Pediatric
Subglottic stenosis

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96.4.12
Introduction

• Incidence of subglottic stenosis in intubated neonates
  – 1970s and 1980s: 0.9% ~ 8.3%
  – After 1983: < 4.0%
  – After 1990: < 0.63%
• Suspected congenital SGS: 5%
• Acquired SGS: 95%

Laryngoscope 111 (1) 2001, 48-51
Definition

• Normal subglottic lumen diameter
  – Full-term neonate 4.5 - 5.5 mm
  – Premature babies 3.5 mm
  – Narrowed
    • < 4 mm in full-term neonate
    • < 3 mm in premature babies
Congenital v.s. Acquired SGS

- Congenital subglottic stenosis

<table>
<thead>
<tr>
<th>Cartilaginous Stenosis</th>
<th>Soft-Tissue Stenosis</th>
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<tbody>
<tr>
<td>Cricoid cartilage deformity</td>
<td>Submucosal fibrosis</td>
</tr>
<tr>
<td>Normal shape</td>
<td>Submucosal gland hyperplasia</td>
</tr>
<tr>
<td>Small for infant’s size</td>
<td>Granulation tissue</td>
</tr>
<tr>
<td>Abnormal shape</td>
<td></td>
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<tr>
<td>Large anterior lamina</td>
<td></td>
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<tr>
<td>Oval (elliptic shape)</td>
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<tr>
<td>Large posterior lamina</td>
<td></td>
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<tr>
<td>Generalized thickening</td>
<td></td>
</tr>
<tr>
<td>Submucous (occult) cleft</td>
<td></td>
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<tr>
<td>Other congenital cricoid stenosis</td>
<td></td>
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<tr>
<td>Trapped first tracheal ring</td>
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</tbody>
</table>

- Acquired SGS
  - Intubation
  - External trauma
  - High tracheotomy
  - Infection/Inflammation
  - Burn
    - Thermal
    - Chemical
  - Tumor
  - Dystrophic cartilage
# Myer-Cotton grading system

<table>
<thead>
<tr>
<th>Grade</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade I</td>
<td>No Obstruction</td>
<td>50% Obstruction</td>
</tr>
<tr>
<td>Grade II</td>
<td>51% Obstruction</td>
<td>70% Obstruction</td>
</tr>
<tr>
<td>Grade III</td>
<td>71% Obstruction</td>
<td>99% Obstruction</td>
</tr>
<tr>
<td>Grade IV</td>
<td>No Detectable Lumen</td>
<td></td>
</tr>
</tbody>
</table>

- No obstruction ~ 50% obstruction
- 51% obstruction ~ 70% obstruction
- 71% obstruction ~ 99% obstruction
- No detectable lumen
Trauma

• External laryngeal trauma
  – Blunt trauma (vehicle accident)
  – Clothesline injury
  – More common in adult

• Internal laryngeal trauma
  – Iatrogenic
  – Prolonged intubation
Pathophysiology

• Prolonged intubation
  – Pressure necrosis
  – Mucosa edema and ulceration
  – Mucociliary stasis
  – Secondary infection and perichondritis
  – Healing with secondary intention
    • Granular tissue and fibrous tissue
Animal model -1

- 60 Newzealand white breeder rabbits
  - Group A: Anterior 120° wounding
  - Group B: Posterior 120° wounding
  - Group C: Circumferential

- Results
  - 120° groups: CSA reduction 12-56%
  - 360° groups: CSA reduction 32-82%

Annals of Otology, Rhinology, & Laryngology 115(8): 611-616
Animal model -2

• Acute phase
  – Mucosal ulceration
  – Inflammation
  – Granulation
• Later phase
  – Collapse of injured cartilage
  – Submucosal thickening and fibrosis
Acute phase

- Acute airway obstruction
- Mucosal ulceration
- Necrotic cartilage fragment
- Granulation tissue
Submucosal fibrosis

Control
Chronic inflammation

- Sarcoidosis, lupus erythematosus, Behcet’s syndrome, Wegener’s granulomatosis, relapsing polychondritis, pemphigoid, epidermolysis bullosa, amyloidosis, major aphthous ulceration

- **Gastroesophageal reflux (GER)**
  - 24-hour esophageal pH probe using dual probe technique
  - Upper pH probe studies
    - 27 of the 55 had a pH of less than 4.0 more than 1% of the study time

Reflux animal model

- New Zealand white breeder rabbits
- Subglottic injury by diode laser
- Acid or saline reflux treatment
- Pepsin 0.3mg/mL + Taurodeoxycholic acid 0.155 mg/mL

Am J Gastroenterol 2006;101:1186-1192

**Figure 1.** Subglottic wounding and simulated reflux. After the posterior subglottis was wounded using a diode laser (A), a pharyngeal catheter (arrow) was inserted into the hypopharynx using a minimally invasive endoscopic technique via the transoral route (B).

**Figure 2.** Development of posterior subglottic stenosis after wound ing and reflux treatments. Severe stenosis of the proximal posterior subglottis (arrow) was found in the acid reflux group (A), in contrast to the saline reflux wound control (D), 6 wk after injury.

**Figure 3.** Different degrees of posterior subglottic stenosis among different groups. (A), acid reflux group; (B), nonacid reflux group; (C), saline reflux control group; (D), unwounded control group. Stenosis of the subglottic lumina and thickness of the posterior subglottic walls were greatest in the acid reflux group, compared with the other groups.
Posterior glottic wounding and simulated reflux

Figure 4. Histological sections of the uninjured subglottis treated with acidic solutions. Mucosal ulceration, cartilage exposure, and necrosis of the posterior subglottis were observed at week 1 postoperatively on trichrome stain (A), and granulation tissues (arrow) were found in the injured posterior subglottic mucosa at week 2 postoperatively on H&E stain (B). Extensive fibrosis, thickening, and collagen deposition in the injured posterior subglottic walls were identified at week 4 postoperatively on trichrome stain (C). Inflammation, mucosal erosion (arrows), delay of epithelial growth, and necrotic cartilage fragments (asterisks) were also continuously found (D) (×40).
Comprehensive history

- Term baby or premature
- Apgar score
- Birth weight
- Detailed history of intubation
- How long has extubation been tolerated
- Presence or absence of stridor
- Presence or absence of cry
- Quality of cry or voice
- Detailed history of feeding
- History of aspiration
- Pulmonary status
- Details of other medical problems
- Age at tracheotomy
- Any prior airway surgery
Endoscopic evaluation

- Flexible
- Rigid
  - Glottic area
    - Passive arytenoid mobility
    - Glottic pathology (web, scar, adhesion, fixation or paralysis of vocal cords)
  - Subglottic area
    - Site, maturity, length and consistency of the obstruction
  - Suprastomal area
    - Collapse, granuloma, fibrous tissue, long tracheocutaneous tract
Evaluation of GER and GLPR

• Most reliable test
  – 24-hour esophageal pH probe using a dual probe technique

• In conjunction with
  – History
  – Esophagoscopy
  – Esophageal biopsy
FEES and FEESST

- Videofluoroscopic swallowing studies
  - Impossible in pediatric patients
- Assessment
  - Functional anatomic state or larynx
  - Safety of swallowing
  - Laryngeal adductor reflex
- Predict
  - Which children are at risk for aspiration following surgery
Therapy
Therapy

- Close observation
- Tracheotomy
- Anterior cricoid split
- Laryngotracheal reconstruction
- Single-stage laryngotracheal reconstruction
- Cricotracheal resection
- Stenting
Close observation

- Grade I or mild grade II SGS
- Reactive larynx
  - Allow the reactivity to quiet down
- Significant GLPR
- Other medical condition
  - Age, weight, oxygen dependent pulmonary disease, neurological disease with potential for aspiration, craniofacial anomalies
Tracheotomy

- Most appropriate initial step in safely caring for a child with SGS beyond the neonatal period of SGS
  - Allow a neonate time to grow and gain weight
  - Optimize the pulmonary status
Anterior cricoid split -1

- Patient selection
  - Extubation failure on at least 2 occasions due to subglottic laryngeal pathology
  - Weight > 1500 g
  - Off ventilator support for at least 10 days before procedure
  - Supplemental O2 requirement less than 30%
  - No congestive heart failure for at least 1 month before procedure
  - No acute respiratory tract infection
  - No antihypertensive medication for at least 10 days before the procedure
Anterior cricoid split -2
Laryngotratheal reconstruction -1

• Anterior cartilage graft with the tracheotomy left in place and no stent
• Long-term (several months) stenting with or without cartilage grafts
• Short-term (4-6 weeks) stenting with cartilage grafts, either anterior or posterior
Laryngotracheal reconstruction -1
Single-stage laryngotratccheal reconstruction

- Use of cartilage grafts to obtain stability of the reconstructed airway and compress the prolonged stenting period of traditional LTR methods into a briefer period of endotracheal intubation
  - 2 to 4 days of intubation for anterior cartilage grafts alone
  - 7 days if posterior graft is used
- Success:
  - Weight > 4 kg
  - Gestational age > 30 weeks
Cricotracheal resection -1

- For severe SGS in infants and children
- Potential complication
  - Injury to recurrent laryngeal nerve
  - Partial dehiscence of the anastomosis
  - Interference with normal laryngotracheal growth
Stenting

• Montgomery T tube
  – Hollow silicone
  – Both a stent and a tracheotomy tube
  – Little tissue reaction
  – Risk
    • Obstruction, especially when the inner diameter is small
Post-LTR voice?
Post-LTR voice -1

- Zalzal et al, 1991
  - Breathiness
  - Low pitch
  - Restricted pitch range

- Smith el al, 1993
  - Supraglottic compression
  - Glottic incompetence
  - Vocal fold immobility
  - Anterior commissure changes
  - Lack of vertical level approximation of the vocal fold edges
Post-LTR voice -2

Clary et al, 1996

- Dysphonia
  - Harshness
  - Whisper
  - Ventricular phonation
  - Inappropriate pitch

- Anatomical findings
  - Abnormal vocal fold mobility
  - Subglottic stenosis
  - Anterior commissure blunting
  - Supraglottic compression/vibration
Behavior treatment

- Intervention begin before decannulation after reconstruction


- “Easy phonation” method
  - Reduce supraglottic structure vibration

- Mouthing
  - Encourage the child to articulate words without phonation

- Use of an electrolarynx
Thanks for attention!