Subglottic Stenosis (SGS)

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Grand Rounds Presentation
November 13, 2002
Introduction

- SGS – congenital or acquired narrowing of the subglottic airway
Introduction

♦ 20th century most cases of SGS due infection
  – Syphilis, tuberculosis, typhoid, and diphtheria
  – Treated with tracheotomy
  – Unsuccessful attempts at dilation

♦ After 1960 sharp increase in incidence in neonates
  – Increased survival of low-birth-weight infants
  – 1965 McDonald and Stocks introduced long-term intubation in neonates requiring ventilatory support
  – 24% rate of mortality with tracheostomy
Introduction

- Subsequent development of laryngotracheal procedures for SGS developed for the neonatal patient
  - Mild laryngotracheal stenosis (LTS)
    - 1971 – Grahne describe the Rethi procedure
    - 1974 – Evans and Todd describe success with laryngotracheoplasty
      - Castellated incisions of the anterior cricoid and upper trachea with stenting
    - 1980 - Cotton and Seid describe the anterior cricoid split (ACS)
Introduction

– Severe LTS
  • 1972 – Fearon and Cotton use cartilage grafts to enlarge the subglottic lumen
    – Septal cartilage, auricular cartilage, costal cartilage, hyoid bone, and SCM flaps have been used
  • 1992 – 4 quadrant cartilage division

– Single-stage laryngotraceoaneploplasty reconstruction (SS-LTR)
  • Has developed over past 10 years
  • Allows for removal of the tracheostomy tube
Infant vs. adult larynx
- Boundaries of the supraglottis, glottis and subglottis are the same
- Larynx is 3X larger in adults
- Glottis is proportionately larger in infants
- Glottis is the narrowest portion of airway in adults
- Subglottis in infants
Anatomy

- Boundaries of the subglottis
  - Superior – inferior surface of the TVCs
  - Inferior – lower border of the cricoid
Definition of subglottic stenosis:

- Full term infant – lumen < 4.0 mm in diameter
- Premature infant – lumen < 3.5 mm in diameter
Embryology

- foramen cecum
- hypobranchial eminence
- laryngotracheal groove
- branchial arch
- epiglottal swelling
- primitive glottis
- arytenoid swellings
- terminal sulcus
- palatine tonsil
- root of tongue
- laryngeal cartilages
Etiology of SGS

♦ I. Congenial SGS
  – Membranous
  – Cartilagenous

♦ II. Acquired SGS
  – Intubation
  – Laryngeal trauma
  – Autoimmune
  – Infection
  – GER
  – Inflammatory diseases
  – Neoplasms
Congenital SGS

- SGS considered congenital if no history of previous intubation
- 5% of all cases of SGS
- 3rd most common congenital airway abnormality (after laryngomalacia and vocal cord paralysis)
- Failure of laryngeal lumen to recanalize
Congenital SGS

♦ Types

- Membranous
  - Fibrous connective tissue
  - Hyperplastic submucous glands
  - Granulation tissue

- Cartilaginous
  - Small cricoid
  - Elliptical cricoid
Congenital SGS
Acquired SGS

- 95% of cases of SGS
- 90% due to long-term or prior intubation
  - Duration of intubation
  - ETT size
  - Number of intubations
  - Traumatic intubations
  - Movement of the ETT
  - Infection
Acquired SGS

- Gastroesophageal reflux (GER)/Laryngopharyngeal reflux (LPR)
  - 1983 – Bain et al. – first to suggest GER as a cause of SGS
  - 1985 – Little – applied acid to subglottis of dogs
  - 1991 – Koufman – applied acid and pepsin to subglottis of dogs
GER/LPR and SGS

♦ 1991 – Koufman –
  – 73% of 32 patients with LTS had abnormal lower pH probe results
  – 67% had abnormal upper pH probe results

♦ 1998 – Walner (1998) – 74 pediatric patients with SGS had 3 times greater incidence of GER than the general pediatric population
GER/LPR and SGS

Currently no consensus on criteria for diagnosis of LPR by pH probe

– Location of pH sensor
– Interpretation of results
GER/LPR and SGS

- Cotton and O’Connor recommend GER workup in all pediatric patients with SGS
- Empiric treatment in all patients
  - Perioperative period
  - 3 months postop in asymptomatic patients
Pathogenesis of acquired SGS

- Initial injury – compression of mucosa by an ETT or cuff
- Ischemia
- Necrosis
- Decreased mucociliary flow
- Infection
- Three stages of wound healing
  - Inflammatory
  - Proliferative – granulation tissue
  - Scar formation – contraction and remodeling
Initial presentation

- Pediatric
  - If congenital and severe – airway distress at birth
  - Failed extubations in a neonate in the ICU
  - If mild congenital or acquired – recurrent croup-like illnesses and feeding difficulties
Initial presentation

- Adults
  - History of prior intubation and
  - Progressive SOB and loud breathing
Diagnosis

- History (pediatric)
  - H/o premature delivery
  - Birth wt.
  - Intubation
    - When, how many times, difficult or traumatic
    - Tolerance to extubation if intubated
  - Aspiration
  - Feeding
  - Growth curves
  - Pulmonary status (O2 requirements, h/o BPD)
  - Vocalization
Diagnosis

- **History (Adults)**
  - Review intubation records
  - Pmhx
    - Diabetes
    - Cardiopulmonary disease
    - Reflux
    - Systemic steroid use
Initial presentation

♦ Physical exam – Complete H/N exam
  – Observe
    • Stridor or labored breathing
    • Retractions
    • Breathing characteristics on exertion
    • Voice quality
  – Head
    • Other abnormalities (cleft lip/palate, retrognathia, choanal atresia)
  – Neck – tracheostomy
Diagnosis

♦ Differential
  – Congenital
    • Laryngomalacia
    • Tracheomalacia
    • VC paralysis
    • Cysts
    • Clefts
    • Vascular compression
    • Mass
Diagnosis

- **Differential**
  - Infection/Inflammation
    - Croup
    - GER
    - Tracheitis
  - Neoplastic
    - Subglottic hemangioma
    - Recurrent respiratory papillomas
  - Foreign body
Diagnosis

- Radiographs
  - Plain films – inspiratory and expiratory neck and chest
  - +/- airway fluoroscopy
  - Barium swallow
  - CT
  - MRI
Diagnosis

♦ Flexible nasopharyngolaryngoscopy
  – Nose/Nasopharynx
    • Pyriform aperture stenosis
    • Choanal atresia
  – Supraglottis
    • Structure abnormalitis
    • Laryngomalasia
  – Glottis
    • VC mobility
    • Clefts/webs/masses
  – Immediate subglottis
Diagnosis

- Gold standard for diagnosis of SGS
  - Rigid endoscopy
    - Properly equipped OR
    - Experienced anesthesiologist
    - Preop discussion about possible need for trach
Preoperative Evaluation

- **Rigid endoscopy**
  - Intubation – 3mm inner diameter ETT for a full term infant with a leak at 30 cm of H2O

- **Perform DL, B, and E**
  - Closely evaluate the interarytenoid area for stenosis or clefts
  - Evaluate position of cords

- **Determine size, extent, and location of the stenotic lesion**
  - Use an ETT or bronchoscope to measure the lumen
  - Measure from undersurface of the cord to the lesion
  - R/o other stenotic areas
Grading Systems for SGS

- Cotton-Myer (1994)
- McCaffrey (1992)
- Lano (1998)
Grading Systems for SGS

- Cotton-Myer
  - Based on relative reduction of subglottic cross-sectional area
  - Good for mature, firm, circumferential lesions
  - Does not take into account extension to other subsites or length of stenosis
- **Cotton-Myer grading system for subglottic stenosis**

<table>
<thead>
<tr>
<th>Classification</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>
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<tr>
<td>Grade III</td>
<td>71% Obstruction</td>
<td>99% Obstruction</td>
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<tr>
<td>Grade IV</td>
<td>No Detectable Lumen</td>
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Grade II SGS
Grade III SGS
Grade IV SGS
Grading Systems for SGS

- McCaffrey
  - Based on subsites (trachea, subglottis, glottis) involved and length of stenosis
  - Does not include lumen diameter
Grading Systems for SGS

- McCaffrey
Grading Systems for SGS

Lano

- Based on subsites involved
- Does not take into account length of stenosis or lumen diameter
  - Stage I – one subsite involved
  - Stage II – two subsites involved
  - Stage III – three subsites involved
- Lano showed correlation between this staging and likelihood for successful decannulation
Management of SGS

- Medical
- Observation
- Tracheostomy
- Airway expansion procedure
Management of SGS

◆ Medical
  – Diagnosis and treatment of GER
  – Pediatric – consultation with primary physician and specialists (pulmonary, GI, cardiology etc.)
  – Adult
    • Assess general medical status
    • Consultation with PCP and specialists
    • Optimize cardiac and pulmonary function
    • Control diabetes
    • Discontinue steroid use if possible before LTR
Management of SGS

- Observation
  - Reasonable in mild cases, esp. congenital SGS (Cotton-Myer grade I and mild grade II)
    - If no retractions, feeding difficulties, or episodes of croup requiring hospitalization
    - Follow growth curves
    - Repeat endoscopy q 3-6 mo
  - Adults – depends on symptoms
Management of SGS

Tracheostomy
- Often the initial step in treatment of pediatric acquired SGS
- May be avoided in patients with congenital SGS
- Allows time for the infant to mature
  - Lungs – BPD
  - Wt. – 10 kg (Cotton)
- 2%-5% mortality in children
  - Accidental decannulation and plugging
Cotton’s Stages of Reconstruction

- Stage 1 – complete evaluation of the airway
- Stage 2 – expansion of the subglottic lumen with preservation of function
- Stage 3 – stabilization of the expanded lumen framework (grafts and/or stents)
- Stage 4 – healing
- Stage 5 – decannulation
Surgery for SGS

♦ I. Endoscopic
  – Dilation
  – Laser

♦ II. Open procedure
  – Expansion procedure (with trach and stent or SS-LTR)
    • Laryngotracheoplasty
    • Laryngotracheal reconstruction
Management of SGS

How do you decide which procedure to perform

– Status of the patient
  • Any contraindications
    – Absolute
      • Tracheotomy dependent (aspiration, severe BPD)
      • Severe GER refractive to surgical and medical therapy
    – Relative
      • Diabetes
      • Steroid use
      • Cardiac, renal or pulmonary disease
Management of SGS

♦ Endoscopic
  – Dilation
    • Practiced frequently before advent of LTR
    • Requires multiple repeat procedures
    • Low success rate but an option for patients who cannot undergo LTR
Management of SGS

♦ Endoscopic
  - Laser
    • 66-80% success rate for Cotton-Myer grade I and II stenoses
    • Factors associated with failure
      – Previous attempts
      – Circumferential scarring
      – Loss of cartilage support
      – Exposure of cartilage
      – Arytenoid fixation
      – Combined laryngotracheal stenosis with vertical length >1cm
Laser excision of subglottic web
Laser excision of subglottic web
Cotton-Myer grade II subglottic web amenable to laser excision
Management of SGS

- Grade III and IV stenoses require an open procedure
Laryngotracheoplasty (LTP) without cartilage grafting

- Anterior Cricoid Split (ACS)
- Posterior Cricoid Split (PCS)
- Combined ACS and PCS
- Four quadrant cricoid cartilage division
ACS

Indication

- full term infants, congenital SGS
  - Ideal lesion is mild, anterior, fibrotic with normal cricoid
  - Subglottic cysts
ACS

 Criteria

− ≥ 2 failed extubations secondary to subglottic pathology
− Wt. > 1500g
− ≥ 10 days off ventilator support
− < 30% supplemental O2 requirement
− No CHF > 1 mo
− No acute respiratory tract infection
− No antihypertensive meds ≥ 10 days
Anterior Cricoid Split
PCS

- Indications
  - Posterior stenosis
  - Posterior stenosis with posterior glottic component
  - Glottic obstruction due to vocal fold fixation
Posterior cricoid split
Four-Quadrant Cricoid Cartilage Division

♦ Indications:
  – Severe subglottic stenosis (Cotton-Myer grade III and IV) with glottic extension
  – Previously failed LTP with or without grafting

♦ Success
  – 76% overall decannulation in 31 patients reviewed (Cotton, 1992)
    • 35% with glottic involvement
    • 19 patients had previous LTP procedures
    • All patients had prolonged stenting (avg 6.6 mos.)
Four-Quadrant Cricoid Cartilage Division
LTP without grafting

- Indications for no grafting
  - Brittle diabetics
  - Multiple previously failed grafts

- Requires long-term stenting
  - Up to 6 months
LTP with grafting

- Placement depends on location of stenosis
- May be done with
  - Tracheostomy and formal stenting or
  - With an ETT – (i.e SS-LTP)
LTP with grafting

♦ Grafts

- Cartilage
  - Cartilage has less resorption than bone
  - Costal cartilage, auricular, septal, thyroid

- Bone
  - Good structural support
  - Hyoid
Anterior Grafting

- **Indications**
  - Anterior SGS
  - Anterior collapse

- **Graft**
  - Elliptical
  - Larger and thicker than posterior grafts
  - Large external flange
  - Perichondrium faces luminal surface
  - Knots are external
  - Vicryl suture
Posterior grafting

- Indications
  - Posterior SGS
  - Glottic extension

- Try to avoid complete laryngofissure

- Graft
  - Elliptical
  - Thinner than anterior graft
  - Width
    - .05 to 1.00 mm/yr of age
      up to 1 cm (Cotton, 1999)
LTP with grafting

♦ Stents
  – ETT
  – Silastic sheet rolls
  – Montgomery T-tubes
  – Laryngeal stents
    • Teflon stents (Aboulker – long or short)
    • Silastic stents (Montgomery)
Aboulker stent
Long Aboulker Stent with wired-in tracheostomy tube
Short Aboulker Stent
Radiograph of Aboulker Stent placement
Silastic Sheeting used for laryngeal stenting
Placement of silastic sheeting for laryngeal stenting after LTR
Montgomery T-tube
Montgomery T-tube
Placement of Montgomery T-tube

A

B
Cricotracheal Resection (CTR)
CTR

- 1953 – Conley
  • first successful CTR
- 1964 – Ogura and Powers
  • Used for successful treatment of traumatic SGS
- 1970s – technique of choice for acquired SGS in adults
- 1978 – Savary
  • First CTR in a child
- 1993 – Monnier
  • First pediatric series
    - 15 cases for LTS
CTR – Use for high grade SGS
Exposure for LTR
CTR – Line of resection in relation to recurrent laryngeal nerve.
Elevation of perichondrium from anterior cricoid arch to avoid recurrent laryngeal nerve injury
CTR – anterior cricoid arch excised
CTR – removal of soft tissue of posterior cricoid plate
CTR – optional partial laryngofissure for increased luminal diameter
CTR – dissection of party wall
Completed CTR
CTR – Complete larngeofissure for repair of glottic stenosis
CTR – tracheal mucosal flap for reconstruction of posterior glottis
CTR – completed reconstruction with stay sutures
CTR – relation of stay sutures with the recurrent laryngeal nerve
Completed CTR with end to end reanastamosis
Optional PCS in combination with CTR for posterior glottic stenosis
Outcomes (CTR)

- Complications
  - Restenosis
  - Aspiration
  - Arytenoid prolapse
  - Recurrent laryngeal nerve injury
Postoperative Care

- Intensive care unit
- Intensivist familiar with these cases
- Patients with trach and stent
  - Abx
  - Antireflux
  - Trach care teaching
  - Often discharged in several days
  - Repeat endoscopy q 3-4 weeks for stent evaluation
  - Stent duration
    - Depends on purpose
      - Hold graft in place – as little as one weeks
      - Counteract scar formation – months to a year
Postoperative Care

♦ ACS or SS-LTP
  – More intense care
  – Intubated 7-14 days with ETT as stent
  – Broad spectrum abx
  – Antireflux
  – Chest physiotherapy and log rolling
  – May need paralysis
  – Extubate when audible air leak at 20 cm H20
  – Decadron 1mg/kg 12hrs prior to extubation and 5 days postextubation
Complications

- Atelectasis
- Pneumonia
- Malpositioned ETT
- Wound infection
- Granulation tissue
- Restenosis
- Tracheocutaneous fistula
Outcomes

- **Measure of success**
  - Decannulation
  - Vocal preservation
  - Unlimited activity
Outcomes (pediatrics)

- Cotton reports overall success rate of 92%
  - Grade II - 97%
  - Grade III - 91%
  - Grade IV - 72%

- Bailey (1988) – 131 LTR
  - 92% success with LTP w/o cartilage grafting
  - 80% success with grafting
Outcomes (Adults)

* Lano (1998) – 41 cases
  - Overall 80% decannulated
  - Used all three grading systems
    - Surgical outcome correlated with Lano and McCaffrey system
    - 94%, 78%, and 20% success with Lano stage I, II, and III respectively
    - Best predictor Cotton-Myer grade X Lano stage
Outcomes (Adults)

♦ Lano (1998)
  - First to report on outcomes in patients with DM
    - 9 patients
    - 75% failure rate
      - Most common cause – restenosis
      - One dehiscence required a T-tube
    - Impaired wound healing
      - Decreased microvascular blood flow
      - Increased bacterial load
Outcomes (CTR)

- 1999 – Monnier
  - 69 CTR performed (48 children, 21 adults)
  - All Cotton-Myer grade III and IV
  - Adults 100% decannulation
  - Children 95% decannulation

- 1999 - Stern and Cotton
  - 38 pediatric CTRs
  - All Cotton-Myer grade III and IV
  - 33 patients decannulated

- Overall success rate in the literature is 94% (Monnier, 1999)
Outcomes (CTR)

- 1992 – Grillo
  - 80 CTRs in adults
  - 97% successful decannulation
    - 22.5% normal voice and no symptoms with exertion
    - 60% mild voice changes and no exertional Sxs
    - 10% hoarse voice and slight wheeze or SOB with exertion
Prevention

- ETT – most common cause of SGS
  - Choose appropriate sized ETT
    - Should allow air leak at 20 cm H2O
  - Secure the tube to prevent movement
  - Reduce patient movement if possible
  - Monitor cuff pressure
  - Avoid blind intubations
  - Avoid accidental extubations
  - Avoid multiple reintubations
  - Minimize duration of intubation
  - Intravenous anti-reflux medications
Prevention

- Decline in the incidence of SGS in neonates in past 30 years
  - 1960s upwards of 22% in intubated neonates
  - 1971-1979 – 0.9%-8.3%
  - 1980-1989 – 0.0%-4.2%
  - 1990-1999 – 0.0%-0.63%
Prevention

- Education
- Increasing awareness of contributing factors
- Routine use of steroids
- Increased use of CPAP
Case

- 50 y/o woman referred for shortness of breath and history of subglottic stenosis
HPI

- Intubated twice
  - Last intubation 8 years ago for hysterectomy
- Developed SGS one year later
- 8 laser and dilation procedures since then at an outside hospital
- **Pmhx - diabetes**
- **PE**
  - Head and Neck normal
  - Flexible laryngoscopy
    - Mobile TVC
    - Thin circumferential scar web at immediate subglottis
Rigid Endoscopy
Case 1
CTR for Case 1 - Exposure
CTR for Case 1 - revealing SGS and tracheal rings to be excised
External exposure of SGS
Perichondrium removed from anterior cricoid plate
Anterior cricoid plate removed
Soft tissue removed from posterior cricoid plate
Placement of stay sutures for reanastomosis and to test tension
Suprahyoid release
Closure of completed CTR with reanastamosis