Pediatric Otolaryngology for Anesthetists
followed by the delightful
Airway Disorders in Infants and Children

Andrew M. Shapiro, MD
Private Practice, Pediatric Otolaryngology
Clinical Associate Professor of Surgery
Pennsylvania State University College of Medicine
What does a pediatric otolaryngologist do?

- Inflammatory, congenital and neoplastic disorders involving the head and neck
  - Simple surgeries in fairly healthy kids
  - Big surgeries in fairly healthy kids
  - Simple surgeries in sick kids
  - Big surgeries in sick kids

- Ear surgery
- Nasal and sinus surgery
- Airway surgery
- Pharyngeal surgery
- Craniofacial surgery
- Tumors and congenital anomalies of the head and neck
**Organization**

- Emphasize that there are distinct qualities required when caring for children
- Understand the anesthetic implications of otolaryngologic surgery
- Understand special situations and patient circumstances
- Review significant ENT airway conditions
Characteristics of pediatric anesthesia

- Laryngospasm, bronchospasm, concurrent illnesses

Physiologic differences

- Higher metabolic rate
  - ↑ O2 requirement
  - Temperature management
- ↓ Chest wall compliance
  - High closing volumes

Evolving psychological status must be appreciated from neonates to adolescents

Dental
Characteristics of Pediatric Otolaryngology Patients

- "Healthy" PedENT patients are often "sick" on the day of surgery
  - Congestion, runny nose, cough
  - "a case cancelled is not a case done"

- "Sick PedENT patients tend to have chronic lung disease from prematurity, aspiration, cystic fibrosis, or reactive airway disease"
Points of convergence

The surgeon and the anesthetist are a TEAM (and I’m not just saying that!)

Maintain good surgical access while preserving the ability to sustain ventilation (or vice versa)
Otologic Cases

- Myringotomy and tube insertions
  - Most common procedure under GA
  - Mask anesthetic
    - Older children may benefit from IV/LMA
    - Premed? Narcotic?

- Tympanoplasty/tympanomastoidectomy
  - No muscle relaxant during procedure
  - No nitrous oxide
  - Secure tubes and IV’s; lots of “turning” during case
Nasal and Paranasal sinus surgery

- Expect secretions and blood
- Expect a generous helping of vasoconstrictors
  - Control blood pressure
- Expect a “touchy airway”
Anatomic Classification

Supraglottic
- Nose
  - Choanal atresia
  - NOWCA
- Craniofacial Dysmorphology
  - Pierre Robin Syndrome
  - Treacher collins
  - Aperts
  - Crouzons
  - Moebius
- Macroglossia
  - Beckwith Wiedemann Syndrome
  - Down’s Syndrome
- Tumors
  - Hemangioma
  - Neuroblastoma
- Laryngomalacia

Glottic
- Vocal cord paralysis
- Tumors and cysts
  - Laryngoceles
  - Papillomatosis
  - Cystic hygroma
  - Laryngoceles

Subglottic
- Atresia
- Webs

- Stenosis
- Webs
- Atresia
- Tumors
  - Hemangioma
  - Cystic Hygroma
  - Cysts

Trachea
- Tracheomalacia
- Stenosis
- Cyst
- Atresia

Extrinsic
- Goiter
- Vascular Ring
- Hemangioma
- Cystic hygroma
- Teratoma
- Mediastinal masses
Introduction

The Pediatric Airway

Anatomy

Nasal/Pharyngeal
- Obligate Nosebreathing

Laryngeal
- Supraglottis
- Glottis
- Subglottis
  - Cricoid

Upper trachea

Figure 26: Pediatric Airway
Anatomy of pediatric airway

SUSAN GILBERT
The Nose and Pharynx

- Anatomy
  - Nasal Cavities
  - Pharynx
    - Nasopharynx
    - Oropharynx
    - Hypopharynx
Obligate Nosebreathing
Obstruction at the Pharyngeal Level

- Stertor (vs. stridor)
- Often worst when asleep
- Often improved by positioning
  - Neck extension, sniffing position
Tonsils and adenoids

- Chronic tonsillitis
- Tonsillar hyperplasia
  - OSA 2% incidence. 10% SDB
  - Peaks 2-5 years old
  - Second peak in adolescence
  - Medical treatment
    - Weight loss
    - Management of infection
  - CPAP
  - Surgical therapy
    - T/A, UPPP
    - Highly effective in “normal” children
T & A: techniques

**Tonsillectomy**
- "Cold"
  - Guillotine
  - Dissection and snare
  - Microdebrider
- "Hot"
  - Cautery
  - Bipolar cautery
  - Laser
  - Coblation

**Adenoidectomy**
- Curette
- Cautery
- Microdebrider

**Adjunctive measures**
- Steroids
- Local Anesthetics
- Analgesics
- Antibiotics
- Antiemetics
Higher risk tonsillectomy

- Age < 3 years
- Documented profound OSA
- Neuromuscular disorders
- Chromosomal anomalies
- Craniofacial/airway disorders
- Recent upper respiratory infection
- Bleeding disorder
- Active infection or peritonsillar abscess
- Severe obesity
Upper airway obstruction in neurologically impaired children

- Hypotonia reduces predictability of T&A
  - Reasonable approach if significant adenotonsillar hypertrophy is present
  - UPPP? Kershner et al Int J Ped Oto 2002
- Tracheotomy vs. salivary diversion, laryngeal diversion, supraglottoplasty, midfacial and maxillary advancements
- BiPAP/CPAP
- Increased perioperative morbidity
- Individualized treatment - no reasonable studies to clearly delineate best treatment options
Postoperative problems can be minimized by anesthetic techniques

- Apnea
- Laryngospasm
- Postobstructive pulmonary edema
- Bleeding

- Judicious narcotics
  - Local anesthetic
- Steroids/Antiemetics
- Propofol
- Timing of extubation
- Immediate gentle positive pressure
Now, the real reason I’m here...
Introduction

The Pediatric Airway

Anatomy

- Nasal/Pharyngeal
  - Obligate Nosebreathing
- Laryngeal
  - Supraglottis
  - Glottis
  - Subglottis
    - Cricoid
- Upper trachea
Stridor

Definition
- Distinguish from stertor

Causes
- Laryngomalacia
- Vocal cord paralysis
- Subglottis stenosis
Cross Sectional Airway Diameter

Adult
1mm edema = 81% of normal area

20mm

Term Newborn
1mm edema = 44% of normal area

5mm
Clinical presentation

- Failed extubation attempts in NICU
- Stridor
- Recurrent croup
- Progressive respiratory failure with stridor
- Feeding difficulties
- Failure to thrive
- Persistent cough
- Tracheotomy
Evaluation

- **History**
  - Details of extubation attempts
  - Presence, absence, and characteristics of stridor
    - Onset/Progression
    - Impact of position
  - Nature of cry
  - Feeding abnormalities
  - Prior airway interventions
  - Cardiopulmonary status
  - Term or premature
  - Apgar
  - Birth weight/weight gain
  - Other medical problems

- **Physical examination**
- **Imaging**
- **Endoscopy**
Evaluation

- **History**
- **Physical examination**
  - Complete head and neck examination
    - Craniofacial disorders, retrognathia, nasal obstruction, laryngomalacia, vocal cord paralysis
  - Body Habitus
  - Degree of dyspnea
  - Quality of stridor
    - Changes with position, activity
  - Cry/Voice
  - Auscultation of chest
- **Imaging**
- **Endoscopy**
Evaluation

- History
- Physical examination

Imaging

- Hi KV AP and Lateral plain films
- Airway fluoroscopy/Barium Swallow
- MRI in patients with suspected vascular/mediastinal pathology
- Endoscopy
Evaluation

- History
- Physical examination
- Imaging

Endoscopy

- **Flexible**
  - Need for sedation and inability to control airway and ventilation
  - Useful for proximal airway evaluation at bedside or as outpatient
  - Distal airway evaluation in intubated patients

- **Rigid**
  - Spontaneous ventilation
  - Microlaryngoscopy
    - Webs, glottic scarring, interarytenoid adhesions, fixation or paralysis
  - Subglottis
    - Size, maturity, length, stomal site
  - Remainder of tracheobronchial tree
  - Sizing of airway
Airway Endoscopy - Stages

1. Preparation and Communication
   a) Equipment
   b) Monitoring

2. Induction

3. Diagnostic Laryngoscopy and topical anesthetic

4. Diagnostic Suspension laryngoscopy
   • Controlled airway for microscopy or bronchoscopy
   and Diagnostic Bronchoscopy

5. Therapeutic intervention
Anesthesia for airway endoscopy

- Clear communication essential
- Avoid jet in young children

Techniques
- Apneic technique
- Spontaneous ventilation in young children
  - Topical anesthetic?
- In older children (5-10 years) relaxant with controlled ventilation

**NEVER ABOLISH SPONTANEOUS RESPIRATION UNLESS AN ALTERNATIVE AIRWAY IS ASSURED**
Anesthesia for Laser Endoscopy

- Assure patient and staff protection
  - Have a fire “plan of action”

- Minimize FiO2

- Avoid adding fuel to the fire when possible
  - Endotracheal tubes/packs

- Apneic ventilation
  - Relaxant extends working time, accuracy
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    - Hemangioma
    - Cystic Hygroma
    - Cysts
  - Trachea
    - Tracheomalacia
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    - Cyst
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  - Extrinsic
    - Goiter
    - Vascular Ring
    - Hemangioma
    - Cystic hygroma
    - Teratoma
    - Mediastinal masses
Nasal Disorders

Choanal Atresia

- Obstruction in posterior nasal cavity
- 90% bony, 10% membraneous
- Bilateral in 40%; other congenital anomalies in 50%
- Failure to pass #6 catheter
- Unilateral- observe
- Bilateral
  - Oral airway; gavage; repair; tracheostomy
Nasal Disorders

- Pyriform Aperture Stenosis
- Hairy polyp
- Encephalocele/Glioma
Craniofacial disorders

Pierre Robin Syndrome

- Micrognathia, cleft palate, glossoptosis
- Respiratory distress worst with feeding
- Nasopharyngeal airway
- Improvement with mandibular growth
  - Distraction osteogenesis
Craniofacial Disorders

Treacher Collins Syndrome

- Autosomal Dominant
- Findings
  - Antimongoloid slant
  - Lower lid coloboma
  - Auricular malformation
  - Malar/mandibular hypoplasia
Craniofacial Disorders

Crouzon’s Syndrome

- Midfacial hypoplasia
- Glossoptosis, posterior
  pharyngeal compromise
Break time!
Laryngeal Disorders
Laryngomalacia

- Most common cause of stridor in neonate
- Etiology: collapse of supraglottic structures into airway lumen, creating turbulent flow and obstruction
- Idiopathic—Anatomy vs. innervation
- GERD relationship (suck swallow dyscoordination)
- Coarse, non musical inspiratory stridor during first few weeks of life
  - Accentuated by supine position, feeding
  - Cry is normal
- Evaluation: Flexible laryngoscopy, airway fluoroscopy, BS
- Treatment
  - Spontaneous resolution by 2 years in vast majority of patients
  - Epiglottoplasty
  - Tracheostomy
Vocal Cord Paralysis

2nd most common cause of congenital stridor

Bilateral
- **Etiology**
  - Idiopathic, CNS lesions, birth trauma
- **Presentation**
  - Progressive stridor, voice may be normal
  - High risk for aspiration

Unilateral
- **Etiology**
  - Mediastinal anomalies, idiopathic (heart, TEF surgery), trauma
- **Presentation**
  - Hoarse cry, feeding difficulties, aspiration

Evaluation
- Endoscopy
- Imaging
  - MR or CT of Brain, Neck and Mediastinum
- Laryngeal EMG

Management
- Tracheotomy: spontaneous recovery in >50% within 2 years
- Vocal cord lateralization: arytenoidectomy vs. transverse cordotomy
Congenital laryngeal webs

- Incomplete recanalization of laryngotracheal anlage
- Sx: Mild dysphonia to airway obstruction
  - 1/3 have associated anomalies, most often subglottic stenosis
  - Chromosome 22q11.2 deletion (VCFS)
- Rx: Observation-> surgery-> tracheotomy

Laryngeal Atresia
- Acute airway obstruction
- TE fistula may allow some ventilation
- Tracheostomy is lifesaving
- Polyhydramnios may provide a clue, allow for preoperative preparation
Laryngeal Cyst

- Congenital saccular cyst
  - 25% of laryngeal cysts
  - Obstruction of saccule with accumulation of mucus
- Valleeicular cyst
- Subglottic cyst
Subglottic hemangioma

1.5% of congenital airway anomalies
- Female 2:1 Male. ½ with cutaneous hemangioma
- Usually asymptomatic at birth, rapid growth after 2 months through 12 months
- Symptoms mimic recurrent croup

Treatment options
- Observation, tracheostomy, steroids (systemic and local), interferon, surgical excision
Recurrent Respiratory Papillomatosis

- HPV 6,11
- Entire respiratory tract
- Infancy through adult
- No cure
- Surgical therapy, medical adjunct
- Vaccine holds promise
Subglottic stenosis

- **Congenital**
  - Rare
  - Incomplete recanalization
  - More mild
    - Elliptical cricoid

- **Acquired**
  - Most common
  - 1-8% of intubated neonates
  - Other causes
    - Trauma
    - Burns
    - Neoplasms
    - Infection
    - Collagen vascular disorders
Pathogenesis of acquired subglottic stenosis

- Intubation
- Pressure injury
- Mucosal edema
- Ulceration
- Perichondrial injury
- Cartilage necrosis
- Fibroblasts & Granulation tissue
- Circumferential scarring
Subglottic Stenosis – the recipe

- Congenital subglottic stenosis
- GERD
- Infection
- Nasogastric tube
- ETT size and properties
- Movement of ETT
- Reintubations
- Duration?
## Staging

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<tr>
<td>Grade I</td>
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<td>71%</td>
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<tr>
<td>Grade IV</td>
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Evaluation:

GER/GERD, GLPR/GLPRD

- GER is common in children with subglottic stenosis and usually asymptomatic.
- GER/GLPR likely exacerbates SGS and compromises repair.
- No gold standard to differentiate GER and GERD.
- Dual pH probe:
  - 50% of candidates have upper probe pH<4 more than 1% of the time.
  - Majority had no symptoms.
Evaluation: Swallowing Dysfunction

- Increased risk of aspiration postoperatively
- Rely on history
  - Videofluoroscopic examination
    - Limited in patients with food aversion or congenital aerodigestive anomalies
  - FEES
Management

- Observation
- Tracheostomy
- Endoscopic techniques
- Cricoid split
- Augmentation Laryngoplasty
- Partial cricotracheal resection
Observation

- Non tracheotomized Grade I or mild grade II
  - Occasional symptoms – infrequent hospitalizations
  - No retractions
  - No feeding difficulties

- Tracheotomized patients
  - Reactive larynx
  - Age/weight/pulmonary status/neurologic disease/aspiration potential/craniofacial or systemic abnormalities
Endoscopic Management

- Mild SGS
  - May be required following open repair techniques

- Techniques
  - Dilation
  - CO2 laser
    - wedge resections
Tracheotomy

- Temporizing measure
  - Allows for growth prior to definitive procedure
  - Time for improvement of BPD
- Facilitates discharge
- Gold Standard?
  - Mortality rate varies with degree of obstruction above stoma
  - Impairment of speech and language skills
  - Nursing/childcare issues
History of airway reconstruction

- **1930’s**
  - Chevalier Jackson recognizes that many children with laryngeal stenosis do not outgrow their obstruction – permanent tracheotomy was treatment of choice

- **1960’s**
  - McDonald and Stocks: long term intubation for the management of prolonged ventilatory support in newborns
  - Greater survival potential of premature newborns
  - Shift of subglottic stenosis from older children and adults to premature infants
History of airway reconstruction

- Increased incidence of subglottic stenosis recognized
- Treatment consisted of repeated dilations
  - Dogma was “never divide the larynx” to avoid growth disturbance
- 1956 Rethi: Expansion of larynx and trachea with long term stent
- 1970’s Fearon and Cotton: Pedicled thyroid cartilage grafts
- 1980’s Free cartilage grafts allow for posterior and anterior grafting
- 1993 First series of successful cricotracheal resections reported
Cricoid Split

- **Overview**

- **Indications**
  - Acquired subglottic stenosis in neonate (>1500g) without significant coincidental airway or pulmonary disease
  - <$30\%$FiO2, <$35$mm Pressure, no vent support

- **Surgical technique**

- **Outcome**

- **Complications**
Augmentation Laryngotracheoplasty

- Overview
- Indications
- Surgical technique
  - Single stage vs. 2 stage
  - Source of donor cartilage
  - Autologous materials
- Outcome
- Complications
Single Stage LTR

- Uses cartilage grafts for expansion and a short phase of stenting with ETT
- Stoma is grafted and closed
- Postoperatively
  - 0-14 days of intubation in ICU
  - +/- Paralysis and sedation
  - Bronchoscopy and downsize prior to extubation
Results

- >90% success rates in most series
- Success is dependent upon degree of stenosis
- <50% in severe grade III and IV stenosis
Partial Cricotracheal resection

- Overview
- Indications
- Surgical technique
- Outcome
  - Complications
Adjunctive measures

- **Stenting**
  - Useful for areas of stenosis beyond subglottis (posterior glottic stenosis)
  - Result in addition granulation tissue and scarring,

- **Mitomycin C**
  - Antineoplastic antibiotic inhibits fibroblast formation

- **Fibrin glue**
  - Holds mucosal flaps, produces an airtight seal
Postoperative care

- **PICU**
- **Intubation for 0 – 14 days for single stage**
  - Sedation – minimal paralysis
  - Bronchoscopy/downsizing/extubation
Complications of Airway Reconstruction

- **Intraoperative**
  - Hypoxia
  - Pneumothorax
  - Pneumomediastinum
  - Vocal cord paralysis

- **Early Postoperative**
  - SQ emphysema
  - Seroma
  - Hematoma
  - Single Stage
    - ETT obstruction
    - Unplanned extubation
    - Narcotic withdrawal
    - Pulmonary problems
    - Nasal alar ulceration
    - Failed extubation

- **Intermediate postoperative**
  - Granulations
  - Restenosis
  - Graft displacement
  - Graft resorption
  - Chonditis
  - Suprastomal/posterior glottic stenosis

- **Late Postoperative**
  - Voice problems
  - Epiglottic/arytenoid collapse
  - Web
  - Tracheocutaneous fistula
Tracheal Anomalies

Tracheomalacia

- Abnormal flaccidity of trachea leading to collapse on expiration
  - Collapse of greater than 20% on endoscopy (spontaneous ventilation)
  - Primary vs secondary
    - MRI
  - Rarely occurs with laryngomalacia

Rx:
- Mild - typically improves within 1-2 years
- Reflux therapy
- Severe - tracheostomy with PPV
- Surgical correction varying success
  - Stent placement (internal or external)
  - Segmental resection
  - Cartilage grafting
Tracheal Disorders

Tracheal Stenosis

- Congenital vs. acquired
- Symptoms depend upon severity and length
- Complete tracheal rings
- Biphasic or expiratory stridor, wheezing, failure to thrive, bronchiolitis, cough, recurrent croup
- Very gentle endoscopy!
- Rx:
  - Conservative for mild cases; resolution with growth
  - Severe cases: segmental resection vs. anterior split with perichondrial grafting vs slide tracheoplasty or homograft tracheal transplantation
  - Complications: granulation tissue at anastamotic site
Tracheal Disorders

Vascular Compression

- 3% of population with anomalies of great vessels
  - Rarely result in airway obstruction
- Rings vs slings
- Double aortic arch most common ring
- Innominate artery most common sling
- Right aortic arch with aberrant left subclavian
- Barium swallow and MR are essential
Conclusions

- Diagnosis of airway disorders in the neonate requires a comprehensive and systematic approach.
- Stridor is not a diagnosis, but a symptom: the characteristics will help localize the source.
- Twenty five years ago – *once a trach, always a trach*.
  - Now, almost all tracheotomy dependent children with airway obstruction can eventually be decannulated.
- Important to have a *bag of tricks*, as different approach works in different patients.
- List of options for restoration of the pediatric airway continues to expand.