Pediatric Chronic Rhinosinusitis

Francisco Pernas, MD
Faculty Advisor: Shraddha Mukerji, MD
The University of Texas Medical Branch
Department of Otolaryngology
Grand Rounds Presentation
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Outline

- Background
  - Definitions, Incidence, Signs and symptoms
- Pathophysiology
- Mucociliary clearance
- Inherited ciliary disorders
  - PCD, CF
- GER and Sinusitis
- Role of Adenoidectomy
- Controversy in FESS
Background
Sinusitis

- **Common Cold**
  - Improve within 5-7 days
  - Longer than 10 days → Acute or Chronic Sinusitis
  - Longer than 3 weeks → Chronic Sinusitis
Rhinosinusitis - broadly defined as an inflammation and/or infection involving the nasal mucosa and at least one of the adjacent sinus cavities

Acute rhinosinusitis (AS) – the persistence and worsening of upper respiratory symptoms for greater than a 7-day course but lasts less than 4 weeks.

Subacute rhinosinusitis (SAS) - is defined as nasal symptoms lasting 4 weeks to 12 weeks
Chronic Rhinosinusitis (CRS) – persistence mucosal inflammation for > 12 consecutive weeks despite medical therapy or occurrence of more than four episodes of symptoms a year with persistent radiographic changes

Chronic Recurrent Rhinosinusitis (CRRS) - consists of multiple acute episodes with complete resolution of disease between episodes
Rhinosinusitis

ACUTE
- Less then 3 months
- S. Pneumo, H. Flu, M. Catarrhalis
- More severe symptoms
- General stems from acute viral infection

CHRONIC
- Greater than 3 months
- S. Aureus, $\alpha$-hemolytic strep, m. catarrhalis
- Milder symptoms
- Additional symptoms present:
  - chronic cough, bronchitis, fatigue, malaise, and depression
5–10% of children with URI develop acute rhinosinusitis

Subset of that progress to chronicity
Day and night cough
Purulent nasal discharge
Nasal airway obstruction
Headache, irritability, or facial pain
Fever
Postnasal drip
Signs and Symptoms

- Nasal Discharge
- Cough
- Cough worsening at night
- PND
- Nasal Congestion
- Fever
- Headaches
- Facial pain
Anatomy

- **Maxillary Sinus**
  - first to develop at day 65 of gestation
  - seen on plain films at 4-5 months
  - slow expansion until 18 years

- **Ethmoid Sinus**
  - develop in third month of gestation
  - ethmoids seen on radiographs at one year
  - enlarges to reach adult size at age 12
**Anatomy**

- **Sphenoid Sinus**
  - originates in fourth gestational month from posterior part of nasal cavity
  - pneumatization begins at age 3
  - rapid growth to reach sella by age 7 and adult size at age 18

- **Frontal Sinus**
  - begins in fourth month of gestation from superior ethmoid cells
  - seen on radiographs at age 5-6
  - grows slowly to adult size by adolescence
Bones of nasal cavity and paranasal sinuses at birth

- Sinus represents one or more anterior ethmoidal cells opening into semilunar hiatus of middle nasal meatus
- Sinus represents one or more middle ethmoidal cells opening into middle nasal meatus
- Sinuses represent two or more posterior ethmoidal cells opening into superior nasal meatus
- Sphenoidal sinus within bony shell (sphenoidal concha) located anterior and lateral to body of sphenoid bone (broken line indicates sinus lateral to sphenoid body)
- Body of sphenoid bone
- Hypophyseal fossa
- Vestigial remnant of Rathke's pouch
- Medial plate of pterygoid process
- Lower border of highest nasal concha
- Lower border of superior nasal concha
- Superior nasal meatus
- Middle nasal concha (cut edge) (inter nasal concha completely removed)
- Maxillary sinus with opening into semilunar hiatus (striped area represents membrane forming most of medial wall of sinus)
Growth of frontal and maxillary sinuses throughout life

- Frontal sinus within frontal bone
- Middle nasal concha
- Nasal septum
- Nasal cavity
- Inferior nasal concha
- Palate
- Left orbit
- Maxillary sinus within maxilla
- Molar tooth
Adjunctive Tests

- to improve after treatment or as pre-operative study
- Ideally should Imaging not indicated for uncomplicated patients.
- CT scan may be indicated if suppurative complications suspected, patient fails be obtained after several weeks of medical therapy

- Sinus aspirate is indicated:
  - severe toxic illness, acute illness not responsive to antibiotics within 72 hours, immunocompromised patients, suppurative complications and workup for fever of unknown origin
  - Oropharyngeal/Nasopharyngeal swabs do not correlate with sinus aspirate
  - Endoscopically guided middle meatus swab correlates fairly well with sinus aspirate
CT Irregularities

- Maxillary Sinus
- Ethmoidal Sinus
- Ethmoidal Air
- Inferior Turbinate Thickening
- Cell
- Frontal Sinus Thickening
- Ethmoidal Sinus Thickening
- Sphenoid Sinus Thickening
- Opacification
- Swelling
Pathophysiology
Factors Predisposing to Recurrent or Chronic Sinusitis

- Recurrent URI
- Allergy
- Anatomic Deformity
- Gastroesophageal Reflux
- Adenoids
- Immunodeficiency Syndrome
- Cystic Fibrosis
- Immotile Cilia
CYCLE LEADING TO CHRONIC SINUSITIS

Secretions thicken; pH changes.

Mucosal gas metabolism changes.

Cilia and epithelium are damaged.

Changes in host milieu creates medium for bacterial growth in closed cavity.

Mucosal congestion or anatomic obstruction blocks airflow and drainage.

OSTIUM IS CLOSED

Mucosal thickening creates further blockage.

Retained secretions cause tissue inflammation.

Bacterial infection develops in the sinus cavity.
Pathophysiology

Systemic:

- Viral URI
- Allergy
- Immotile cilia
- Cystic fibrosis
- Immune disorder
Pathophysiology

Local:

- Trauma
- Swimming/Diving
- Rhinitis Medicamentosa
Pathophysiology

Mechanical:

- Choanal Atresia
- Deviated Septum
- Polyps/Foreign Body
- Turbinate/Adenoid Hypertrophy
- Hypoplastic Sinus
Mucociliary clearance
Mucociliary clearance

- Ciliary function very important
- Ostia are small and located in locations not conducive to spontaneous drainage

Important factors:
- Number of cilia
- Structure
- Activity
- Coordinated Activity
Mucociliary clearance

- Cilia work best:
  - Temp of 37°
  - Humidity near 100%

- Respiratory Epithelium
  - Goblet cells (20%) produce mucus
  - Ciliated cells (80%)

- Normal mucus velocity range from 3-25mm/sec
Fig 1. Molecular anatomy of cilia.
Mucociliary clearance

- Decreased in CRS
- Return to normal as early as 6 months post FESS
Decreased MCC

- Kartagener syndrome (Primary ciliary dyskinesia)
- Cystic fibrosis
- Pseudohypoaldosteronism type I
- Radiotherapy
- GERD
- Rhinosinusitis
Inherited ciliary dysfunction
Primary ciliary dyskinesia

- Autosomal recessive
- Dynein arm defects (total, partial, inner, outer or both arms)
- Deficiency of outer arms more detrimental to beat frequency
- Extensive genetic heterogeneity
Incidence – 1:16,000 births
- No sex or racial predilection
- Associated with dextrocardia, sinusitis, rhinitis, pneumonia, and otitis media
- Male infertility is common
- Evidence of female infertility is inconclusive
Most common mutation

\textit{DNAI1} and \textit{DNAH5}, which encode for components of the outer dynein arm complex

Mutations in these genes are seen in 38% of patients.
Cystic Fibrosis

- Most common inherited lethal disease in whites
- Autosomal recessive
- Defect in CFTR gene (508delF most common)
- 1604 mutations have been identified
- CFTR encodes a cAMP modulated Cl channel protein
- Decreased chloride secretion with resultant water retention within cell
Reduced height of epithelial lining fluid
Decreased hydration of mucus
Thicker/stickier mucus adherent to bacteria
Leads to infection and inflammation

Viscosity leads to dysfunction:
- Resp tract
- Sweat glands
- Pancreas
- Other exocrine glands
- GI tract
GERD
Prospective analysis

Ages 2-18

30 patients who failed CRS conservative treatment

24hr PH probe was performed
GERD and CRS

- 63% were found to have pathologic reflux
- Incidence in general population is 5%
- 32% had reflux into nasopharynx
- 79% of patients CRS symptoms improved with GERD treatment
- 71% of patients with GERD also had asthma
- Only 44% of patients without asthma had GERD
GERD and CRS

- Pathophysiological characteristics of GERD in CRS unknown, but there is an association.
- Theory – Acid causes inflammatory reaction leading to decreased mucociliary clearance.
- Asthmatics use medications that decrease LES tone and cause hypersecretion of gastric acid.
Role of Adenoidectomy
Role of adenoidectomy

- Adenoidectomy & FESS most common procedures when medical management fail.
- Adenoids may cause predisposition to sinus infections:
  - Obstruction
  - Stasis
  - Reservoir (biofilms)
- Retrospective review
- 460 children
- Underwent adenoidectomy for symptoms of nasal obstruction, snoring and mouth breathing
- All patients received pre-op sinus x-ray
- X-ray graded
### Role of adenoidectomy

- **52.3% incidence of sinusitis** in patients who underwent adenoidectomy.
- **79.3% bacterial isolation rate.**
- **19.5%** had 2 or more bacteria isolated.

#### Table 1 Sinusitis grade based on Water’s view

<table>
<thead>
<tr>
<th>Sinusitis grade</th>
<th>No. of patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 0</td>
<td>192 (46.8%)</td>
</tr>
<tr>
<td>Grade 1</td>
<td>127 (31.0%)</td>
</tr>
<tr>
<td>Grade 2</td>
<td>44 (10.7%)</td>
</tr>
<tr>
<td>Grade 3</td>
<td>47 (11.5%)</td>
</tr>
</tbody>
</table>

#### Table 2 Bacteria isolated from adenoid tissue

<table>
<thead>
<tr>
<th>Organism</th>
<th>No. of patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>H. influenzae</em></td>
<td>117 (28.5%)</td>
</tr>
<tr>
<td><em>S. pneumoniae</em></td>
<td>89 (21.7%)</td>
</tr>
<tr>
<td><em>S. pyogenes</em></td>
<td>86 (21.0%)</td>
</tr>
<tr>
<td><em>S. aureus</em></td>
<td>64 (15.6%)</td>
</tr>
<tr>
<td>MRSA</td>
<td>18 (4.4%)</td>
</tr>
<tr>
<td>Others</td>
<td>31 (7.6%)</td>
</tr>
<tr>
<td>Multiple bacteria</td>
<td>80 (19.5%)</td>
</tr>
</tbody>
</table>
Role of adenoidectomy

- Adenoid size did not correlate to grade of sinusitis
- Bacterial isolation rate increased with adenoid grade
- Study suggests adenoids etiology in CRS is more as reservoir than an obstruction
Role of adenoidectomy

- Confounders:
  - Sinus x-rays
  - Retrospective review
  - Adenoidectomy for non-sinus reasons
  - Which came first?
    - Sinus infection colonizing adenoids
    - Adenoid infection colonizing sinuses
9 studies
- Six were cohort studies (level 2b)
- Four were case series (level 4)
- Typically adenoidectomy performed after failed therapy and CT confirmation of sinusitis
## Adenoidectomy outcomes

<table>
<thead>
<tr>
<th>Author/year</th>
<th>N</th>
<th>EBM</th>
<th>Mean age</th>
<th>Sinus diagnosis</th>
<th>Adenoid technique</th>
<th>Minimum F/U</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Huggill/1952</td>
<td>25</td>
<td>4</td>
<td>NR</td>
<td>Recurrent sinus symptoms</td>
<td>Curette</td>
<td>1 month</td>
<td>21/25 (82%) were symptom free. 24/25 (96%) were improved or symptom free 25/45 (56%) patients were improved 6 months following surgery compared to 8/33 (24%) non-adenoid pts ($p &lt; 0.01$) 7/10 (70%) caregiver expectations were met or exceeded, 88% all major symptoms were better or cured</td>
</tr>
<tr>
<td>Takahashi/1989</td>
<td>45</td>
<td>2b</td>
<td>NR</td>
<td>Recurrent sinus symptoms</td>
<td>NR</td>
<td>6 months</td>
<td></td>
</tr>
<tr>
<td>Rosenfeld/1995</td>
<td>10</td>
<td>2b</td>
<td>4</td>
<td>Failed antibiotic therapy, CT scan</td>
<td>Curette</td>
<td>2–3 months</td>
<td>35/44 (80%) of caregivers reported symptomatic improvement 14/30 (47%) of caregivers reported symptomatic improvement IV antibiotics with selective adenoidectomy were similar to those treated with only IV antibiotic therapy 22 of 27 (85%) caregivers reported symptomatic improvement 33/64 (51.6%) of caregivers reported symptomatic improvement 60/121 (49.6%) were successfully treated with adenoidectomy and did not require FESS</td>
</tr>
<tr>
<td>Vandenbergh/1997</td>
<td>44</td>
<td>4</td>
<td>4.4</td>
<td>Failed antibiotic therapy</td>
<td>NR</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>Ramadan/1999</td>
<td>30</td>
<td>2b</td>
<td>6</td>
<td>Failed antibiotic therapy, CT scan</td>
<td>NR</td>
<td>6 months</td>
<td></td>
</tr>
<tr>
<td>Don et al./2001</td>
<td>37</td>
<td>4</td>
<td>6.4</td>
<td>Failed antibiotic therapy, CT scan</td>
<td>NR</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>Tuncer et al./2004</td>
<td>27</td>
<td>2b</td>
<td>6</td>
<td>Failed antibiotic therapy, CT scan</td>
<td>Curette</td>
<td>9 months</td>
<td></td>
</tr>
<tr>
<td>Ramadan/2004</td>
<td>64</td>
<td>2b</td>
<td>5.41</td>
<td>Failed antibiotic therapy, CT scan</td>
<td>NR</td>
<td>6 months</td>
<td></td>
</tr>
<tr>
<td>Ramadan et al./2007</td>
<td>121</td>
<td>4</td>
<td>6.9</td>
<td>Failed antibiotic therapy, CT scan</td>
<td>EC</td>
<td>NR</td>
<td></td>
</tr>
</tbody>
</table>
Adenoidectomy outcomes

- 70% of patients improve subjectively after adenoidectomy
- Study seems to suggest once medical therapy fails, adenoidectomy should be considered first-line surgical therapy.
Retrospective review

143 children underwent adenoidectomy after having failed medical tx for CRS

All children had:
- Allergy testing
- Ig w/u
- Sweat test

Pts w/ CF, immunodeficiency, fungal infection, or prior sinus surgery excluded
Failures of adenoidectomy

- Around 50% fail to improve
- Remaining 50% required FESS
- Children with asthma required further surgical tx earlier
- Younger children had failure rate of 15 months compared with mean of 27.5 months for kids >6 y/o
- Allergy, CT score, and sex had no statistical impact on the mean failure time
Immunological investigation in the adenoid tissues from children with chronic rhinosinusitis

Seung-Youp Shin, MD, Gil-Soon Choi, MD, Hae-Sim Park, MD, PhD, Kun-Hee Lee, MD, PhD, Sung-Wan Kim, MD, PhD, and Joong-Saeng Cho, MD, PhD, Seoul and Suwon, Korea
Immunological study

- Adenoid tissue in CRS patients more severe inflammation
- Elevated tissue remodeling associated cytokines
- Did not evaluate infiltration of cytokines into nasal mucosa
Reservoir for bacteria
Interfere with mucociliary clearance
Obstruction *may* cause nasal stasis and increase risk for CRS
Asthmatics less likely to benefit from adenoidectomy
Older children obtain longer lasting relief than kids <6y/o
Controversy in FESS

- Effects on bony facial growth
- Long debated concerns regarding creating hypoplastic sinuses and asymmetric facial growth
- 2 recent long-term studies demonstrate no effect on facial skeleton
Functional endoscopic sinus surgery—A retrospective analysis of 115 children and adolescents with chronic rhinosinusitis

Vanessa Siedek*, Klaus Stelter, Christian S. Betz, Alexander Berghaus, Andreas Leunig

Ludwig Maximilians-University, Department of Otorhinolaryngology, Head and Neck Surgery, Marchioninistr. 15, 81377 Munich, Germany

<table>
<thead>
<tr>
<th>Evaluation of the follow-up questionnaire of 71 patients after FESS.</th>
<th>All</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better general condition?</td>
<td>75%</td>
<td>77%</td>
<td>71%</td>
</tr>
<tr>
<td>Better QOL?</td>
<td>71%</td>
<td>70%</td>
<td>71%</td>
</tr>
<tr>
<td>Had revision</td>
<td>12.6%</td>
<td>13.8%</td>
<td>11.0%</td>
</tr>
<tr>
<td>Approval of operation again if necessary?</td>
<td>88%</td>
<td>96%</td>
<td>76%</td>
</tr>
</tbody>
</table>

Answers concerning sinonasal symptoms in questionnaires graded in four SNOT groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>SNOT points</th>
<th>Level of complaints</th>
<th>All children</th>
<th>Smokers</th>
<th>Non-smokers</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>≤12</td>
<td>No or little</td>
<td>32 (43.8%)</td>
<td>4 (11.4%)</td>
<td>28 (73.8%)</td>
</tr>
<tr>
<td>II</td>
<td>&gt;12 and ≤32</td>
<td>Little to moderate</td>
<td>26 (35.6%)</td>
<td>18 (51.4%)</td>
<td>8 (21.0%)</td>
</tr>
<tr>
<td>III</td>
<td>&gt;32 and ≤52</td>
<td>Moderate to severe</td>
<td>13 (17.8%)</td>
<td>11 (31.4%)</td>
<td>2 (5.2%)</td>
</tr>
<tr>
<td>IV</td>
<td>&gt;52</td>
<td>Severe to extreme</td>
<td>2 (2.7%)</td>
<td>2 (5.7%)</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>
Influence of extensive functional endoscopic sinus surgery (FESS) on facial growth in children with cystic fibrosis
Comparison of 10 cephalometric parameters of the midface for three study groups

A. Van Peteghem *, P.A.R. Clement

- Retrospective study
- CF Patients with CRS
- Cephalometric on midface in 23 patients
- 9 had no surgery during childhood
- 9 had surgery prior to growth spurt
- 5 had surgery after spurt
- CONCLUSIONS: Extensive FESS after the first and before the second growth spurt has no impact on the outcome of facial growth.
Cephalometric analysis

- Retrospective age-matched cohort (67 pts)
- Performed anthropomorphic analysis w/ 12 standard facial measurements
- Facial analysis by FPS
- Conclusions: Both quantitative and qualitative analyses showed no statistical significance in facial growth
Treatment principles

- Appropriate antibiotic for susceptible microbes
- Levels to exceed MIC
- Irrigation and drainage or secretions improve local defense mechanisms
- Antimicrobials appear to lessen risks of orbital and intracranial complications
Medical Treatment

- Chronic Rhinosinusitis
  - 4 to 6 week course of beta lactam stable antibiotic
  - Adjuvant therapy with nasal steroids commonly employed
  - Antihistamines especially if underlying allergic condition suspected
  - Mucolytics may thin secretions
  - Consider reflux treatment
Surgical treatment

- Step-wise approach reasonable: adenoidectomy, nasal endoscopy ± antral lavage/cultures
- Tonsillectomy if OSA or recurrent strep
- Conservative FESS if child is miserable and failed medical and initial surgical therapy.
### Surgical Treatment

**TABLE 2: Relative Indications for Pediatric Sinus Surgery**

<table>
<thead>
<tr>
<th>Suppurative complications</th>
<th>Fixed obstructions</th>
<th>Sinusitis aggravating pulmonary disease</th>
<th>Chronic sinusitis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stronger</td>
<td>Refractory polyps</td>
<td>Asthma</td>
<td>Impact on quality of life, school attendance</td>
</tr>
<tr>
<td>Medial subperiosteal orbital abscess (CF, AFS)</td>
<td></td>
<td></td>
<td>Persistent mucosal disease in sinus outflow tracts on CT after maximum medical therapy</td>
</tr>
<tr>
<td>Complicated sphenoid or frontal sinusitis</td>
<td>Antrochoanal polyp</td>
<td>Cystic fibrosis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inverted papilloma</td>
<td>Immunodeficiency</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other suspected tumor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CF, cystic fibrosis; AFS, allergic fungal sinusitis; CT, computed tomography.
Conclusion

- Different etiologies involved in acute versus chronic
- Special population of children that develop CRS
- GERD and adenoid contributes to CRS
- Medical therapy mainstay of treatment
- If medical therapy fails, conservative surgery should be pursued in step-wise fashion
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