Pediatric obstructive sleep apnea – Adenotonsillectomy and beyond (a surgeon’s perspective)

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Disclosures

- None
Outline

- Evaluation and management of sleep-disordered breathing in “routine” pediatric patients
- Tonsillectomy & adenoidectomy outcomes
- Thoughts on the role of polysomnography (PSG)
- Evaluation and management of pediatric patients with persistent OSA after T&A
Basic approach

- OSA is state-specific obstruction (or partial obstruction) at some point (or points) of upper airway – from tip of nose to trachea
- Find obstruction
- Alleviate obstruction
Sleep-disordered breathing

- A spectrum of disease (primary snoring → OSA); differentiated by PSG
- Similar presenting signs/symptoms
- Most otolaryngologists treat SDB and not necessarily OSA
  - Approx 90% of T&A without pre-op PSG
  - Most common reason for PSG = doubt about diagnosis
  - Reasons for not obtaining PSG = Long wait time, cost, availability

(Mitchell, Laryngoscope, 2006)
Clinical History

- Patient/family history not highly predictive of abnormal PSG
- However, variety of questionnaires available as fairly reliable diagnostic tools
  - Pediatric Sleep Questionnaire (PSQ) – Sleep Related Breathing Disorders portion
    - 22-item closed response questionnaire
      - Breathing
      - Sleep quality including daytime sleepiness
      - Behavior/attention
    - 85% sensitivity and 81% specificity for diagnosis of OSA
    - 7/22 “positive” responses predictive of OSA

  (Chervin, Sleep Medicine, 2000)
Clinical History

- Snores?
  - How long has this been a problem?
  - Every night? Parts of nights?
  - Associated with increased effort?
  - Gasps or changes/pauses in breathing pattern?
  - Mouth breathing?
- Restless? Wakes because of breathing abnormality?
- Unusual sleep positions/neck hyperextension?
- Daytime symptoms
- Bedwetting?
- Effect on behavior and/or QOL?

- Review of other ENT signs/symptoms
  - Swallow
  - Stridor
  - Epistaxis
  - Sinonasal
  - Allergies?

- Other medical issues
  - Down syndrome
  - Neuromuscular issues (diminished tone)
  - Craniofacial abnormalities
  - Obesity
Physical Exam

- BMI
- Head & neck exam
- Flexible endoscopic exam (?)
Nasal Exam

- External deformity (projection, deviation, etc)
- Inferior turbinates
- Nasal septum
- Other (polyps, masses, etc)
Oral cavity Exam

- Retrognathia
- High arched palate/dental crowding
- Tonsil size
- Tongue-palate position
Flexible endoscopy?

- If tonsils small or absent
- Co-existing symptoms
  - Stridor
  - Nosebleeds
  - Dysphagia
  - Hoarseness
Initial decision-making

- Surgery (tonsillectomy & adenoidectomy)
- Medical management
- Sleep study
- Observation
Initial decision-making

- Surgery (tonsillectomy & adenoidectomy)
- Medical management
- Sleep study
- Observation

What does the data say?
Tonsillectomy and adenoidectomy

- Very common
  - ~500,000 T&A’s/year in US
  - Most are for sleep-disordered breathing
  - Average age: 4-6 years
  - ~90% T&A > 15 years old for chronic tonsillitis
- AAP guidelines:
  - “If OSA and exam consistent with adenotonsillar hypertrophy, T&A is first line therapy”
Outcomes of T&A

- Effects on sleep parameters as measured by PSG
- Effects on quality of life
- Effects on behavior
- Effects on healthcare utilization
T&A for OSA

- 79 children with OSA studied with pre- & post-op PSG
- AHI improved in all children after surgery
- All children with pre-op AHI <10 normalized
- 73% with pre-op AHI >10 normalized
- Caregivers reported snoring at 3 months follow-up in all patients with persistent OSA

(Mitchell, Laryngoscope, 2007).
T&A in obese children with OSA

- 72 subjects: 33 obese, 39 normal weight
- Similar mean ages (6-7) and PSG-surgery intervals
- More Hispanic children in obese group
- Significant differences ($p < .001$) in pre-op PSG parameters between groups:
  - AHI: obese 23.4 (3.7-135), normal 17.1 (3.9-36.5)
  - Apnea index: obese 6.2, normal 2.2
  - Hypopnea index: obese 13.5, normal 12.5
  - Arousal index: obese 24.8, normal 10.8
  - REM %: obese 12.2%, normal 20%
- No differences between pre-op SpO2 nadir (80%)

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<thead>
<tr>
<th>Population</th>
<th>Pre-operative</th>
<th>Surgery</th>
<th>Post-operative</th>
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<tbody>
<tr>
<td>Obese children with OSA</td>
<td>Mild OSA 10% (n=3)</td>
<td>T &amp; A</td>
<td>No OSA 24% (n=8)</td>
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<td>Moderate OSA 20% (n=6)</td>
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<td>Mild OSA 46% (n=15)</td>
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<td>Severe OSA 70% (n=24)</td>
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<td>Moderate OSA 15% (n=5)</td>
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<td>n = 33</td>
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<td>Normal-weight children with OSA</td>
<td>Mild OSA 5% (n=2)</td>
<td>T &amp; A</td>
<td>No OSA 72% (n=28)</td>
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<td>Moderate OSA 36% (n=14)</td>
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<td>Mild OSA 18% (n=7)</td>
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<td>Severe OSA 59% (n=23)</td>
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<td>Moderate OSA 10% (n=4)</td>
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<td>n = 39</td>
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T&A for Quality of Life

- QOL of children with OSA significantly worse than those of healthy children without OSA

- QOL of children with OSA similar to children with asthma or juvenile rheumatoid arthritis
T&A for QOL

- 60 children with OSA completed OSA-18 QOL survey before and 3 months after T&A
- Changes in total scores and all domain scores significantly improved post-op

T&A for QOL

- 61 patients with OSA & SDB tested with pre- and post-op OSA-18 QOL tool
  - 43 with OSA (AHI range 5-46, mean = 21/hr)
  - 18 with mild SDB (AHI range 0-4.9, mean = 3/hr)
- Pre-op QOL diminished for both OSA and mild SDB groups
- QOL improved in all domains regardless of severity of pre-op PSG

(Mitchell, Otolaryngology – Head & Neck Surgery, 2005).
OSA and Neurocognitive & Behavioral Issues

ON SOME CAUSES OF BACKWARDNESS AND STUPIDITY IN CHILDREN:
AND THE RELIEF OF THESE SYMPTOMS IN SOME INSTANCES
BY NASO-PHARYNGEAL SCARIFICATIONS.

Read in the Section of Otology at the Annual Meeting of the
British Medical Association, held in Leeds, August, 1889.

BY WILLIAM HILL, B.S.C., M.B, LOND.,
Senior Demonstrator of Anatomy and Assistant in the Aural Department,
St. Mary's Hospital; formerly Registrar and Pathologist, Central
London Throat and Ear Hospital.

It is not at all uncommon to find children who suffer from deaf-
ness, the result of enlargements of the lymphoid (tonsillar) tissues
of the naso-pharynx and fauces, described by their parents and
teachers as being backward and even stupid. This backwardness
and stupidity is usually accounted for by the defect in hearing,
and the characteristic foolish expression of such children has been
explained on purely physical grounds, as due to the obstruction
in the proper air-way resulting in the open mouth and pinched,
fallen-in condition of the alæ nasi. The fact, however, that
children, the victims of nasal and pharyngeal obstructions, often
suffer from headaches, especially when engaged in study, and
frequently evince marked inability to fix their attention on their
lessons or work for any length of time, has in recent years led
many to suspect that these symptoms were not altogether due to
the deafness, and that the stupid adenoid physiognomy, though
partly explicable on physical grounds, was in part a reflection of
some evident hampering of the cerebral functions. It is true
that mouth-breathing and faulty respiration, added to insanitary
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OSA and Neurocognitive & Behavioral Issues

- Several studies have shown increased behavior problems in children with OSA
  - Approx 30% with OSA score abnormal range with standard behavioral instruments
  - Both externalizing symptoms (hyperactivity, aggression, attention) and internalizing symptoms (anxiety, depression, somatization)
- Several studies have shown reduced neurocognitive performance in children with OSA and primary snoring as compared with normal healthy children without OSA or PS

(Kennedy, Pediatric Pulmonology, 2004).
(O’Brien, Pediatrics, 2004).
T&A for Behavior

- 52 children (mean age 7) with OSA (mean AHI = 16.2/hr) assessed with pre- and post-op Behavior Assessment System for Children (BASC)
- Improvements measured after T&A in all areas regardless of sex, age, ethnicity, parental education, parental income, or relative severity of OSA

(Mitchell & Kelly, Laryngoscope, 2005).
Children with OSA had significantly more hospital and outpatient visits and more use of antibiotics resulting in 215% elevated healthcare use compared to controls.


Following T&A, total healthcare costs were reduced by 1/3 (change not seen in control or untreated group).

Most of decreased cost due to reduction in upper respiratory tract infections, antibiotics (and other medications), doctor visits.

T&A versus observation

- **ChildHood AdenoTonsillectomy study (CHAT)**
  (Marcus, NEJM, 2013).
  - **Inclusion:**
    - 5-9 year old, AHI > 2, T&A candidate
  - **Exclusion:**
    - Significant comorbidities, severe OSA, morbid obesity

460 pts with PSG-proven OSA → Baseline exam, neuropsych eval, QOL survey → T&A 230 → Baseline exam, neuropsych eval, QOL survey

Obs 230
CHAT study patient selection

1244 considered T&A candidates by peds ENT; screened with PSG

*** 594 (48%) had AHI>2
Mean AHI = 4.7

43 (3%) of 594 excluded for severe OSA

460 randomized to T&A versus watchful waiting
T&A versus observation – CHAT study PSG results

- After 7 months:
  - T&A: AHI 4.7 → 1.1
  - Observation: 4.7 → 3.1
  - AHI “normalizes” (AHI < 2) over 7 months in 46% of children without T&A and in 79% with T&A
    - In obese/overweight, normalization in 29% of observation and in 68% of T&A

- Predictors of OSA resolution:
  - Low AHI
  - Not obese
  - Not African American
T&A versus observation – CHAT study: cognitive, behavior, & QOL

- After 7 months:
  - No significant difference in attention or executive function between T&A and observation groups
  - Significant difference in behavior (as measured by caregivers and teachers) and quality of life

- 72% of patients in T&A group had *both* AHI normalization and symptom resolution
- Only 20% of patients in observation group had *both* AHI normalization and symptom resolution
CHAT summary

- T&A is highly effective at normalizing AHI and symptom resolution
- Observation is somewhat effective in normalizing AHI and poor at symptom reduction

- ...Pediatric Adenotonsillectomy Trial for Snoring (PATS) is underway for patients with AHI < 3
  - May be game-changer in terms of patient management and role of PSG
Role of PSG?

- PSG considered “gold standard” for diagnosis of OSA
- But…
  - Similar morbidity and benefit of treatment between primary snoring and mild OSA in terms of CV impact, quality of life, neurocognition, and behavior
  - Using PSG results as sole metric for effectiveness of T&A may neglect other benefits that are important to patients and families
  - PSG may not capture full breadth of disease
- Distinction between primary snoring and OSA is an arbitrary one defined by the test itself
Medical management

- CPAP
  - Pro:
    - It works!
    - Addresses both mechanical and functional obstruction
    - Non-specific
  - Con:
    - Only works if you wear it…
Medical management

- OSA shown to have increased inflammatory mediators

- Growing literature showing some success with use of:
  - Topical nasal steroids
  - Montelukast
  - Oromyofunctional therapy
  - Rapid maxillary expansion/oral appliances

- Weight loss
Persistent OSA after T&A

- Long history of success
- The “low hanging fruit” for surgical management
  - Generally favorable risk-benefit ratio
  - Can be curative in many cases
- However…
  - Failure (based on abnormal post-op PSG) ranges from 10-40%
  - Risk factors for persistent OSA after T&A:
    - Obesity
    - Severe pre-op OSA
    - Down syndrome
    - Craniofacial abnormalities
    - Achondroplasia
    - Neurologic issues (hypotonia, cerebral palsy, etc)
    - Teenager
    - Asthma/reactive airway disease

(Imanguli, Laryngoscope, 2016)
Approach to persistent OSA after T&A

- Review sleep study
- Review symptoms

Room for improvement with medical approach?
  - Poorly controlled environmental allergies
  - Nasal steroid & saline for significant chronic rhinitis
  - Leukotriene receptor antagonist

- Is PAP an option?
Physical Exam

- **General:**
  - Voice
  - Stridor
  - Mouth-breathing
  - BMI
  - Midface and mandibular hypoplasia

- **Nasal:**
  - Structural integrity
  - Septal deviation
  - Mucosal edema
  - Inferior turbinate hypertrophy
  - Polyps/masses
Physical Exam

- Oral cavity:
  - Tonsils
  - Palate
  - Tongue (size & position)
  - Lingual tonsil (?)
  - Posterior pharyngeal mass
Physical Exam

- Flexible fiberoptic exam
  - Posterior nasal passage
  - Adenoid re-growth
  - Pharynx – asymmetry, collapse, lesions
  - Tongue base – lingual tonsil, masses
  - Larynx – laryngomalacia, masses, cord mobility
Limitations

- Anatomy during office exam ≠ anatomy during sleep
  - Patient position
  - Pharyngeal & laryngeal tone
  - Poor cooperation
State-specific examinations

- Use of pharmacologic agents for sedation
- Goal of reproducing upper airway behavior similar to natural sleep ("simulated sleep")

Drug-induced sleep endoscopy (DISE)

Cine MRI
Anesthetic technique

Dexmedetomidine

- $\alpha_2$ adrenergic agonist
- Sedative, anxiolytic, and analgesic effects
- Simulates non-REM sleep well
- Slower onset (need 10 min loading dose)
- Longer half-life
- Less muscular relaxation
- More normal respiratory effort and reflexes

Ketamine

- NMDA receptor antagonist
- Causes dissociative anesthesia
- Does not compromise respiratory drive or airway tone
- Potential for hallucinations, nightmares, emergence delirium as side effect
- Counteracts hypotension/bradycardia associated with dex

Propofol

- Global CNS depression via GABA and NMDA receptors
- Fast onset
- Short acting
- Decreases genioglossus neuromuscular activity
  - Tongue base collapse
  - Airway obstruction oxygen desats at increased doses
Anesthetic technique

- Agents that adversely affect airway dynamics:
  - Benzodiazepines
  - Barbiturates
  - Opioids
  - Inhalational agents
  - Topical lidocaine
DISE technique

- No pre-medication
- No topical decongestants or topical anesthetics
- Mask induction; IV placed
- Titrate IV anesthetic to tolerate trans-nasal endoscopy, yet maintain respiratory reflexes
- No oral airway; avoid jaw thrust; avoid oxygen
- Examine all levels of airway
- Photo and video documentation
DISE – what are we looking at?

- **Nose**
  - Septal deviation
  - Turbinate size
  - Other
- **Adenoid**
- **Velum**
  - Assessing anterior-posterior obstruction
- **Lateral pharyngeal wall**
  - Tonsil size (if present)
  - Dynamic collapse/extrinsic compression
- **Tongue base**
  - Assess anterior-posterior obstruction
  - Lingual tonsils
- **Supraglottis**
  - Static or functional obstruction

- For each location, assess view obtained at most and least obstructed points in respiratory cycle.
- Evaluate sites with & without jaw thrust as well as with body position changes.
Grading system

**Adenoid**
- 0 = Absent adenoids
- 1 = 0-50% Obstruction of choana
- 2 = 50%-99% Obstruction of choana
- 3 = Complete obstruction of choana

Grading system

- **Velum**
  - 0 = No obstruction (complete view of tongue base and/or larynx)
  - 1 = 0-50% Anterior-posterior closure (some view of tongue base/larynx)
  - 2 = 50%-99% Anterior-posterior closure (no view of tongue base/larynx, but not against posterior pharyngeal wall)
  - 3 = Complete closure against posterior pharyngeal wall

Grading system

- Lateral pharyngeal wall
  - 0 = No obstruction
  - 1 = 0-50% Lateral obstruction
  - 2 = 50%-99% Lateral obstruction
  - 3 = Complete obstruction

Grading system

- **Tongue base**
  - 0 = No obstruction (complete view of vallecula)
  - 1 = 0-50% Obstruction (vallecula not visible)
  - 2 = 50%-99% Obstruction (epiglottis not contacting posterior pharyngeal wall)
  - 3 = Complete obstruction (epiglottis against posterior pharyngeal wall)

Grading system

▪ Supraglottis
  ▪ 0 = No obstruction (full view of vocal cords)
  ▪ 1 = 0-50% Obstruction (vocal cords partially obscured but >50% visible)
  ▪ 2 = 50%-99% Obstruction (>50% of vocal cords obscured)
  ▪ 3 = Complete obstruction (glottic opening not seen)

DISE outcomes

- DISE evaluations in children with OSA are significantly different compared to those without SDB
- More severe OSA is associated with more severe obstruction seen on DISE
  (Steinhart, Acta Otolaryngolog, 2000)

- More severe OSA associated with DISE showing obstruction at multiple sites; mild OSA associated with single site obstruction
  (Ulualp, Laryngoscope, 2013)

- Lots of research ongoing on this topic!
Cine MRI

- 128 high resolution images over 2 minutes during snoring or oxygen desats (“cine” because it looks like movie)
- With sedation, but less needed (no airway instrumentation)
- Static and dynamic images
- Can assess multiple levels of airway concomitantly
- Look at in multiple orientations (usu sagittal and axial)
- Can see depth of tissues (e.g. lingual tonsil hypertrophy vs macroglossia/glossoptosis)
- Good at viewing:
  - Oropharynx
  - Nasopharynx
  - Retroglossal
  - Supraglottis
- Not good at viewing:
  - Nasal passage
Cine MRI
Pro:
- Examine multiple levels simultaneously
- No airway instrumentation
- Can see depth of lingual tonsil and adenoid
Con:
- Surgeon not present
- No positional maneuvers
- Poor view of nasal passage and larynx
- Anesthesiology comfort level

DISE
Pro:
- OR setting with anesthesiologist and surgeon working together
- Can proceed to directed surgery
- Can assess positional maneuvers
- Examine entire airway
Con:
- View only one level at a time
- Level of sedation needed for instrumentation may exacerbate collapse (i.e. false positives)
Surgery beyond T&A

- Most studies find persistent obstruction is at level of tongue base or supraglottis
- Frequently, obstruction at multiple sites

- Numerous options:
  - Adenoidectomy revision
  - Inferior turbinate reduction
  - Septoplasty
  - Uvulopalatopharyngoplasty
  - Lingual tonsillectomy
  - Midline posterior glossectomy
  - Hyoid suspension
  - Supraglottoplasty
  - Epiglottopexy
  - Maxillary/mandibular distraction
  - …Upper airway neurostimulation (hypoglossal)
Nasal/Nasopharyngeal

- Revision adenoidectomy
  - Re-growth not common, but more likely in those undergoing primary adenoidectomy age <3 and with environmental allergies

- Inferior turbinate reductions
  - No peds studies on nasal surgery alone for OSA
  - Retrospective review, 51 children age 3-12 yrs
  - 28 T&A only, 23 T&A w/ITR
  - Statistically significant reduction in AHI and increase in nasal cross-sectional area

(Cheng, Laryngoscope, 2012)
Palate

- Pillar closure at time of T&A is not helpful and increases chance of swallow/speech problems
- Limited peds data on UPPP
Tongue & tongue base

- Lingual tonsillectomy
  - Relatively common site of obstruction
  - Higher incidence in Down syndrome, obese, GERD
  - Risk profile similar to standard (palatal) tonsillectomy
  - Can be difficult to determine if concomitant macroglossia

- Systematic review of 6 studies
  - 141 patients with lingual tonsillectomy alone
  - Mean age: 9.7 years
  - Mean AHI: pre-op 13.9 → post-op 8.0
  - Success:
    - AHI < 5: 60%
    - AHI < 1: 20%
    (Manickam, Laryngoscope, 2016).
Midline glossectomy
Tongue suspension
Laryngomalacia

- **Classic/congenital**
  - Infants
  - Inspiratory stridor
  - Worse with feeding, agitation
  - Treatment:
    - Mild - Observation, reflux management, weight checks
    - Severe (FTT or “scary” breathing) - supraglottoplasty
Laryngomalacia

- Sleep-variant or occult
  - Prevalence of 3.9% among children with OSA
  - Presents as snore, though occasionally snore described as “unusual” or with stridor component
  - Arytenoid complex collapse > epiglottic collapse
  - Approx 50% of occult laryngomalacia have neuromotor delay with hypotonia
  - Occasionally history of congenital laryngomalacia symptoms
Supraglottoplasty
Supraglottoplasty outcomes for OSA

- Systematic review of 4 studies
  - Total of 77 patients
  - Mean age = 5.7 years
  - Mean AHI: pre-op 12.1 → post-op 4.4
- Success:
  - AHI < 5: 58%
  - AHI < 1: 16%
  
  (Manickam, Laryngoscope, 2016).
Hypoglossal Nerve Stimulator (Inspire)
Hypoglossal Nerve Stimulator (Inspire)

- Excellent results seen in adults thus far (STAR trial)
- Current multi-institutional study in peds population:
  - Down syndrome
  - Prior T&A
  - Failed CPAP
  - Age 10-21 years
  - AHI 10-65/hr
  - BMI percentile ≤ 95%
  - Excluded if: need MRI, active cardiac disease, swallow issues
Tracheostomy

- Highly effective
- Useful in children with multiple levels of obstruction or neurological impairment
- Increased risk profile and care requirements
Questions?