Pediatric Sleep
Disordered Breathing

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Outcome Objective

- Discuss primary care screening and evaluation of pediatric snoring and obstructive sleep apnea (OSA)
- Discuss comorbidities associated with pediatric OSA
- Discuss medical and surgical management of pediatric OSA

- The medical and dental provider should be able to evaluate and appropriately manage or refer pediatric patients with large tonsils, snoring and OSA symptoms
Epidemiology of OSA

- Snoring 11-12% prevalence (up to 27%)
- 40% of children referred for snoring will have OSA
- OSA 3% overall prevalence
- Prevalence increased with low socioeconomic status, male gender, African American race, low birth weight, obesity
- Sleep disordered breathing 13-39% of obese 10-16 yr olds.

Primary snoring may have sleep disturbance and behavioral changes. Treatment for primary snoring is continued observation especially in early am / REM sleep.
Screening for OSA

- AAP recommends screen all children for snoring
  - BMI > 30 (Weight > 95th percentile)
  - Two questions if negative, then OSA unlikely
    - Does your child have chronic, loud snoring?
    - Does your child have chronic, daytime mouth breathing?


Historical Perspective

- 1837 Charles Dickens
  - The Posthumous Papers of the Pickwick Club
  - Joe: an obese, hypersomnolent boy

- 1889 Hill
  - “the stupid looking lazy child who frequently suffers from headache at school, breathes through his mouth instead of his nose, snores and is restless at night”

- 1918 Osler “Pickwickian” hypersomnolent and morbidly obese

- 1965 Menashe two non-obese children with adenotonsillar hypertrophy with resolution after surgery
Pathogenesis

- Repeated episodes of decreased breathing (airflow) of upper airway origin during sleep
- Decreased airway caliber (anatomic, neuromuscular)
- Increased effort to maintain airflow thru diminished lumen
- Increased intraluminal negative pressure
  - Combined with compliant airway and Bernoulli effect results in collapse of airway and cessation of airflow
Cessation of Airflow Physiologic Changes

- Acidosis
- Hypercapnia
- Hypoxemia

- Central and peripheral chemoreceptors and baroreceptors are stimulated to cause arousal and awakening from sleep, sleep fragmentation
Obstructive Sleep Apnea
Secondary Physiologic Changes

- Chronic hypoxemia, acidosis and hypercapnia result in:
  - Vagal bradycardia, ectopic beats, arrhythmia (SIDS)
  - Pulmonary vasoconstriction (pulmonary hypertension, right heart failure)
  - Systemic vasoconstriction (hypertension)
  - Erythropoiesis (polycythemia)
  - Sleep fragmentation/loss of sleep (sleepiness, behavioral changes, learning problems)
  - Excessive motor activity (restless sleep)
Child with cor pulmonale
## Differences Between Adult and Pediatric OSA

<table>
<thead>
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<th>Features</th>
<th>Adult</th>
<th>Child</th>
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<tr>
<td>Snoring</td>
<td>Intermittent</td>
<td>Continuous</td>
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<tr>
<td>Mouth breathing</td>
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<td>Common</td>
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<tr>
<td>Obesity</td>
<td>Common</td>
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<td>Failure to thrive</td>
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<td>Daytime hypersomnolence</td>
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<tr>
<td>Gender predilection</td>
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<td>Most common obstructive event</td>
<td>Apnea</td>
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<tr>
<td>Arousal</td>
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<tr>
<td>Treatment</td>
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<td>CPAP in most</td>
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<td>Surgery</td>
<td>CPAP in some</td>
<td>CPAP in some</td>
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<td></td>
<td>Selected cases</td>
<td>T&amp;A in most</td>
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CPAP, continuous positive airway pressure.
Symptoms and Features Often Found in Pediatric OSA

**Nocturnal**
- Snoring
- Mouth breathing
- Pauses with breathing
- Frequent awakening
- Restless sleep
- Nightmares
- Enuresis
- Diaphoresis

**Daytime**
- Mouth breathing
- Hyponasal speech
- Hypersomnolence
- Poor school performance
- Aggression/discipline problems
- Hyperactivity
- Inattentive
- Morning headache
- Weight problems (failure to thrive or obesity)
- Frequent URI
- Chronic rhinorrhea
- Difficulty swallowing
OSA in Neonates and Infants

- Differences in respiratory physiologic responses
  - Central neuropathways that control respiration not completely developed, leading to hypoventilation, central apnea and period breathing
  - Response to hypoxemia and hypercapnia not fully developed due to chemoreceptor immaturity
  - Laryngeal abduction and diaphragmatic coordination incompletely developed

- History is usually observational
  - Respiratory distress, stridor, cyanosis, feeding difficulties, pectus excavatum, failure to thrive, near miss sudden death, SIDS

- GERD and apnea are associated
Behavioral Problems

- Sleep disturbances with decreased REM sleep:
  - Hyperactivity
  - Aggression
  - Depression
  - Hypersomnolence
  - Learning difficulties
Neurocognitive and Behavioral Morbidity in Children with Sleep Disorders

- Daytime hyperactivity and inattention are associated with restless sleep
- Anxiety and depressive symptoms are associated with global sleep problems
- Sleep fragmentation appears to be major factor leading to impaired daytime functioning
  - Fragmentation increased in OSA, periodic limb movement and primary snoring

Snoring and Preschool Children

- 249 children age 2-3 yrs based on parent report of no snoring, transient snoring (snored at age 2 but not at age 3), and persistent snoring > 2 times a week at age 2 and 3.
  - Persistent snorers had significantly higher behavioral problems, particularly hyperactivity, depression and inattention.
  - Nonsnores had significantly stronger cognitive development than transient or persistent snorers

DSM-IV Diagnosis and OSA

- Prospective cohort study 79 children scheduled for T&A and 27 controls. Structured diagnostic interview and PSG before and 1 year after surgery.
  - Baseline:
    - Attention and disruptive behavioral disorder diagnosis 36.7% in T&A pts, 11.1% controls
    - ADHD 27.8% T&A pts, 7.4% controls
  - One year postoperative evaluation:
    - A&DBD 23.1%
    - ADHD 50% of patients from baseline no longer met criteria

Sleep & Attention Deficit Hyperactive Disorder

- Retrospective evaluation of sleep studies of 33 children with ADHD (age 3-16 yrs)
- Sleep disordered breathing (64%) and periodic limb movements of sleep (30%) more common in children with ADHD
- Obese children more at risk and more severe

OSA in Children: Implications for the Developing CNS

- Learning and school performance impacted by restlessness, aggressive behavior, sleepiness and poor test performance
- Dose-response for attention, memory scores and OSA PSG findings
- Reversible cognitive deficits on IQ tests (general conceptual ability scores)
- Summary: sleep disturbances, whether due to poor sleep habits, snoring or OSA, may induce reversible learning deficits if corrected early. However, there may be long-lasting residual deficits in learning capability “learning debt”

Sleep Disordered Breathing and Verbal Skills

- 76 children age 6-9 yrs (primary snoring, OSA, non-snoring healthy controls) using multi-method assessment of verbal abilities and language neurodevelopment
  - Snoring & OSA showed lower receptive language
  - Snoring & OSA patients showed lowered levels of vocabulary development and ability
  - Summary: snoring and OSA higher rate of language-learning disability

54 children with OSA (AHI 6.3 +/- 1.5) and 17 matched controls (AHI 0.6 +/- 0.1) underwent PSG and 15 minute pictorial memory task with 4 trials, followed by recall at 10 minutes and the next morning.

- Mean learning scores in controls were incrementally better than in children with OSA.
- Both immediate and overnight recall performance were worse among OSA children.
- OSA children exhibited a decline in recall performance.

Suggests OSA children require more time and increased number of learning opportunities to reach immediate and long-term recall performance. Thus both acquisition and retention of newly learned material is compromised.

Kheirandish-Gozal L. etal. Obstructive sleep apnoea is associated with impaired pictorial memory task acquisition and retention in children. Eur Respir J 2010;36:164-169
SDB and Daytime Sleepiness Associated with Poor Academic Performance in Teenagers

- Survey of 3393 students
- Adolescents suffered from inadequate sleep (<8 hrs)
  - 49% week nights, 83% on weekends
  - 23% snore, 10% with witnessed apnea
- Daytime sleepiness significantly associated with poor academic performance
- Report of snoring or witnessed apnea independent predictor of poor academic performance

Sleep Disordered Breathing and Academic Grades

- 163 overweight children aged 10-17 yrs (severe OSA, mild OSA, snoring, non-snoring)
  - Significant difference in academic grades and behavior with emphasis on inattention and learning difficulties
  - Sleep disordered breathing may result in significant functional impairment at school
    - Learning problems, incomplete & incorrect work, careless errors, poor classroom performance, diminished study skills, poor note taking, lack of preparation for class and examinations, lack of organization.
  - Average ½ grade apart between OSA and non-snoring
    - OSA: 30% C grade, 0% A grade
    - Snoring: 15% C grade, 15% A grade

Beebe DW. etal. The association between sleep disordered breathing, academic grades, and cognitive and behavioral functioning among overweight subjects during middle to late childhood. SLEEP. 2010;33(11):1447-1456.
Screening for OSA

- AAP recommends screen all children for snoring
  - BMI > 30 (Weight > 95th percentile)
  - Two questions if negative, then OSA unlikely
    - Does your child have chronic, loud snoring?
    - Does your child have chronic, daytime mouth breathing?
- ADHD +/- Behavioral issues
- Poor school performance and learning disability
American Academy of Pediatrics, 2002 Clinical Practice Guidelines Related to OSAS

- All children should be screened for snoring.
- Complex high-risk patients should be referred to a specialist.
- Patients with cardiorespiratory failure cannot await elective evaluation.
- Diagnostic evaluation is useful in discriminating between snoring and OSAS with overnight polysomnography (sleep study) the gold standard.
- T & A first line therapy for most, CPAP for those who are not good candidates.
- High-risk patients should be admitted after surgery.
- Patients should be reevaluated post-operatively.

Physical Examination

- Complete Head & Neck examination with emphasis on areas of potential obstruction
  - Growth and development chart
  - Breathing pattern and quality of speech
  - Pharyngeal dimensions, anatomy and function
  - Velopharyngeal neuromuscular function
    - Passavant’s ridge, lateral and anteroposterior velar mobility, gross and fine motor of tongue
    - Evaluate for submucosal cleft palate
  - Oral for tonsil size and lingual anatomy
  - Nasal for septal deviation, turbinate hypertrophy, nasal mucosa, adenoid size
  - Cervical and thoracic examination for other causes
  - Neuromuscular especially CN V, IX, X, XI, and XII for motor control and coordination of swallowing, phonation, respiration, tone
  - Dysmorphic features as previously discussed
Speech Articulation Errors In Adenotonsillar Hyperplasia

- Phoneme errors are common
  - /m/
  - /n/
  - /ng/
- Require nasal air escape for proper formation
Diagnosis of OSA

- Survey of 603 Otolaryngologists in North America with 183 performing 24,000 T&A
  - Surgical indication
    - Recurrent tonsillitis 42%
    - Obstructive breathing of any type 59%, OSA 39%
    - Poor school performance 17%
    - Poor attention 11%
  - Preoperative evaluation
    - Office-based, sleep-related H&P 93%
    - Objective testing for OSA < 10%
    - Laboratory-based PSG < 5%

Adequacy of Clinical History in Diagnosing OSA

  - 11 of 12 applicable articles demonstrated that clinical evaluation is inaccurate in the diagnosis of pediatric OSAS compared to overnight polysomnography
  - 34% of children had history of OSA but normal PSG
  - Tonsillar hypertrophy was correlated to more severe apnea among preschool-age children, but not among school-age children
  - 59 children with clinical OSA and normal PSG, with T&A group showing dramatic reduction in clinical assessment score compared to randomized control group and a much higher percentage of asymptomatic (82% vs 22%)
Ancillary Studies for OSA

- Radiography
- Cephalometric study
- Computed tomography
- Videofluoroscopy
- Endoscopy
- Sleep audio or video recording
- Polysomnography
- Ferritin level for periodic limb movement disorder of sleep, goal > 50.
Radiography

- Lateral and anteroposterior x-rays
  - Adenoid size and overall craniofacial anatomy, airway dimensions, tonsil hypertrophy
  - Relative adenoid size >0.64 ratio of occlusion at area of maximal thickness highly correlates with OSA

- Cephalometric
  - Recording of bony landmarks not indicated in OSA but may be helpful in suspected facial dysmorphia

- Computed tomography
  - Accurate but expensive with little information about function

- Videofluoroscopy
  - Cineradiographic recording of a patient’s sleep while sedated
  - Combined with other polysomnographic measurements, can assist in evaluation of infants to determine location of obstruction

Miscellaneous Studies

- Chest radiography, echocardiography and electrocardiography may be helpful in evaluation of complex case or in child with concerns about complications of OSA
Endoscopy

- Flexible fiberoptic nasopharyngoscopy
  - Provides anatomic and functional information
  - Greatly helpful in evaluation especially of neonates, infants and complex patients
  - Evaluate adenoid especially if tonsils normal

- Rigid endoscopy
  - Nasopharyngeal, oropharyngeal and supraglottic evaluation in craniofacial patient, neonates and infants especially if complicated laryngotracheal problems
Sleep Audio or Video Recording

- Inexpensive, easy study
- Information on sleep behavior
  - Snoring, pauses, apnea, restlessness
- Disadvantages
  - Background noise, requires parental compliance, difficulty in distinguishing between true apnea and depressed respiration or hypopnea
Indications for Polysomnography

- AAT 1996
- AAP 2002
- AASM 2011
- AAOHNS recommend for confusing patient scenarios, neurologically impaired or high-risk patients
Practice Parameters for the Respiratory Indications for Polysomnography in Children  AASM 2011

- Polysomnography (PSG) in children performed and interpreted in accordance with AASM Manual for Scoring of Sleep and Associated Events (standard, s)
- PSG is indicated when clinical assessment suggests OSA (s)
- Children with mild OSA who undergo T&A with residual symptoms (s)
- Children with mod-severe OSA, obesity, craniofacial anomalies, neurologic disorders, Down syndrome, Prader-Willis syndrome, myelomeningocele who undergo T&A (s)
- Titration of positive airway pressure (s)
- Clinical assessment suggests congenital central alveolar hypoventilation syndrome or sleep related hypoventilation due to neuromuscular disorders or chest wall deformities. Selected cases of primary sleep apnea of infancy (guideline, g)
- Clinical evidence of sleep related breathing disorder in infants who have experienced an apparent life-threatening event (ALTE) (g)
- Children being considered for T&A to treat OSA (g)

Aurara RN etal. Practice parameters for the respiratory indications for polysymnography in children. SLEEP 2011:34(3); 379-388
Indications for Polysomnography

- AAP and AAT recommend for evaluation of pediatric snoring
- AAOHNS recommend for confusing patient scenarios, neurologically impaired or high-risk patients
- Parents or providers may want it prior to surgical intervention.
Polysomnography “sleep study”

- Multiple physiologic and neurophysiologic simultaneous recordings
  - Electroencephalogram (2-3 leads)
  - Electrocardiogram
  - Nasal and oral airflow by thermisters
  - Oxygen saturation monitoring
  - Chest strain gauges or esophageal manometry for thoracic respiratory movement
  - Electro-oculogram for REM vs non-REM sleep stages
  - Electromyogram of the chin for muscle tone & activity
  - End-tidal PCO2 by nasal sampling
  - Videorecording of study
Definition of Apnea

- Adult: cessation of breathing for 10 sec
- Child: cessation of breathing for 6 sec or pause lasting 2 respiratory cycles or pause associated with a change of 4% oxygen saturation.
Types of Apnea

- Central: CNS dysfunction
  - Sleep study demonstrates lack of respiratory movement with apnea

- Obstructive: upper airway obstruction
  - Sleep study demonstrates respiratory movement despite cessation of airflow

- Mixed: both above
  - Sleep study begins with central and progresses to obstructive which is frequently seen in young children
Polysomnographic Tracings
Central Apnea
Polysomnographic Tracings
Obstructive Apnea
Definition of Hypopnea

- 50% or greater decrease in the amplitude of the nasal/oral airflow
- Paradoxical breathing
- Decrease in oxygen saturation of >4% or arousal following the hypopnea
Normal Values for Pediatric Polysomnography

- Apnea/Hypopnea Index < 1
- Central apnea index < 0.9
- Baseline oxygen saturation > 92%
- Oxygen desaturation > 89%
- End-tidal CO2 > 45 mm Hg for < 10% of total sleep time

Grading of Pediatric OSA

- Normal  
  AHI < 1
- Mild OSA 
  AHI > 1 and < 5
- Moderate OSA 
  AHI > 5 and < 10
- Severe OSA 
  AHI > 10
## Etiology

### Anatomic
- Nasal: nares, septal hematoma, septal deviation
- Nasopharyngeal: choanal atresia/stenosis, polyp, cyst, adenoid hypertrophy, cleft palate or VPI repair
- Oropharyngeal: tonsillar hypertrophy, macroglossia, retrognathia/micrognathia
- Supraglottic: laryngotracheomalacia, vallecular cyst
- Craniofacial syndrome: Crouzon, Apert, Treacher Collins, Down

### Neuromuscular
- Cerebral palsy
- Down syndrome
- Myotrophic dystrophy
- Arnold-chirri malformation
- Syrinomyelobulbia

### Miscellaneous
- Congenital myxedema
- Prader-Willi syndrome
- Obesity
- Sickle-cell disease

Adenotonsillar hypertrophy is most common cause of respiratory obstruction of the upper airway in children
Dysmorphic Patients

- Site of airway obstruction usually multifactorial
  - Bony restrictions of the skull base
  - Poor velopharyngeal and neuromuscular control
- Common Findings
  - Maxillary hypoplasia
  - Nasal septal deviations
  - Micrognathia
  - Retrognathia
  - Choanal atresia or stenosis
  - Platybasia
  - Macroglossia
Removal of Obstruction
- Adenotonsillectomy
- Uvulopalatopharyngoplasty
- Hyoidplasty
- Aryepiglottiplasty
- Septorhinoplasty
- Choanal atresia repair
- Tongue reduction

Bypass of Obstruction
- Oral airway (neonates)
- Nasopharyngeal airway
- Feeding nipple
- Tracheotomy

Manipulation of Airway
- Orthognathic surgery
- Oral prosthesis
- Tongue suspension
Medical Therapeutic Options

- Diet or weight reduction
- Nasal continuous positive airway pressure
- Nasal bilevel positive airway pressure
- Thyroid replacement (for congenital hypothyroidism)
- Environmental control and treatment for allergies
- Medications
  - Medroxyprogesterone, nasal steroids, protriptyline, acetazolamide, theophylline
Topical Nasal Steroid and OSA

- 41 children aged 2-11 yrs, treated with mometasone furoate for 1 month with evaluation by lateral neck x-ray and obstructive sleep apnea (OSA-18) quality of life survey.
  - Significant improvement in OSA-18 QOL survey
  - Significant reduction in size of adenoid
  - Allergy, sinusitis and obesity did not impact outcome
  - 17 of 41 patients tested positive for allergies

Evaluation and Management of Obstructive Sleep Apnea in Healthy and High-Risk Children

A

High-Risk Children
- Young Age
- Neuromuscular Disorders
- Craniofacial Disorders
- Complicating Medical Conditions
- Sickle Cell Disease
- Pulmonary Disease
- Others

History
- Physical Examination
- Supporting Information
- Observation, Video/Audio tapes

B

Consider T&A if T&A hypertrophy exists (postop monitoring needed)

Polysomnography

- History
- Physical Examination
- Supporting Information
- Observation, Video/Audio tapes
- Special Studies
  - Laryngeal examination
  - Radiographs
  - Others

Consider postop sleep study for children with complications of OSA

Cured

OSA persists

CPAP
UPPP
Tracheotomy
Other
Risk factors for Postoperative Respiratory Complications in Children with OSAS Undergoing Adenotonsillectomy

- Patient under 3 yrs
- Known or suspected severe OSAS
- Cardiac complications of OSAS
- Failure to thrive
- Obesity
- History of prematurity
- Neuromuscular disorders
- Craniofacial anomalies
- Severe asthma
- Recent respiratory infection

Adenotonsillectomy Outcomes

- A multicenter Retrospective Study looking at overall efficacy of adenotonsillectomy (T&A) in the treatment of obstructive sleep apnea syndrome in children
  - 578 children, mean age 6.9 yrs, 50% obese
  - T&A resulted in significant AHI reduction from 18.2 +/- 21.4 to 4.1 +/- 6.4 (p< 0.001)
  - 157 (27%) complete resolution of OSA (AHI < 1)
  - Age > 7 and BMI score (obesity) were two principal factors contributing to post T&A residual OSA
  - Among nonobese children, asthma and severity of OSA contributed to post T&A residual OSA

Behavioral improvement following Adenotonsillectomy for OSA Persist

- 23 children undergoing T&A for polysomnography-proven OSAS who demonstrated a significant improvement in behavior (agression, atypicality, depression, hyperactivity using Behavior Assessment System for Children) at 6, 9 and 18 months after surgery (p<.05).

Adenotonsillectomy Improves both OSA and mild SDB

- 40 children with mild SDB (AHI < 5) and OSA with pre and postoperative PSG and behavioral assessment system for children (BASC)
- SDB mean AHI 3.1, OSA mean AHI 25.3
- Mean preop BASC scores for SDB and OSA similar
- Both groups showed significant improvement after T&A in BASC scales for atypicality, depression, hyperactivity and somatization that were not significantly different.
- Summary: severity of SDB doesn’t impact improvement in behavior after adenotonsillectomy

Postoperative Polysomnography

- Adenotonsillectomy thought to “cure” 80% of patients
  - 47 children, 31 with PSG proven OSA
    - Disease specific and Global QOL worse for children with OSA compared to controls
    - Children who underwent ATH had significant improvement in QOL and PSG compared to children without surgery
  - 29 children (mean age 7) with severe OSA (AHI > 30)
    - OSA-18 changed from 77.6 to 33.2 (p<.0001)
    - RDI changed from 63.9 to 14.2 (p<.0001)
  - Significant change, however, OSA does not resolve in majority and follow up PSG is indicated to identify those who may need additional therapy
Obstructive Sleep Apnea Cases

- 6 year old male with significant tonsil hypertrophy and nasal obstruction
- 3 year old female with Down syndrome
- 11 year old with CP
- 7 year old with sickle cell anemia
6 year old with large tonsils

- 3 yr old female with parental concerns about snoring
  - Adenoid hyperplasia triad
    - Hyponasality
    - Snoring
    - Chronic mouth breathing
  - Adenoid facies
    - Long narrow face
    - Narrow upper jaw
    - Steep mandible
    - Open anterior bite
    - Low tongue placement
    - Increased cervicomental angle
Down Syndrome Patients

- Prone to obstructive sleep disorders
- Characteristic anatomic craniofacial features
  - Small oropharynx and nasopharynx
  - Relative macroglossia
- Characteristic neuromuscular control problems
  - Poor gross motor and fine motor control of velopharyngeal function and tongue
  - Decreased muscle tone
Sickle Cell Disease (SCD) and OSA

- **Superimposition of OSAS upon underlying hemoglobinopathy gives rise to increased morbidity.**
  - Hypoxemia, hypercarbia and acidosis predispose to sickling
  - Surgery can precipitate vaso-occlusive crisis or ischemia

- **Increased cause of ATH in SCD**
  - Compensatory hypertrophy of lymphoid tissue following splenectomy
  - Reactive enlargement due to repeated infections with encapsulated organisms
  - Increased hematopoietic needs 2nd to chronic hemolytic anemia

- **Preoperative management—Maddern et al.**
  - Polysomnography, chest radiograph, CBC, liver function, quantitative hemoglobin electrophoresis, consult pediatric hematologist
  - 2-3 week prior transfused with washed packed RBCs to bring preoperative hematocrit to minimum of 35% and ratio of HbA to HbS of 60:40
  - 2 days prior admitted for final transfusion, hydration, hemoglobin electrophoresis
  - Penicillin prophylaxis
  - Now most will transfuse to achieve a hematocrit of 30% and not worry about ratios

- **Postoperatively**
  - Admission, observation, monitoring, IV fluid, O2 therapy and tapering of pain medications and sedation as tolerated
  - Polysomnography at 6 wks to 6 months

- **13 of 21 patients underwent T&A**
  - all had complete resolution of apneas (>10 s)
  - end tidal PACOS decreased an average of 12 mm Hg
  - oxygen saturation did not significantly change
  - no complications of surgery

Role of Dentists

- Among providers treating children, dentists are most likely to identify adenotonsillar hypertrophy and are best suited to act as “gatekeepers” in need of treatment for obstructive sleep apnea.
- Discuss risks of obstructive sleep apnea
- Discuss that they should inform primary care provider that this has been identified as an issue
- Referral to ENT for surgical management if appropriate

References

- Bailey
- Cumming
- Selected articles as referenced in the text

Questions?