




## Endoscopic Management of the Pediatric Airway



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Pediatric Otolaryngology  
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## Disclosure Information

- Scientific advisory board:
  - Acclarent Medical
    - Airway balloon dilator
- Royalties
  - Gyrus / Olympus
    - Tonsillectomy tool
  - Boston Medical Products
    - Suprastomal stent
- Consultant (no financial relationship)
  - Hood Laboratories
    - Tracheotomy tube
  - Bryan Medical
    - Speaking valve, tracheotomy tube
  - Storz
    - Esophagoscopy tool
- And I also use many products off-label!



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## 2011 - Trends

- Evolution, both of operative techniques, and the patients themselves
- Collaboration
- Pre-operative evaluation and optimization
- New tools
- Endoscopic techniques compliment open reconstructive techniques



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### Topics

- Airway balloon dilation
  - Including complimentary interventions
- Endoluminal stent placement
- Suprastomal stent placement
- Supraglottoplasty
- Laryngeal keel placement
- Laryngeal cleft repair
- Tracheal pouch management
- TEF repair

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### We Will Not Cover

- Vocal cord lateralization
- Laryngeal cysts
- Papilloma
- Laser arytenoidectomy / cordotomy
- Subglottic hemangioma
- Posterior graft LTR

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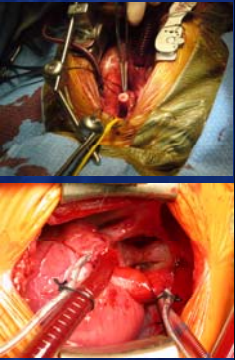
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### Context

- I enjoy open airway surgery
  - In 2010:
    - LTRs 28
    - CTRs 6
    - Clefts 4
    - Slides 20
- But increasingly I am turning to endoscopic surgery to either replace or compliment open reconstruction



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### Airway Balloon Dilation

- This is not new
  - Resurgence of interest
- High pressure balloon dilation
  - Primary intervention
  - Complimentary procedure
  - Adjunctive procedure



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### Laryngeal and Tracheal Balloon Dilation

- Airway dilation is a potentially useful adjunctive method of managing stenosis
  - Endotracheal tubes, cat tail dilators, etc
- Balloon dilation offers advantages compared to traditional dilation approaches
  - Only radial force applied, no shear forces
  - More effective diameter of dilation
  - Low risk



MEET MY NEW HAMMER!

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### Current Experience

- Since 2001, over 1500 balloon dilations performed
  - 1 complication
  - Even my more cynical colleagues are converting!
- As with standard dilation techniques, not effective for everything



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### Equipment

- Blue Max 20 angioplasty or Acclarent Inspira Air balloon dilators
- Rated burst pressures range from 20 atmospheres (5 - 9mm balloons) to 8 atmospheres (12 - 16mm balloons)
- A balloon pump inflates the device
  - 20 Atmospheres = 300lbs / square inch



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### Technique

- Endoscopically guided balloon placement
  - Usually direct placement into the trachea
  - Occasionally through the suction port of a ventilating bronchoscope or tracheoscope
- Patient is pre-oxygenated, then Propofol bolus
- Balloon is inflated to rated burst pressure
  - Pressure is maintained for either 2 minutes, or until the oxygen saturation drops to 90%
- Balloon is then deflated and removed



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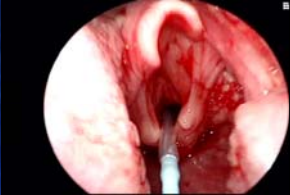
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### Guidelines

- Formula:
  - Take the outer diameter of an age appropriate endotracheal tube
  - Add 1mm for laryngeal dilation
  - Add 2mm for tracheal dilation

*Example: A 4 year old child should take a 5.0 ETT, with an outer diameter of 6.8mm, therefore I would choose a 8mm balloon to dilate the larynx, and a 9mm balloon to dilate the trachea*



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### Primary Intervention

- A/P graft LTP
- Post-op restenosis
- Balloon dilation



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**Primary Intervention - Tracheal Stenosis**

- 12 year old boy with an endotracheal cuff injury following prolonged intubation after a car accident
- Tracheal resection – lost to follow-up
- Returns at 6 months with stridor
- 3.5 ETT airway



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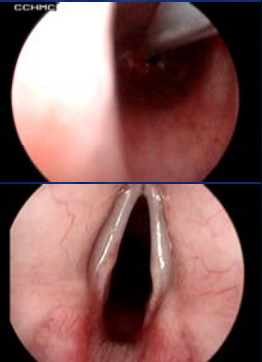
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**Tracheal Stenosis**

- Dilation with 10mm balloon at 17 atmospheres
- 4 dilations at 1-2 week intervals
- Now 4 year follow-up



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**Complimentary Procedure**

- Stabilize airway prior to definitive intervention



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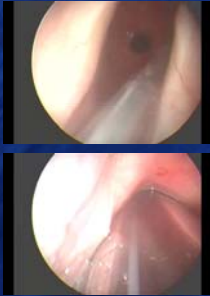
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### Complimentary Procedure

- Subglottic dilation prior to CTR
- 2.5 ETT airway in a 56 yr old woman with no tracheotomy
- Dilated with 10mm balloon at 17 atmospheres for 3 minutes
- Asymptomatic for 22 months



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### Complimentary Procedure 6 Week Old Girl

- Transferred with stridor
- Term delivery
- Apnea at home at 2 weeks – intubated by the ambulance crew, transferred to local hospital. 4.5ETT
- Extubated 3 days later
- Home day 7
- Increasing stridor



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### 6 Week Old Girl

- Balloon dilation with a 5mm balloon at 20 atmospheres for 30 seconds
- Now leaking around a 3.0 ETT
- 5 days later “elective” LTR
- Today I would have tried to avoid the LTR!



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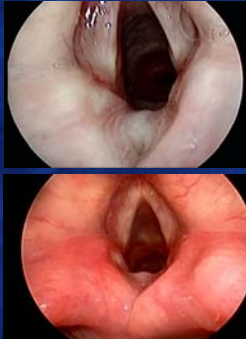
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### Complimentary Procedure

- Tracheal dilation prior to slide tracheoplasty
  - Intubation injury with 70% of trachea length stenosed
  - Serial balloon dilation, nebulized ciprodex, temporary stent
  - Stenosis stabilized to 40% of tracheal length
  - Transcervical slide tracheoplasty



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### Acquired SGS - Concentric

- If thick fixed scar, open airway surgery usually indicated
- If “soft and fresh”, or a thin “web” of scar, then endoscopic intervention may be an option
  - If severe, then adjunctive procedures may be required

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### Outcomes

- Dilations at 7-10 day intervals x 3 - 4
  - After second dilation consider mitomycin C, and increased balloon size
- If 5 or more dilations required, dilation alone was inadequate at providing a stent or tracheotomy free airway

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 **Complications**

- Anesthetic circuit (jet) mediated oxygen extravasation
- Pulling balloon so hard lumen blocks (can't deflate)
- Negative pressure pulmonary edema
- Airway rupture

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 **The Complication**

- 1500 balloon dilations
  - 1 complication
    - 4 month old boy with complete tracheal rings, PA sling and right bronchial stenosis
    - Distal tracheal re-stenosis following slide tracheoplasty
    - On 3rd balloon dilation balloon slipped into right mainstem



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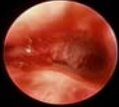

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 **The Complication**

- Third dilation – balloon enters right mainstem bronchus
- Bronchial rupture – no symptoms, not intubated, spontaneously healed
- Resolution of right bronchial stenosis
  - Not a recommended technique
- Tracheal stenosis recurred
- Complete resolution after tracheal resection – now asymptomatic



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### Advantages / Disadvantages

- Advantages
  - Radial dilation - no shear forces
  - Precise high pressure dilation
- Disadvantages
  - Cost
  - Balloon "slips" easily



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### Adjunctive Procedures

- Surgical (sharp blade or laser)
  - Posterior cordotomy
  - Endoscopic scar lysis
  - Endoscopic cricoid split
  - Endoscopic suprastomal stent placement
- Medical
  - Mitomycin C
  - Topical or nebulized Ciprodex use



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### Adjunctive Procedure - Acquired SGS

- Thin webs are amenable to endoscopic intervention
  - Balloon dilation
  - Scar division and serial balloon dilation

7 year old ex-24 week preemie, stridor, exercise intolerance, 3.5ETT no leak  
→ Sickle knife, steroid injection, 9mm balloon



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### 7 Year Old Girl

- 4.5 ETT 6 weeks later
  - Redilated
- 4.5 ETT at 1 year
  - asymptomatic



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### Adjunctive Procedure

- With tracheal scar division
  - 6 month old with intubation history and severe stridor and retractions
  - Tracheal scar division
  - A single balloon dilation
  - Asymptomatic airway at 18 month follow-up



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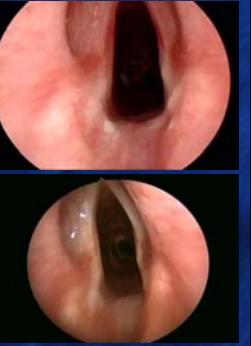
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### Adjunctive Procedure

- With steroid injection
  - Idiopathic late onset tracheal stenosis
  - Athlete with 3.5ETT airway on presentation
  - Serial dilations with Kenalog injections
  - 14mm → 16mm balloon
  - Maintaining 7.0 ETT airway



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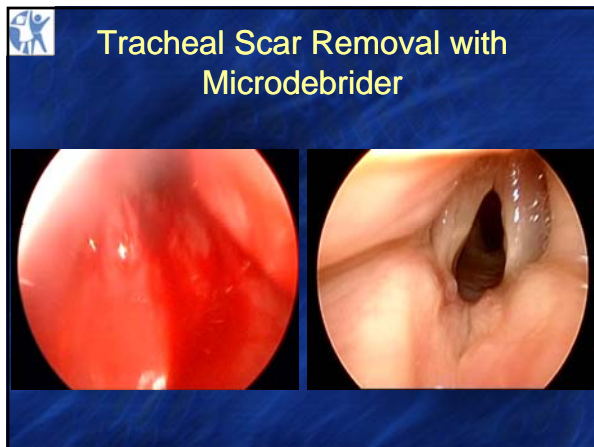
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 **Evolution**

- Increasingly I am incising scar tissue
  - Sickle knife vs laser
  - "Mercedes star" incisions
- Then injecting Kenalog
- Then balloon dilating
- Repeat dilation
  - Increase balloon size?
  - Number of dilations?
  - Intervals?

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 **6 Year Old Girl**

- Ex-preemie, prolonged intubation, past cricoid split
- Past "bouginage" dilation
- Stridor at rest, exercise intolerance, 3.0 ETT airway
- Sickle knife division, kenalog injection, dilation



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 **6 Year Old Girl**

- Returns 2 weeks later
- Now 4.5 ETT airway
- Asymptomatic
- Re-dilation 10mm balloon
- Age appropriate airway at 1 year



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 **6 Year Old Boy**

- 6 year old boy, tracheotomy dependent since birth, Grade 2-3 SGS
- Recent ETT dilation
- Referred with a Grade 4 SGS



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 **6 Year Old Boy**

- Hole "punched" through stenosis with small alligator forceps
- Balloon dilation



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 **6 Year Old Boy**

- Endoscopic placement of a suprastomal stent



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### 6 Year Old Boy

- Stent removed 8 weeks later
- 1 further balloon dilation
- Decannulated
- 6 months later age appropriate airway



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### Balloon Dilation - Conclusions

- 30 years ago, endoscopic management was the mainstay of airway disease
- Open airway reconstruction dominated the subsequent 3 decades
- New tools have re-awakened an enthusiasm for endoscopic airway surgery
- Currently endoscopic and open airway management are seen as complimentary



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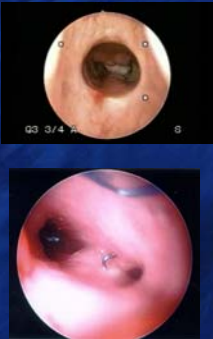
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### Tracheal Stents

- Placed for the management of tracheal stenosis or tracheomalacia
- May be extremely useful
- May be extremely dangerous
- 2 main styles
  - Hollow silicone stents
  - Expandable metal wire stents



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### Expandable Wire Stents

- Placed for management of tracheomalacia or tracheal stenosis
- Potentially permanent, and may allow "normal" mucociliary clearance
- In some cases (50-75%), eventually will get problems associated with granulation tissue formation or stenosis
- Styles include Palmaz, Wallstent, etc
- "Cure" may be worse than the disease



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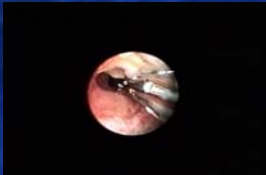
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### Stent Placement

- These may be placed radiologically guided, or endoscopically guided, over a balloon catheter
- A range of lengths and diameters
- May be further expanded in the future



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### Metal Stent Complications

- Stent may get bent
  - May require premature removal



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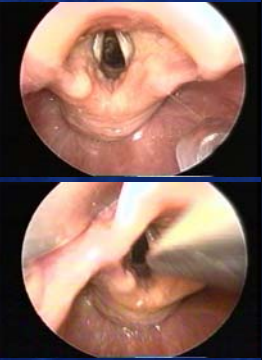
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### Metal Stent Complications

- Stent may have granulation tissue occluding the lumen
- Removal can be challenging
  - A "windlass" technique
  - Palmaz usually come out in one lump of metal
  - Wallstents come out as a mass of broken wire and blood
  - A tolerant anesthetist useful



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### Metal Stents – Current Indications

- Recalcitrant tracheal stenosis
  - Especially following salvage repair of complete tracheal rings
- Aim is to remove the stent within 2 weeks to 3 months
  - **BEFORE IT GETS STUCK!**



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### Endoluminal Stent Placement

- Better for stenosis than malacia
- The proximal stent should not abut conus elasticus
- Potential for complications:
  - Migration
  - Granulation / stenosis at either end
  - Biofilm formation



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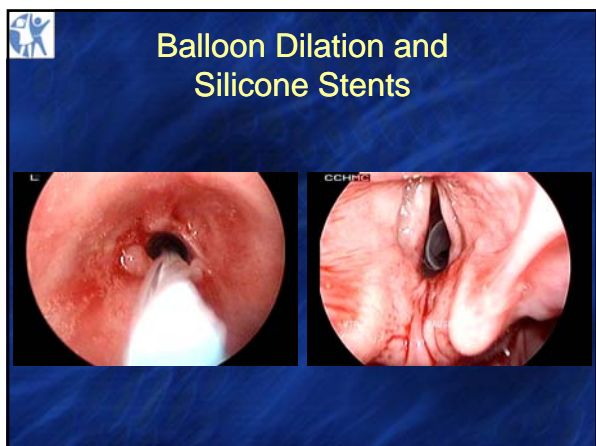
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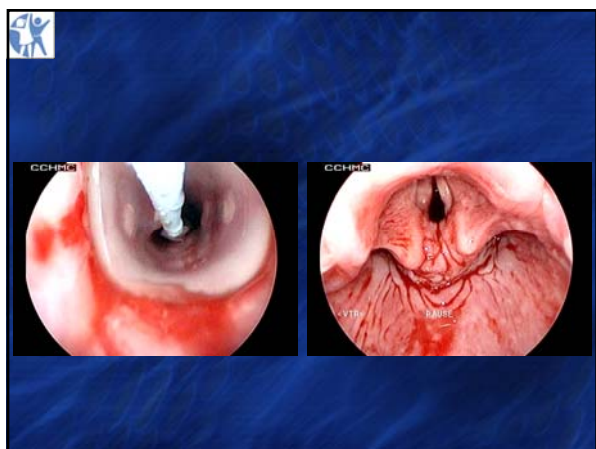
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### Hood Silicone Stents

- Teenager with recalcitrant tracheal stenosis post MVA and tracheal resection (with innominate blowout!)
- Dilation, silicone stent placement
- Due to return 6 weeks later
- Returns 6 years later

The image consists of two side-by-side endoscopic views of the trachea. The top image shows a hood silicone stent being placed over a stenotic area. The bottom image shows the hood silicone stent in place, covering the stenotic area.

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 **Silicone Stents**

- 1 week later, further balloon dilation
- Asymptomatic



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 **Endoscopically Placed Suprastomal Stents**

- When should a suprastomal stent be removed in a 2 stage procedure?
- What to do if you wish to replace the stent?



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 **Endoscopically Placed Suprastomal Stents**



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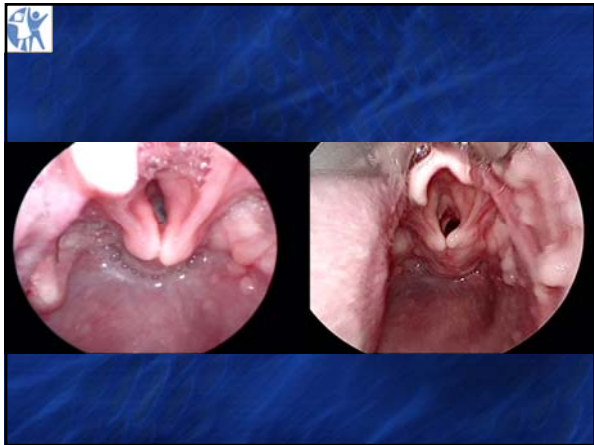
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**Supraglottoplasty**

- Required in 5 - 10% of cases
- Intervention should be tailored to the awake flexible laryngoscope appearance of the larynx
  - Unless sleep apnea pattern
- Anesthetized larynx cannot be trusted
- Bronchoscopy required
- Rarely tracheotomy still an appropriate alternative

Two endoscopic views of the larynx illustrating the procedure of supraglottoplasty. The top image shows the pre-operative state with a narrow airway, and the bottom image shows the post-operative result with a significantly widened airway.

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### Supraglottoplasty Technique

- Release aryepiglottic folds
  - +/- Resect 1 or both cuneiforms
  - +/- Trim edge of epiglottis
- Intubate vs not
- Steel vs laser
- Better to be conservative than aggressive



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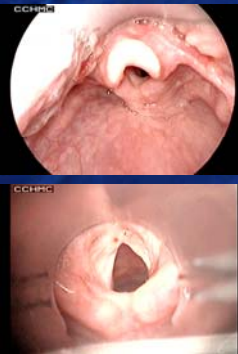
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### Laryngeal Keel Placement

- Especially for acquired anterior webs in an older child
- Suspend, cord spreaders, divide scar
- Silicone sheet as a keel to cover raw surfaces till they remucosalize



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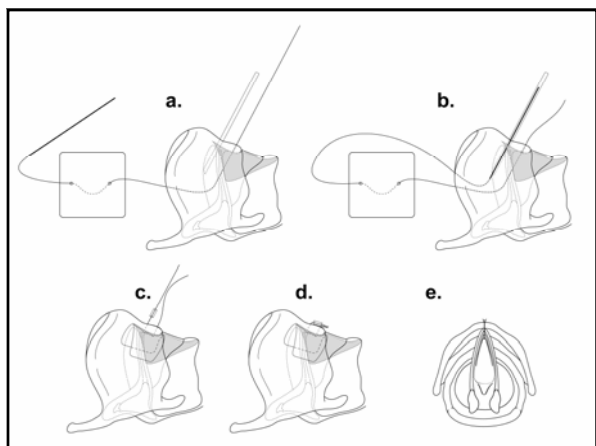
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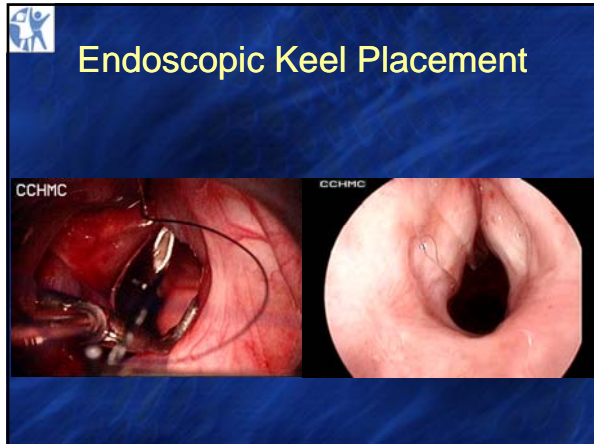
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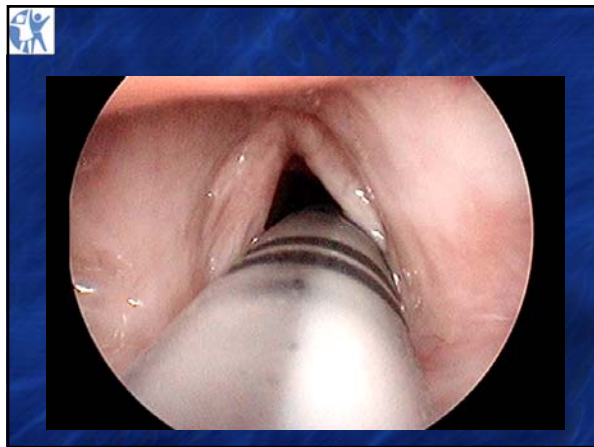
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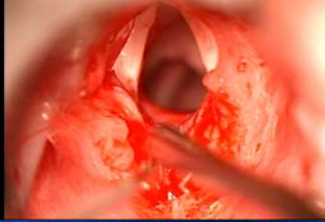
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### Laryngeal Cleft Repair

- A simple (if inelegant) suggestion
  - Make sure mucosa denuded
  - Repair high
  - Most proximal suture through cartilage, using PDS
  - Tisseel?



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### Laryngeal Cleft Repair



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### Tracheal Pouches

- If a tracheoesophageal fistula is proximal in the trachea, then ligation from a thoracic approach is challenging, and likely to result in a deep pouch
- A deep proximal pouch is at risk of cannulation with endotracheal or tracheotomy tubes



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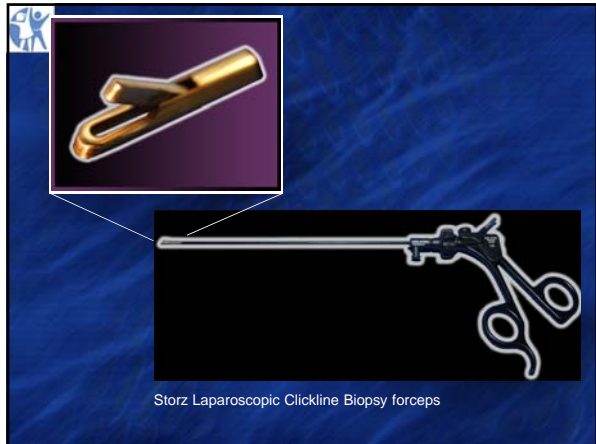
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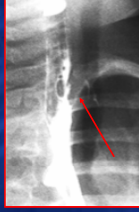
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### Recurrent TEF

- Most TEFs are repaired by Pediatric surgeons through a thoracotomy
- Proximal TEFs are more difficult to repair, and therefore carry a higher risk of failure
- The right candidate
  - Proximal TEF
  - Long skinny TEF
- The concept
  - De-epithelize tract
  - Prevent passage of air or fluid through tract
  - Pressure occlude tract



The slide includes two images: a chest X-ray in the top right showing a red arrow pointing to a tract in the thoracic region, and an endoscopic view in the bottom right showing a circular tract in tissue.

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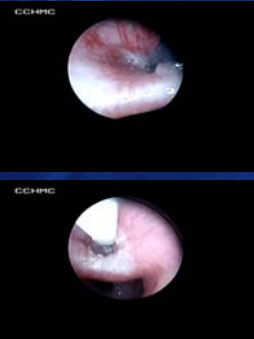
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### Technique

- 2 scope technique
  - Ventilating bronchoscope
  - Flexible esophagoscope
- De-epithelize tract
  - Bugbee electrocautery
- Glue tract
  - Tisseel with extra aprotinin
- Occlude tract
  - Cuffed ETT or trach tube with cuff distal to pouch
  - Cuff up 48 - 72 hours



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### Pushing the Envelope

- Patient CC
- TEF repair (carinal), long segment esophageal atresia
- Recurrence
- Endoscopic salvage?



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### Patient CC – 6 months later



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## Conclusions

- 30 years ago, endoscopic management was the mainstay of airway disease
- Open airway reconstruction dominated the subsequent 3 decades
- Currently endoscopic and open airway management are seen as complimentary

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