Management of Benign tracheal stenosis

25/7/2014

Anatomy

- Begins at inferior border of cricoid at C6 till T4-T5
- 11 cm in length. 15-20 cartilages
- Tracheal rings receive blood supply from submucosal plexus and hence at risk of necrosis from ET/TT cuffs
- Diameter in males > females
- Coronal and sagittal: male 25 and 27 mm, female 21 and 23 mm
- Stridor at rest would indicate <30% normal lumen or 5mm diameter or less

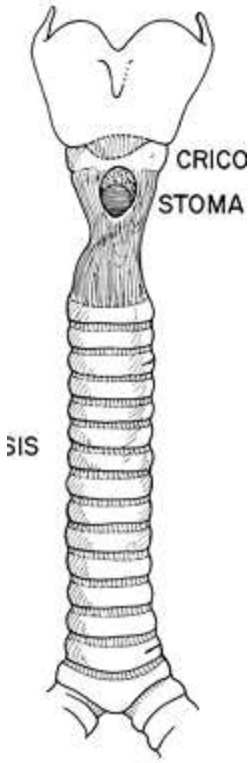
Salassa JR et al. Ann thoracic surg 24:100-107, 1997

Wain JC et al. Sem in Thorac cardiovasc Surg. 21: 284-289

Etiology

- Post intubation tracheal stenosis
- Post tracheostomy tracheal stenosis – suprastomal
    - Stomal strictures
    - Stricture at the level of the cuff
- Granulomatosis with polyangitis, relapsing polychondritis
- Sarcoidosis, tuberculosis, amyoidosis
- Stenosis at surgical anastamotic sites
- Idiopathic

ET/TT cuff related
3-4 cm from cricoid
Respond well to radial dilatation (transient)



LTS due to a tracheostomy too high in trachea

Might respond to dilatation, but risk of airway edema and worsening

Type of stenosis

- Structural and benign
- Degree of stenosis: Myer-cotton grading I up to 50% stenosis, II 50% - 70%. III 70-99%, IV complete (100%)
- Location of stenosis – upper, mid and lower trachea. Right and left main bronchus
- Complex stenosis – stenosis along with cartilage fracture or tracheomalacia, tortuous strictures, those with contractions
- In complex stenosis endoscopic management is difficult

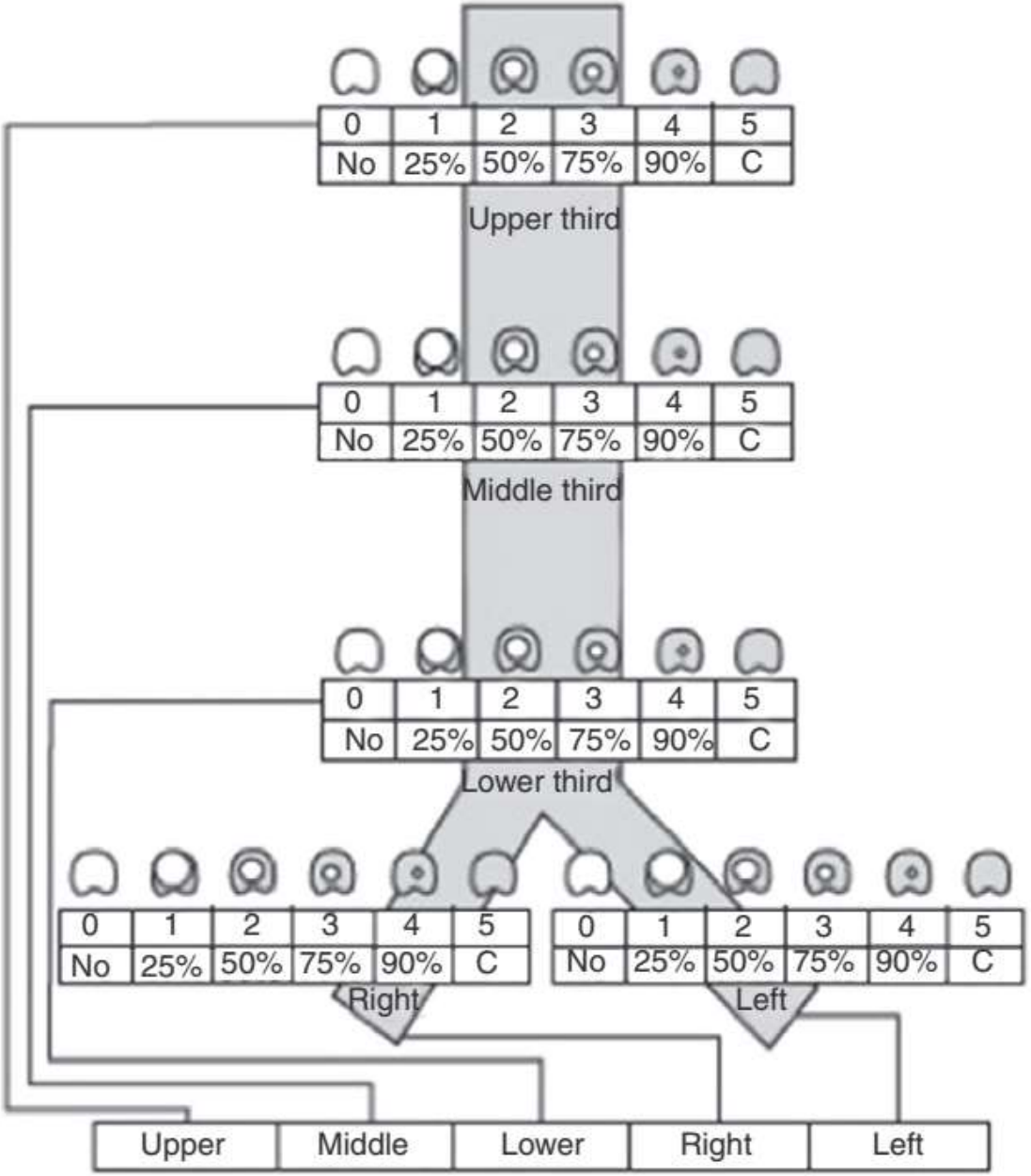
Barros Casas D, et al. Arch Bronconeumol. 2014;50(8):345–354
Freitag L et al. Eur Resp J 2007; 30: 7-12

Classification of stenosis

Stenosis	Type	Character
Structural	1	Exophytic/intraluminal
	2	Extrinsic
	3	Distortion
	4	Scar/stricture
Dynamic or functional	1	Damaged cartilage/malacia
	2	Floppy membrane

	Location
I	Upper third of the trachea
II	Middle third of the trachea
III	Lower third of the trachea
IV	Right main bronchus
V	Left main bronchus

Freitag L et al. Eur Resp J 2007; 30: 7-12



Freitag L et al. Eur Resp J 2007; 30: 7-12

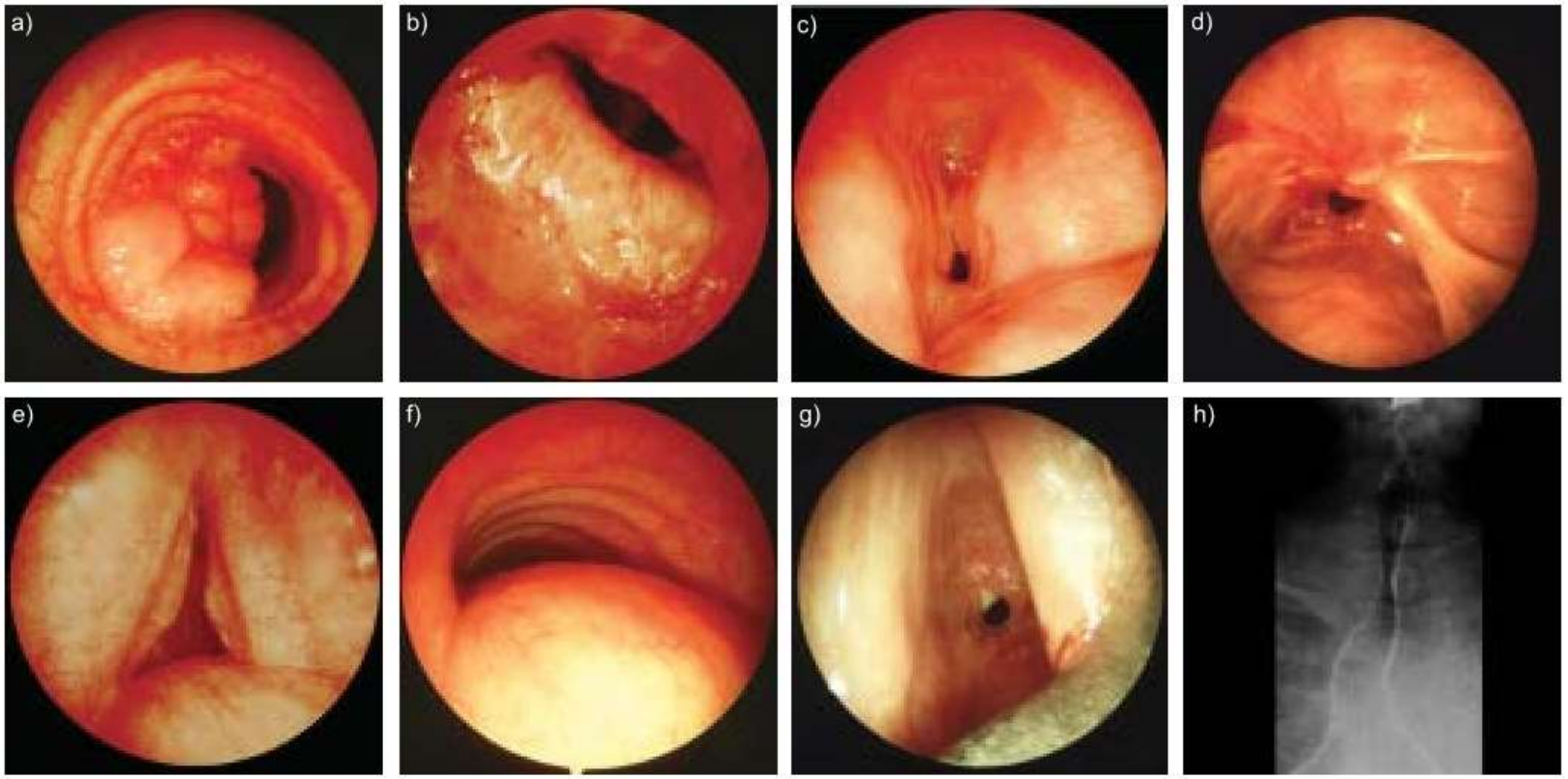


FIGURE 2. Clinical examples of the degrees of stenosis. a) Intraluminar tumour or granulation; b) distortion or buckling; c) extrinsic compression; d) scar stricture; e) scabbard trachea; f) floppy membrane; g) abrupt transition (web stenosis); h) tapered transition (hour glass stenosis).

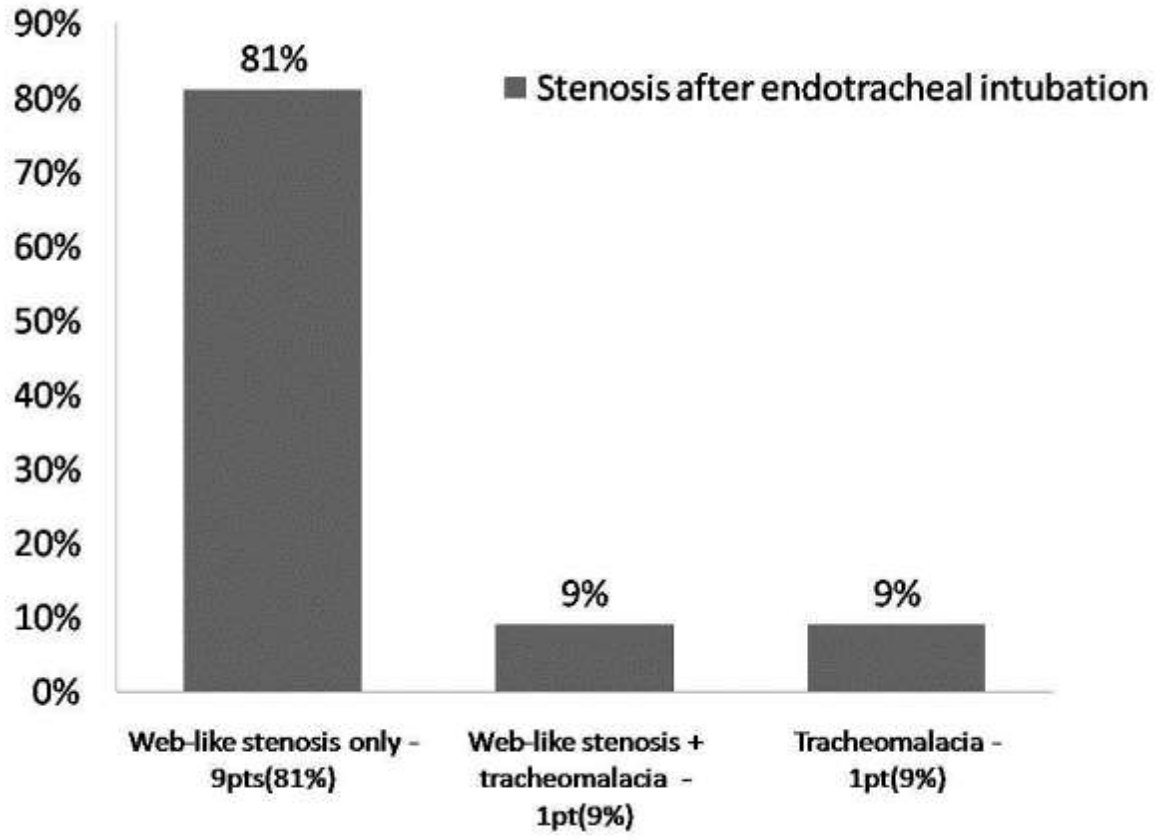


Figure 2
Site and type of the stenosis in the post intubation group.

Zias N et al. BMC Pulmonary Medicine2008, 8:18

Post tracheostomy stenosis

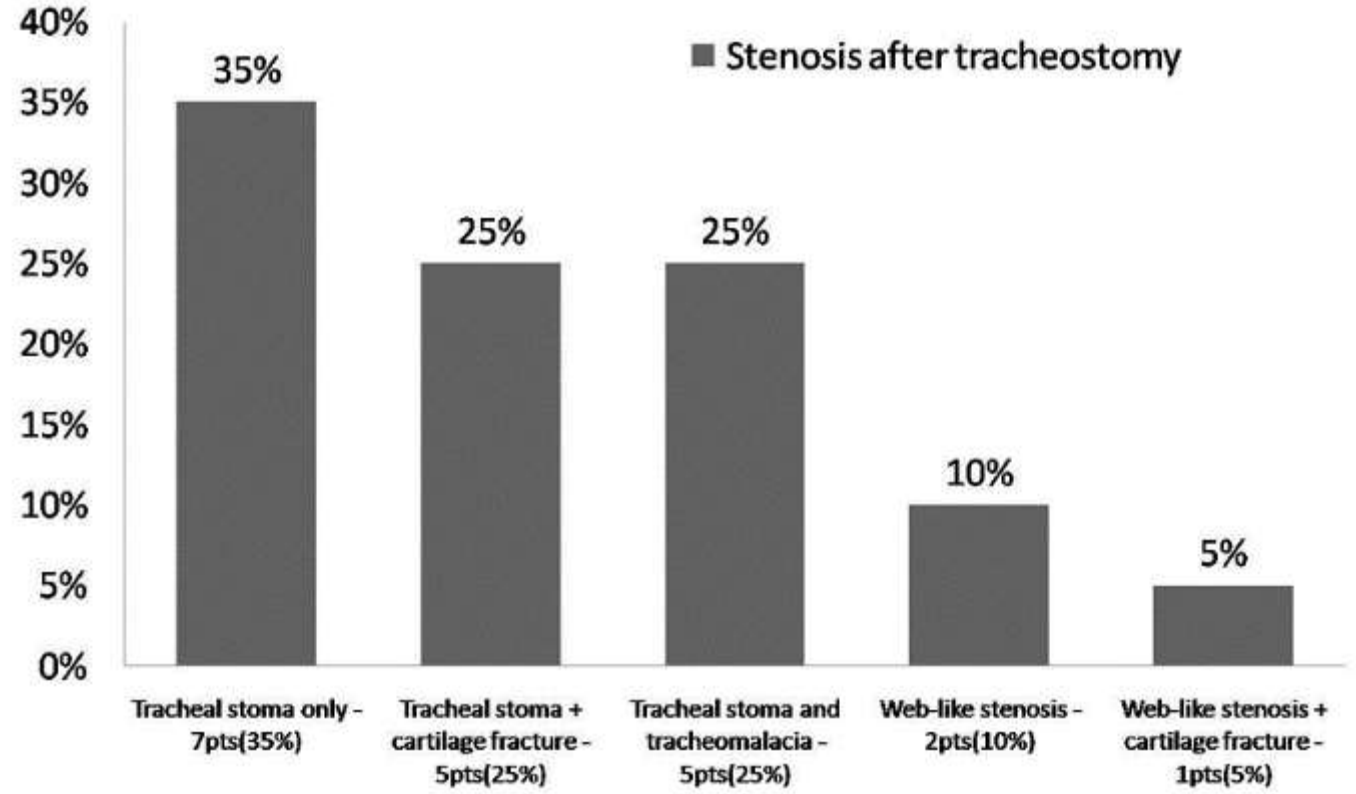


Figure 1
Site and type of the stenosis in the post tracheostomy group.

Zias N et al. BMC Pulmonary Medicine2008, 8:18

Post tracheostomy stenosis Percutaneous (PCT) vs. surgical (SGT)

PCT group

- Stenosis closer to vocal cord 1.6 cm
- Mean time to onset of symptoms 5 weeks
- Subglottic location makes surgery a difficult option

SGT group

- Distance from vocal cord 3.4 cm
- Time of presentation, mean of 28.5 weeks
- Surgical correction possible

Raghuraman G et al. Chest 2005 Mar;127(3):879-85

How to assess?

- PFT: not evident till tracheal lumen <10 mm.

  Flattening of expiratory and inspiratory limbs may be noted[1]
- CT and virtual bronchoscopy[2]
- Flexible bronchoscopy
- Myer-Cotton system
- Stenotic Index (SI) = CSA_{normal}-$CSA_{abnormal}$/CSA_{normal} × 100

  CSA cross sectional area

[1]Acres JC, et al. Chest. 1981;80:207–11
[2] Taha MS et al. Eur Arch Otorhinolaryngol. 2009;266:863–6

Surgery for PITS

- Surgery has been considered treatment of choice, whenever feasible
- Reported success rate >90% , failure ranging from 5 to 15%
- Mortality up to 5%
- Data from India are limited, 92.85% success at the anastomotic site at 2 years follow up has been reported*

Grillo HC, et al. J Thorac Cardiovasc Surg 1995;109(3):486—92
Rea F, et al. Eur J Cardiothorac Surg 2002;22:352—6.
Ciccone AM, et al. Eur J Cardiothorac Surg 2004;26:818—22
*Nandakumar R. J Laryngol Otol. 2011Sep;125(9):958-61

Inoperable cases

- Excessive length of damaged airway
- Comorbid illness precludes surgery
- Some complex injuries involving larynx as well as trachea
- Reasons for delaying surgery – active inflammation, use of high dose steroids etc.

Bronchoscopic management

- Contraindications to surgery
- Temporary measure prior to surgery
- As a complement to surgery and in post operative stenosis
- As a primary therapy

Non surgical management of stenosis

- Dilatation with balloons, bougies, an dilators
- Laser resection (Nd:YAG)
- CO_2 Laser resection
- Covered and uncovered metal stents insertion
- Self-expandable silicone stents
- Silicone stents
- Montgomery T tube insertion

Balloon bronchoplasty

- Silicone balloons
- High pressure syringe required to carry out the procedure
- Determine the length of the stenosis prior to dilatation
- Can be done with flouroscopic guidance with a skin marker to know the site of stenosis
- Catheter is positioned in such a way that 0.5 cm of balloon is visible proximally
- Usually 2 to 3 inflations 30 seconds each

John R Mc Ardle et al. J Bronchol 2005;12:123–127

John R Mc Ardle et al. J Bronchol 2005;12:123–127

Reference	Population	Methods	Outcome	Comments
Shitrit D, et al. Eur J Cardiothoracic Surg. 2010 Aug;38(2):198-202	Retrospective study 35 patients, 92 balloon dilatations (14 transplant recipients, 14 other benign, rest were malignant)	Flouroscopy guided, done with flexible bronchoscopy Guidewire passed through stenotic segment, f/b dilatation*	Immediate improvement and maintained up to 1 month 25 of 35 (71%) required stent	Long term follow up 33+/- 4 months 6 atm pressure for 10 s
Mayse ML et al. Chest 2004 Aug;126(2):634-7	Retrospective 24 patients (benign diseases)	No flouroscopy Rigid (RB) 61% FB 39% Desired pressure maintained	Mechanical debridement 68% Stent 47% Laser 19%	26% only balloon bronchoplasty No follow up

- Balloon dilatation has been done with flexible[1] as well as rigid bronchoscopies
- 4/7 required repeated procedures including deployment of stent in one patient[1] (30 to 120 s inflation time)
- Has been used in post lung transplant patients with stenosis.[2] Immediately effective in a study of 10 patients, 5 of them subsequently required stent

[1]Sheski FD et al. Chest. 1998 Sep;114(3):796-800
[2]De gracia J et al. Respir Med. 2007 Jan;101(1):27-33. Epub 2006 Jun 13.

Flexible bronchoscopy alone

- For patients with comorbid illness, where surgery or few other interventions requiring GA can be avoided
- Majority were subglottic stenosis (81 of 115) and were web like (97 of 115). 56 had >50% stenosis
- Balloon bronchoplasty, NdYAG laser for granulation tissue
- When 3 or more intervention in 6 months, high dose rate (HDR) brachytherapy with 10 Gy was given
- Cumulative survival rates at 1, 2, and 5 years : 80%, 73%, and 62% respectively

Rahman NA. J Cardiothorac Surg. 2010 Jan 17;5:2

NdYAG laser

	Population	Intervention	Outcome	Complications
1994 Study from India[1]	35 benign tracheal stenosis 1.Stomal 80% (n-28) 2. Subglottic 14.3% (n-5) 3.Laryngeal stenosis 5.7% (n-2)	Laser photocoagulation of scar tissue (Nd:YAG) Mean 2.8 procedures per patient	Adequate lumen in 29 patients (83%) *All 5 subglottic stenosis patients had unsuccessful procedure* Mean 23 month follow up, only one patient required surgery	Total 3 cases (8.5%) Bleeding in 2, Cervical emphysema in 1

[1]Rau BK et al. Ann Acad Med Singapore. 1994 May;23(3):333-4.

NdYAG laser

	Population	Intervention	Outcome	Complications
Mehta AC, et al. Chest 1993; 104:673-77	18 patients Laser applied twice and if fails, more definitive therapy	Laser photocoagulation of scar tissue (Nd:YAG) And GD (gentle dilatation)	12 successful 8 of which required only 1 session	> 1cm scar and tracheomalacia in those who failed (difficulty in surgery)

[1]Rau BK et al. Ann Acad Med Singapore. 1994 May;23(3):333-4.

Other lasers

- CO_2 lasers can be used to give precise radial incisions, used in ENT
- Nd-YAG laser is preferred for airway resection because of its predictable effects on living tissue (*i.e.* photocoagulation or vapourization), depending on the amount of energy applied
- FiO_2 to be kept <40%
- Not to be used in extrinsic compression

ERS/ATS statement on interventional pulmonology. ERJ 2002

Other LASER

TABLE 1 Laser equipment for bronchoscopic applications

Type of laser	Wavelength nm	Biological effects	
		Vaporisation	Coagulation
Nd-YAG	1064	+++	+++
CO_2	10600	+#	-
Argon	488–514	-	++
Dye	360–700	Activate photochemicals	
Diode	810	+	++
Excimer	193–351	Tissue destruction by mechanical effect	
YAP-Nd	1340	?	++

Nd-YAG: neodymium:yttrium aluminium garnet; CO_2: carbon dioxide; YAP-Nd: yttrium aluminium pevroskite:neodymium. +: moderately good; ++: good; +++: excellent; ?: doubful effect. #: precise cutting effect.

CT Bolliger et al. Eur Respir J 2006; 27: 1258–1271

Electrocautery

- Electrical current for tissue heating is called diathermy/electrocautery
- Various probes can be used: biopsy forceps, knives, cutting loops, blunt probes etc. to deliver
- Mainly used for palliative therapy in malignant tracheal obstruction. Can be used in benign as well
- Similar effectiveness as compared to NdYAG laser

CT Bolliger et al. Eur Respir J 2006; 27: 1258–1271

Electrocautery

- As compared to Nd YAG, electrocautery and Argon Plasma Coagulation (APC) act superficially
- When deep coagulation is preferred – LASER; for superficial APC and electrocautery
- Deep anticoagulation not preferred: when blood vessels are nearby, surgically treated patients with altered anatomy

Advantages

- Cost effective (compared to LASERs). Both APC and electrocautery are much cheaper
- Less electrical energy
- Can be done with flexible bronchoscopy

van Boxem TJ, et al. Chest 2000; 117:887–891.
Hooper RG, et al.Chest1985; 87: 712–714

Argon Plasma Coagulation(APC)

- Ionized Argon gas jet flow is used instead of alternating current (electrocautery) to cause flow of electrons
- Shares the same indications and advantages of electrocautery
- It causes homogenous and diffuse tissue coagulation, by spraying larger surface areas
- Apart from treating early stage cancers, useful in management of granulation tissue and web like stenosis

CT Bolliger et al. Eur Respir J 2006; 27: 1258–1271
Grund KE, et al.Endosc Surg Allied Technol1994; 2: 42–46.

Mitomycin C

- Anthracycline antibiotic. Alkylating agent which inhibits DNA synthesis.
- Usually used along with CO_2 laser and rigid bronchoscopic dilatation
- 0.4 to 1 mg/mL has been used in various studies
- Not much useful, but can delay restenosis to a certain extent

Madan K et al.J Bronchol Int Pulmonol. 2012

Intralesional steroid

- Intralesional steroid along with balloon bronchoplasty in 10 patients, found effective at 7 months follow up
- No long term data available

Nouraea SA et al. Otolaryngol Head Neck Surg. 2011 Oct;145(4):623-7

Airway stents

- Named after C.R. Stent who invented a compound to cast dental splints

Classification of airway stents

- Based on the *material* used : *polymers and metals* (hybrid stents are an exception, metal stents covered with silicone and metal-enforced polymer stents)
- Based on *method of deployment* : by rigid or flexible instruments
- Based on *positioning* : T-tubes (require tracheostomy), straight stents (held in place by the contact pressure), bifurcated stents (placed over the carina)

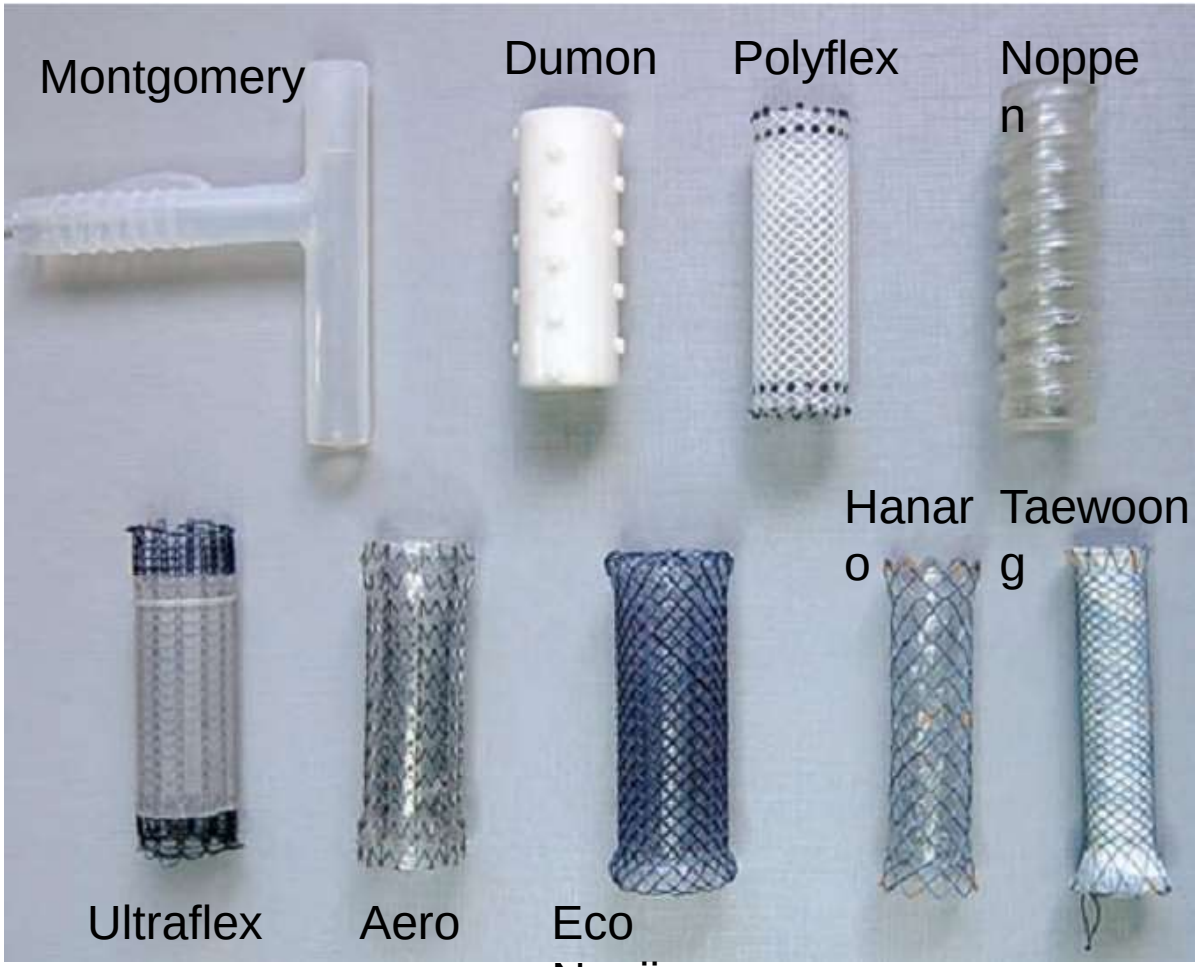
Freitag L. Airway stents. Eur Resp Monograph 2010

T-Tubes

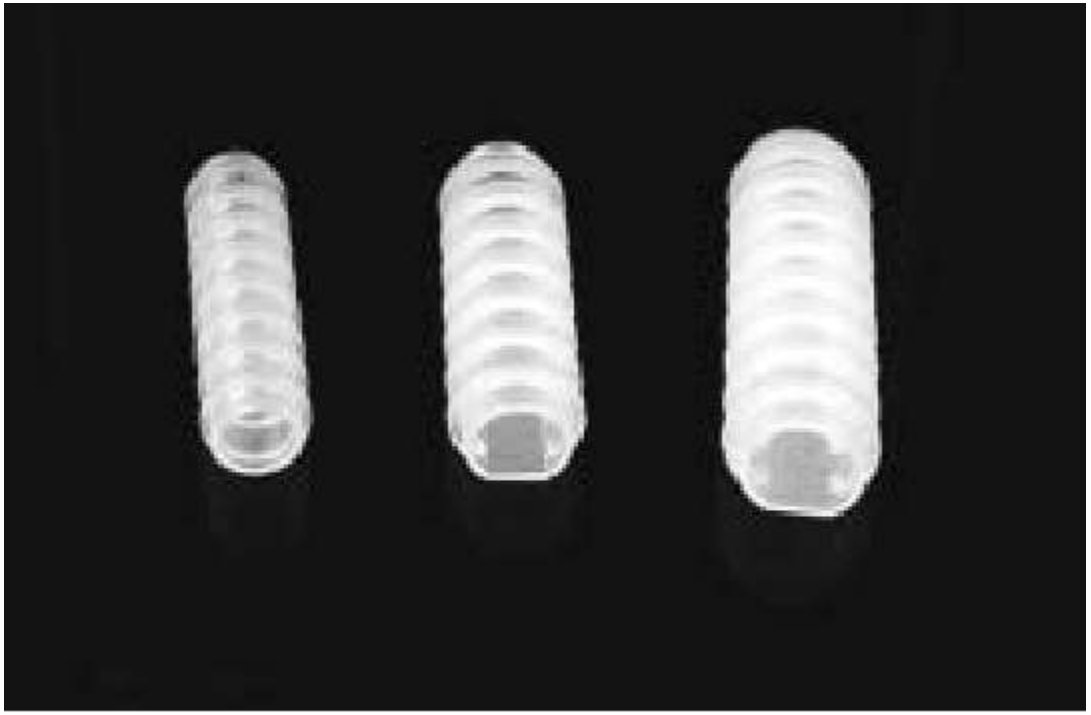
- Different diameters and lengths of the three limbs available
- Can be used in tracheal stenosis even up to vocal cords level
- Voice and humidification can be preserved
- Migration unlikely to occur
- One of the safest stents for very high tracheal/subglottic stenosis

Carretta A,et al.Eur J Cardiothorac Surg 2009; 36: 352–356

Straight stents



Freitag L. Airway stents. Eur Resp Monograph 2010



Ryu RJ et al,Eur Respir J 2006; 28: 1029–1035

Natural stents:

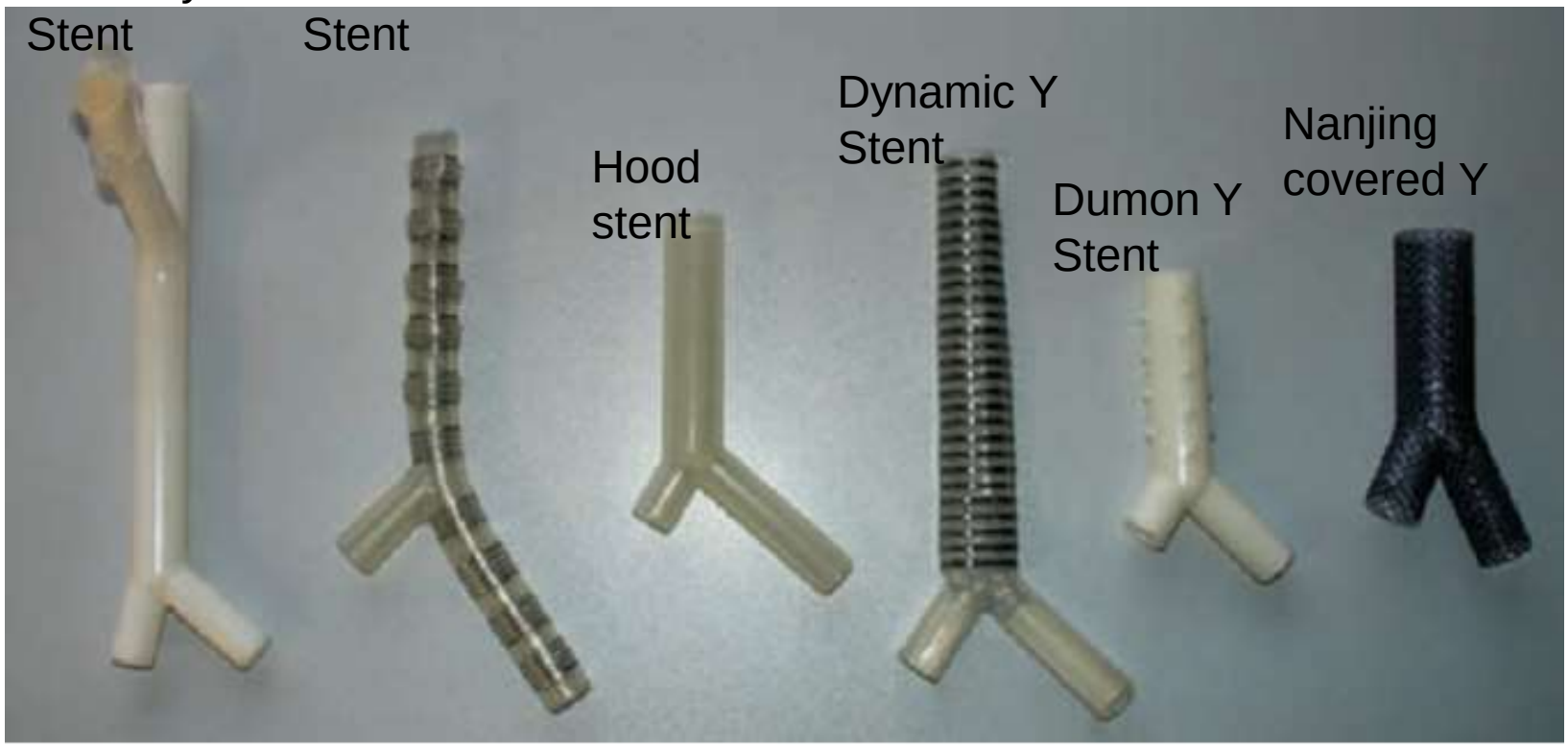
Silicone straight stents (Samsung Medical Center)
Has“C” circular studs on its
outer surface

mimics the posterior membrane of the trachea

increase stent-to-wall contact

maintain physiological airway constriction and dilation.

Bifurcated stents



Freitag L. Airway stents. Eur Resp Monograph 2010

Biodegradable stents

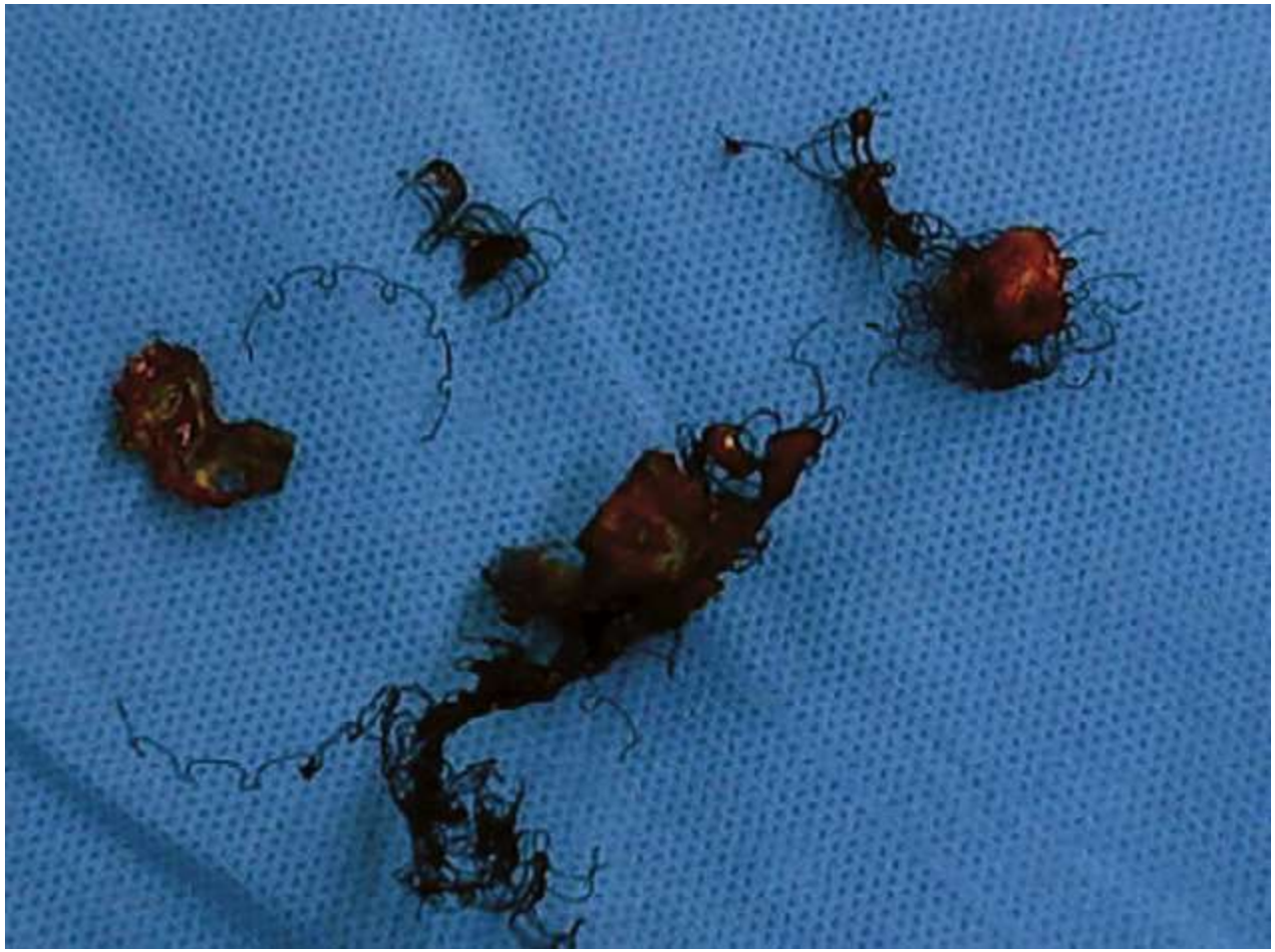
- Post lung transplant, 7 anastomotic complications in 6 patients over 6 years (stenosis – 5, malacia 2)
- Biodegradable polydiaxanone stents deployed over guide wire
- Stents dissolved by an average of five months
- 4 of 6 patients developed restenosis requiring re-stenting
- 50% patient stent free at one year and doing well

Lischke R, et al. Eur J Cardiothorac Surg 4:619-624, 2011

Expandable stents–poor outcomes

Reference	Population	Intervention	Complications	Follow up
Nashef SA et al. Ann Thorac Surg. 1992 Nov;54(5):937-40.	15 patients total Pure stenosis - 6 Fibroinflammatory stenosis – 4 Malacia 5	Expanding wire stents	Granulation tissue in 12 (removal of stent in 3)	13 months follow up 9 had stents in situ, doing well
Eller RL. Ann oto Rhino; Laryngol. 2006 Apr; 115(4):247-52	16 benign stenoses (81% were PITS) Total of 26 stents	Self-expandable metal stents	Granulation 81% Complication requiring surgical Rx 87%	14 stents removed Mean duration 12.4 months
Charokopos et al. Eur J of Cardiothorac surg. 2011oct 40	11 PITS (all were tracheostomised)	Dilatation f/b covered nitinol stent insertion	Obstructive granulation tissue in four patients Stent migration 2/11	Late results: 3 died of unrelated Tracheitis & halitosis recurrent 4

Piece-meal removal of SEMS



Charokopos et al. Eur J of Cardiothorac surg. 2011oct 40

When not to stent?

- Non viable lung beyond the obstruction
- Expandable metallic stents are to be avoided if planned for surgery. Known to increase the length of stenosis

Problems with stents

- Metallic – piecemeal removal (up to 73%) an resultant problems mucosal tearing, rebleeding, tension pneumothorax and post op ventilation [1]
- Silicone stents – migration[2], granulation tissue and mucus plugging

[1]Lunn W et al. Endoscopic removal of metallic airway stents. Chest 2005; 127: 2106-2112

[2]Dumon J.P.et al. Seven-year experience with the Dumon prosthesis. J Bronchology 1996; 31: 6-10

Problems with stents

	Martinez-Ballarin JI[1]	Jeong BH[2]	Dumon JF[3] Benign (malignant)
Migration	17.5%	32%	18.6% (6.0%)
Granulation tissue	6.3%	33%	17.2% (1.4%)
Mucostasis	6.3%	30%	5.7% (1.4%)
Malacia	NR	16%	NR

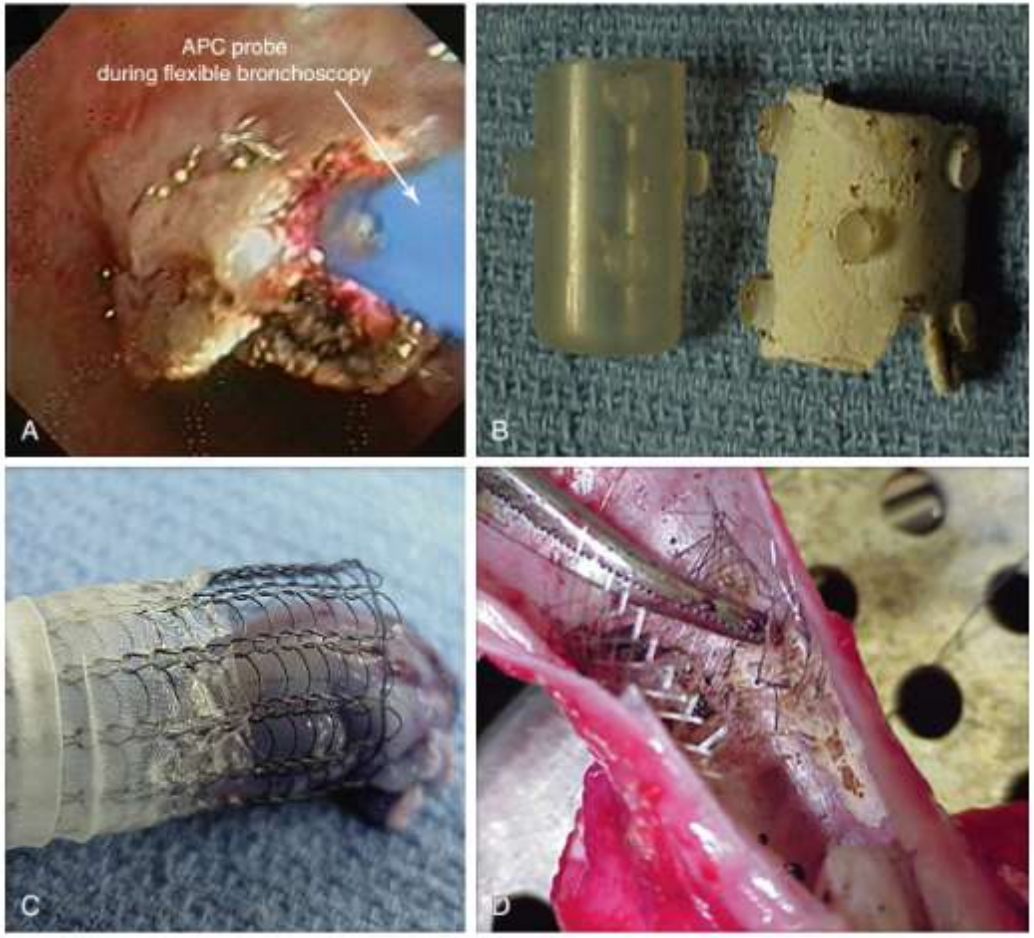
[1]Martinez-Ballarin JI[1]et al. Chest. 1996 Mar;109(3):626-9
[2]Jeong BH et al. J Cardiovasc Thorac Surg. 2012 Jul;144(1):217-22
[3]Dumon JF et al. J bronchology. 1996: 3; 6-10

Granulation tissue management

- Medical therapy
- Neodymium doped-yttrium aluminum garnet laser
- Argon-plasma coagulation[2]
- Photodynamic therapy
- Cryotherapy
- Brachytherapy

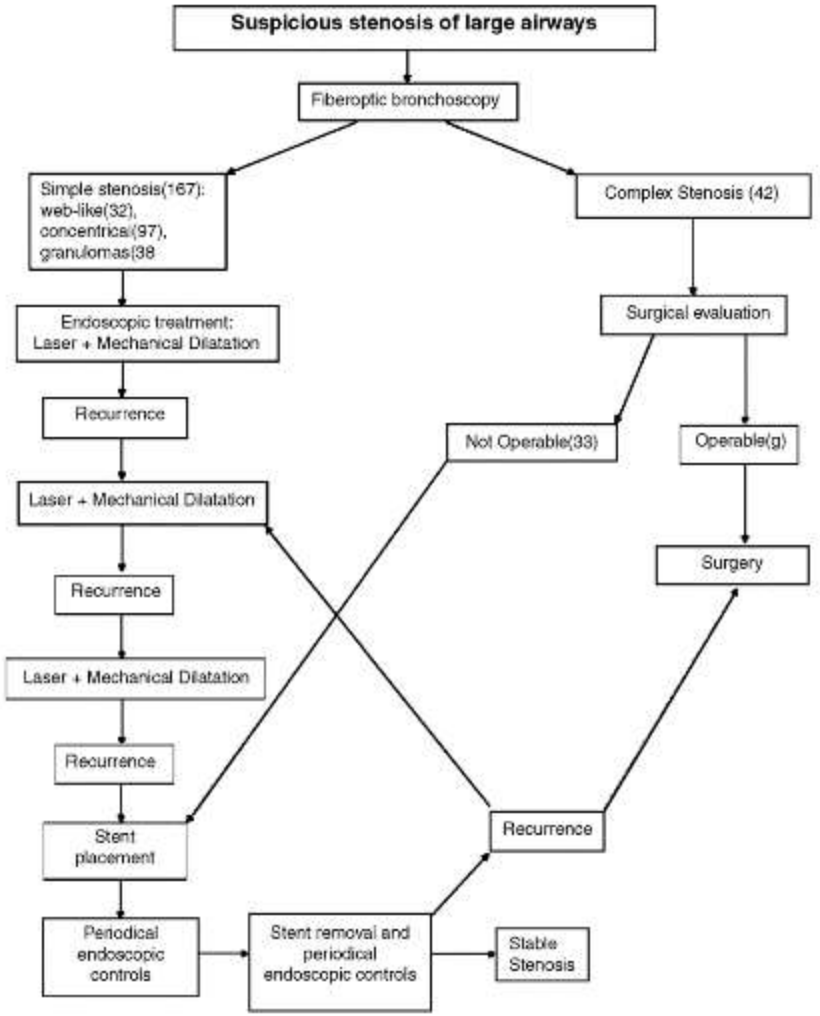
Colt HG et al. J Bronchol 1998; 5: 209-212

Granulation tissue – problems with APC



Colt H, Murgu S. Saunders 2012.Bronchoscopy and central airway disorders, chapter 3 page 28-41

Primary bronchoscopic Rx



G. Galluccio et al. Eur J of Cardio-thoracic Surgery 35 (2009) 429—434

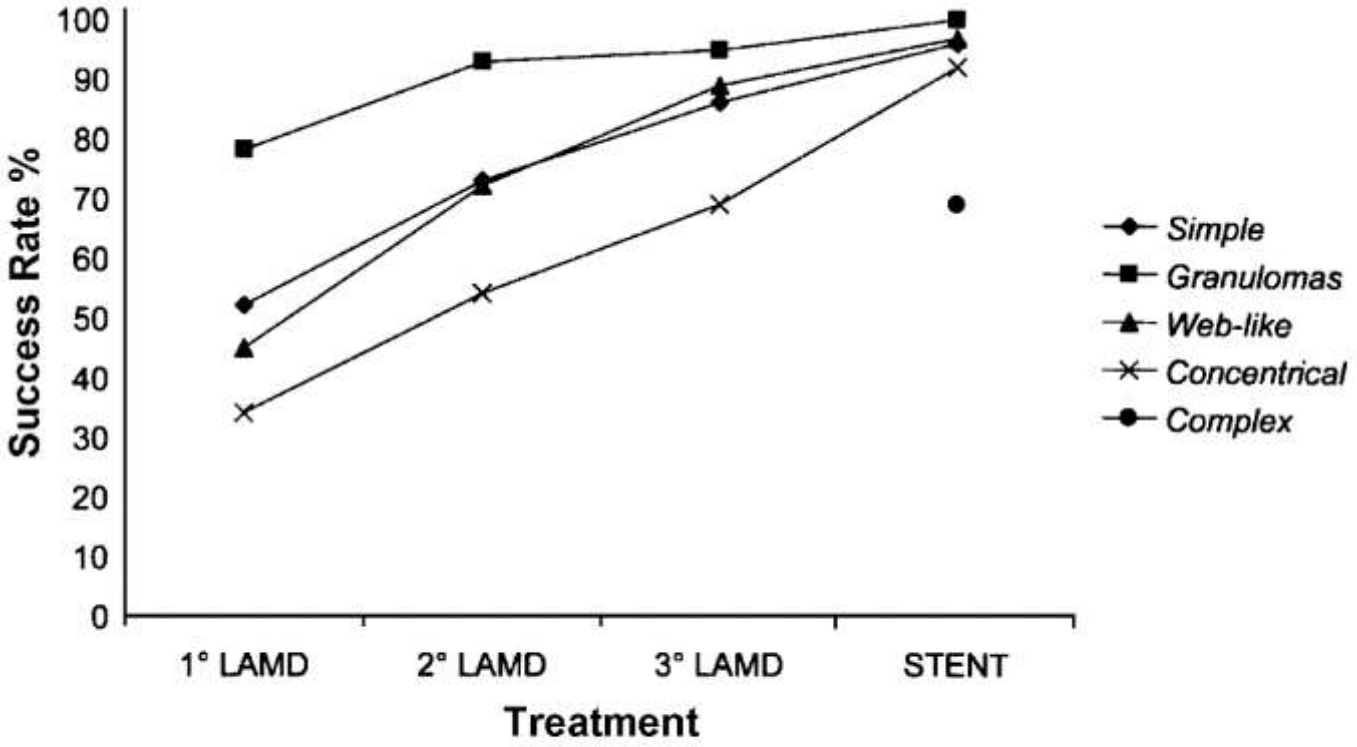
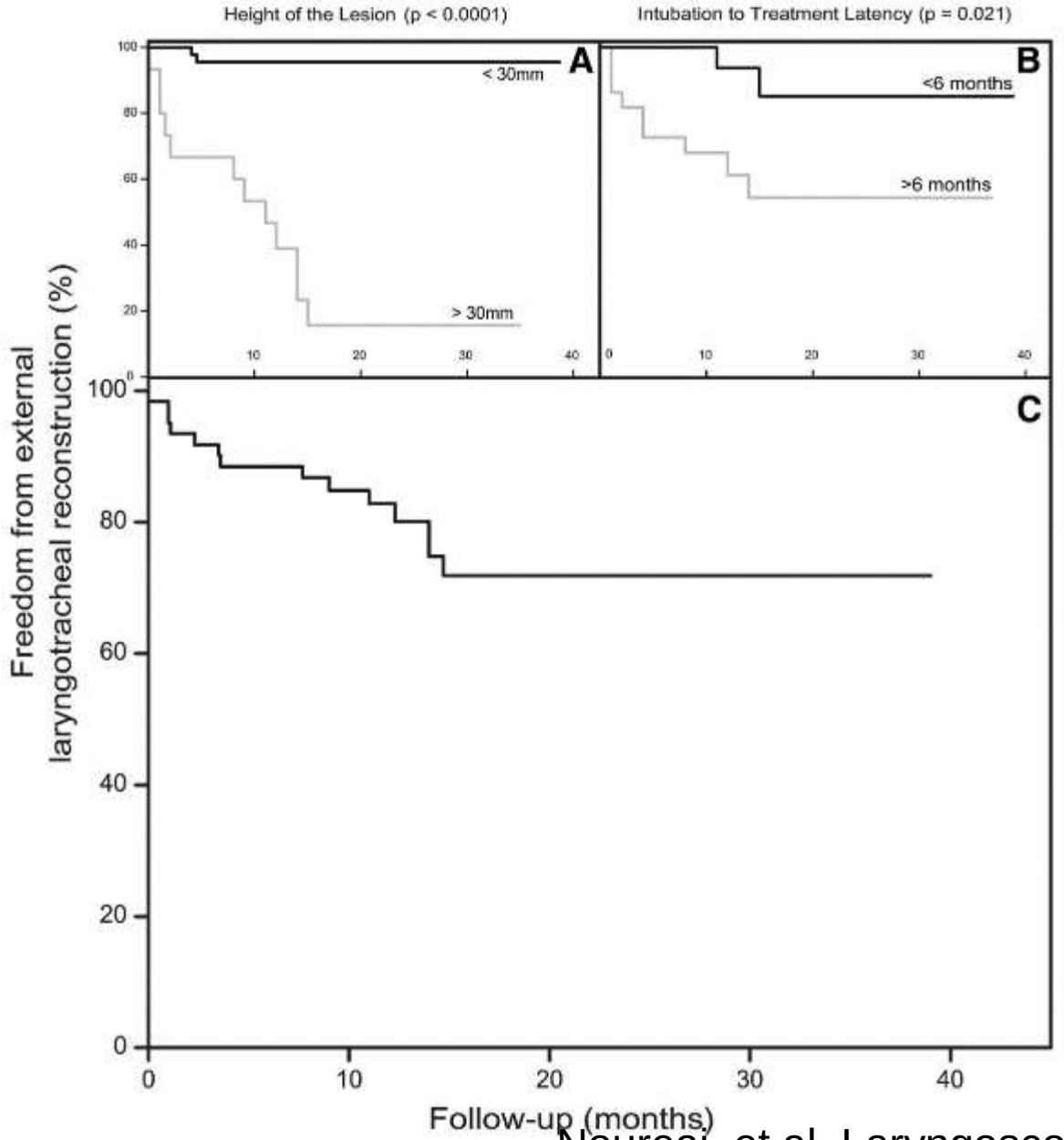


Fig. 2. Trend of resolution after endoscopic treatment; LAMD: laser assisted mechanical dilatation.

G. Galluccio et al. Eur J of Cardio-thoracic Surgery 35 (2009) 429—434

Primary bronchoscopic therapy

Reference	Study design	Patients		conclusions
Noureai et al. Laryngoscope 2007 Jun; 117(6):1073-9	Prospective 2003 - 2006	62 patients, average length 18 mm 82% Myer cotton III or IV	Tracheal resection done for long segment or near complete collapse of tracheal cartilage support	96% success with <30 mm Only 20% success with >30 mm 14 pts (23%) surgery



Noureal et al. Laryngoscope 2007 Jun; 117(6):1073-9

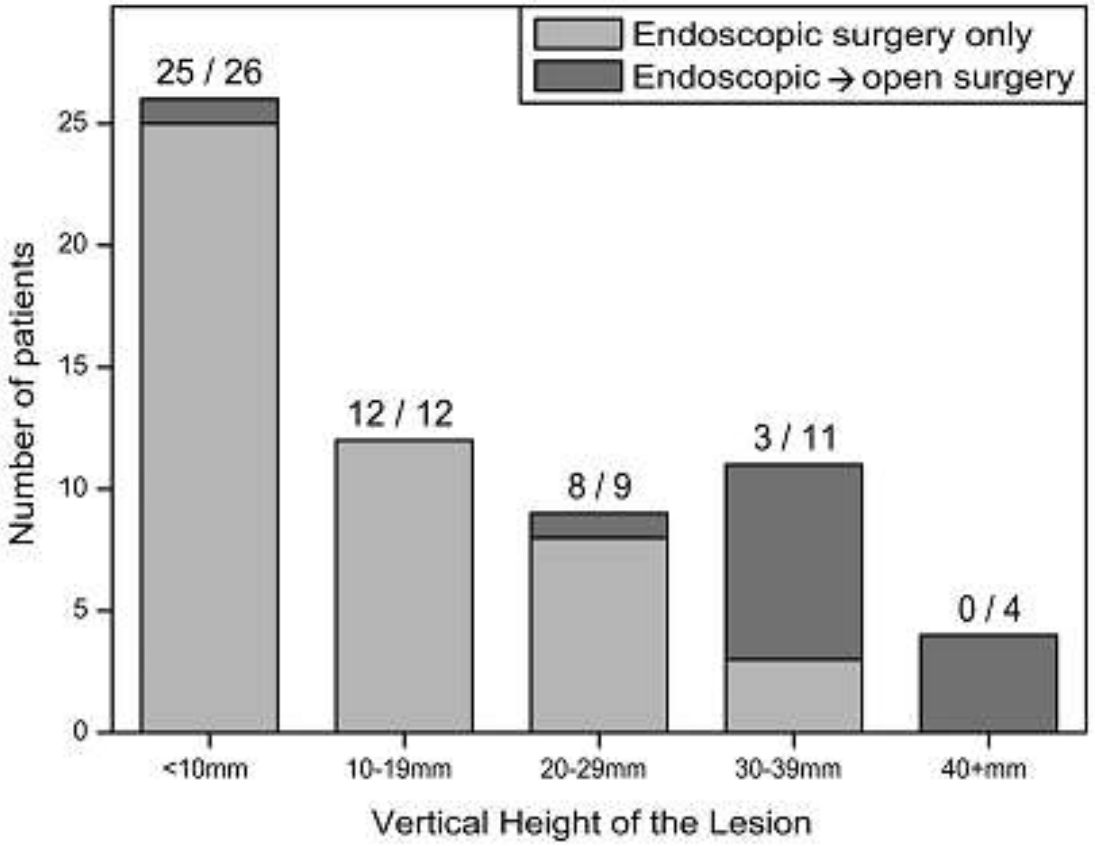


Fig. 3. Likelihood of successful endoscopic management of a lesion as a function of its height. The numerators above the bars refer to the number of cases that were successfully managed with endoscopic surgery, and the denominators are the overall number of patients within that group.

KTP laser – potassium titanyl phosphate laser f/b balloon dilatation
Stent deployed in grade IV and grade III >15 mm length
1 treatment mortality – stent related
Overall Rx mortality 1.6% increased to 2.9% when stent was used

Noureai et al. Laryngoscope 2007 Jun; 117(6):1073-9

- Recently reported success in endoscopic therapies is due to advances in technology and therapeutic options available
- Early detection of lesions: only granulation tissue formation
- Late lesions have destruction of cartilage and a mature circumferential scar

Preoperative endoscopy

- 54 out of 65 benign tracheal stenosis required therapy prior to surgery
- Two to eight rings were resected and 54 patients had remarkable improvement on follow up
- Laser (37), tracheostomy (38), endoluminal prosthesis (16) were the preoperative therpies

Rea F et al.Eur J Cardiothorac Surg. 2002 Sep;22(3):352-6

Endoscopic treatment in severe stenosis

- 22 patients over two years
- 3/6 of complete stenosis and 8/10 of circumferential stenosis with cartilage involvement – improved
- 15% (3 patients) required surgery
- May be an alternative to surgery even in severe stenosis

Schweinfurth JM. Ann Otol Rhinol Laryngol. 2006 Jan;115(1):30-4

Central airway complications following transplant

- Incidence ranges from 1.6% to 33%[1]
- 9-13% of anastomosis would require some form of therapy[2,3]
- Six type of complications known ,including early and late complications: bronchial stenosis, dehiscence, bronchomalacia, fistula, obstructive granulomas, endobronchial infections

[1]Santacruz JF, et al. Proc Am Thorac Soc 2009;6:79–93.
[2]Shennib H, et al. Ann Thorac Surg 1994;57:506–11.
[3]Ruttmann E, et al.J Heart Lung Transplant 2005;24:275–81

Post lung transplant patients

- 41 of 312 (13.1%), had tracheobronchial stenosis, malacia, granulation tissue and dehiscence
- 26 patients underwent balloon dilatation, of which except seven rest required stent/additional intervention
- Mortality associated with interventional bronchoscopy was 2.4% (1 of 41)

Chaajed PN et al.Chest. 2001 Dec;120(6):1894-9

Post lung transplant patients

- Can be managed similar to other benign tracheal stenosis
- Balloon bronchoplasty alone may help in many of the patients
- A recently proposed objective classification of airway complications following lung transplant may be helpful in deciding the type of management[1]
- Stents and biodegradable stents have been used successfully[2]

[1]Dutau et al. European Journal of Cardio-Thoracic Surgery (2013) 1–6
[2]Lischke R, et al. Eur J Cardiothorac Surg 4:619-624, 2011

Endoscopic grading of post lung transplant airway complication

- Both immediate and late complications are known post lung transplant, at the anastomotic sites
- Various classifications have been proposed for classifying airway complication following lung transplant [1-4]
- Recently proposed MDS classification (M macroscopic appearance, D diameter of bronchial lumen, S suture) (next slide)

[1]Shennib H, et al. Ann Thorac Surg 1994;57:506–11
[2]Couraud L, et al. Eur J Cardiothorac Surg 1992;6:496–7.
[3]Chhajed PN, et al. Semin Respir Crit Care Med 2004;25:413–23.
[4]Thistlethwaite PA, et al. J Thorac Cardiovasc Surg 2008;136:1569–75

M (macroscopic aspect)
- M0: scar tissue
- M1: protruding cartilage
- M2: inflammation/granulomas
- M3 : ischaemia/necrosis

• Extent of abnormalities in regard to the anastomosis:
- (a) Abnormalities localized to the anastomosis
- (b) Abnormalities extending from the anastomosis to the bronchus intermedius or to the extremity of the left main bronchus, without lobar involvement
- (c) Abnormalities extending from the anastomosis to lobar or segmental bronchi
- (d) Abnormalities affecting the lobar and/or segmental bronchi, without anastomotic involvement

D (diameter)
- D0: normal to a fixed reduction <33%
- D1: expiratory reduction (malacia) >50%
- D2: fixed reduction from 33 to 66%
- D3: fixed reduction >66%

• Extent of abnormalities in regard to the anastomosis:
- (a) Abnormalities localized to the anastomosis
- (b) Abnormalities extending from the anastomosis to the truncus intermedius or to the extremity of the left main bronchus, without lobar involvement
- (c) Abnormalities extending from the anastomosis to lobar or segmental bronchi
- (d) Abnormalities affecting the lobar and/or segmental bronchi, without anastomotic involvement

S (sutures)
- S0: absence of dehiscence
- S1: limited dehiscence (<25% of circumference)
- S2: extensive dehiscence (from 25 to 50%)
- S3: very extensive dehiscence (>50%)

• Localization: e: anteriorly; f: other localizations

Dutau et al. European Journal of Cardio-Thoracic Surgery (2013) 1–6

Idiopathic tracheal stenosis(ITS)

- Endoscopic management of 23 patients with ITS
- Web like stenosis in 61% and complex in 39%
- Mechanical dilatation alone 52%, along with LASER 30% and stenting in 18%
- High recurrence rate: 30% at 6 months, 87% at 5 years

Perotin JM et al. Ann thorac Med. 2011 Jul;92(1):297-301.

Stenosis due to tuberculosis

- Common and under recognized
- Wrongly labeled as asthma
- Stricture at multiple site and bilateral involvement make surgery technically difficult

Stenosis due to tuberculosis

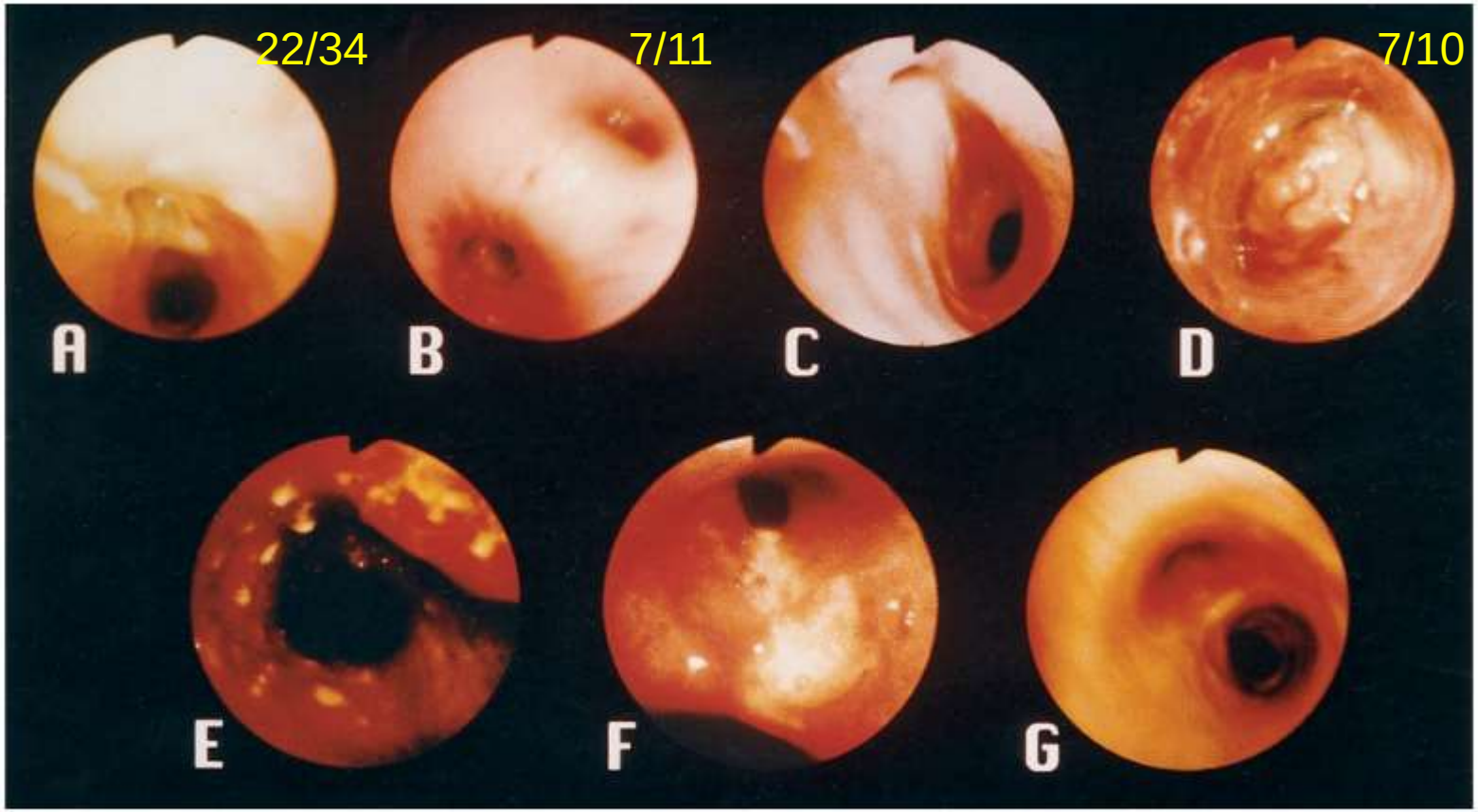


FIGURE 1. Classification of EBTB by bronchoscopic finding. *Top:* A, actively caseating type; B, edematous-hyperemic type; C, fibrostenotic type; and D, tumorous type. *Bottom:* E, granular type; F, ulcerative type; and G, nonspecific bronchitic type. See Results section for the explanation of each type

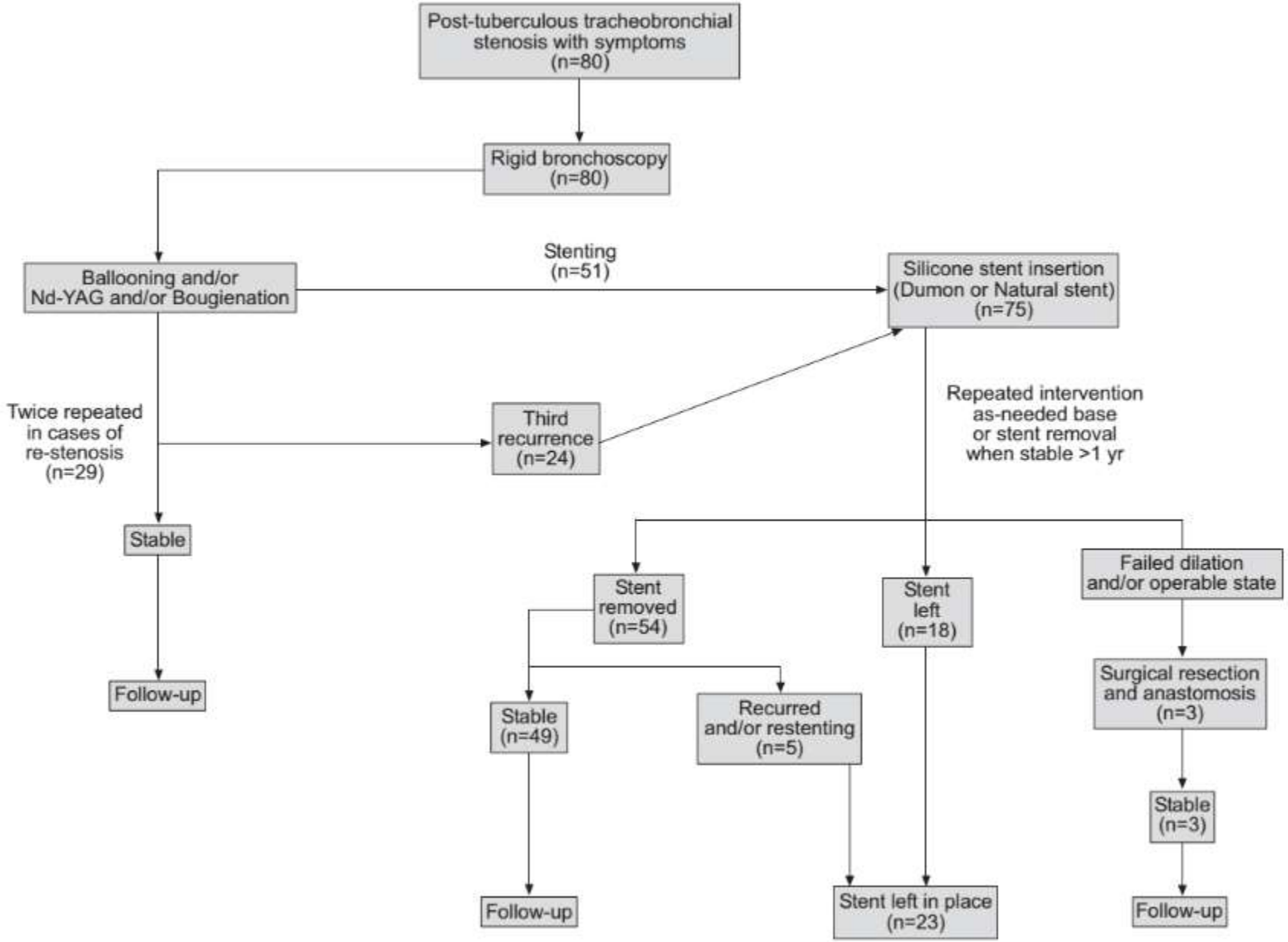
Hee soon chung et al. CHEST 2000; 117:385–392

Reference	Country	No.	Site	Treatment	Outcome
Lee (Ref. 2)	Korea	59	LMB (31) Trachea (10) RMB (7) LMB+LLL (3) RMB+BI (3) Trach+RMB (2) Trach+LMB (2) LMB+LUL (1)	101 balloon dilatations in 59 patients (mean no. of sessions per patient 1.7, range 1–4)	Deaths 3 (unrelated) Symptomatic improvement 83% Recurrence 80% 5 stent insertions 2 left pneumonectomies
Lee (Ref. 3)	Korea	19	LMB (19)	Balloon dilatation and metallic stent 19	Immediate improvement 73% Patency rates 64% at 3 years, 42% 6 years Granuloma 1 Fracture of stent 2
Kato (Ref. 4)	Japan	36	LMB (25) RMB (7) RLB (1) Trachea (1) Trachea+ RMB+LMB (2)	Bronchoplastic reconstructive surgery 36	Increases in pulmonary function Deaths 3 Anastomotic leak 7 Granuloma 5
Nomori (Ref. 5)	Japan	2	Trachea (1) LMB (1)	Dumon silicone stent 2	Granuloma causing restenosis and requiring removal of stent 2
Wan (Ref. 6)	Hong Kong	7	LMB (5) Mid trachea (1) Trachea+RMB (1)	Dumon silicone stent (11 stents in 7 patients)	Deaths 0 Spontaneous pneumothorax 1 Migration 2 Re-insertion X5 stent in 1 patient
Huang (Ref. 7)	Taiwan	3	Trachea+LMB (2) LMB (1)	Staged dilatations+stent insertion 3	Stent removed and patient remained well 1 Granulation tissue post-removal Stent migration 1
Sawada (Ref. 8)	Japan	5		Gianturco expandable metallic stent after dilatation 5	Restenosis 2, treated by laser ablation Haemoptysis 1

Jaiswal P et al. J R Soc Med 2005;98:26–28

Reference	Intervention	Patients	Outcome	Comments
Iwamoto et al. CHEST 2004; 126:1344 –1352	5 dilatation alone 6 dilatation & Dumon stent	11 patients with tracheobronchial TB	8 out of 11 improved (all 6 stented improved)* 1 lobectomy for complete occlusion	Migration and granulation tissue in stented patients
SY Low ERJ September 1, 2004 vol. 24 no. 3 345-347	Balloon dilatation, Nd:YAG, Dumon stent	21 symptomatic tracheobronchial stenoses due to TB		
Ryu YJ et al. Respirology.2006 Nov;11(6):748-54.	94 patients 100 stents (43 Dumon 57 'Natural')	74% were post TB	Successful stent removal. 54% Dumon 49% Natural	Complication rates similar in both stents at 42 months
Duan HF. Zhonghua Jie He He Hu Xi Za Zhi, 2007 May;30(5):339-42.	Balloon dilatation alone 2 to 7 sittings required	25 patients with bronchial stenosis as a result of TB	No complications A 2 to 36 months f/u no restenosis	16 patients followed > 1 year average of 5.5+/- 2 mm diameter maintained

Reference	Patients	Intervention	Outcome	Comments
Ding WM. Zhonghua Jie He He Hu Xi Za Zhi, 2010 Jul;33(7):510-4. (Chinese) Abstract in English	149 patients	25 patients with bronchial stenosis as a result of TB	Complications 3.4% At 12 months f/u restenosis 3.4% (?criteria)	No difference in general outcome and airway diameter at 3, 12 months. It was similar to the values obtained immediately after dilatation
So Yeon Lim et al. Respirology. 2011 Aug; 16(6):959-964	71 patients of Post TB tracheobronchial stenosis	Silicone stenting, and in f/u bronchial toileting	40 patients had successful stent removal (median 12.5 months) 27 had stent re-insertion 4 had surgery	Successful stent removal independently associated with *atelectasis <1 month before stent* and absence of complete lobar atelectasis.



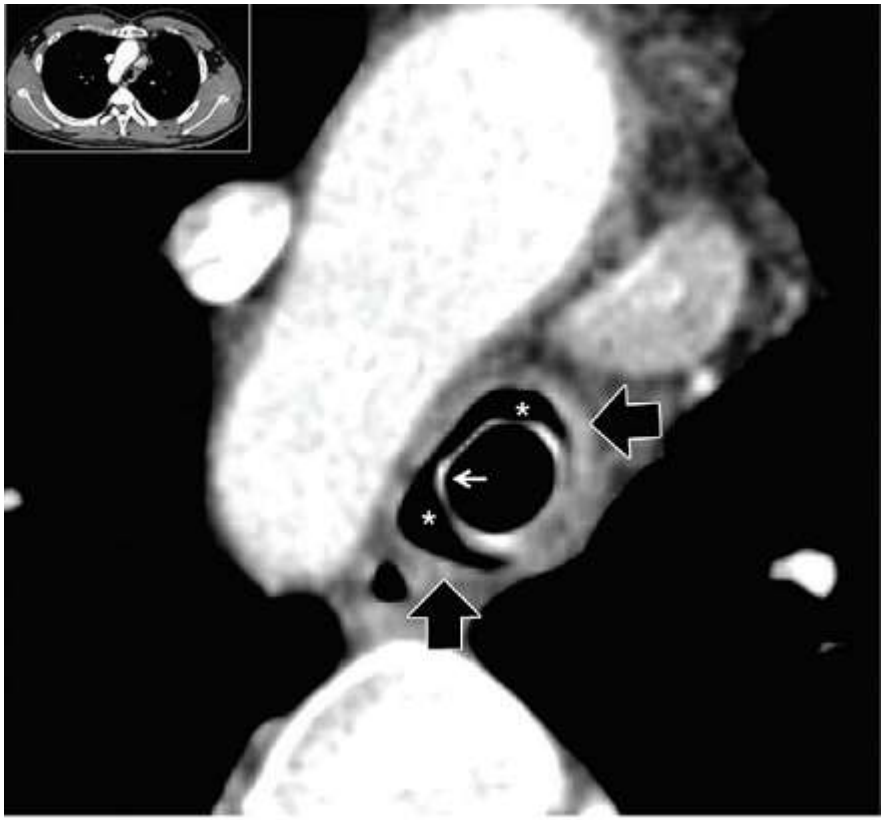
Ryu RJ et al,Eur Respir J 2006; 28: 1029–1035

Long term tolerance of stents in TB

- Some benign disease groups (tuberculosis, sarcoidosis, war gas exposure, and inhalation burns) have multiplicity of involvement or long length of stenosed segment. This precludes surgery and may require stenting for long duration
- 17 patients with ‘Natural’ silicone stent followed up
- Tolerated for a median period of 7.9 years (range 3-11)
- Late complications included granulation tissue (76%), migration(70%), mucostasis (17%)

Verma A et al. ASAIO J. 2012 Sep-Oct;58(5):530-4.

When to remove the stent?

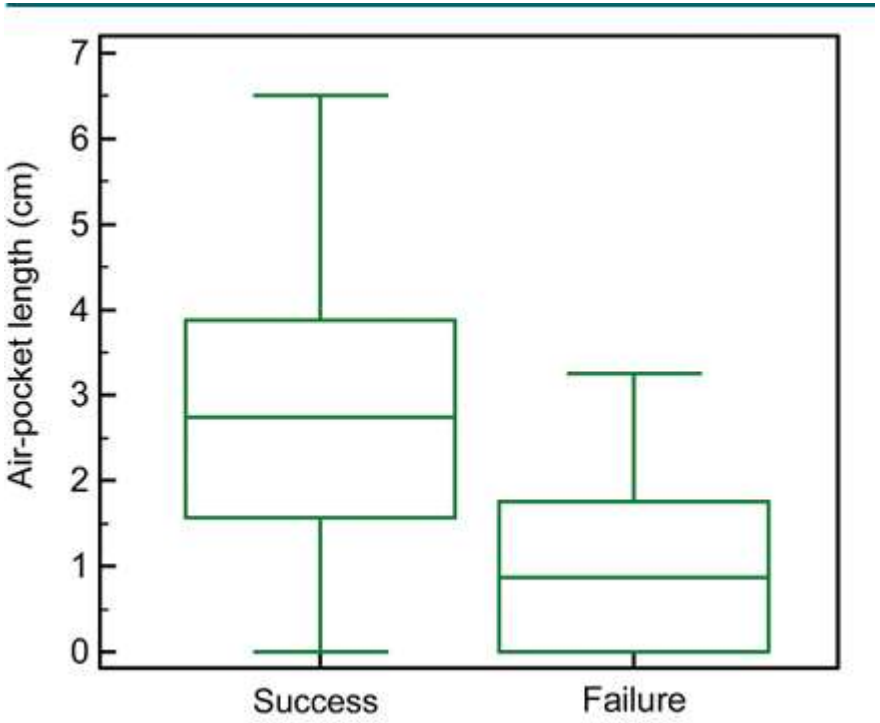


Permeation of air in the space between the outer surface of the stent and the airway wall occurs

Suggests regression and healing of the stenosis

Hence an optimal indicator of stent removal

Verma A, et al. Radiology. 2012;263(2):562-8.



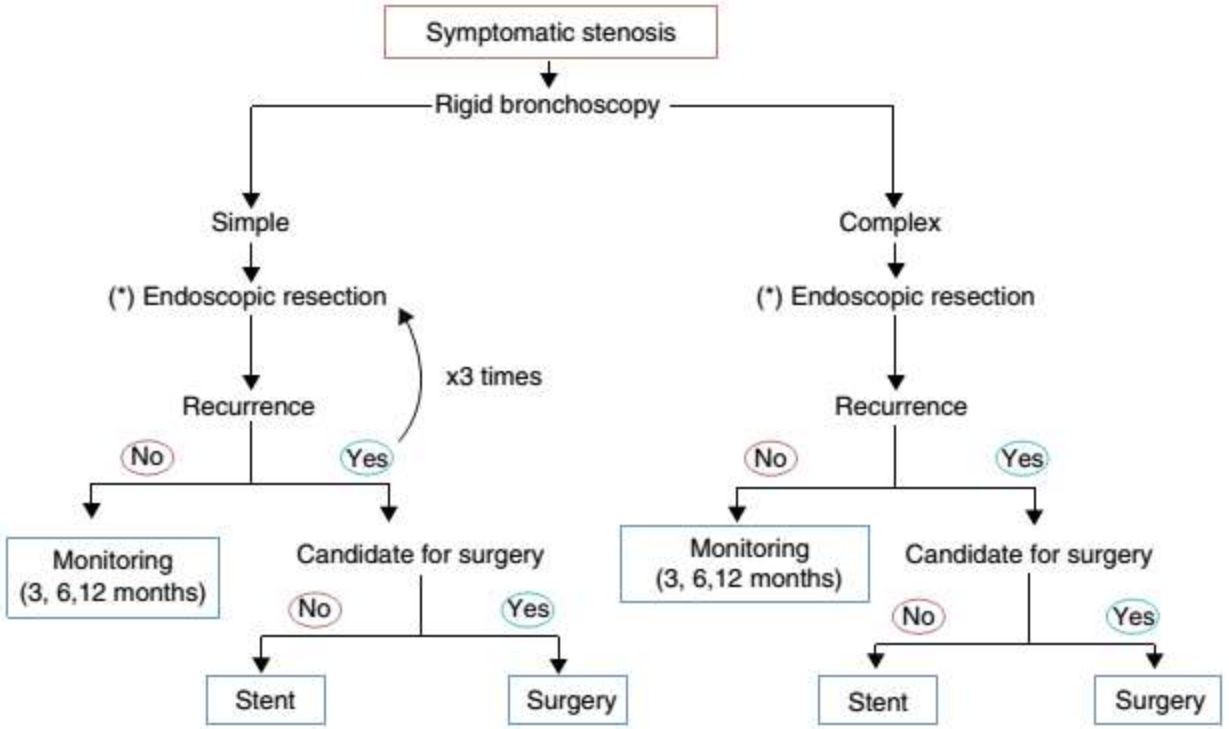
Parameter	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)
Air pocket length (cm)				
>1	84 (26/31) [67, 93]	50 (5/10) [24, 76]	84 (26/31)	50 (5/10)
>2	68 (21/31) [49, 96]	70 (7/10) [22, 94]	88 (21/24)	41 (7/17)

Verma A, et al. Radiology. 2012;263(2):562-8.

Tissue engineered airway transplant

- First patient followed up to five years now
- At end of one year cicatrical stenosis required endoluminal stenting
- However the tissue was well vascularized, epithelialized, normal mucosal clearance
- Doing well, except for intermittent bronchoscopic interventions

Gonfiotti A et al. Lancet. 2014 Jan 18;383(9913):238-44



Barros Casas D, et al. Arch Bronconeumol. 2014;50(8):345–354

Magnitude of problem in PGI

- Benign tracheal stenosis accounted 55.26% of the therapeutic rigid procedures (21 out of 38)
- Median of two procedures per patient
- Rigid bronchoscope alone was used in 57.9% procedures, rest used flexible as well

Madan K et al. Lung India. 2014 Jan-Mar;31(1):9-15

Magnitude of problem in PGI

- From July 2012 till July 2014 a total of 80 rigid bronchoscopies
- 26 out of the 80 (32.5%) were procedures related to benign tracheal stenosis
- A total of 15 patients were treated, with mean 1.73 procedure per patient(2 procedures in 3 and 3 procedures in 4 patients)

Department of pulmonary medicine, PGIMER. Unpublished data

Etiology of benign tracheal stenosis

Indication	Number of patients (%)	
	PGI[1]	Rome[2]
Post intubation tracheal stenosis	12 (80)	167 (79.9)
Post tracheostomy tracheal stenosis	2 (13.3)	34 (16.3)
Post TB tracheobronchial stenosis	1 (6.7)	Others 8 (3.8%)

[1]Department of pulmonary medicine, PGIMER. Unpublished data

[2]Gallucio G et al. Eur J of cardiothorac Surg. 2009 Mar;35(3):429-33

Summary

- Post intubation tracheal stenosis is generally simple and web like
- Simple balloon dilatation or preferably Laser assisted mechanical dilatation (LAMD) may be used as first choice
- Failure of balloon bronchoplasty at least twice, can be managed with stents

Summary

- Complex stenosis (involving cartilage) may be subjected to either surgery or stenting followed by surgery
- Stenosis higher up in the trachea are better managed by T-Tubes
- In inoperable patients endoscopic interventions are the only options

Summary

- A stenosis of 3 cm or more associated with failure, hence surgical resection is to be considered
- Long standing stenosis > 6 months are also better managed surgically
- Multisite involvement and complex stenosis makes Post-TB tracheal stenosis difficult to manage, simple dilatation with or without stenting is helpful