Airway Stenosis: Evaluation and Endoscopic Management

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Outline

- **Introduction**
- **Etiology**
  - Autoimmune Causes
  - Acquired Causes
  - Role of LPR
  - IPSS
- **Evaluation**
  - H&P, Grading, DL/B
- **Endoscopic Management**
  - Mitomycin
  - TGF-β
  - Lasers/Balloon Dilation

Introduction

- Airway Stenosis is both a therapeutic and diagnostic challenge
- Presents insidiously with progressive SOB, brassy cough, wheezing/stridor, possible recurrent pneumonitis
- Many times misdiagnosed as asthma/bronchitis, COPD, CHF

Introduction

- Common etiology (beginning 1965)
  - either cuffed endotracheal or tracheotomy tube
- Less common:
  - external trauma/compression
  - high tracheotomy incision
  - benign tumors
  - ‘nontraumatic, nonneoplastic’ causes

Etiology of SGS

- I. Congenital SGS
  - Membranous
  - Cartilaginous
- II. Acquired SGS
  - Intubation
  - Laryngeal trauma
  - AI (Wegener's; Sarcoid; Amyloid; Relapsing Polychondritis)
  - Infection
  - IPSS (Idiopatic Subglottic Stenosis)
  - GER/LPR
  - Inflammatory diseases
  - Neoplasms

Nonneoplastic, nontraumatic Subglottic Stenosis

- Wegener's Granulomatosis
- Amyloidosis
  - Can present with SG alone
- Sarcoidosis
  - Can present with SG alone
- Relapsing Polychondritis

SGS – Wegener's

- Systemic inflammatory disorder
- Autoimmune
- ANCA C +
- 16-23% incidence of SG stenosis
- SGS can be the lone manifestation of WG

- Treatment
  - Individualized based on degree and acuity of stenosis
  - No major surgery during Wegener's flare ups

Wegener's Granulomatosis

- Classic triad: necrotizing granulomas of the upper respiratory tract and lungs, focal glomerulitis, disseminating vasculitis
  - Treatment: Azathioprine, cyclophosphamide, steroids
- Laryngeal WG
  - Ulcerating lesions induce *subglottic stenosis*
  - Histopathology: *coagulation necrosis* from vasculitis, multinucleated giant cells, palisading histiocytes

Amyloidosis

- Deposition of extracellular fibrillar proteins in tissues
  - Primary (56%), secondary (8%), localized (9%), myeloma associated (26%), familial (1%)
  - Generalized amyloid evaluated by *rectal biopsy* or FNA anterior *abdominal wall fat*
- Locations
  - Tongue > orbit > larynx
  - Laryngeal amyloidosis
    - TVC > FVC > subglottic
  - Management
    - Surgical

Amyloidosis

- Diagnosis
  - Congo red staining and green birefringence under polarized light
  - Fibrillar structure under electron microscopy
  - Beta-pleated sheet on x-ray crystallography and infrared spectroscopy
- 18 biochemical forms identified
  - AL (plasma cells), AA (chronic inflammation), Aβ (cerebral lesions)

Amyloidosis – Management

- Step 1 Biopsy the affected organ
- Step 2 Rule out generalized amyloidosis
  - Rectal bx, echocardiography, bronchoscopy and PFTs, CT of neck/trachea
- Step 3 Rule out generalized plasmacytoma
  - Bone marrow biopsy, bone marrow scintigraphy, serologic and immunologic examininations

Laryngeal Amyloidosis

- < 1% of benign laryngeal lesions
- Most amyloid deposits are AL type
- Typically in men in the 5th decade of life
- Sx depends on site (e.g. glottic amyloidosis → hoarseness)

Sarcoidosis

- Idiopathic, non-caseating granulomas
  - Generalized adenopathy (25-50%), orbit (15-25%), splenomegaly (10%), neural (4-6%)
  - Symptoms: fever, weight loss, arthralgias
  - Head and neck: cervical adenopathy > larynx
  - Evaluation: CXR, PPD, skin test for anergy, ACE levels (elevated in 80-90%)
  - Treatment
    - Oral steroids
  - **Laryngeal sarcoidosis**
    - Supraglottic involvement
    - Typical yellow subcutaneous nodules or polyps
    - Diffusely enlarged, pale pink, turban-like epiglottis

Relapsing Polychondritis

- Inflammation of cartilage and other tissues with high concentration of glycosaminoglycans
  - Episodic and progressive
  - Ear > nasal, ocular, respiratory tract
  - Treatment: symptomatic, steroids
- **Laryngeal RP**
  - Rare
  - Inflammation can lead to laryngeal collapse
  - Treatment usually tracheostomy

Acquired SGS

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

Etiology of subglottic stenosis

Etiology	n = 37 (%)	Number and fraction of 15 patients with multiple level stenosis within each category (%)
Idiopathic	13 (35)	0 (0)
Intubation	10 (27)	7 (70)
Severe reflux	5 (14)	1 (20)
Tracheotomy	4 (11)	3 (75)
Trauma	3 (8)	3 (100)
Neoplasm	1 (3)	0 (0)
Amyloidosis	1 (3)	1 (100)

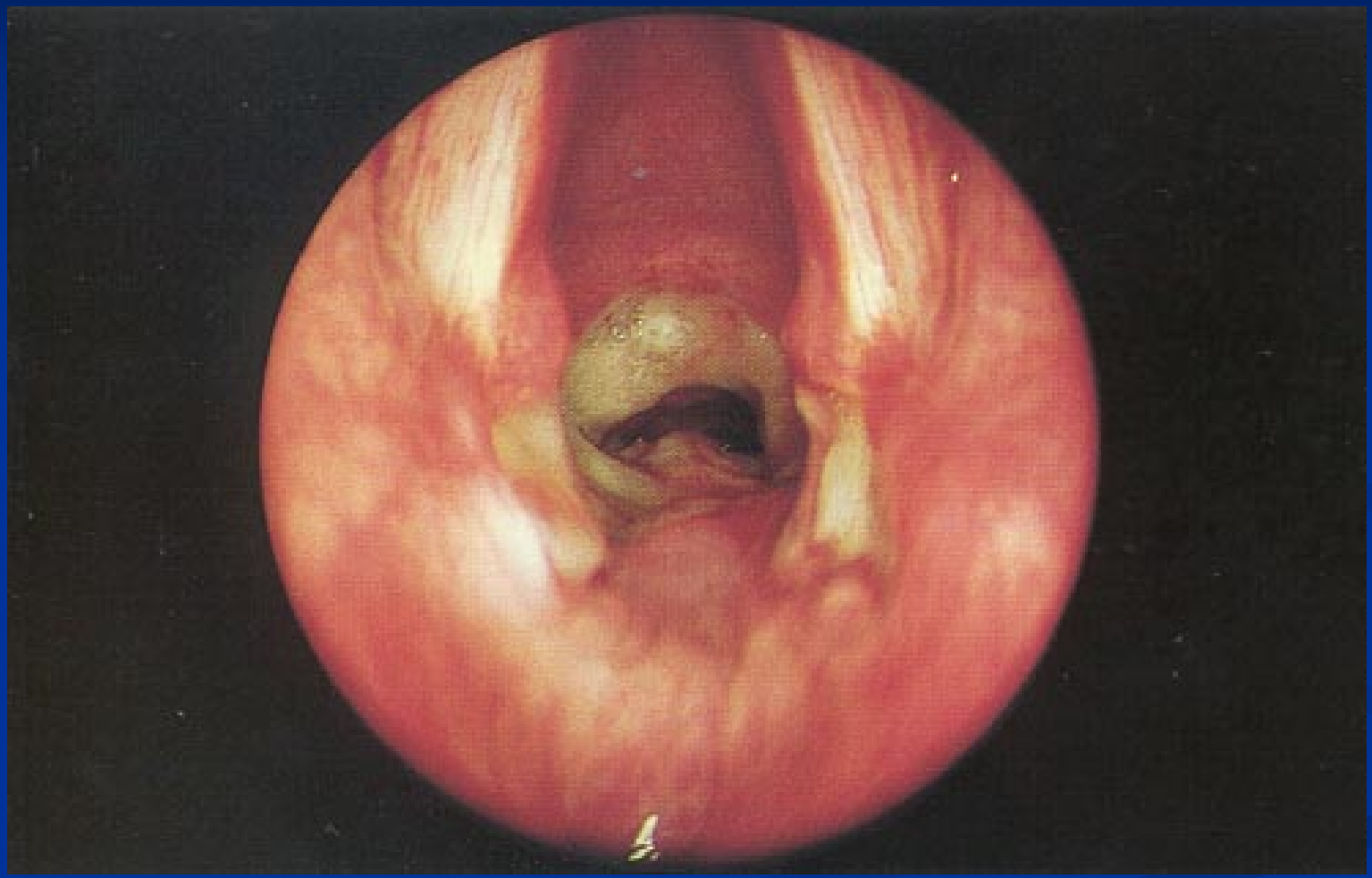
- Poetker DM et al. Association of airway abnormalities and risk factors in 37 subglottic stenosis patients. Otolaryngol Head Neck Surg (2006) 135, 434-437

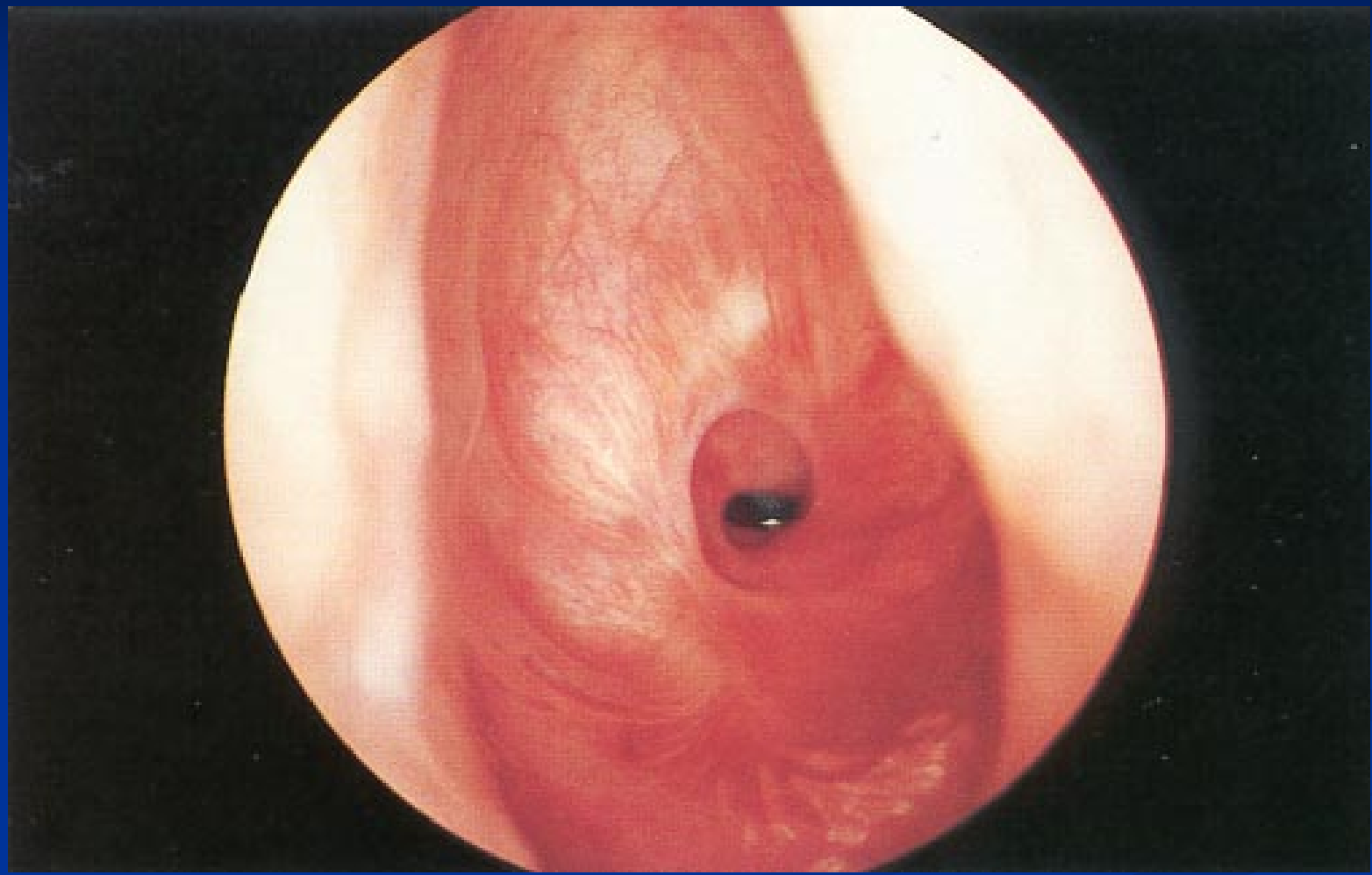
Pathogenesis of acquired SGS

- 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

Pathogenesis SGS

- **Mankarious et al (2003):** Investigated histopathologic features of 6 specimens from pts that underwent tracheal resection
  - Analyzed levels of hyaline cartilage components: collagen type I and II & aggrecan (secreted by chondrocytes)
  - Normal tracheal/cricoid: High ratio of type I to II
  - Specimens: relative decrease in type I and aggrecan
    - Regenerative cartilage: greatly increased amounts of type II collagen and aggrecan
    - Suggests Type I collagen and aggrecan responsibe for cartilage structural integrity
    - Regenerative fibroblasts do not deposit type I collagen





Acquired SGS and PDT

- Ciaglia 1985: Percutaneous dilational tracheotomy (PDT)
- Bartels 2002: 108 PDT patients; 10 with 6 mo f/u; 1 patient with significant stenosis at f/u
  - ? Selection Bias
  - Authors conclude 10% stenosis rate is consistent with open tracheotomy

Acquired SGS and PDT

- Klussman et al (2001): Reported case of complete suprastomal tracheal stenosis/atresia after second PDT
- ? Initial infection leading to destruction and cartilaginous necrosis/Tracheal ring fracture leading to mucosal tears and cicatricial scarring
- Cautioned against use of PDT in secondary tracheotomy

Acquired SGS and PDT

- Hotchkiss & McCaffrey (2003): examined pathophysiology of PDT on 6 cadavers
- 3/6 Trachs were placed incorrectly (range: 3 tracheal rings away to just sub-cricoid)
- Anterior tracheal wall
  - High degree of injury
  - Severe cartilage damage at site of insertion
  - Multiple, comminuted injuries in 2 or more cartilaginous rings
  - Findings suggest acute, severe mechanical injury in PDT

Acquired SGS & LPR

- Gastroesophageal reflux (GER)/Laryngopharyngeal reflux (LPR)
  - 1985 – Little – applied gastric contents/H2O to subglottis of dogs
    - Delayed epithelialization and stenosis formation in lesions treated with gastric contents
  - 1991 – Koufman – applied acid and pepsin to subglottis of dogs; control was H2O
    - 20 dogs with induced submucosal injury
    - Increased level of granulation tissue and inflammation
    - 78% pts with LTS: abnormal acidic pH probes; 67% pharynx reflux

GER/LPR and SGS

- 1998 Walner: 74 pediatric patients with SGS had 3 times greater incidence of GER than the general pediatric population
- 2001 Maronian: 19 pts with SGS
  - 9 pts with IPSS; 10 with acquired SGS
  - 14 pts with pH testing
    - Abnormal (pH <4): 71% IPSS pts and 100% acquired pts

GER/LPR and SGS

- Dedo (2001): Challenged association; largest review of 50 pts with IPSS; Only 7/38 patients had reflux symptoms
- Ashiku (2004): 15/73 IPSS patients had reflux symptoms; No patients had laryngeal signs of reflux
- Both groups concluded no causal relationship between reflux and stenosis in their groups
  - **Only 2 patients in collective cohorts underwent specific reflux testing**

Idiopathic Subglottic Stenosis

- Rare condition of dense fibrous stenosis of the proximal trachea in absence of inciting event
- Affects women; primarily involves subglottic larynx and proximal 2-4 cm of trachea circumferentially
- May be associated with certain autoimmune states
  - Wegener's Granulomatosis
  - Relapsing Polychondritis
  - Rheumatoid Arthritis
  - SLE

Ashiku SK et al. Idiopathic laryngotracheal stenosis. *Chest Surg Clin North Am,* 2003; 13:257

IPSS (Idiopathic Subglottic Stenosis)

- Possible hormonal cause
- To date, presence of estrogen receptors in the affected airway has not been conclusively shown in these patients (Dedo 2001)
- ? Possible link between female preponderance and LPR
  - Progesterone and its impact on LES pressure
  - Major contributing factor toward heartburn and reflux in pregnancy
  - Cyclic hormonal variations in normal women found to impact LES pressure leading to possible reflux

SGS Initial presentation

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

Initial Presentation

- History
  - 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/Neck
    - Other abnormalities (congenital anomalies, tumors, infection)

Diagnosis

- Differential
  - Congenital
    - Laryngeomalacia
    - Tracheomalcia
    - VC paralysis
    - Cysts
    - Clefts
    - Vascular compression
    - Mass

Diagnosis

- Differential
  - Infection/Inflammation
    - Epiglottitis
    - GER
    - Tracheitis
  - Neoplastic
    - Malignancy
    - Recurrent respiratory papillomas; benign lesions
  - Foreign body

Diagnosis

- Radiographs
  - Plain films – inspiratory and expiratory neck and chest
  - CT
  - MRI

Diagnosis

- Flexible nasopharyngolaryngoscopy
  - Nose/Nasopharynx
    - NP stenosis
    - Masses, tumor
  - Supraglottis
    - Structure abnormalities
    - Laryngomalacia
  - Glottis
    - VC mobility
    - 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

Operative Evaluation

- Endoscopy
  - Fiberoptic endoscopic assisted intubation vs. evaluation
  - LMA
  - Spontaneous ventilation, **NO PARALYSIS !**
  - **Consider awake tracheotomy**
- Perform Rigid DL, B, and E
  - Closely evaluate the interarytenoid area for stenosis/stricture
  - Evaluate position of cords
- Determine size, extent, and location of the stenotic lesion
  - Use an ETT/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)

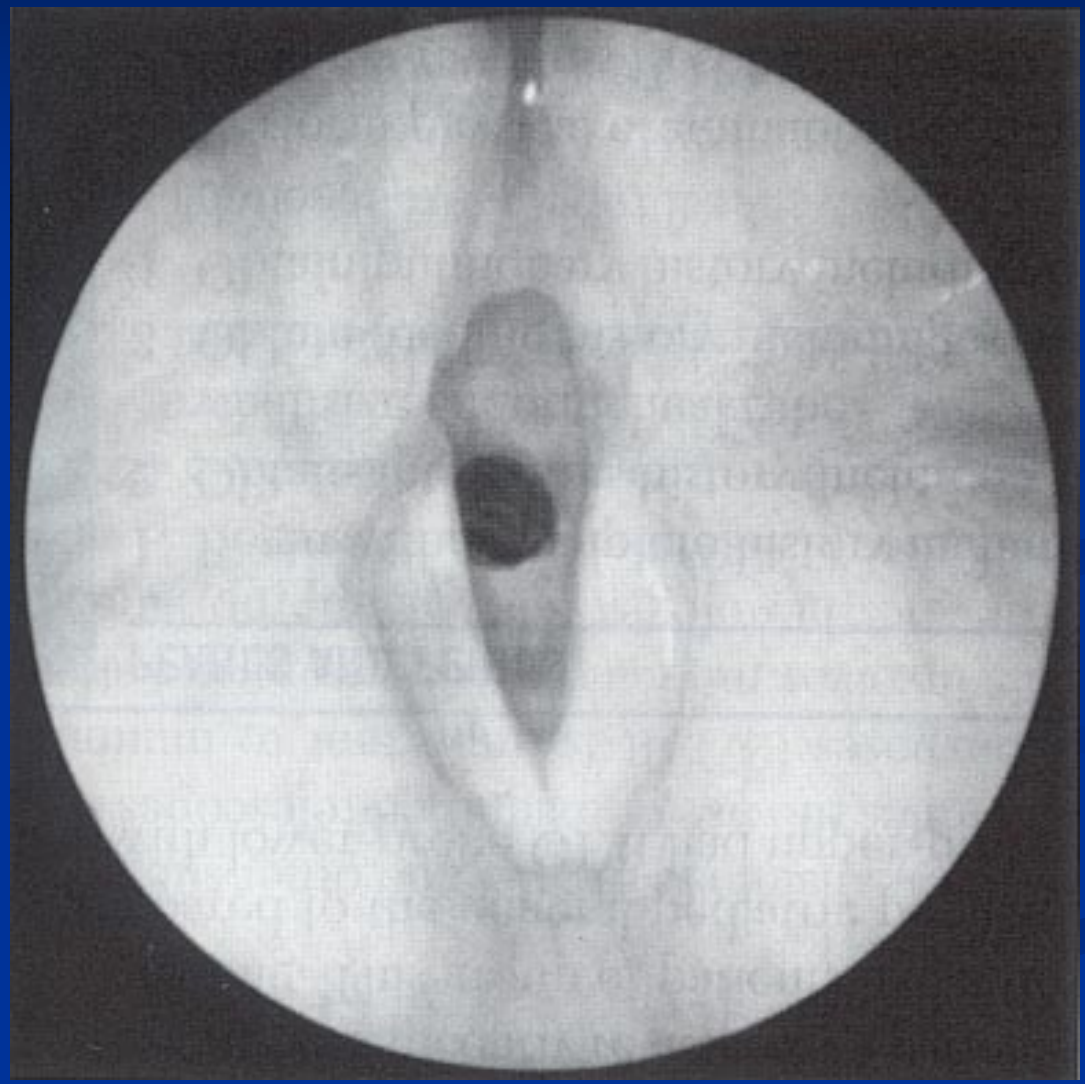
Cotton-Myer Grading System

Classification	From	To
Grade I	0%	50%
Grade II	51%	70%
Grade III	71%	99%
Grade IV		No Detectable Lumen

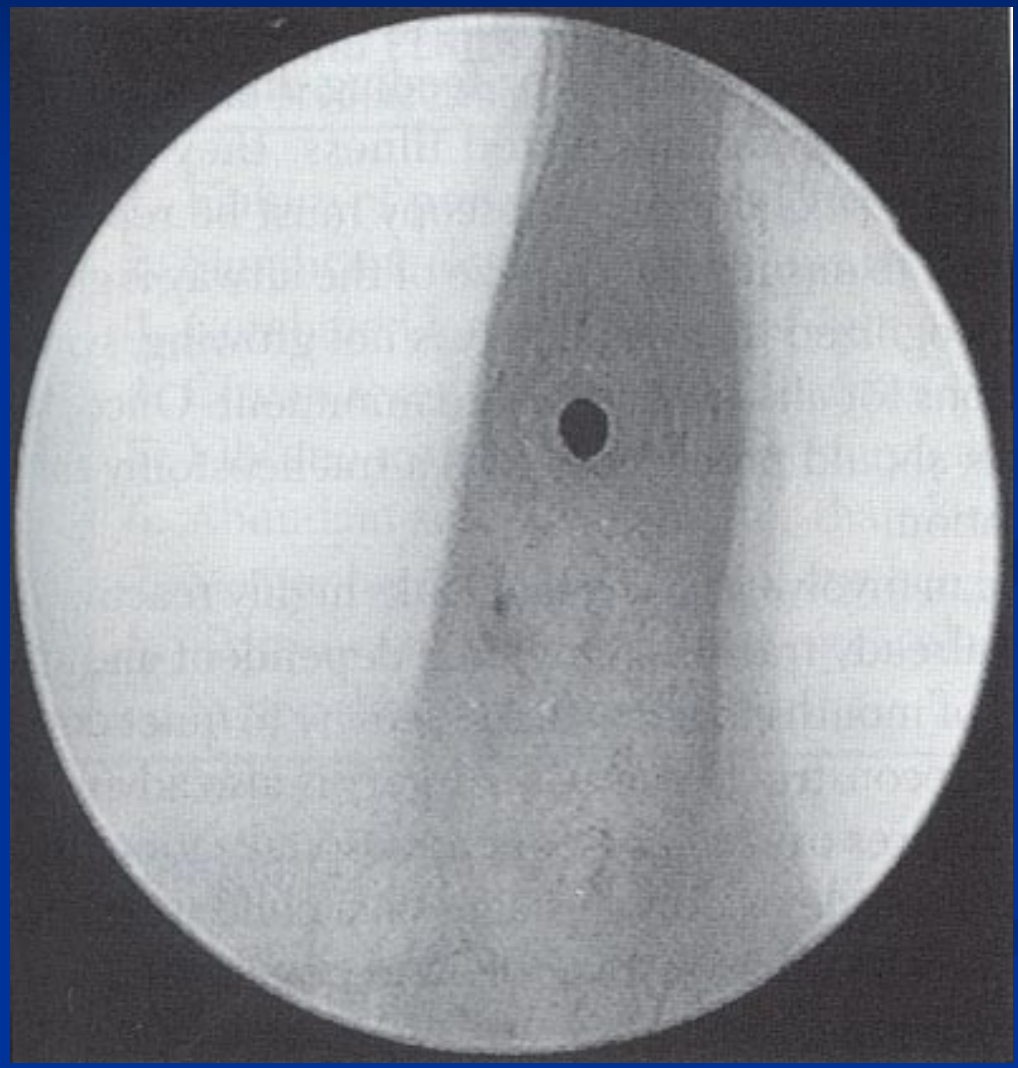
- Cotton-Myer grading system for subglottic stenosis

Classification	From	To
Grade I	 No Obstruction	 50% Obstruction
Grade II	 51% Obstruction	 70% Obstruction
Grade III	 71% Obstruction	 99% Obstruction
Grade IV	No Detectable Lumen	

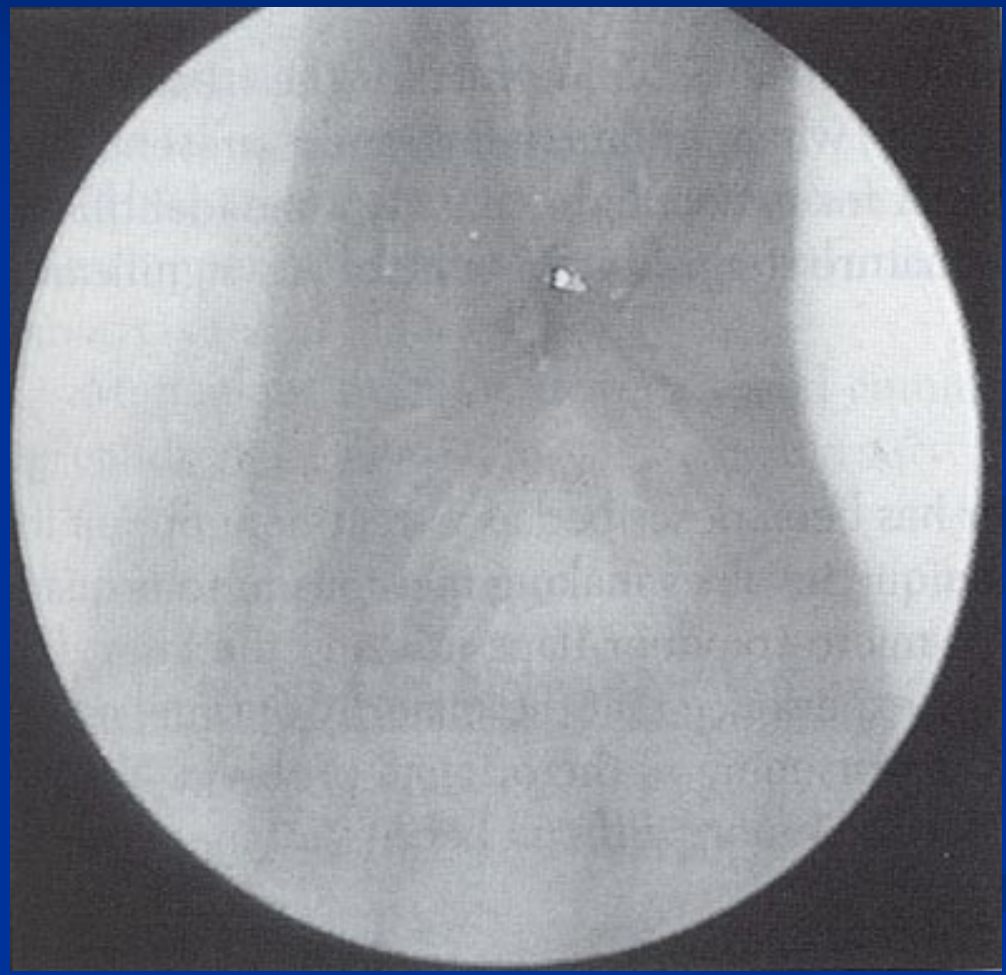
Grade II SGS



Grade III SGS



Grade IV SGS



Myer/Cotton Grading System

- Multiple revision of original system proposed by Cotton in 1984
- First systems criticized for being based on subjective interpretation, although statistically proven to relate grade with prognosis in children
- Myer 1994: used serial ETT measurement to derive Cotton grade

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
  - Gold-Standard Staging in pediatric patients

McCaffrey Grading System

McCaffrey (1991)

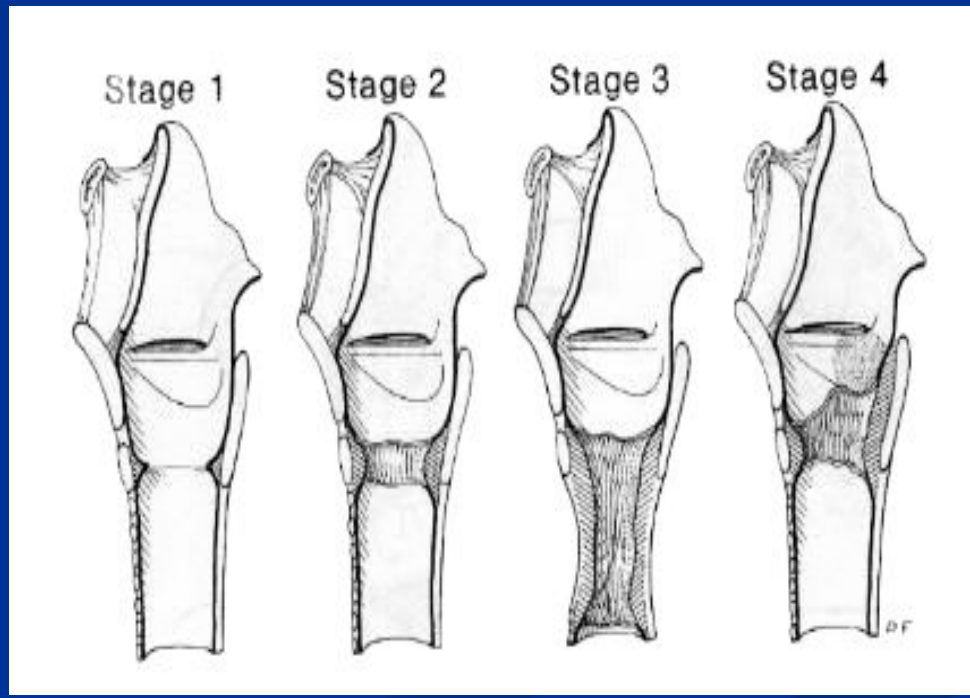
- Relative reduction in cross sectional area not consistently reliable predictor of decannulation in adults
- Reviewed 73 cases of LTS in adults finding location of stenosis to be the most significant factor in predicting decannulation

Grading Systems for SGS

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

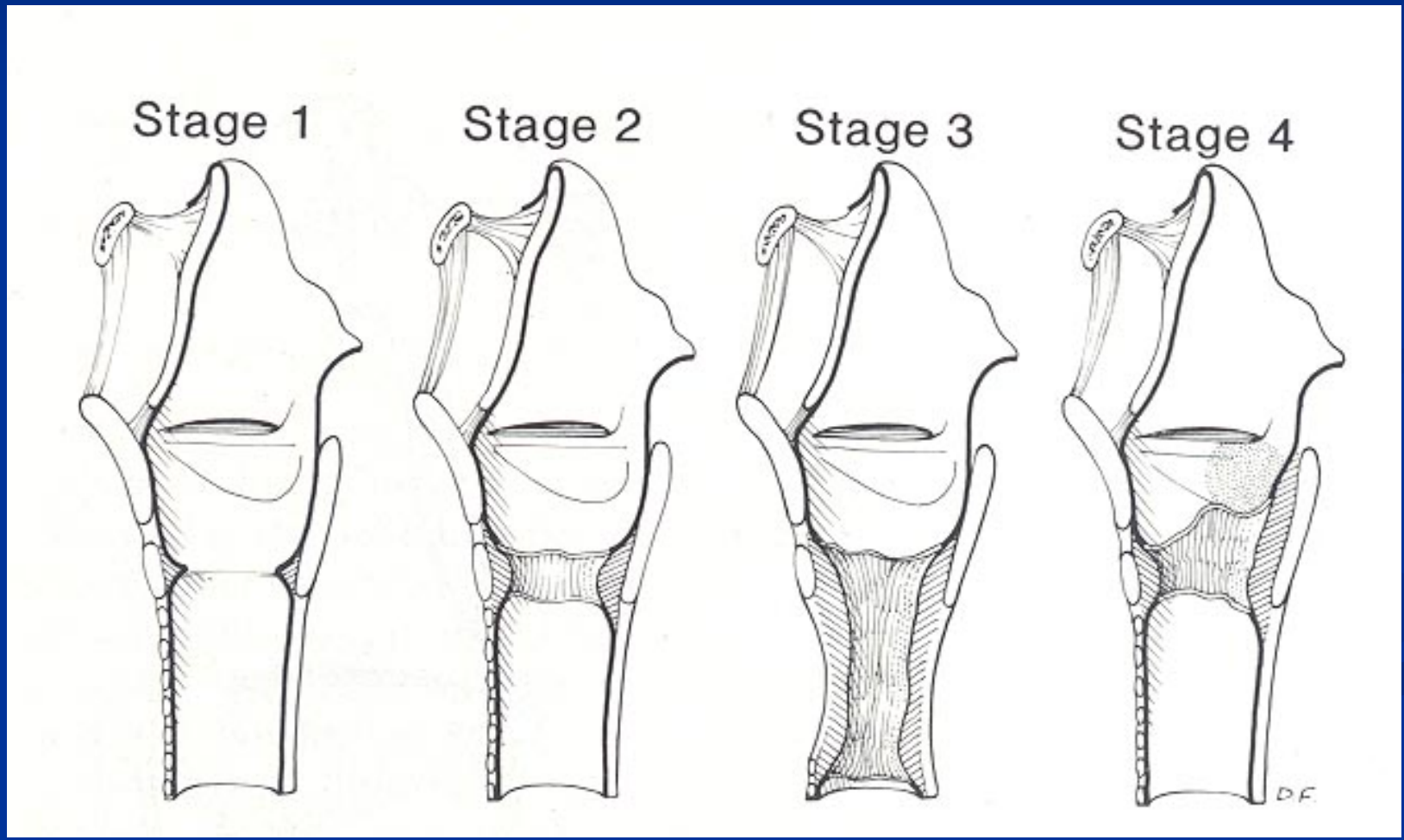
McCaffrey Clinical Staging

- Stage I: confined to subglottis/trachea
- Stage II: SGS, >1cm, confined to cricoid
- Stage III: SGS and involving trachea
- Stage IV:involve glottis with fixation TVC



Grading Systems for SGS

- McCaffrey



McCaffrey Conclusions

Site: glottic, tracheal, subglottic: major factor in type of surgery

- thin (<1cm) subglottic or tracheal lesions--Endoscopic
- thick(>1cm) any site or glottic lesions--Open

Stage: prognostic predictor

- 90% of Stage I and II successfully treated
- 70% of Stage III, 40% of Stage IV

Management of SGS

- Medical
- Observation
- Tracheotomy
- Endoscopic Treatment
  - CO2 laser (with Mitomycin C/Steroid)
  - Rigid vs. Balloon Dilation (with Mitomycin)
- Open 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

Surgery for SGS

- I. Endoscopic
  - Dilation +/- stenting
    - Rigid vs. balloon dilation
  - Laser +/- stenting
- II. Open procedure
  - Expansion procedure (with trach and stent or SS-LTR)
    - Laryngotracheoplasty (Trough technique with mucosal grafting +/- cartilage grafting)
    - Laryngotracheal reconstruction
    - Tracheal Resection with primary anastamosis

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 open LTP procedures
    - Often requires multiple repeat procedures
    - Potentially lower success rate but an option for patients who cannot undergo open procedures

Treatment Options

Goals

1. Maintain patent airway
2. Maintain glottic competence to protect against aspiration
3. Maintain acceptable voice

Surgical Management

Approaches

- Endoscopic: cryotherapy, microcauterization, laser incision or excision of scar tissue, dilatation, stenting

- Open surgical: tracheal resection and reanastomosis, external tracheoplasty with/without grafting and possible stenting

Stents

- Indwelling expandable stents
  - Used in many organ systems: arteries, the urethra, and biliary tree
- Tracheobronchial system:
  - Lower airways for either tumors, or bronchial stenosis after lung transplantation
  - Upper airways (Montgomery T-tube, silicone, mesh stents): used alone or with other modalities

Stents

- Stenting
  - Ensure adequate airway during wound maturation
  - While waiting for pt's condition to improve prior to definitive surgical resection/treatment
  - Silastic T-Tubes most commonly used
    - Permit better hygiene
    - Not prone to obstructing granulation
    - Stent removal possible after 1-2 years with good results

Expandable Stent

Hanna 1997

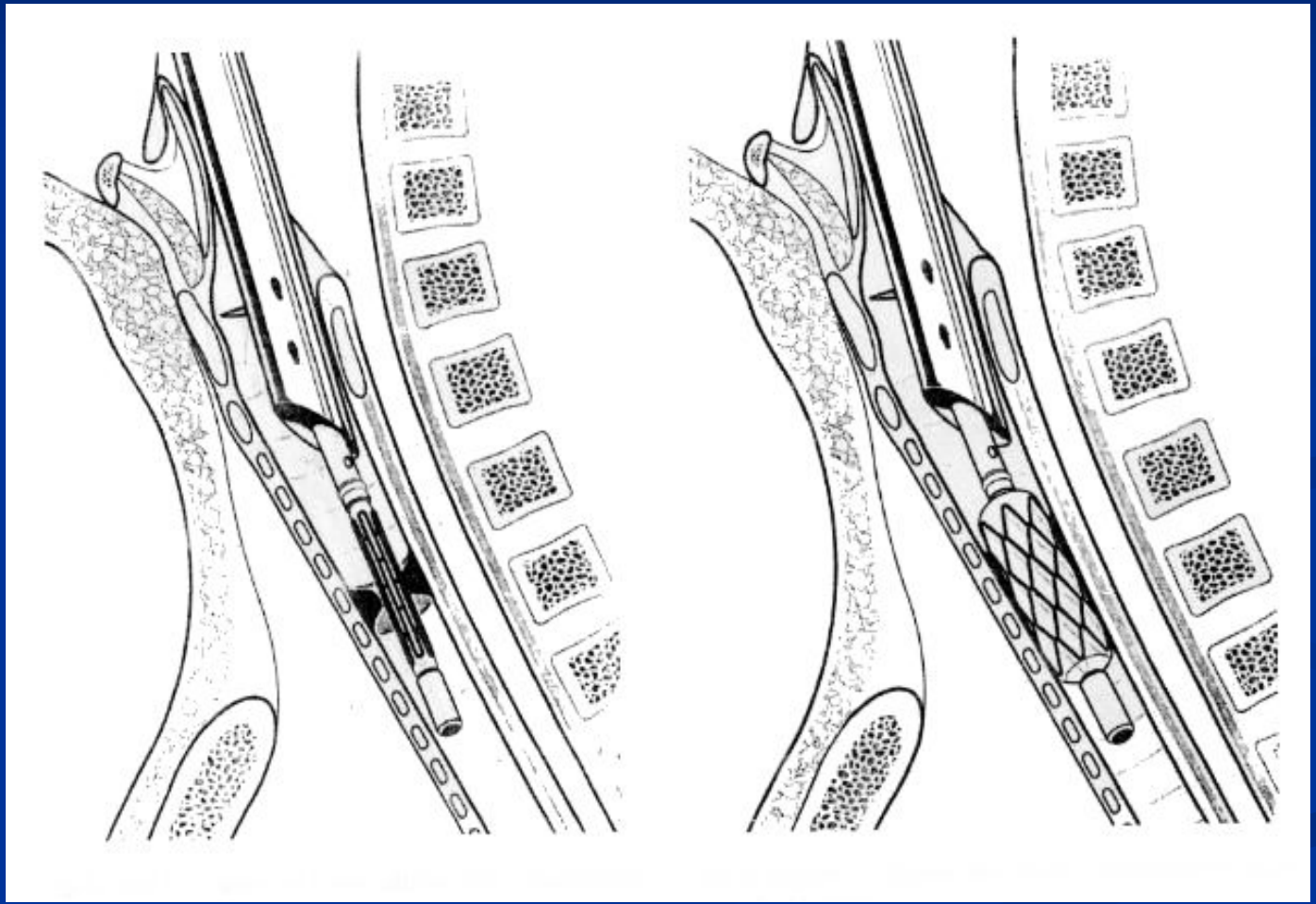
- Canine model(6)
  - Stenosis induced by resection of anterior cricoid arch/tracheal wall to reduce airway diameter by 50%
  - 8 week stenosis maturation period
  - Tracheostomy performed, followed by introduction of titanium mesh stent (Group A), +/- silicone covering (Group B)
  - Euthanasia performed at 4 weeks with gross/histologic exam

Expandable Stent

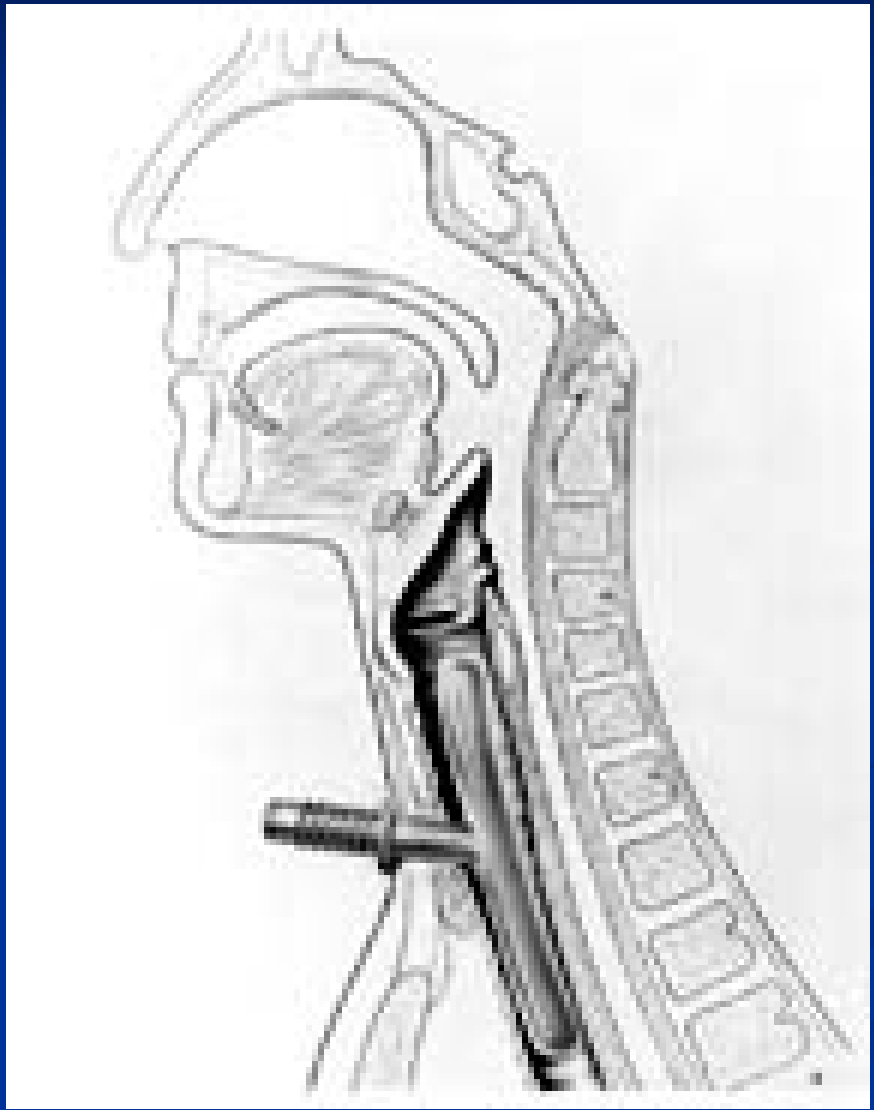
Hanna (1997)

- Stents well tolerated, minimal signs of airway irritation, no infections
- Group A unable to be decannulated due to granulation
- Group B all tolerated decannulation without complication

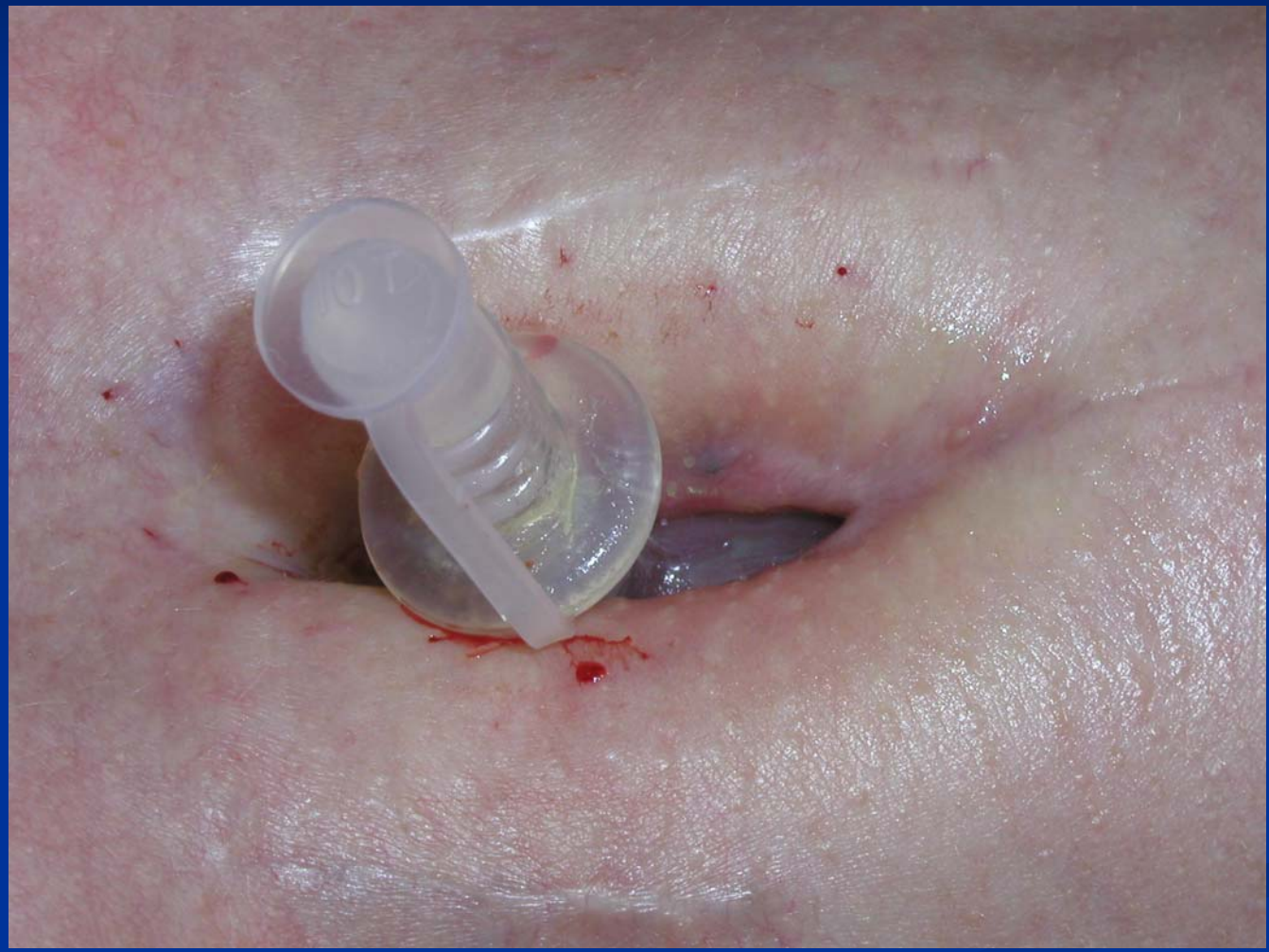
Expandable Stent



Silastic T-Tubes



T-Tubes



Stents

Froehlich (1993)

- Retrospective study of T-tubes in 12 pediatric patients
- 10 acquired after intubation, 2 congenital, (4 extensive tracheomalacia)
- 10 with prior tracheotomy
- 5 Cotton grade 2, 7 Cotton grade 3 (6 required anterior split to fit T-tube)

Stents

Froehlich (1993)

- mean time from insertion to final removal 5.6 months
- 9/12 successful tx (mean time from dx to end of tx 15.3 months)
- Complications: tube migration, accidental tube removal, tube occlusion

Stents

Froehlich (1993)

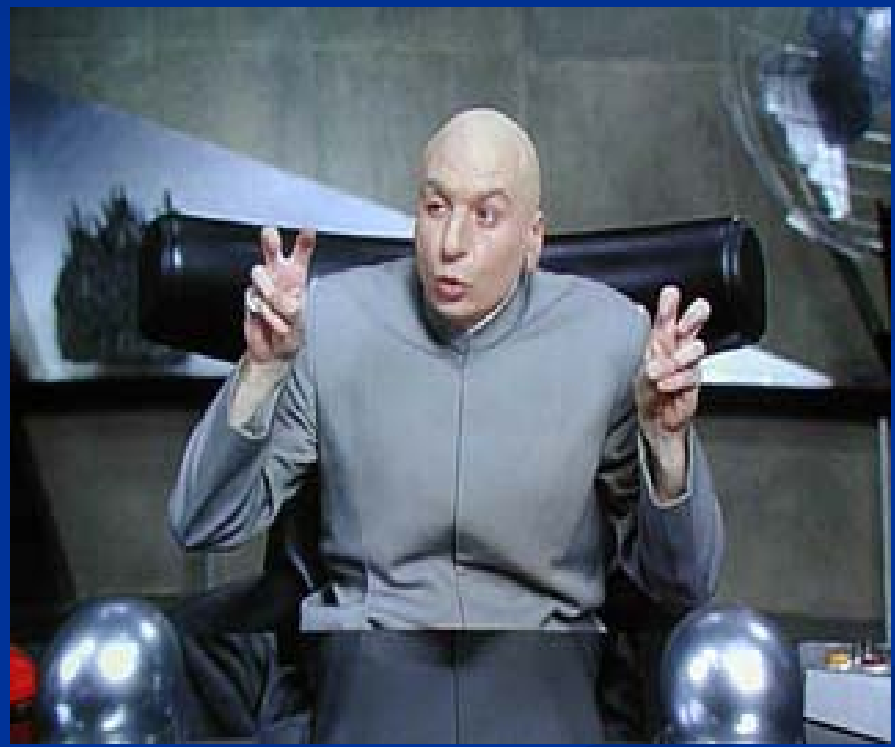
- 75% success rate of long term stenting comparable to either cricoid split or LTR procedures
  - stenting takes longer, increased complications
- T-tube stenting better reserved for cases not amenable to surgery, i.e. tracheomalacia

Endoscopic Approach

- Benefits patients due to less morbidity
- Shorter hospital stay
- Earlier return to work
- Tolerance of repeated procedures, if necessary

"Lasers"

- First medical use (December 1961)
- Strong and Jako (1972)
  - First described CO2 laser for LTS management
- Types:
  - CO2
  - KTP
  - Nd-YAG

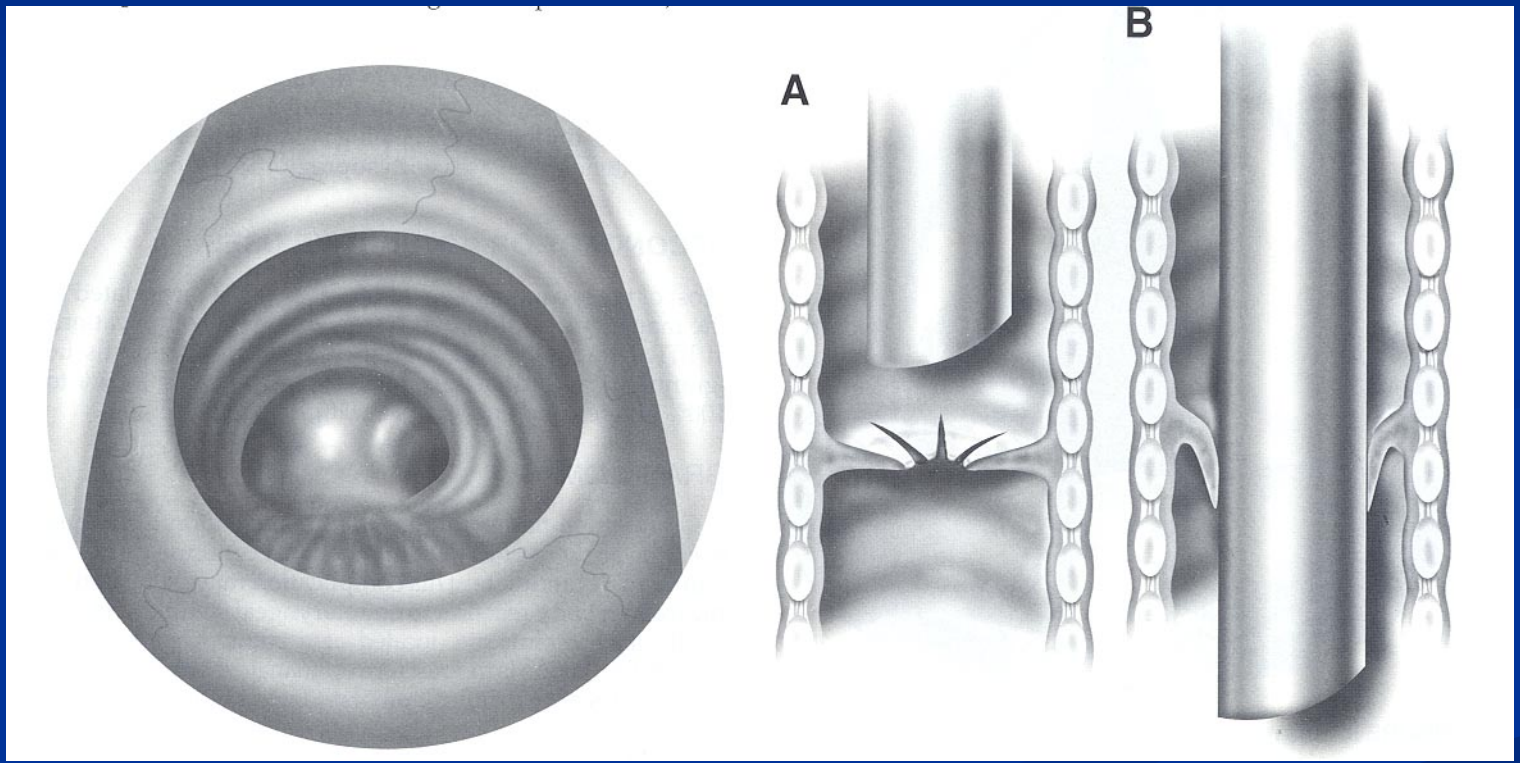


Lasers

- Used as both definitive and as an adjunct to open repair
- *Hall* (1971) delayed collagen synthesis in laser incisions
- Used in conjuncture with other epithelial preserving techniques

Laser excision of subglottic stenosis

Laser excision of subglottic stenosis



Endoscopic Approach

Simpson, et al (1982)

- Retrospective study of 60 patients: 49 laryngeal (supraglottic,glottic, subglottic), 6 tracheal, 5 combined stenosis
- Follow up: 1-8 years
- Age: 2 months-72 years old
- CO_2 laser used to vaporize scar tissue, divide fibrotic bands, or excise redundant tissue
- +/- Silastic stenting, dilatation

Endoscopic Approach

Simpson, et al (1982)

- 39/60 had Silastic stents placed
  - 1/6 supraglottic
  - 2/12 glottic
  - 27/31 subglottic stenosis
  - 4/6 tracheal
  - 4/5 combined

Endoscopic Approach

Simpson, et al (1982)

- Dilatation employed 8/60
  - 0/49 laryngeal
  - 4/6 tracheal
  - 4/5 combined

Endoscopic Approach

	#CASES	*SUCCESS %*	*#PROCEDURES TO SUCCESS*
Laryngeal	49	77.5	2.11
Tracheal	6	33.3	6
Combined	5	20.0	1

Endoscopic Approach

Simpson, et al (1982): Conclusions

- Justified at all levels
- Decreased success with 'severe', combined, extensive (>1cm) or circumferential stenosis; loss of cartilage, and preceding bacterial infection associated with tracheostomy
- Age not associated with failure rate

Management of SGS

- Endoscopic
  - Laser
    - 66-80% success rate for Cotton-Myer grade I and II stenoses (pediatric cases)
    - Closer to 50% success rate in appropriately chosen adults
    - Factors associated with failure
      - Previous attempts
      - Circumferential scarring
      - Loss of cartilage support
      - Exposure of cartilage
      - Arytenoid fixation
      - Combined laryngotracheal stenosis with vertical length >1cm

Scar Inhibitors

- Mitomycin C
  - Antimetabolite of *Streptomyces caespitosus*
  - Possesses antineoplastic and antiproliferative properties
  - Inhibits fibroblast proliferation *in vivo* and *in vitro*
  - Mechanism may involve triggering of fibroblast apoptosis
- 5-FU & B-aminopropionitrile
  - Inhibit collagen cross-linking and scar formation in animal models
- TGF-β

SGS Comparison Study

- Shapshay (2004)
- Retrospective cohort study
- Compare efficacy of 3 endoscopic techniques
  - CO2 laser with rigid dilation
  - CO2 laser, rigid dilation, steroid injection
  - CO2 laser, rigid dilation, topical Mitomycin C application

SGS Comparison Study

- Endoscopic treatment
  - CO2 laser radial incision (Shapshay)
    - 15% success
  - CO2 laser with steroid injection
    - 40 Kenalog in 3 quadrants
    - 18% success
  - CO2 laser with mitomycin-C topical application
    - 0.4 mg/ml Mitomycin-C topically applied 4 minutes
    - 75% success

Table 2. Treatment results

Procedure	Total procedures	# With successful outcome	% With successful outcome
CO_2 laser	20	3	15%
CO_2 with steroid injection	11	2	18.2%
CO_2 with mitomycin-C	16	12	75%

Mitomycin C Metanalysis

Table 1
Summary of literature review

Study type	Human	Animal
Total number of studies	8	12
Average sample size (range)	17.4 (5-36)	28.4 (5-60)
Mean dose	0.96 mg/mL	3.6 mg/mL
Mode application time	4 mins	5 mins
Follow-up time	3-60 months	3-10 weeks
Controlled studies	2	11
Positive outcome	7	9

Note: Lone human dissenting study was highest quality randomized clinical trial

Warner and Brietzke (2008)

TGF-β

- TGF-β: GF secreted by fibroblasts, macrophages and platelets
- Implicated in scarring in many different organ systems and in animal models
- Biopsy specimens of IPSS and intubation related stenosis patients show high levels of TGF-β-2
- IV and local injection of an antibody available
  - Used to treat fibrosis in skin, ureters, kidney and eye
  - Recent study showed inhibition of scarring in rat trachea with continuous infusion of anti-TGFβ

TGF-β

Simpson CB et al (2008)

Pilot Study in Modified Canine Model

8 subjects underwent cautery injury to subglottis

4 treated with saline injection into injury site

4 treated with combination of IV and local injection of anti-TGFβ at day 0 and day 5

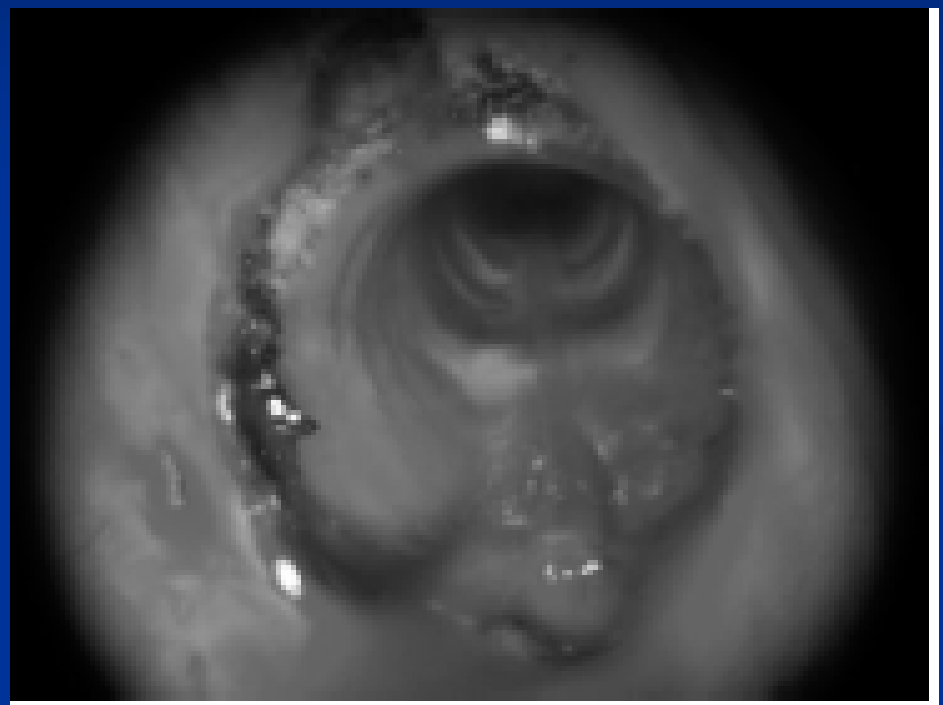


Fig. 1. Circumferential cautery injury to subglottis.

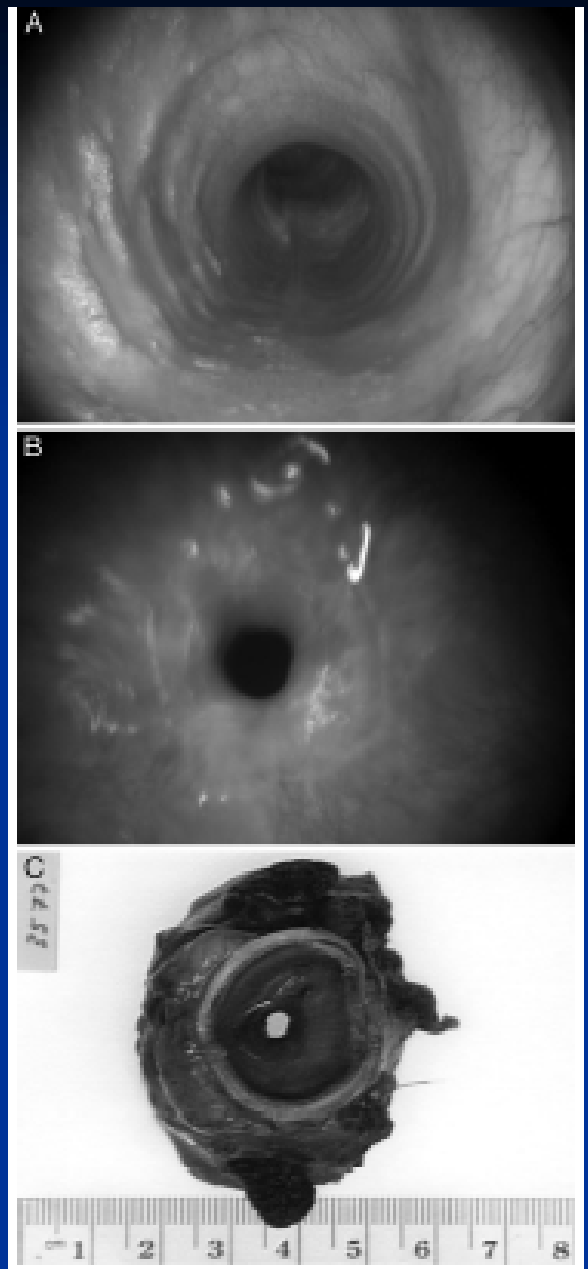


Fig. 2. (A) Preoperative saline control subject, (B) sacrificed saline control subject, (C) postmortem saline control subject.

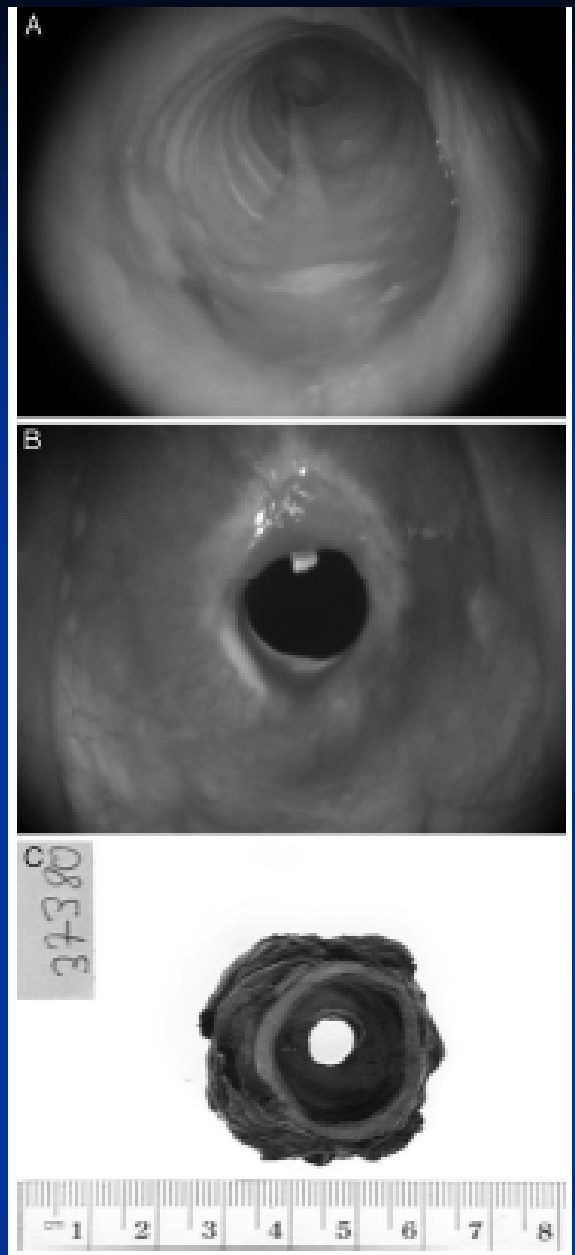


Fig. 3. A preoperative antitransforming growth factor beta (anti-TGFB) subject, (B) sacrificed anti-TGFB subject, and (C) postmortem anti-TGFB subject.

TABLE I.
Measurements of Tracheal Stenosis in Subjects.

Group	Initial Area (mm^2)	Final Area (mm^2)	Stenosis (%)	Endpoint (Day #)
Saline	226	5	98	19
Saline	283	11	96	20
Saline	226	14	94	19
Saline	254	9	96	19
Anti-TGFB	254	35	86	21
Anti-TGFB	283	27	90	21
Anti-TGFB	314	14	96	21
Anti-TGFB*	283	13	95	15

*Excluded animal.
Anti-TGFB = antitransforming growth factor beta.

TGF-β

- Conclusions:
  - IV and local TGFβ injection resulted in a reduction in tracheal stenosis ($p < .05$) and an increase in survival time ($p < .03$) when compared to saline control subjects
  - Anti-TGFβ appears to be useful adjunct in treatment of LTS
  - Further study needed to determine optimal dosing, route of administration and timing of delivery

SGS Balloon Dilation

- Dilation of bronchtracheal stenoses with angioplasty balloons described previously in adults and children +/- stents
- Advantage compared to rigid or bougie dilation
  - Balloons maximize the radial direction and pressure of dilation
  - Less damaging to tracheal wall mucosa
  - Found to have good initial results
    - Often requires stenting of dilated portion
    - Repeated procedures necessary in active processes, e.g. Autoimmune States

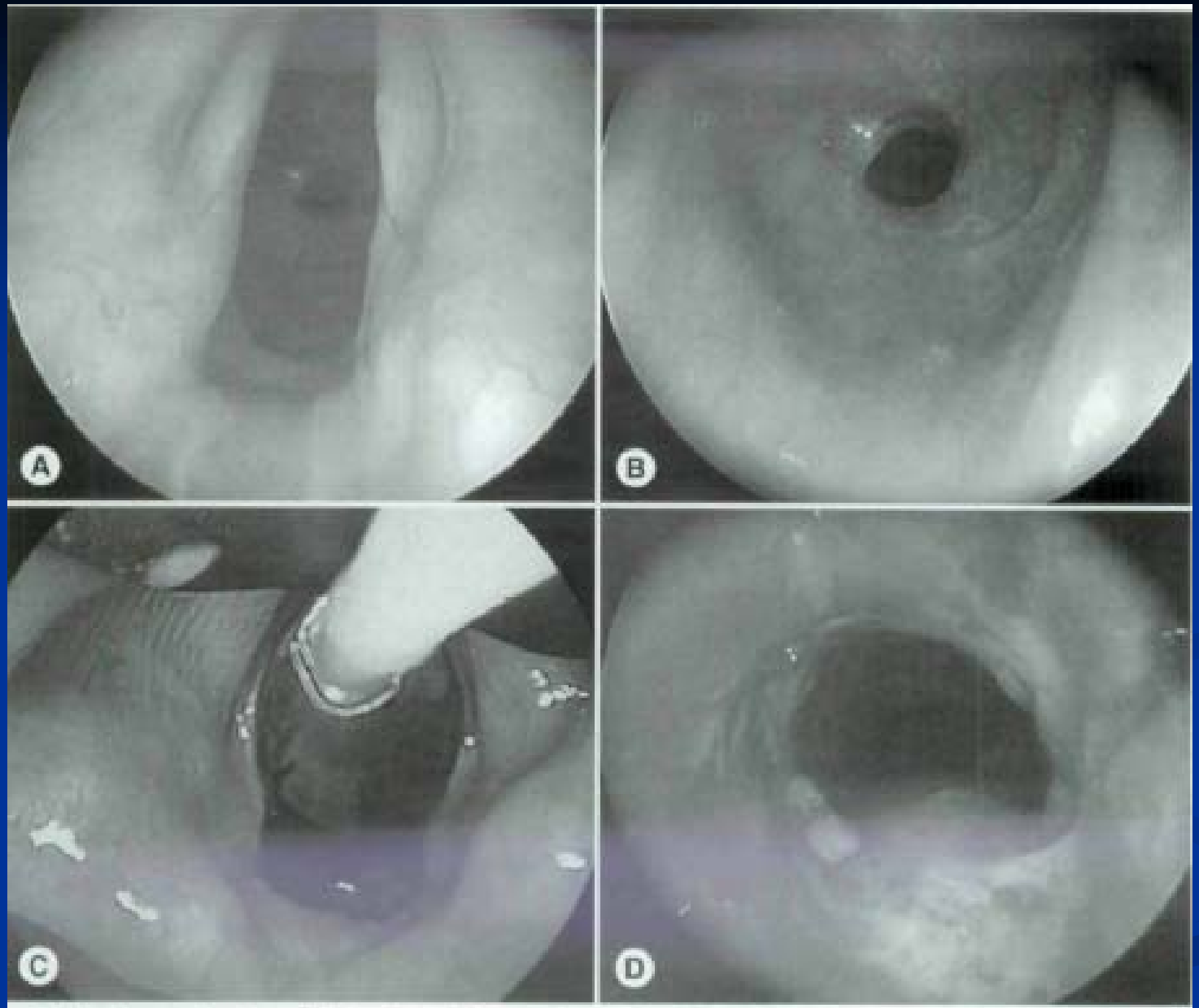
SGS Balloon Dilation

- **Lee and Rutter (2008)**
- 6 patients with IPSS (single discrete stenosis)
- Underwent dilation with 10 to 14 mm balloon in either single or 2 consecutive dilation (in 7 days)
- F/u between 10 and 30 months in 4 patients
  - No symptoms of recurrent airway stenosis
  - One patient required repeat dilation after 22 mos
  - No adverse effects or complications
  - Recommended burst pressure (8 to 17 atm)
  - 4 cm long catheters, center of balloon positioned at midpoint of stenosis
  - **Airway dilated from 2.0 to 3.5 ET size larger than initial size**

PATIENT DATA

Patient	Sex	Age (y)	Procedure Date	Balloon Size (mm)	Airway Endotracheal Tube Size: Before Procedure	Airway Endotracheal Tube Size: After Procedure
1	F	44	Dec 14, 2006	12	3.0	7.0
			Apr 13, 2007	12	4.0	6.0
2	F	60	May 31, 2006*	10	5.0	6.0
			Jun 5, 2006*	14		7.0
3	F	56	Nov 26, 2004	10	2.5	6.5
			Sep 14, 2006	12	4.0	7.0
4	F	41	Apr 27, 2006*	10	3.5	6.0
			May 1, 2006*	12	6.0	6.5
5	F	45	Oct 14, 2004	12	3.0	6.0
6	F	60	Oct 16, 2006	10	4.5	6.5
			Nov 9, 2006	14	6.0	7.0

*Sequential initial treatments done within 7 days.



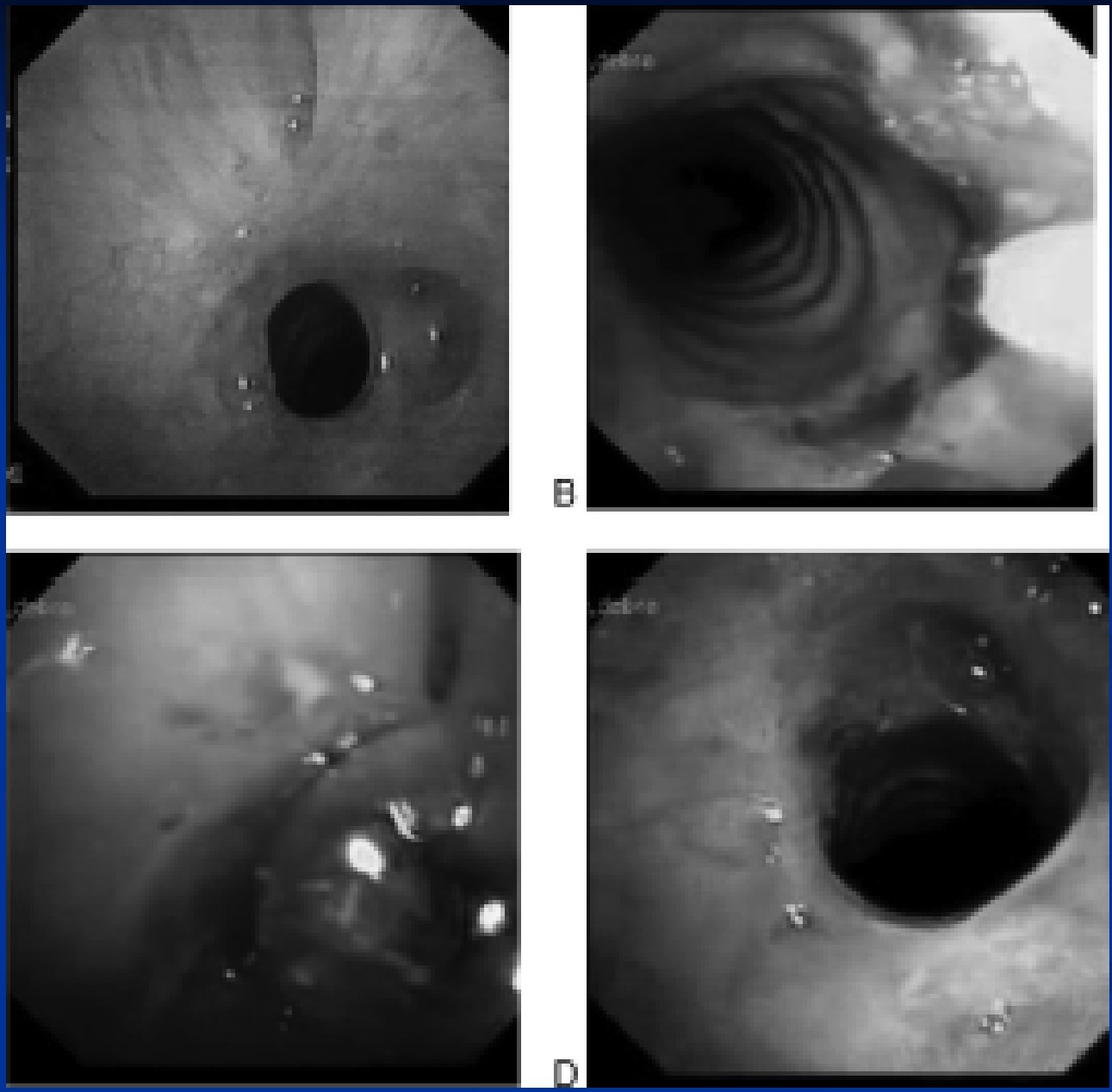
Subglottic stenosis prior to dilation shows 2.5-mm endotracheal tube–sized airway from **A)** glottic and **B)** subglottic views. **C)** 10-mm Balloon in position during dilation. **D)** Postdilation view of stenotic area, now accommodating 6.5-mm endotracheal tube.

Combined Laser & Balloon Dilation

- Andrews et al (2007)
- Performed flexible bronchoscopy for combined Nd:YAG laser radial incision at site of stenosis and balloon dilation in awake, spontaneously breathing patients
- Total of 18 patients underwent 36 procedures
  - 8 pts required only 1 procedure; 5 pts required 2 procedures (72%)
  - 11/18 patients (60%) were obese or morbidly obese
  - Average f/u 22 mos; avg time b/w procedures 9 mos
  - No complication in study group

TABLE I.
Patient Demographics.

Subject	Gender	Age	Body Mass Index (BMI)	Etiology	Procedures
1	F	40	38.2	Idiopathic	3
2	M	74	20	Radiation	4
3	F	50	26.4	Idiopathic	1
4	F	29	24.2	Wegener's	1
5	M	28	33	Wegener's	3
6	F	62	28.2	Idiopathic	1
7	F	48	31.6	Idiopathic	5
8	F	49	29.7	Idiopathic	3
9	F	70	38.7	Idiopathic	2
10	M	68	42.2	Iatrogenic	1
11	F	39	35.2	Iatrogenic	2
12	F	30	21.5	Idiopathic	1
13	F	64	40.6	Iatrogenic	2
14	F	35	32	Idiopathic	2
15	F	47	40.7	Idiopathic	1
16	F	66	32.8	Idiopathic	1
17	M	55	41	Iatrogenic	1
18	F	29	20.8	Inhalation	2

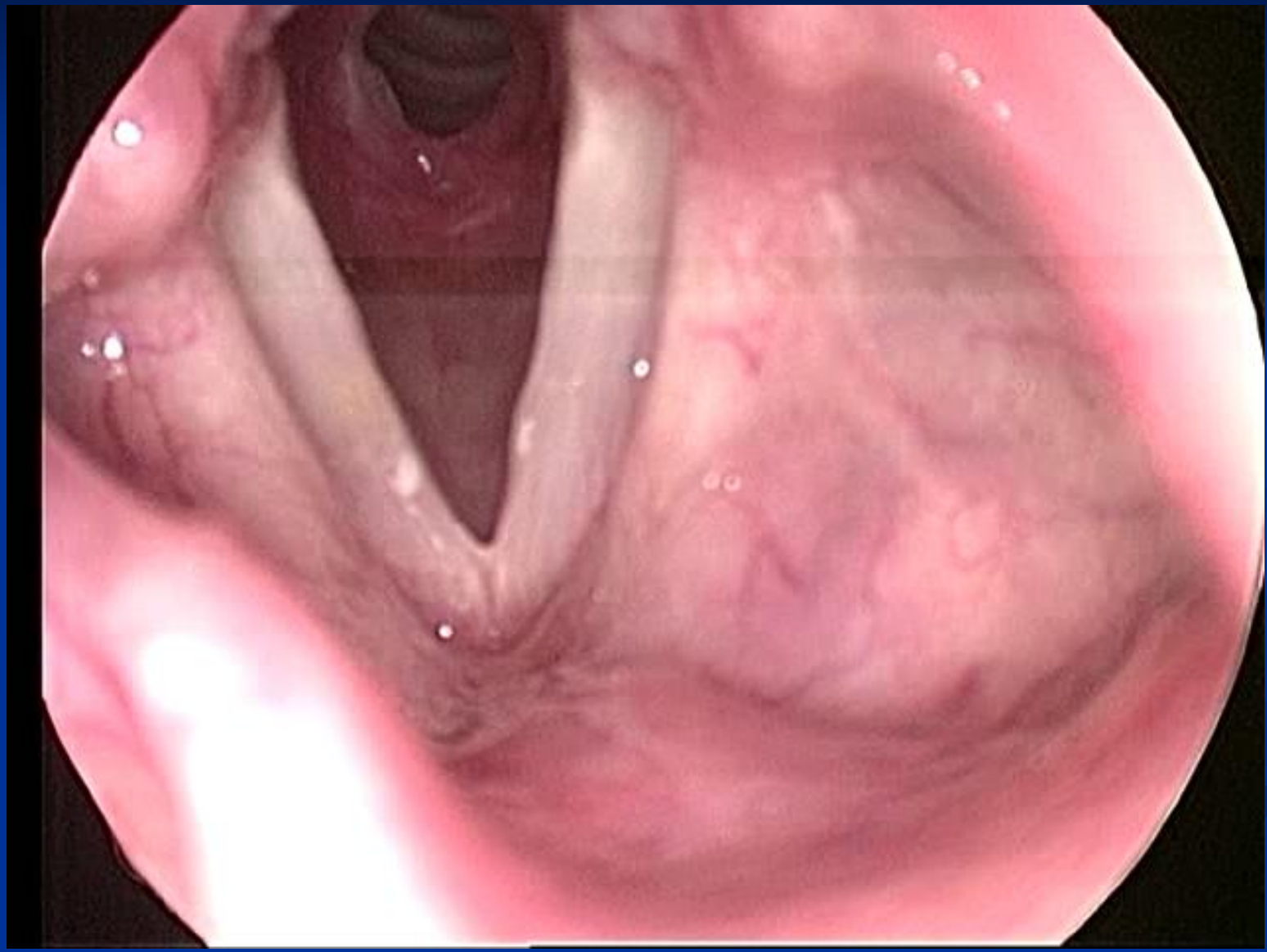

B
D

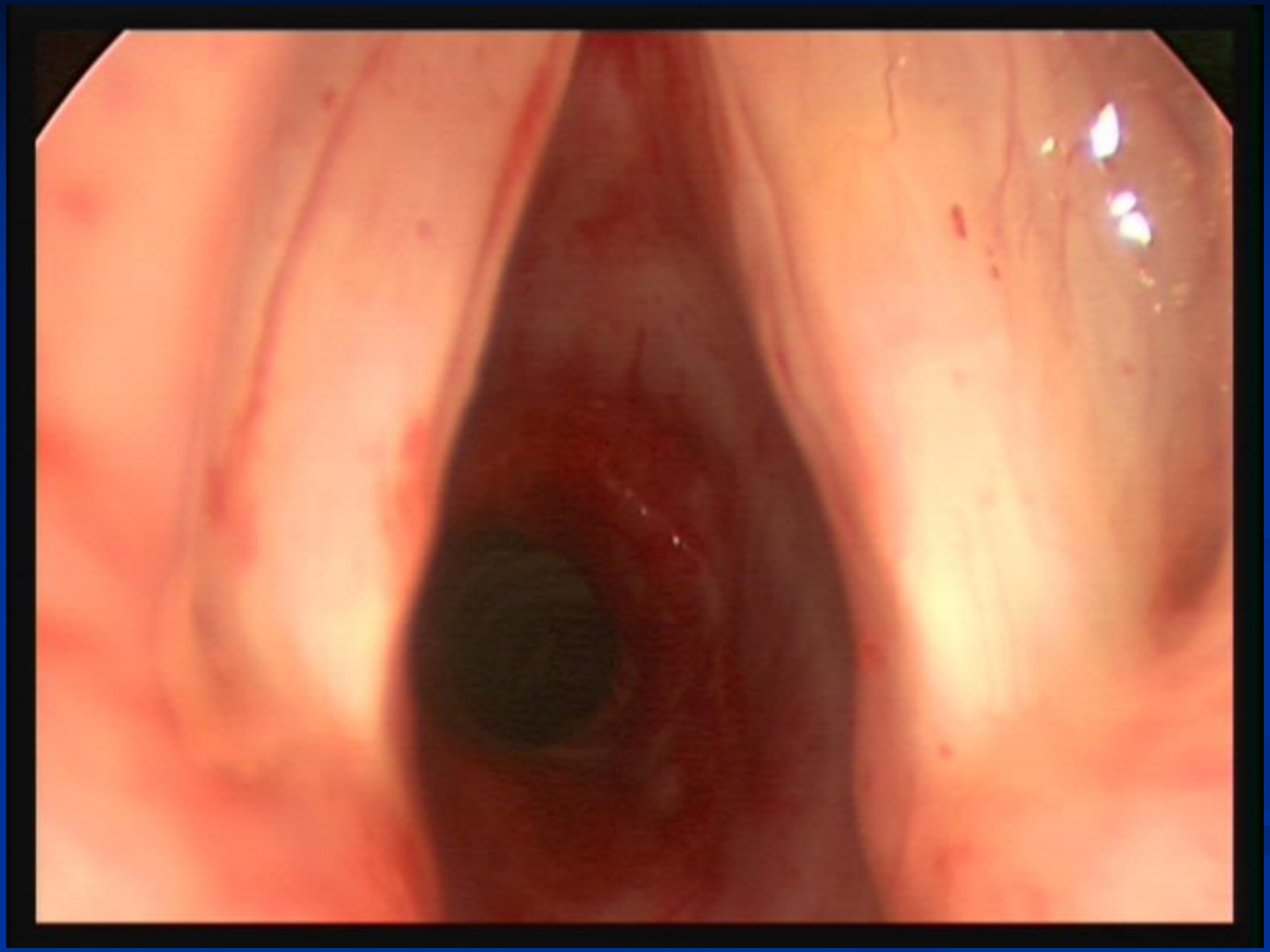
Case Example

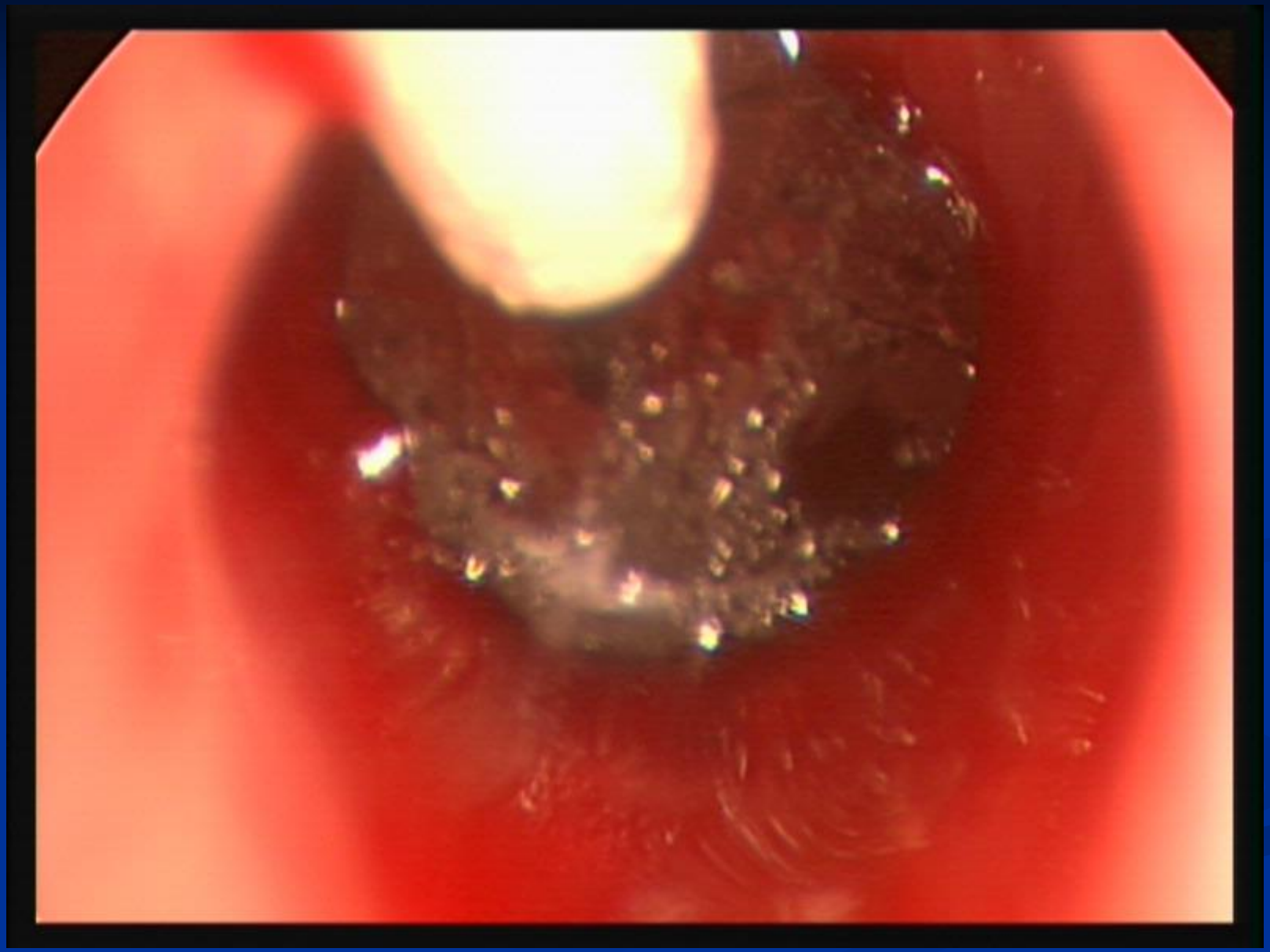
- 58-year-old female with several month history of hoarseness
  - Also has a history of asthma
  - Recent PFTs showed no evidence for asthma.
  - Also had a diagnosis of gastroesophageal reflux disease and feels that her hoarseness has been contributed by the reflux disease
  - Intermittent dysphagia

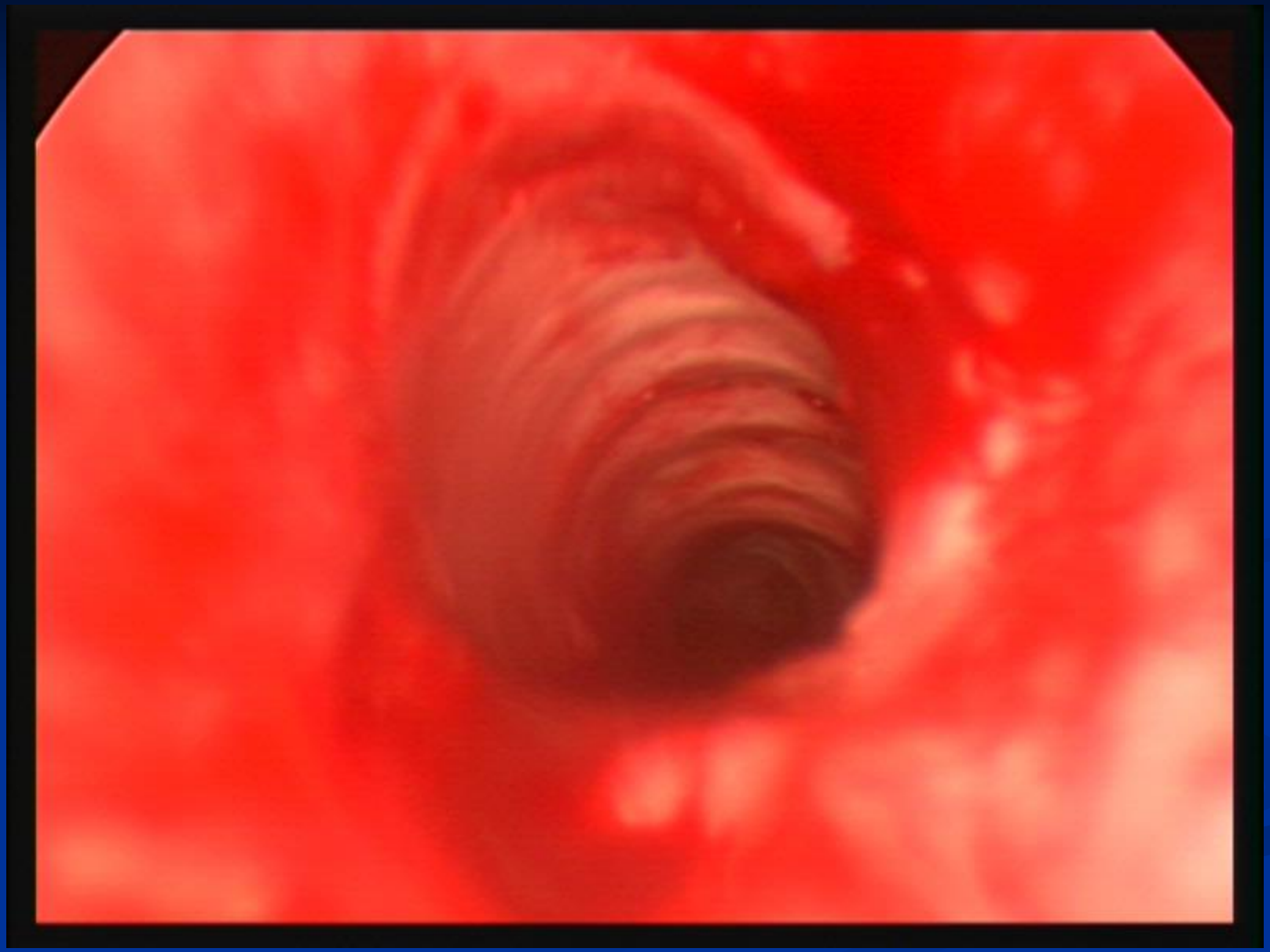
Case Example

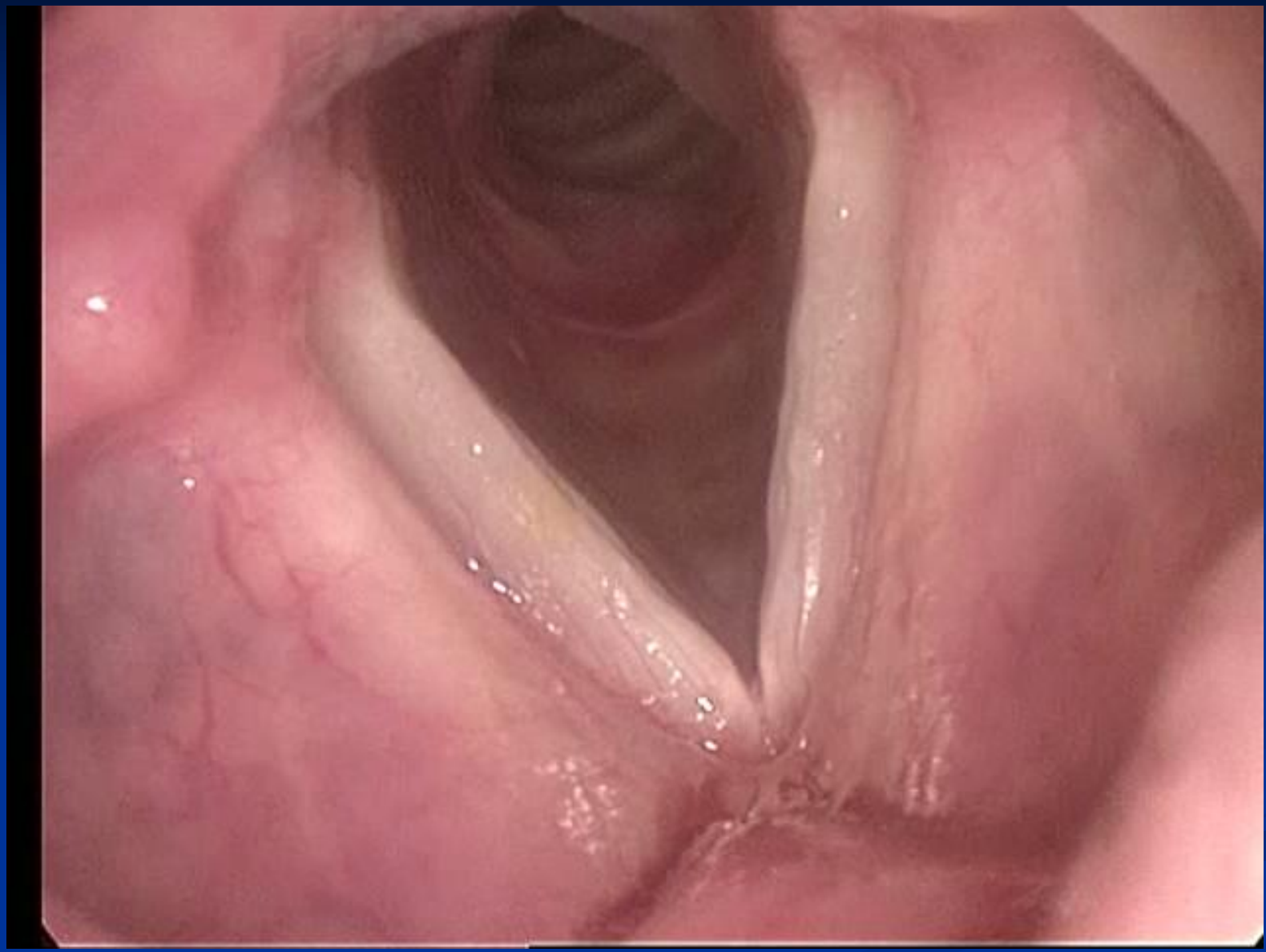
- Laryngo video stroboscopic exam was performed: shows normal vocal fold mobility bilaterally
- Presence of mild nodular thickening of the left anterior vocal cord surface
- More significantly there is approximately 50% stenoses of her subglottic airway at the level of the cricoid cartilage and erythema of this area











Endoscopic Balloon Dilation