomy 21 (small midface / macroglossia / obesity / hypotonia) (50 - 79% prevalence of OSAS)
  - Craniofacial syndromes with micrognathia and/or midface hypoplasia
  - Neuromuscular disorders including cerebral palsy
  - Genetic / metabolic / storage disorders
  - Sickle cell disease
  - Chronic lung disease and hypoventilation syndromes

MANAGEMENT OPTIONS

- Conservative approaches including observation, weight loss in the obese child, and sleep position changes
- Mechanical approaches including positive airway pressure ventilation (continuous and bi-level) and oral appliances
- Medical approaches including oxygen support, medications to decrease mucosal or tissue hypertrophy, and medications to alter sleep patterns
- Surgical approaches to improve airway dimensions, ideally specific to the level of obstruction

SURGICAL MANAGEMENT OF OBSTRUCTIVE SLEEP APNEA

- Nasal (Septoplasty / Turbinate reduction)
- Nasopharyngeal (Adenoidectomy*)
- Oropharyngeal (Tonsillectomy* / UPPP)
- Oral Cavity (Tongue reduction)
- Hypopharyngeal (Lingual tonsillectomy / Base of tongue reduction / Glossoptosis procedures)
- Laryngeal (Supraglottoplasty and related epiglottis & arytenoid procedures)
- Tracheal (Reconstructive procedures / tracheotomy)
- Maxillomandibular advancement procedures
ADENOTONSILLECTOMY (ADENOTONSILLOTOMY)

• Adenotonsillectomy (adenotonsillotomy) is the first line treatment of choice in children with obstructive sleep disorders and lymphoid hypertrophy

• In some children adenoidectomy alone may be sufficient

• Polysomnography-confirmed OSAS resolution occurs in 75-100%* (95%) after T&A in uncomplicated patients

• Postoperative results are less satisfactory in obese children (50%)* and other risk populations


ROLE OF PREOPERATIVE POLYSOMNOGRAPHY

• PSG is the gold standard for the diagnosis of OSAS

• AAO-HNS recommendations as to PSG need*
  – Associated co-morbid factors that suggest adenotonsillar hypertrophy alone is not the sole etiology of the obstruction
  – Associated co-morbid factors that significantly increase the risk of the procedure or immediate postoperative course
  – OSAS symptoms in a child with small tonsils and adenoid
  – Parental or physician requirement for more objective information


ROLE OF POSTOPERATIVE POLYSOMNOGRAPHY

• Severe OSAS documented on preoperative polysomnography

• Co-morbid risk factors that suggest adenotonsillar hypertrophy alone was not the sole etiology of the obstruction

• Persistent postoperative obstructive symptoms*

*Polysomnography defines the severity of the condition but does not define the site of the persistent obstruction

ADENOECTOMY TECHNIQUES

• Curettage resection adenoidectomy

• Power-assisted (microdebrider) resection adenoidectomy*

• Electrocautery (suction diathermy) ablation adenoidectomy

• Radiofrequency ablation adenoidectomy

Images withheld by request.

COMPARISON OF RISKS AND BENEFITS OF TONSILLECTOMY TECHNIQUES

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TONSILLOTOMY

• Aka partial tonsillectomy, intracapsular tonsillectomy, subcapsular tonsillectomy, inside out tonsillectomy

• Concept is the removal of lymphoid tissue medial to the tonsillar capsule avoids (lessens) direct surgical (thermal) trauma to the pharyngeal musculature

• The intact capsule may also provide a biologic barrier to bacteria-laden pharyngeal secretions, lessening the risk of postoperative inflammation

• Theoretically there should be reduced pain and a quicker postoperative recovery**

The performance of tonsillotomy was resurrected by Swedish ORL colleagues in two articles published in the IJPORL in 1999 (carbon dioxide laser technique).

Dr. Peter Koltai and colleagues at the Cleveland Clinic reintroduced tonsillotomy in the U.S. in two articles published in the Laryngoscope in 2002 and in Otolaryngology - Head & Neck Surgery in 2003 (powered microdebrider technique).

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- **TONSILLOTOMY**
  - **Powered Microdebrider**
    - An angled, convex or concave, 15 degree microdebrider blade is used to remove tonsil tissue, beginning medially and proceeding laterally.
    - Originally taken to within the confines of the tonsillar pillars / presently taken to the medial aspect of the tonsillar capsule itself.
    - Remaining lymphoid remnants are monopolar electrodesiccated to form a mature eschar over the intact tonsillar capsule.

- **TONSILLOTOMY**
  - **Powered Microdebrider**
    - This technique has become increasingly popular as a preferred treatment of obstructive tonsillar hypertrophy.
    - There are, however, some potential disadvantages:
      - Its performance does take longer than monopolar electrosurgical and bipolar radiofrequency tonsillectomy, with a slightly higher intraoperative blood loss.
      - Bleeding during the microdebrider tonsil tissue resection can obscure the operative field, increasing the risk of leaving lymphoid remnants or breaching the tonsillar capsule.
      - Concern of regrowth of residual tonsillar tissue and the need for subsequent reoperation for obstructive or infectious indications (not mutually inclusive).

- **TONSILLOTOMY**
  - **Powered Microdebrider**
    - Residual lymphoid tissue has been noted in the tonsillar fossa at the one month follow-up visit five times more frequently in children status post microdebrider tonsillotomy than electrosurgical tonsillectomy*

- **TONSILLOTOMY**
  - **Powered Microdebrider**
    - The incidence of symptomatic residual / recurrent tonsil requiring revision surgery has been quite low:
      - 0.46% in 870 children followed over a mean of 1.2 years (Solares et al. IJPORL 2005).
      - 0.64% in 1731 children followed over a mean of 1.8 years (Schmidt et al. Arch Otolaryngol 2007).


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<tr>
<td>Microdebrider with electrosurgery</td>
<td>Decreased postoperative pain and associated morbidity</td>
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<td>Decreased secondary hemorrhage rates*</td>
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<td>Decreased reintubation rates for dehydration</td>
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<td>Decreased postoperative pain and associated morbidity</td>
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<td>Definite residual/recurrent tonsil tissue concerns</td>
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<td>Monopolar radiofrequency ablation (somnoplasty)</td>
<td>No definitive statements possible due to limited data</td>
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<td>Bipolar electrosurgical scissors</td>
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Surgical Management of Pediatric Obstructive Sleep-Related Breathing Disorders

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Postoperative Hemorrhage Rates (2002-2009)*

- All cases reported:
  - Electrocautery 3.5% / Bipolar RF 4.1% / Tonsillotomy 0.9%
- All cases admitted to the hospital:
  - Electrocautery 3.3% / Bipolar RF 3.3% / Tonsillotomy 0.9%
- All cases taken to the operating room:
  - Electrocautery 2.6% / Bipolar RF 2.2% / Tonsillotomy 0.6%


TONSILLETOLOGY / TONSILLOTOMY SUMMARY

- Tonsil surgery consists of two general techniques – extracapsular tonsillectomy and intracapsular tonsillotomy
- Multiple instruments exist for the performance of these two procedures
- Randomized controlled trials are infrequent, and studies comparing two tonsillotomy techniques or the same instrumentation for tonsillotomy versus tonsillectomy are rare
- The specific choice of technique and instrumentation in each clinical situation eventually depends on the expertise and comfort level of the surgeon

OSAS BEYOND ADENOTONSILLECTOMY

- Most children with OSAS following T & A have a defined level of obstruction which is usually neuromuscular tone (sleep) dependent
- Awake transnasal flexible endoscopy defines pathology in a limited minority
- There may be more than one level of obstruction
- Positive pressure ventilation (CPAP) is a therapeutic option in these children
- If CPAP is inadequate or poorly tolerated, further intervention (or upper airway bypass) is necessary
- Proposed AAO-HNS evidence-based practice priority*

AWAKE FLEXIBLE UPPER AIRWAY ENDOSCOPY

Advantages
- Documents well anatomic pathology not dependent on neuromuscular tone to the level of the larynx
- Residual adenoid / lingual tonsil hypertrophy / some forms of supraglottic prolapse

Disadvantages
- Pathology associated with or exacerbated by decreased neuromuscular tone (dynamic sleep state) poorly assessed
- Tongue base collapse / pharyngomalacia / some forms of supraglottic prolapse

ALTERNATIVE INVESTIGATION OPTIONS

- Polysomnography
  - Defines severity but not level of obstruction
- Airway fluoroscopy & cine MRI
- Rigid operative laryngoscopy & tracheobronchoscopy
- Flexible drug-induced sleep endoscopy (laryngoscopy & tracheobronchoscopy)

RIGID VS FLEXIBLE ENDOSCOPY

- Rigid operative endoscopy is of value for static anatomical pathology
- Flexible drug-induced sleep endoscopy is more useful for dynamic anatomical pathology (as is cine sleep MRI)
**Yellon Staging System for Epiglottic and Base of Tongue Prolapse**


| Grade 0 (normal) | Grade 1 – Epiglottis falls against posterior pharynx but normal position of base of tongue |
| Grade 2 – Prolapse of epiglottis and base of tongue with only tip of epiglottis seen | Grade 3 – Prolapse of base of tongue is complete with no visualization of epiglottis |

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**Limitations of Flexible Drug-Induced Sleep Endoscopy**

- Does not allow simultaneous evaluation of the entire airway / cannot rule sequential obstruction at multiple sites (in contrast to sleep cine MRI)
- Need precise anesthesia state such that the child maintains respirations yet does not react to the transnasal or transoral flexible endoscope
  - In young children with small airways the scope itself may cause obstruction
  - Stimulation effect even in deep sleep (wouldn’t you awaken if someone stuck a tube through your nose or into your airway?)

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**Airway Fluoroscopy**

- Dynamic examination providing a good overview of airway, but...
- Exposes child to significant ionizing radiation
- Limited to airway visualization principally in lateral view only
- Airway visualization additionally compromised by overlapping structures

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**CINE Sleep MRI**

- Dynamic evaluation of airway with no radiation exposure
- Lymphoid tissue (NP / lingual) readily identified
- Multiplanar assessment
  - Anterior to posterior airway assessment in both axial and sagittal planes
  - Right to left airway assessment in both axial and coronal planes
  - Sagittal and coronal images allow multi-level airway assessment
- Cross sectional images with no overlapping structures
- Can be combined physiologic parameter monitoring

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**CINE Axial Views**

- Hypopharyngeal collapse
- Glossoptosis

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**CINE Sagittal Views**
CINE Sleep MRI

- It is common to see some airway motion at hypopharynx, nasopharynx, and oropharynx; however, > 5mm movement or greater than 50% lumen diameter compromise is abnormal.*
- Potentially allows determination of the primary cause of obstruction as well as additional contributing sites
- Important in planning where to address further treatment
- Choice of sedation agent crucial (dexmedetomidine)


SITE SPECIFIC SURGICAL INTERVENTIONS

- **Lingual tonsil hypertrophy**
  Electrocautery / CO2 laser / Microdebrider / Radiofrequency ablation (Coblation)* in T & A position with NT intubation, tongue retraction and 70 degree telescope
- **Arytenoid prolapse**
  Endoscopic partial arytenoidectomy
- **Pharyngomalacia**
  Epiglottopexy
- **Laryngomalacia**
  Supraglottoplasty

BASE OF TONGUE
ENDOSCOPIC COBLATION
Preoperative & Postoperative Lingual Tonsillectomy

MACROGLOSSIA

- **Absolute macroglossia**
  – Trisomy 21
  – Beckwith-Wiedemann
  – Lymphatic VM
- **Relative macroglossia**
  – Usually seen with obesity
  – May be seen with a small pharynx
  – May be associated with poor neuromuscular control

ORAL TONGUE
Surgical Tongue Size Reduction

- Partial glossectomy
  – Multiple geometric approaches (anterior wedge & midline keyhole resection)
  – Marginal resections reduce tongue width and length
  – Central resections reduce tongue bulk, width & height
- Instrumentation affects operative and postoperative needs
- In lymphatic VM macroglossia, timing of tongue reduction relative to floor of mouth / neck treatment debatable

Images withheld by request.
ORAL TONGUE
Alternative Reduction Techniques

Monopolar RFA (volume reduction)
- 1000 J per site
- 1.5-2.0 cm apart
- Six week intervals if multiple treatments
- Perioperative antibiotic and steroid coverage
- Postoperative edema concerns due to expected inflammatory reaction prior to anticipated fibrosis

Bipolar radiofrequency ablation submucosal minimally invasive lingual excision (SMILE) technique
- No ultrasound required (stay midline)
- Submucosal tunnel
- Coblation setting: 9
- Bimanual operation
- Endoscopic monitoring
- Steroid and antibiotic coverage
- Postoperative edema concerns less than monopolar technique due to tissue resection

GLOSSOPTOSIS & HYOPHARYNGEAL COLLAPSE WITHOUT RETROGNATHIA

- Classic wedge resection of tongue base with electrocautery or Nd:YAG laser
- Monopolar radiofrequency reduction via direct needle electrode insertion (Somnus device)
- Bipolar radiofrequency reduction via submucosal SMILE technique with Coblation wand
- Genioglossus advancement mandibular screw suspension (Repose system)
- Hyoid myotomy mandibular screw suspension (Repose system)
- Mandibular segmental osteotomy genioglossus advancement

GLOSSOPTOSIS SECONDARY TO RETROGNATHIA

- Most classically seen in Pierre Robin anomaly
- If severely retrognathic, consider mandibular distraction advancement
- Alternatives:
  - Tongue lip adhesion (labioglossopexy)
  - Temporary bypass tracheotomy

TRACHEOTOMY

- Remains an option if all else fails or there is a significant medical contraindication to other therapies
- May serve as a temporary airway bypass measure awaiting further growth or interval weight loss
- Sometimes necessary for CPAP administration in severe tracheomalacia

POST-INTERVENTION MANAGEMENT

- Immediate postoperative management requires ICU level care in all children with complex airway obstruction
- Subsequent postoperative management must include polysomnography. Given likelihood of multi-level obstruction, need to document that the surgical intervention performed was successful
- Sleep abnormalities may continue to be a concern throughout the child’s life. Need to continue to observe for changes in sleep patterns as child grows