Laryngotracheal Stenosis and Open Airway Reconstruction In Children: a Primer

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Key Reference Material Acknowledgment

Glottic and Subglottic Stenosis

Etiologies

- Iatrogenic causes such as prolonged endotracheal intubation or laryngeal surgery
- External neck trauma
- Congenital stenosis
- Burns or caustic ingestions
- Infection
- Inflammation: e.g. granulomatosis with polyangitis (GPA)
Glottic and Subglottic Stenosis

- May involve vocal folds, subglottic airway or both
- Location: Anterior, Posterior, circumferential, complete
- Symptoms: Stridor, dyspnea, dysphonia, aphonia, failure to extubate
- Physical exam: clinical assessment of stridor (usually biphasic), retractions, air hunger, cyanosis, voice quality
- Other studies: Flexible and rigid laryngoscopy and bronchoscopy (assess vocal fold mobility), imaging studies
Chronic Laryngeal and Subglottic Stenosis (SGS)

- **Congenital**
  - A spectrum of severity, from congenital laryngeal web to stenosis
  - Membranous and cartilaginous
- **Acquired**
  - Intubation – by far the most common cause of SGS in children (90%)
  - External trauma

Anterior glottic/subglottic web-stenosis in child w 22q11.2 del

Acquired SGS in intubated premature infant
Laryngeal and Subglottic Stenosis: Principles of injury

- Cricoid: complete circular cartilaginous ring
- Posterior glottic and subglottic mucosa prone to ulceration and injury from trauma of endotracheal tubes
- Subglottic submucosa prone to edema
- Subglottic space is narrowest portion of pediatric (and also usually adult) airway
Pathophysiology of Posterior Glottic and Subglottic Stenosis

- ET tube induced pressure necrosis (25 cm H2O – mucosal capillary filling pressure)– mucosal edema and ulceration
- Mucociliary stasis and perichondritis
- Chondritis and cartilaginous necrosis
- Healing by secondary intention
  - Granulation tissue formation
  - Fibrin deposition in submucosa leading to scar
  - Healing impaired by poor cartilage blood supply and constant motion from swallowing and head movement
Mucosa capillary perfusion pressure

“To prevent ischemic damage the cuff should exert a pressure no greater than the capillary perfusion pressure of the mucosa.

Although the mean capillary blood pressure is about 26 cm H2O, the venous end of a capillary has a pressure of about 16 cm H2O.

Therefore, obstruction of flow will occur when the lateral wall pressure exerted by a cuff on the trachea is greater than this figure. “

Leigh and Maynard, BMJ, 1979
Subglottic Stenosis rating: Myer/Cotton Classification
Posterior Laryngeal Stenosis

- Similar in mechanism of injury to subglottic stenosis
  - Involves medial arytenoid body and interarytenoid mucosa
  - Scar of interarytenoid muscle and cricoarytenoid ankyloses may occur

Posterior subglottic stenosis.

A, Interarytenoid adhesion with a mucosally lined tract posteriorly.
B, Posterior commissure and interarytenoid scar without a mucosally lined tract posteriorly.
C, Posterior commissure scar extending into the right cricoarytenoid joint.
D, Posterior commissure scar extending into both cricoarytenoid joints.
Management of Laryngotracheal Stenosis
Principles

• Considerations in decision making:
  • endoscopic findings
  • patient age,
  • degree and consistency of stenosis (hard or soft and percentage of stenosis),
  • general condition of the patient

• Management of adults differs from that of children
  • (some operations useful in children are not applicable to adults)

• Secure the airway (most all cases of moderate to severe stenosis)
• Endoscopic procedures – Grade 1 and 2, soft stenosis, early stenosis
• Open procedures – Grade 3 and 4, mature scar, failed endoscopic
Endoscopic Management Principles

- Early stenosis, soft stenosis, mild stenosis Grade 1, 2
  - CO2 laser, balloon dilation, adjunct treatments; e.g. steroid injection, mitomycin application, nebulized steroids, systemic steroids

- Failure of endoscopic management related to:
  - Circumferential cicatricial scarring
  - Abundant scar tissue greater than 1 cm in vertical dimension
  - Fibrotic scar tissue in the interarytenoid area of the posterior commissure
  - Severe bacterial infection of the trachea after tracheotomy
  - Exposure of perichondrium or cartilage during CO$_2$ excision (predisposes to perichondritis and chondritis)
  - Combined laryngotracheal stenosis
  - Failure of previous endoscopic procedures
  - Significant loss of cartilaginous framework
Open Laryngotracheal Reconstruction
Principles

- Goal: improve airway, decannulate tracheostomy, minimize voice detriment, maximize speech development, reduce tracheostomy-related morbidity/mortality
- Consider open surgery: SGS grades 3 and 4, some grade 2
- Individualize treatment according to each patient
- Expansion surgery: a collection of techniques that aim to widen the glottic and subglottic lumen
  - use of laryngeal and cricoid splits, cartilage grafts, and stenting with high success rates of higher than 90%
- Preoperative considerations
  - Assess vocal fold mobility preoperatively
  - Assess neurological status and swallowing
  - Assess pulmonary status
Open Airway Expansion for LTS
Many variations on a theme (divide, expand and graft)

- **Anterior** cricoid split with or without graft (thyroid ala or auricular cartilage) (also termed “anterior laryngotracheal decompression”)
- **Anterior** laryngotracheal reconstruction with costal cartilage
- **Posterior** cricoid split with or without graft
- **Anterior** and **posterior** split and graft
- Endoscopic approaches
  - **Anterior** and **posterior** split (for vocal fold paralysis)
  - Endoscopic **posterior** cricoid split and graft

Anterior LTR graft

Anterior View of Larynx

Posterior View of Larynx

Posterior cricoid graft

Anterior LTR graft
Open Laryngotracheal Reconstruction
Management Considerations

- Surgical technique (anterior, posterior, anterior and posterior, resection)
- Single stage (no tracheostomy or remove existing tracheostomy) vs. double stage
  - ICU management risks during prolonged intubation
- Stenting
  - Duration: Needed to support cartilage grafts (anterior graft 3-4 days, posterior graft ~ 10-14 days)
  - Material, size, duration, location
- Postoperative management
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<th><strong>Single Stage LTR</strong></th>
<th><strong>Double Stage LTR</strong></th>
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<td><strong>Advantages</strong></td>
<td>Avoid tracheostomy or decannulate from tracheostomy (go home without tracheostomy)</td>
<td>No prolonged PICU stay&lt;br&gt;Shorter hospital stay&lt;br&gt;Safety of maintaining airway during postoperative recovery</td>
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<td>Single operation</td>
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<td><strong>Disadvantages</strong></td>
<td>Prolonged PICU stay – paralysis vs. sedation risks&lt;br&gt;Risks of long-term intubation</td>
<td>Second surgery for stent removal&lt;br&gt;Time for tracheostomy downsizing and capping until decannulation</td>
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<td>Accidental extubation&lt;br&gt;Graft dislodgement&lt;br&gt;Pulmonary infection, atelectasis</td>
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<td>Pharmacologic withdrawal from sedation&lt;br&gt;Prolonged hospitalization&lt;br&gt;After discharge: risks of re-stenosis, graft dislodgement, granulation until airway healed</td>
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Tracheal and Cricotracheal Resection (CTR)

- Consider in grade 4, some grade 3 stenosis
- More technically difficult
- Can be combined with posterior cricoid graft (extended CTR) if stenosis close to vocal folds
- Stent with ET tube, tracheal T-tube, suprastomal stent (double stage)
- Complications
  - Arytenoid prolapse
  - Dysphonia
  - Higher risk of failure with concomitant vocal fold paralysis
Suggested Readings


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