Tracheostomy tubes 101

Miguel Divo, MD MPH
Pulmonary, Critical Care Division
Brigham and Women's Hospital
Harvard Medical School

Conflict of Interest Disclosure

- No relationships with commercial entities producing, marketing, re-selling, or distributing health care goods or services patients consume.

- No relationship to tobacco company.

Tracheostomy tubes 101: Objectives

- Who
- When
- How
- Why
- What happens after placement
- Therefore, be familiar with this equipment.

There is only one airway; once you lose it, nothing else matters…

Who requires Tracheostomy tube placement?

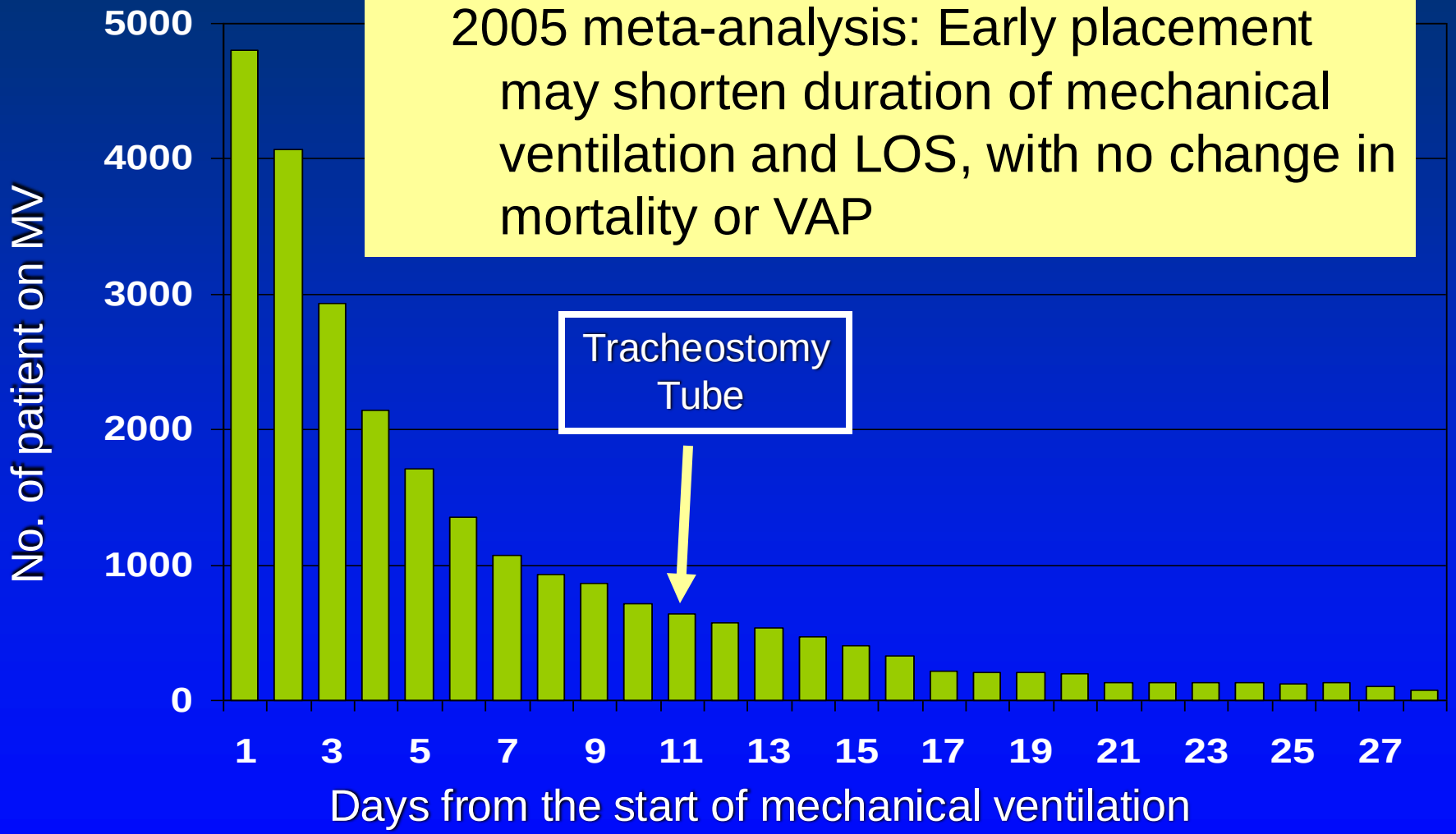
- Upper airway obstruction
- Neuromuscular disease with RF
- Coma
- Difficult to wean patient

Tracheostomy tubes 101: Objectives

- Who
- When
- How
- Why
- What happens after placement
- Therefore, be familiar with this equipment.

Timing for tracheostomy

2005 meta-analysis: Early placement may shorten duration of mechanical ventilation and LOS, with no change in mortality or VAP

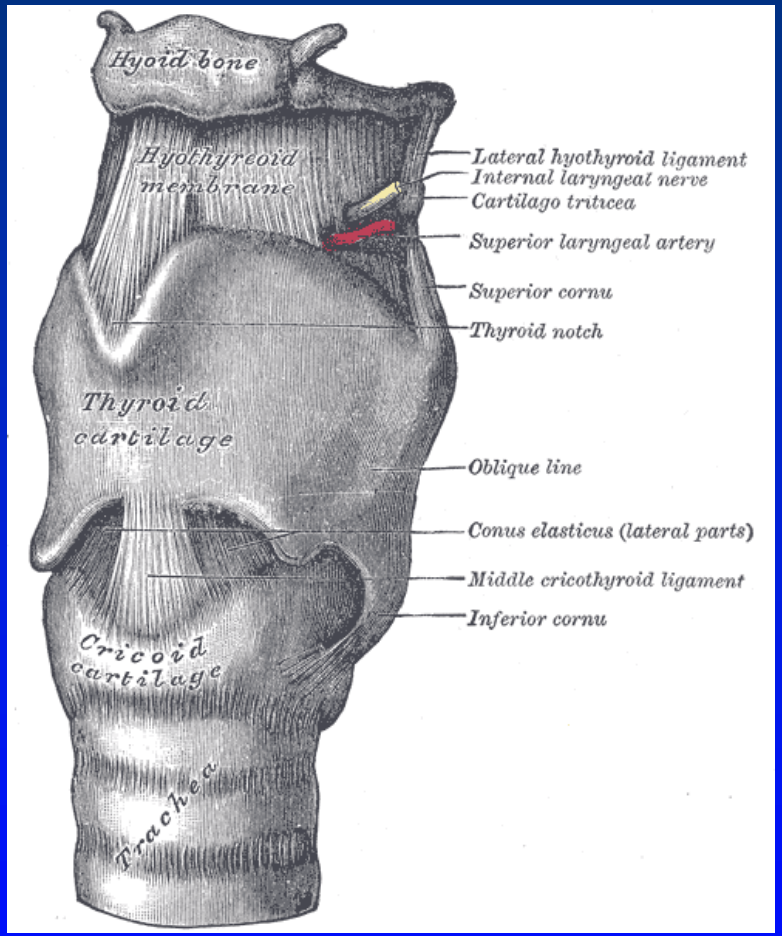


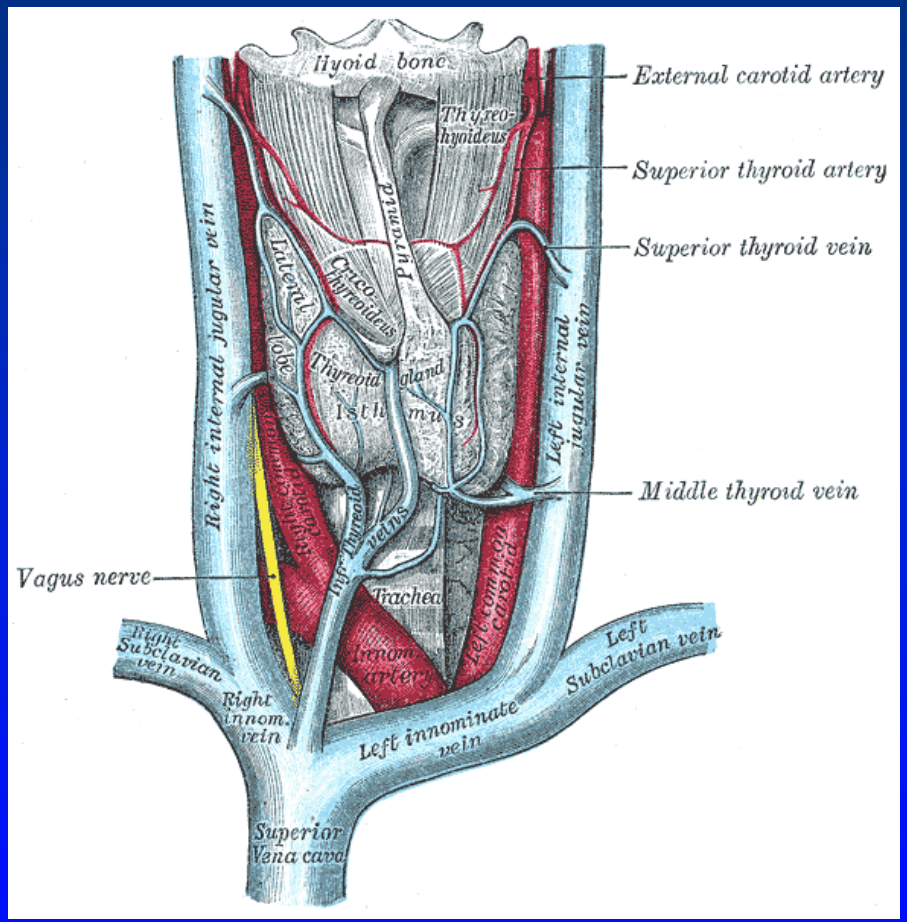
Esteban A et al. *JAMA. 287(3):345-355, 2002.*
Griffiths, j et al, BMJ 2005;330;1243

Tracheostomy tubes 101: Objectives

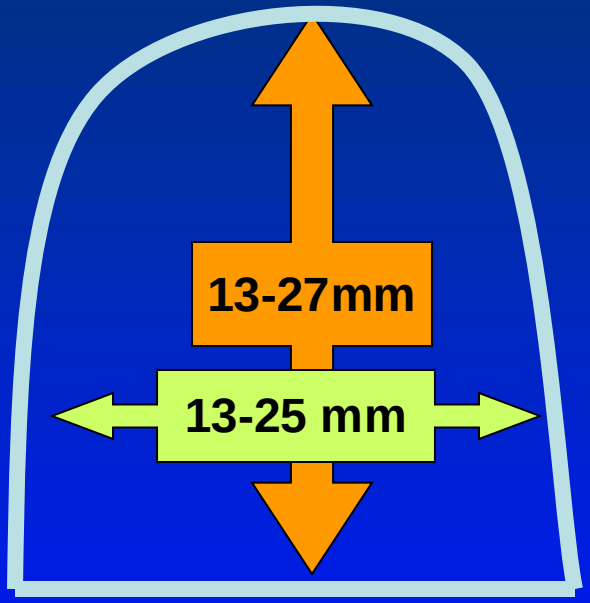
- Who
- When
- How
- Why
- What happens after placement
- Therefore, be familiar with this equipment.

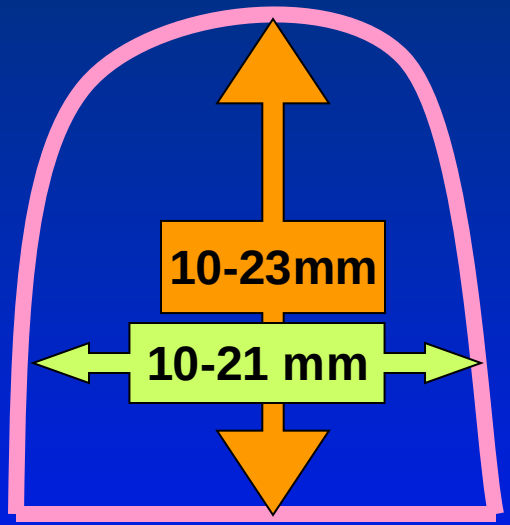
Anatomy refresher





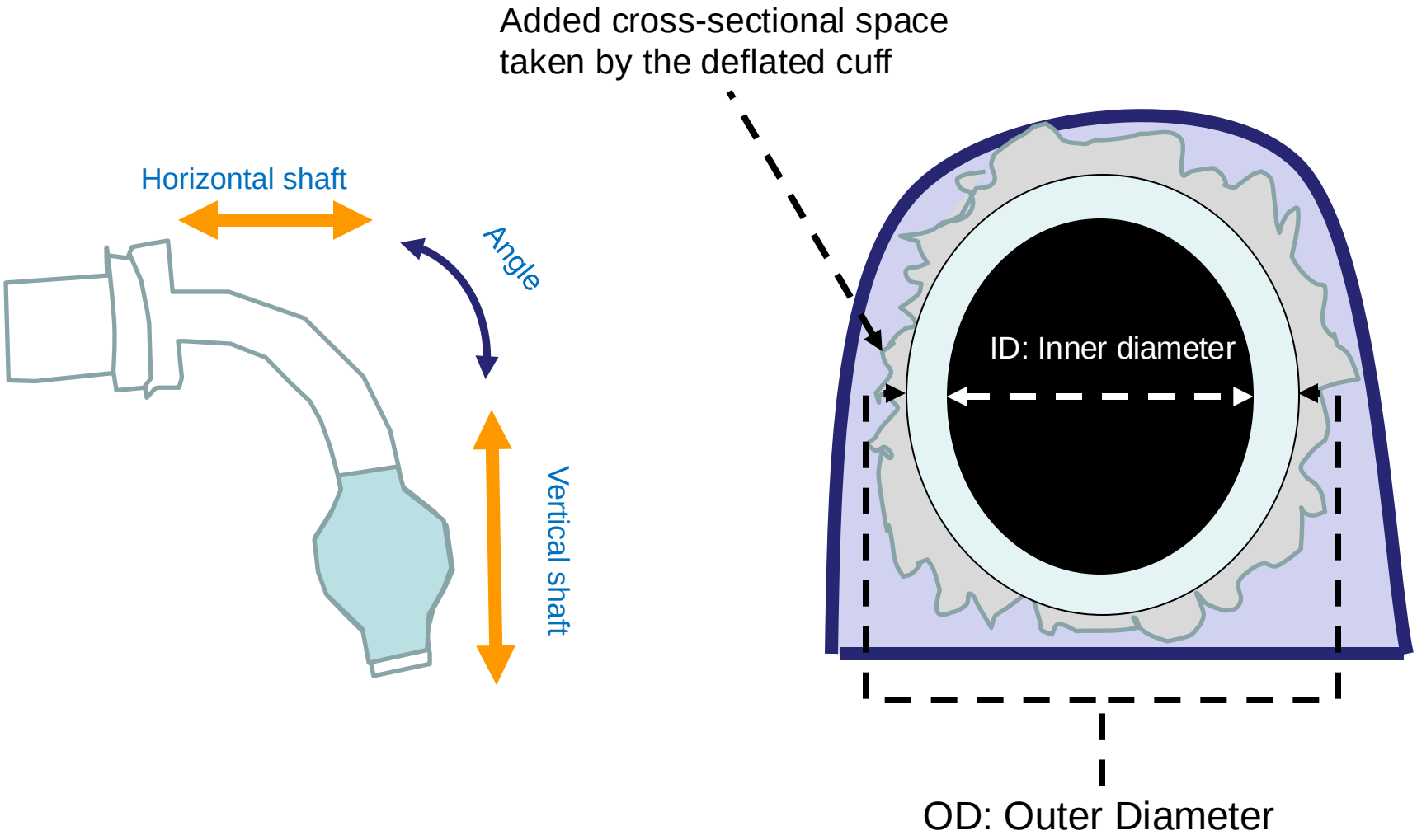
Adult Trachea Dimensions





Breatnach, E.,. AJR Am J Roentgenol, 1984. 142(5): p. 903-6.
Stern, E.J., et al., Radiology, 1993. 187(1): p. 27-31

Tracheostomy tube “anatomy”



Tracheostomy tubes 101: Objectives

- Who
- When
- How
- Why
- What happens after placement
- Therefore, be familiar with this equipment.

Benefits

- Improved patient comfort (reduction in sedation and restraints)= early mobilization
- Potential restoration of speech
- More efficient airway and oral care
- Provision of a more secure airway= easier to transfer
- Decrease WOB (maybe)

Heffner, J.E.,. Clin Chest Med, 2003. **24**(3): p. 389-98

WOB:Contractile Fatigue

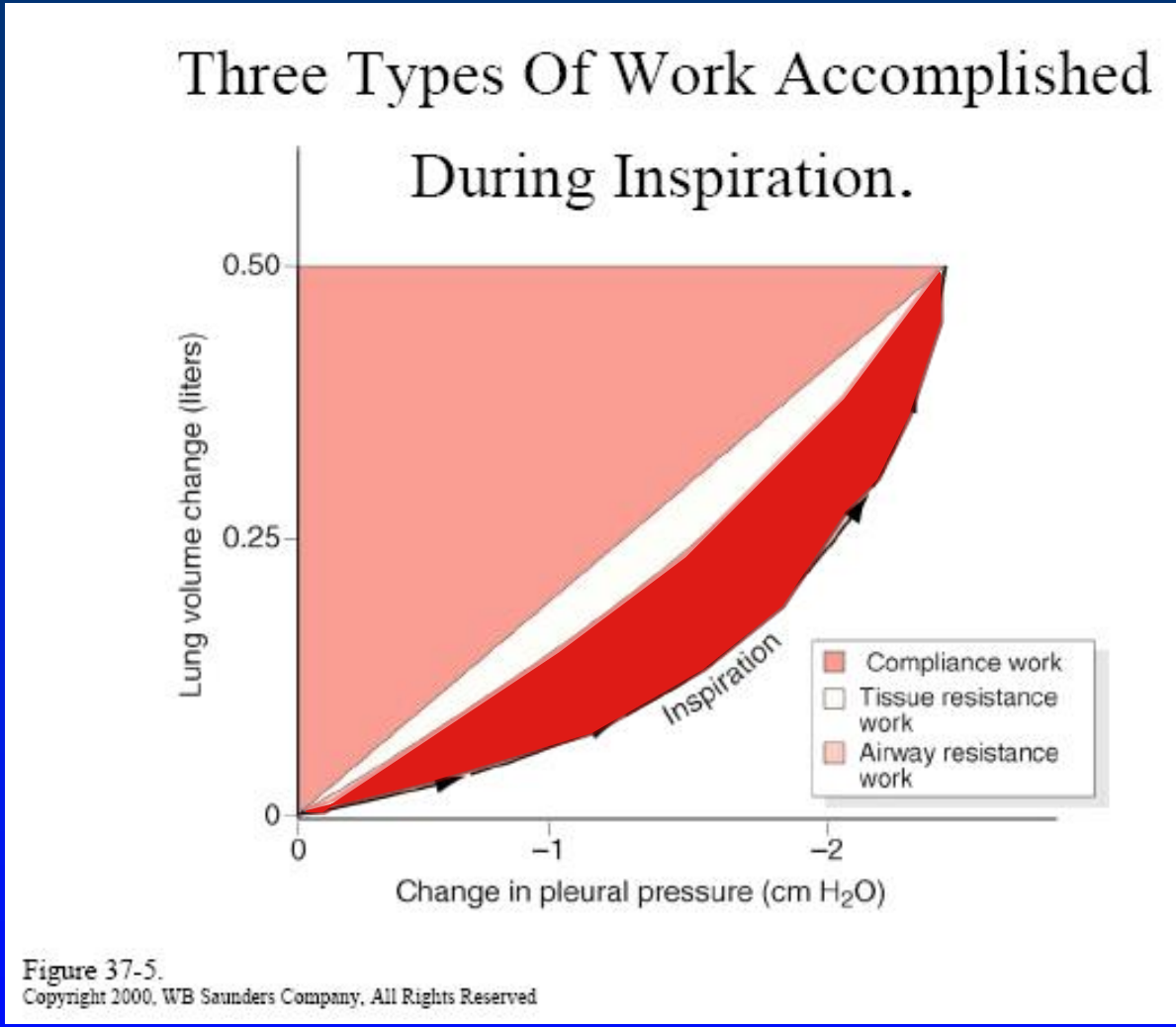
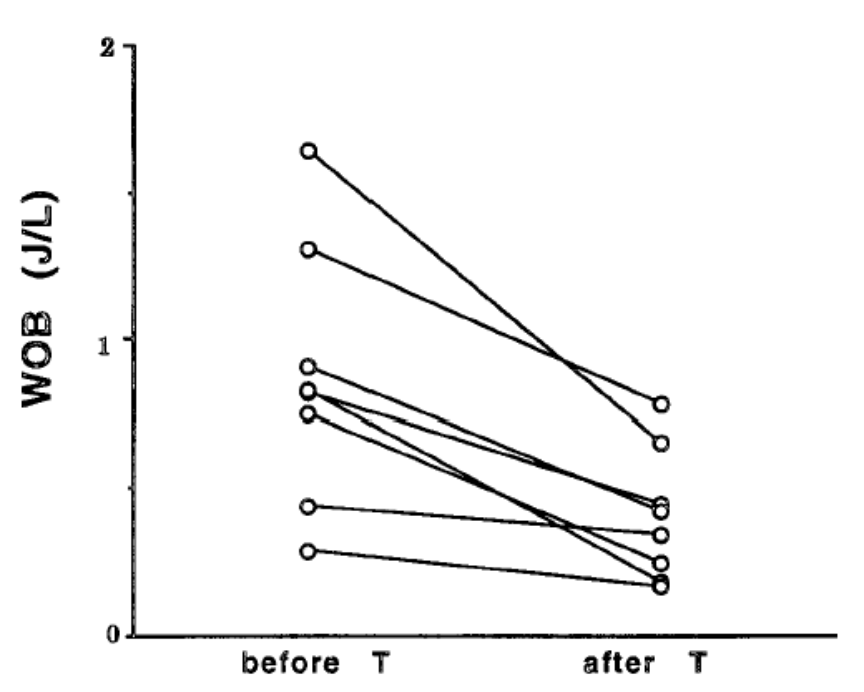


Figure 37-5.

Physiologic benefits

- ↓ in resistive WOB (compared to ETT same diameter)
- ↓ iPEEP
- ↑ Patient-Vent synchrony
- ↓ Dead space



Brochard L et al, Am J Respir Crit Care Med 1999;159:383

Physiologic benefits

$$R \sim \frac{\eta . L}{r^5}$$

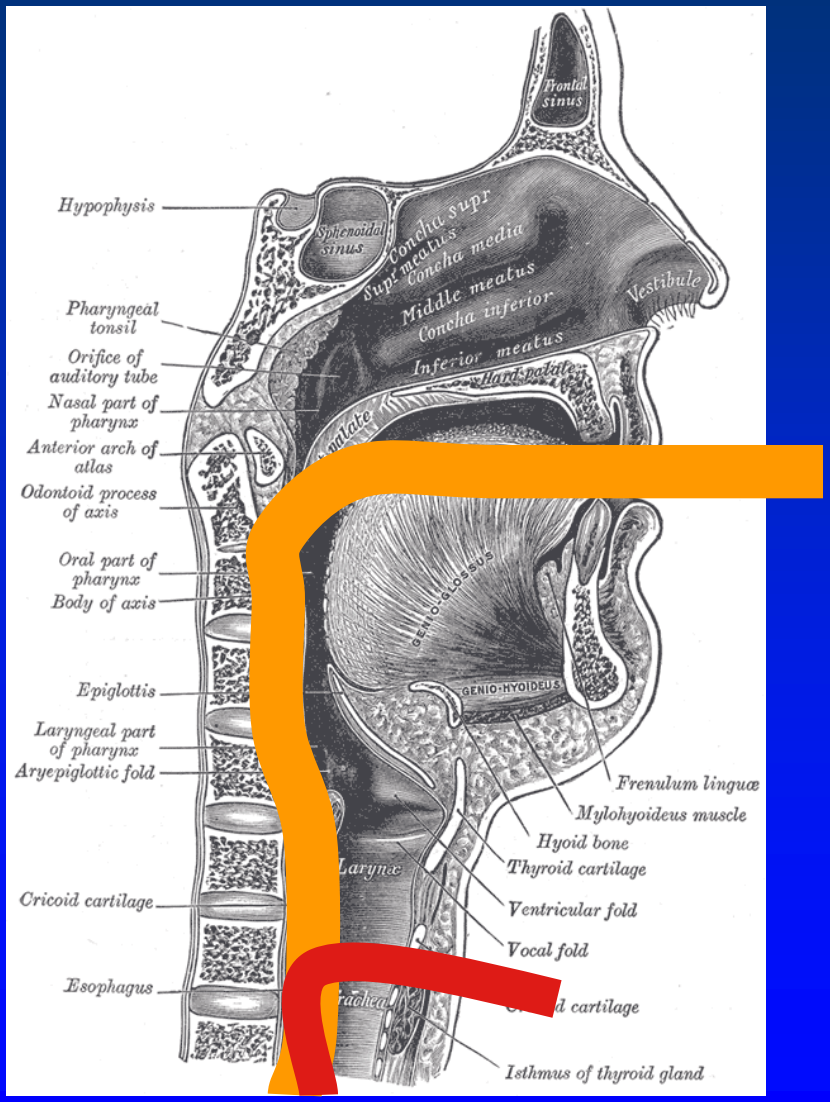
Laminar Flow

Turbulent Flow

Jean Poiseuille (1797-1869)

Endotracheal Tubes

$$R \sim \frac{\eta . L}{r^4}$$

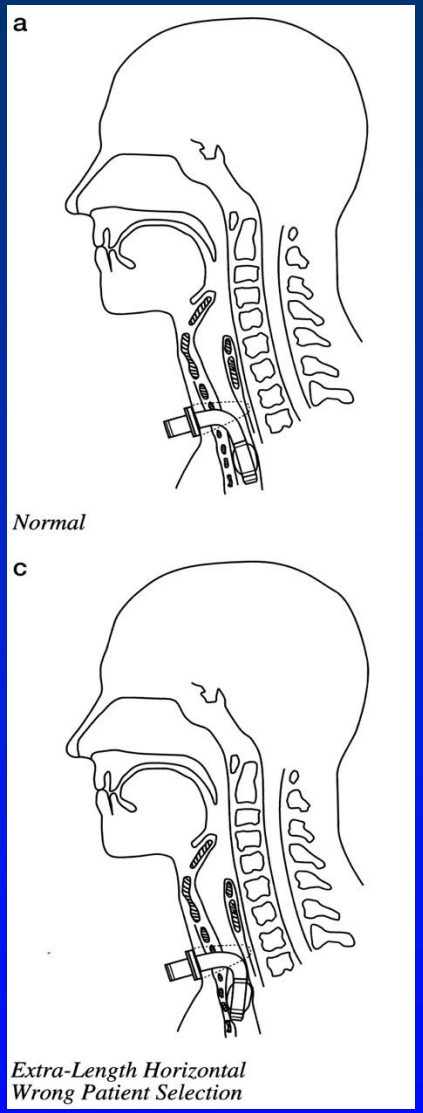


Tube Length

1. Dead Space
2. Resistance

Weaning Limited by Upper Airway

- Retrosp study, 756 with avg 3 wks endotrach tube & 12 wks trach
- 37 (5%) developed failure to wean related to tracheal obstruction
- Treated with longer tube (34) and stent (3)
- 34/37 weaned within one week
- Clues
  - Rising Paw
  - Difficulty passing catheter

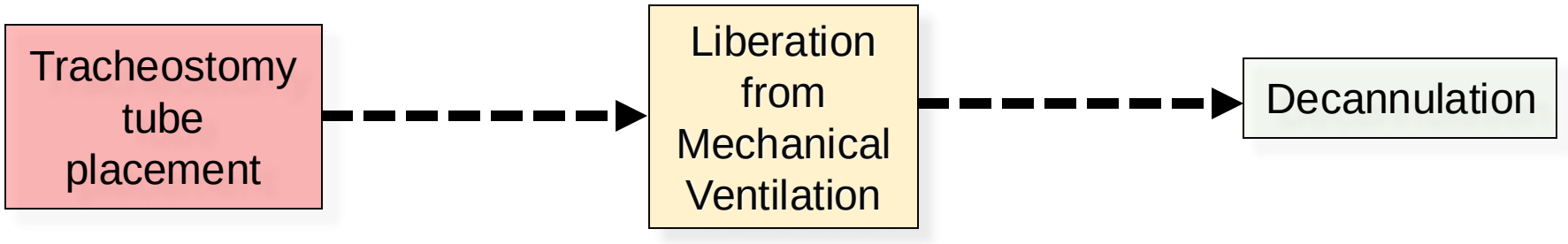


Rumbak, M. J. et al. Chest 1999;115:1092-1095

Tracheostomy tubes 101: Objectives

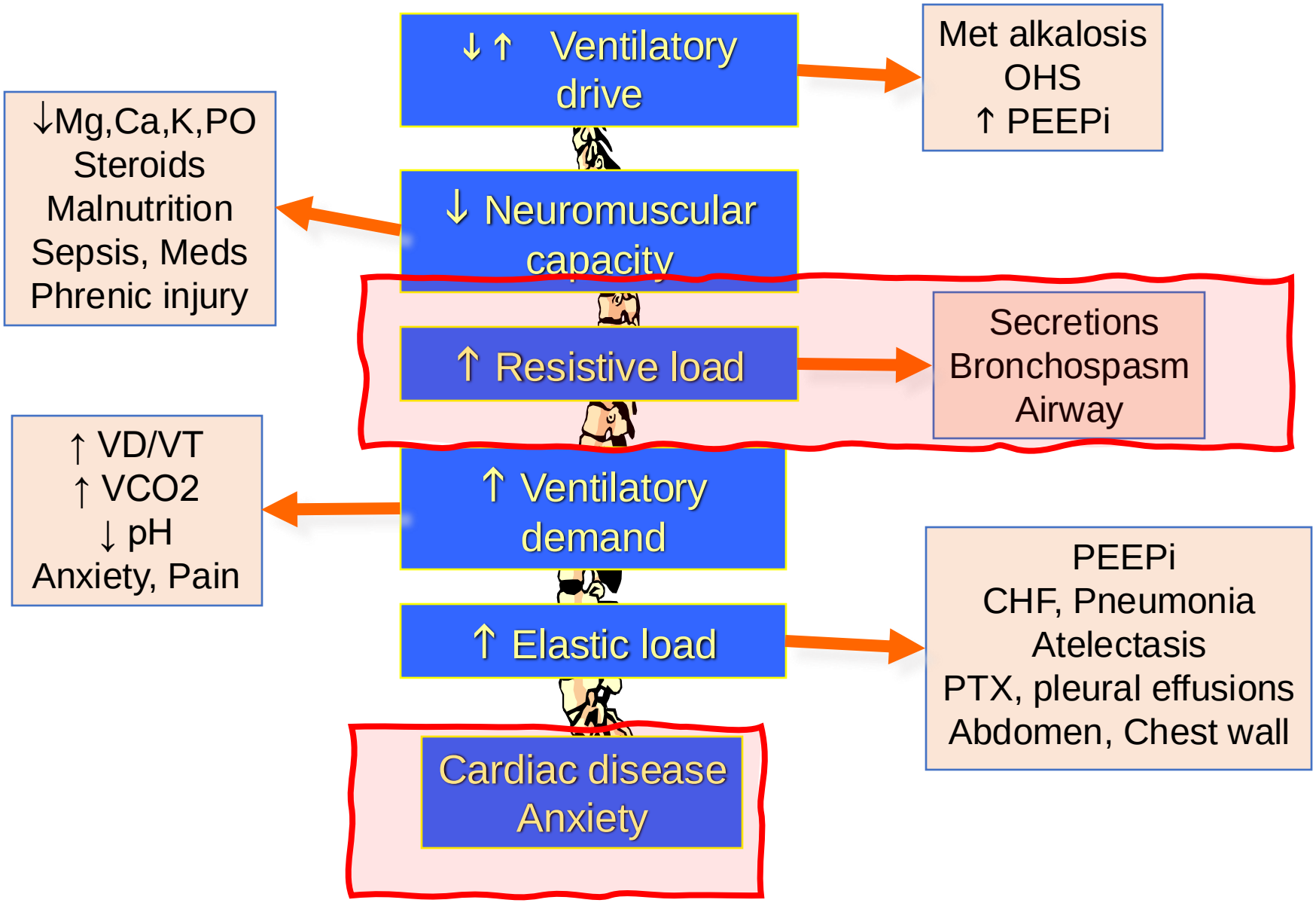
- Who
- When
- Why
- How
- What happens after placement
- Therefore, be familiar with this equipment.

The Post-Insertion Road and Milestones

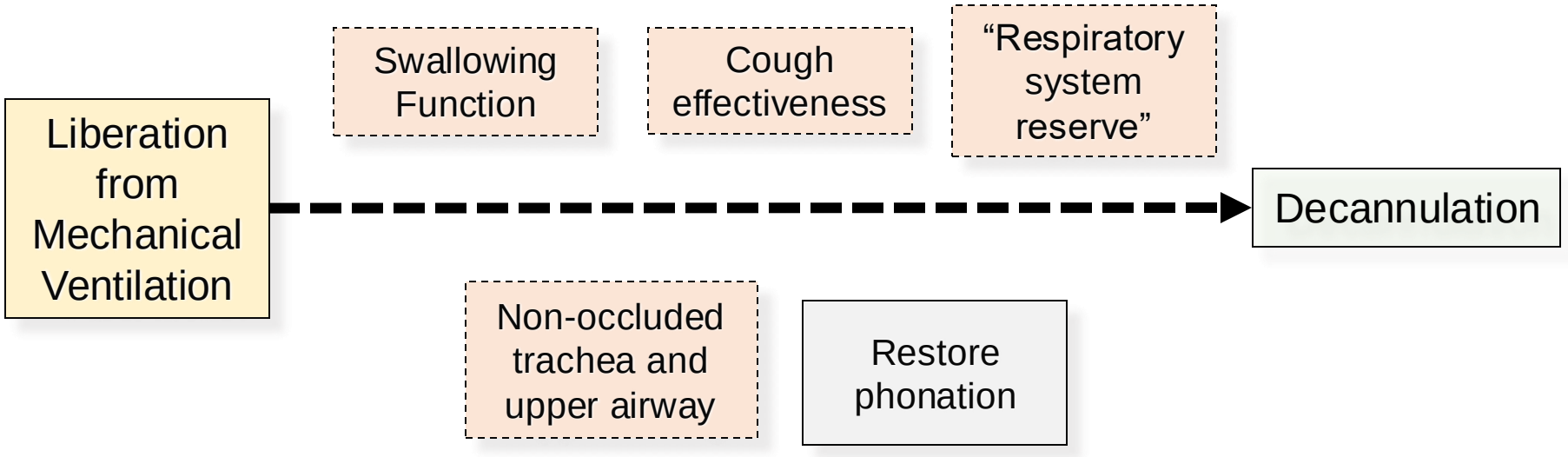


Adapted from Divo et al, Respir Care 2020

Pathophysiology of respiratory failure

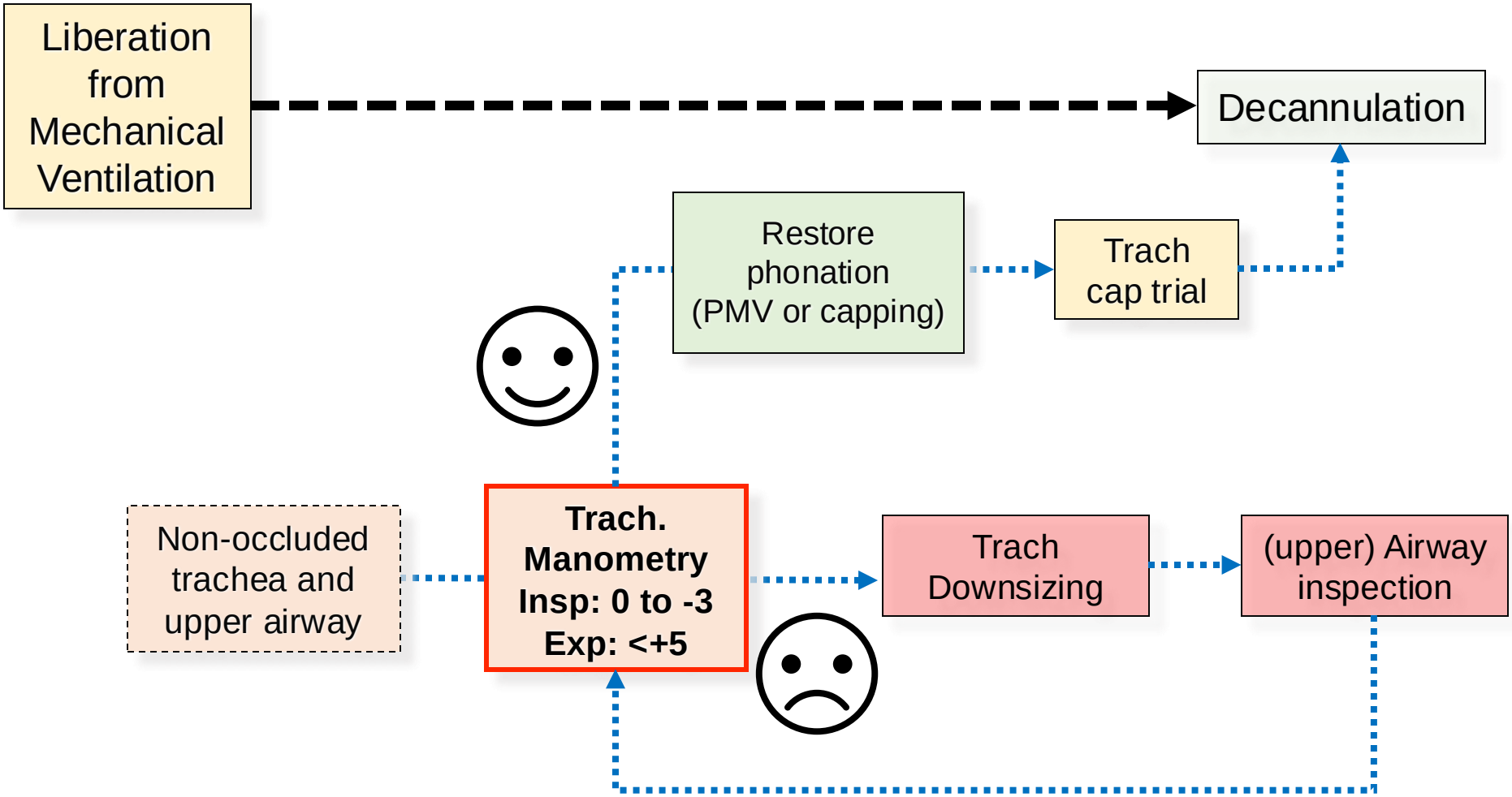


Decannulation is a process



Adapted from Divo et al, Respir Care 2020

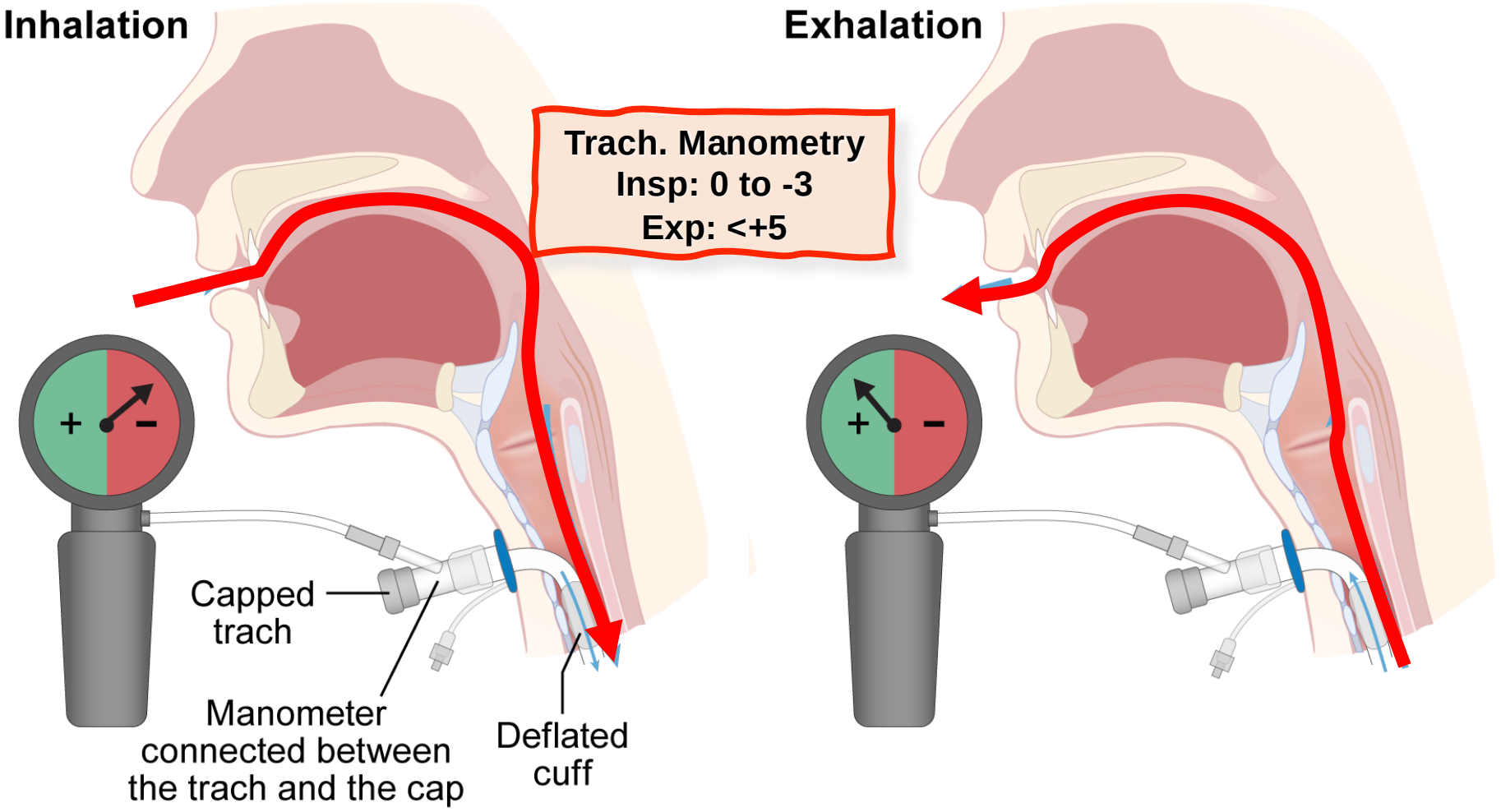
Patent and functional upper airway?



Adapted from Divo et al, Respir Care 2020

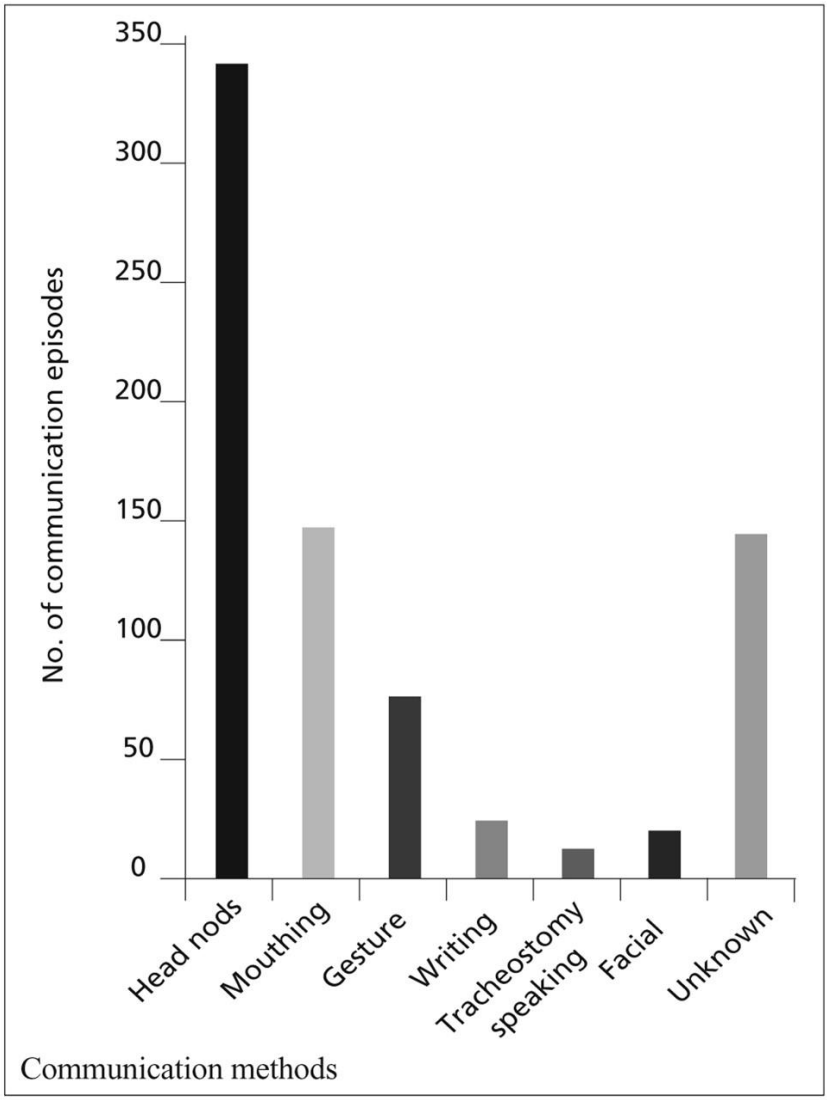
Johnson DC, et al. Clin resp Journal, 2009; 3: 8–14.

Tracheostomy tube manometry



Johnson DC, et al. Clin resp Journal, 2009; 3: 8–14.

Communication while intubated…

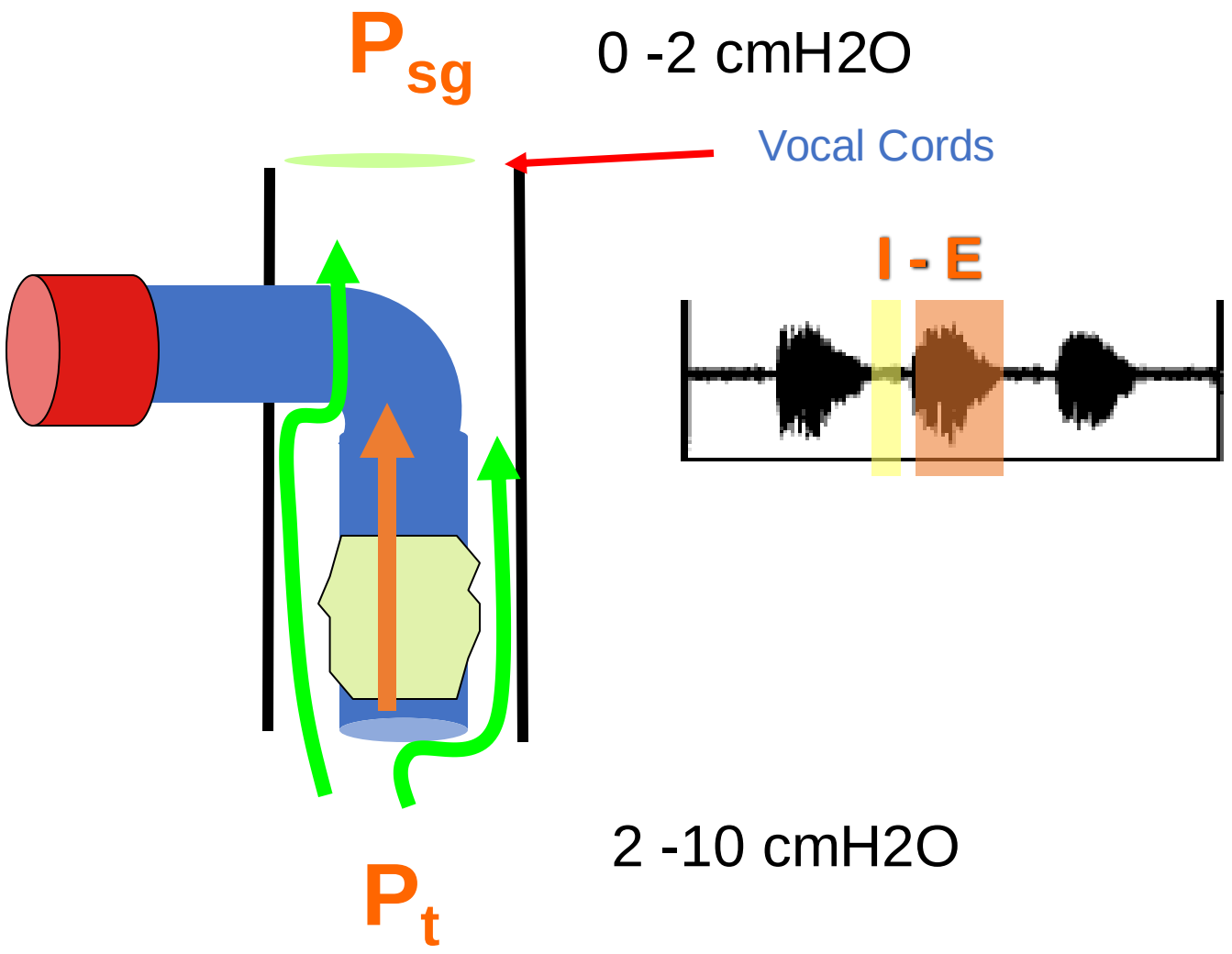


Failure to understand their patients creates frustration, increases stress, and results in minimizing or avoiding interactions.

Patients experience feelings of panic, insecurity, and loss of control, which can result in depression and self-seclusion

- Menzel LK. *Heart Lung.* Jul-Aug 1998;27(4):245-252.
- Hall DS. *Am J Crit Care.* Jul 1996;5(4):293-297.
- Pennock BE, Crawshaw L, et al. *Heart Lung.* Jul-Aug 1994;23(4):323-327.
- Bergbom-Engberg I, Haljamae H.. Crit Care Med. Oct 1989;17(10):1068-1072.
- Happ MB, et al. Am J Crit Care. 2004 May

Understanding phonation physiology



Spontaneously breathing

Resistive load

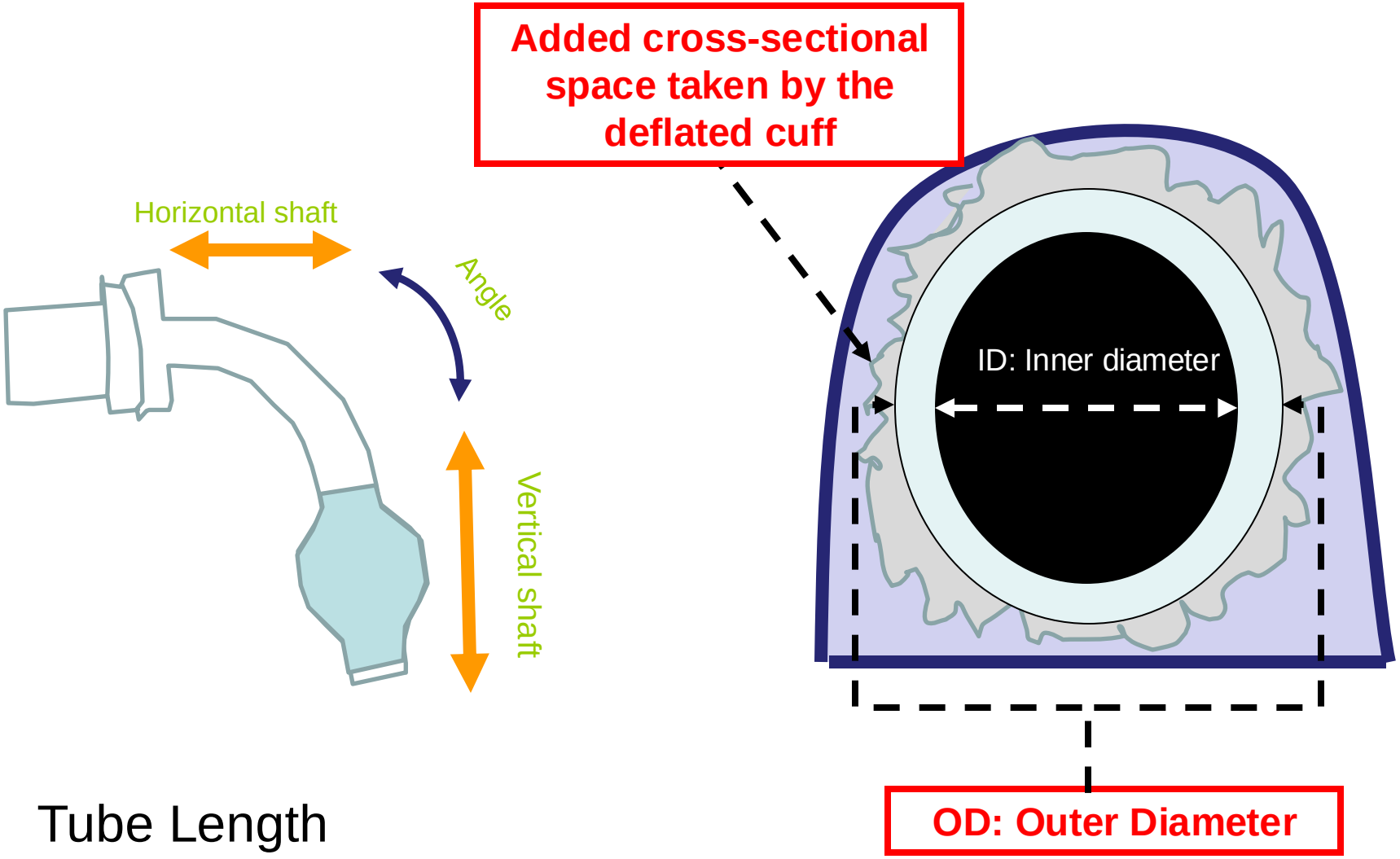
$$R \sim \frac{\eta . L}{r^5}$$

Laminar Flow

Turbulent Flow

Jean Poiseuille (1797-1869)

Tracheostomy tube "anatomy"

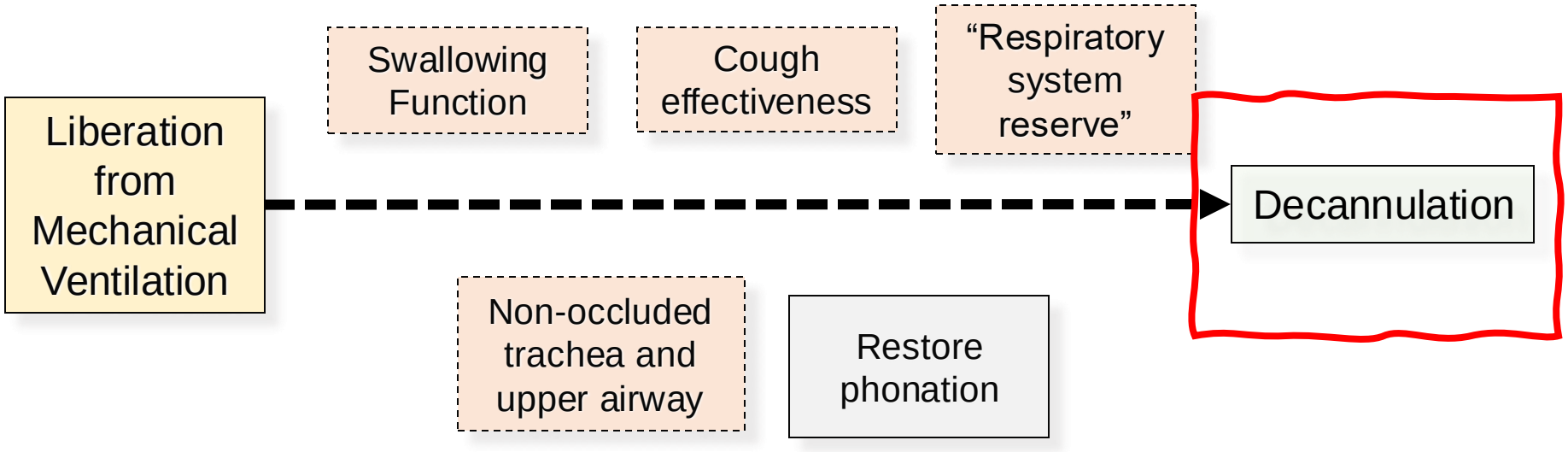


Tube Length

1. Dead Space
2. Resistance

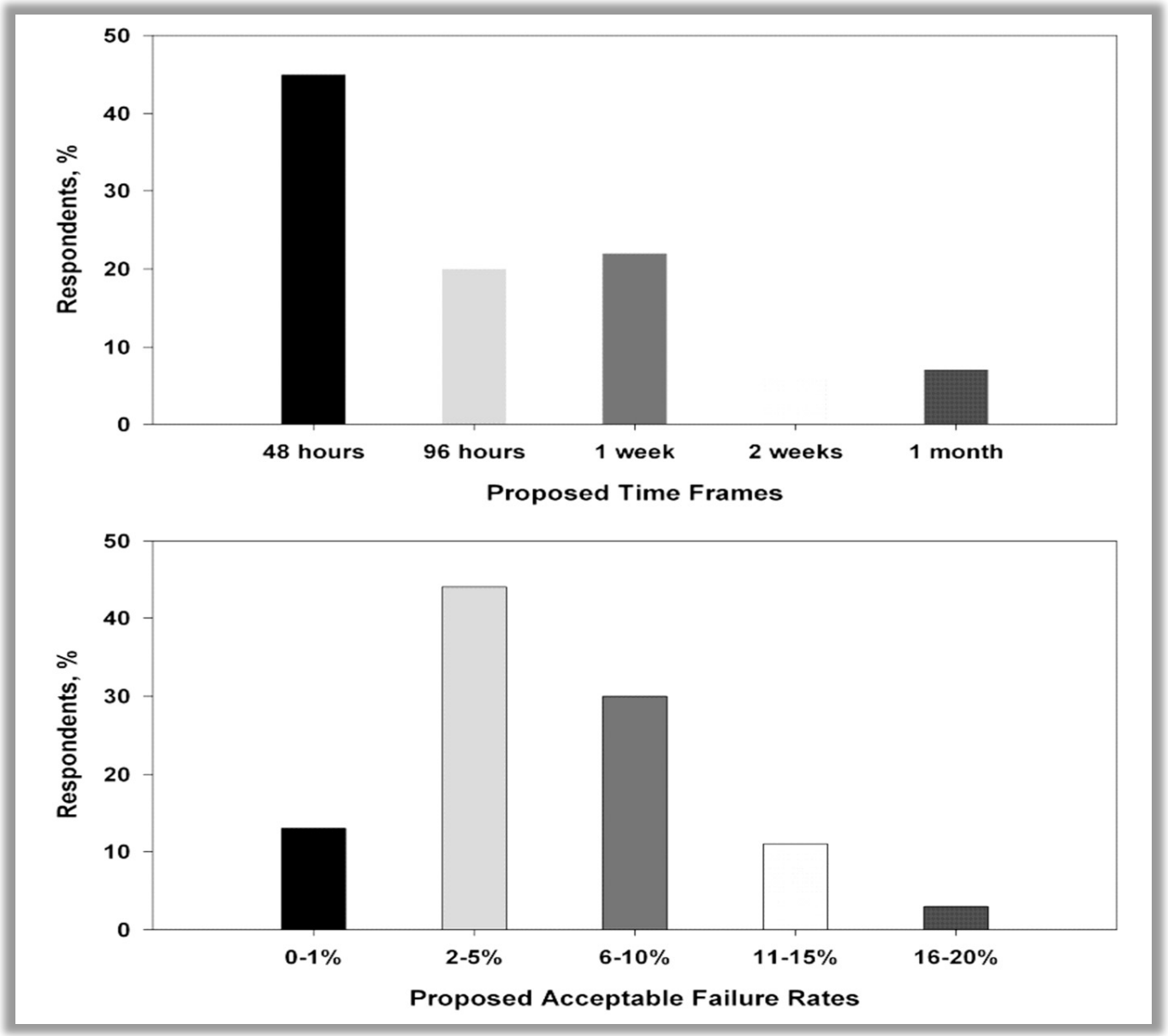
Tracheal cross-section

Decannulation is a process



Adapted from Divo et al, Respir Care 2020

Expert opinion of what represents decannulation failure

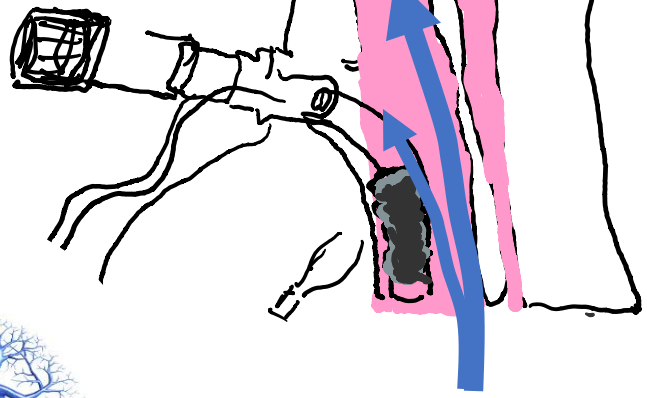


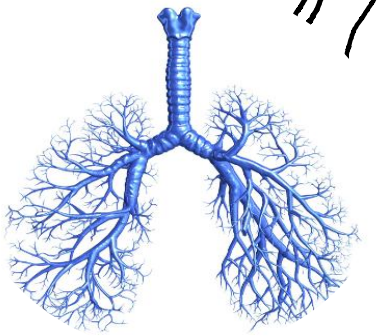
Stelfox H, et al.. *Crit Care*. 2008;12(1):R26.

1. Level of consciousness
2. Coordination
3. Reflexes

Bla, bla, Bla

Swallowing Function

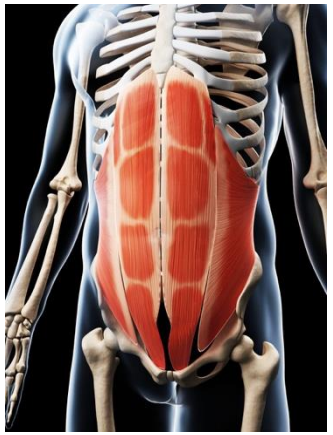




“Respiratory system reserve”:

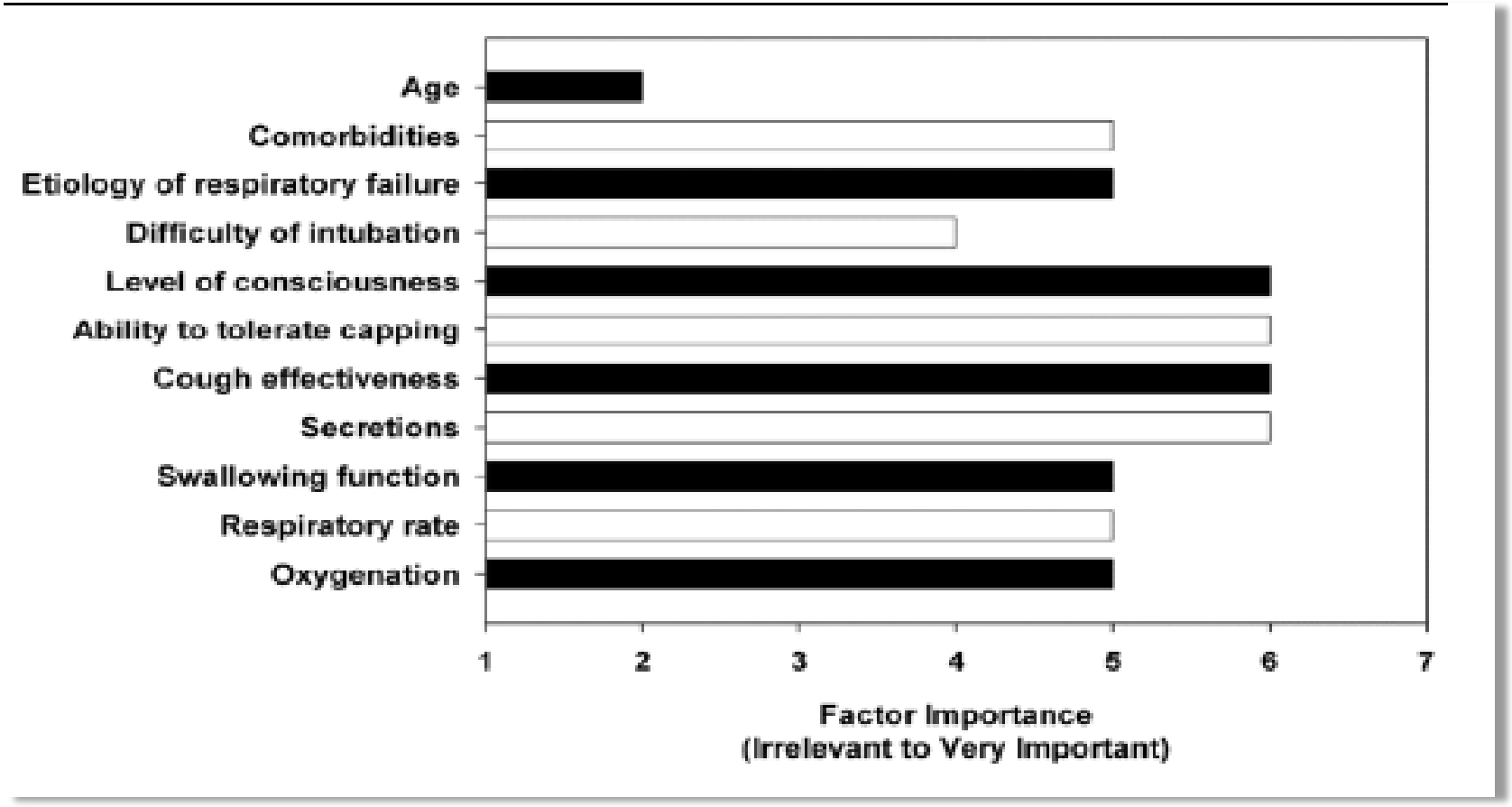
- O2
- PCO2
- Ph

Cough effectiveness



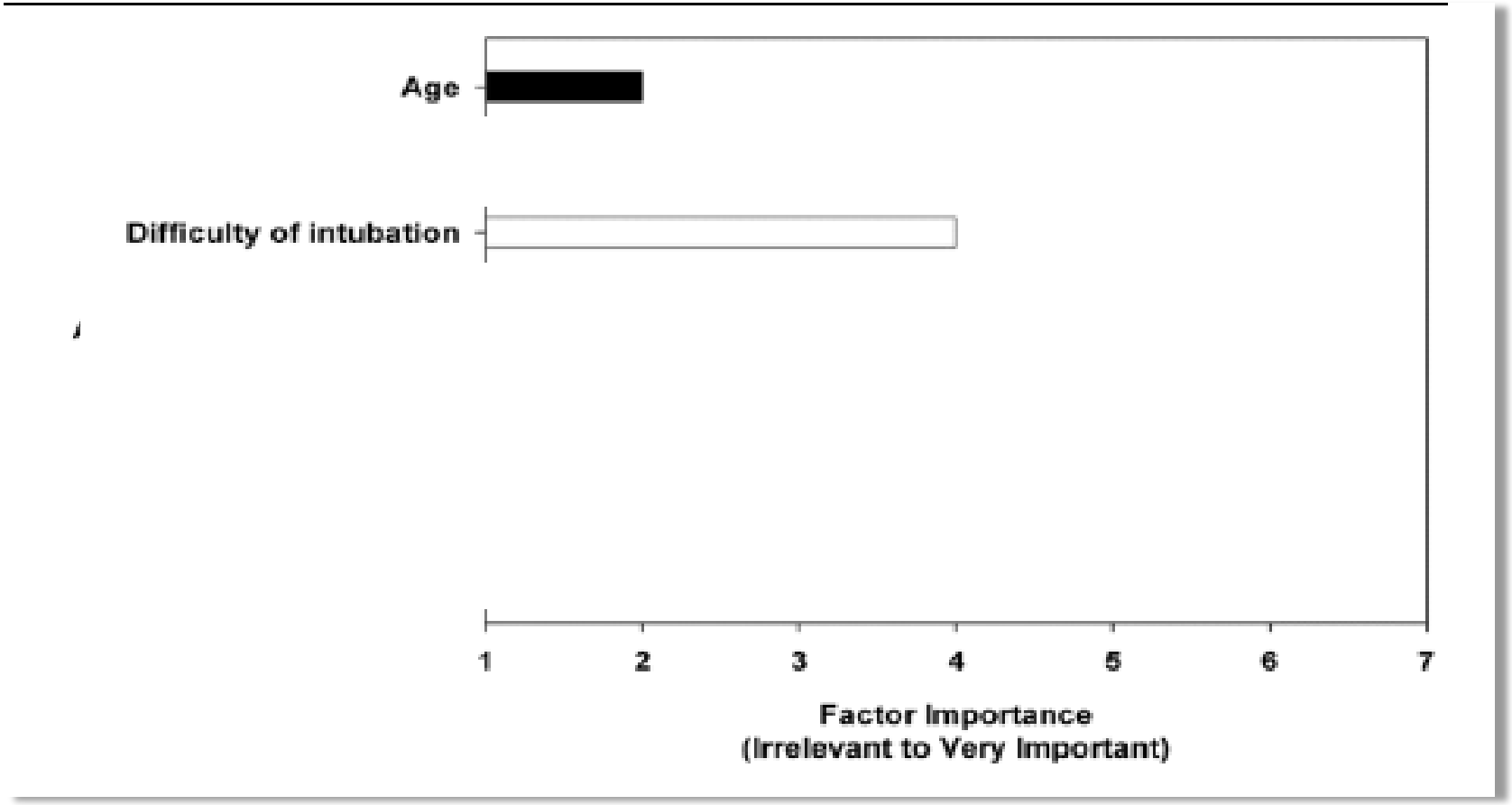
Adapted Stelfox H, et al. Determinants of tracheostomy decannulation *Crit Care*. 2008;12(1):R26.

Expert opinion on the determinants of decannulation



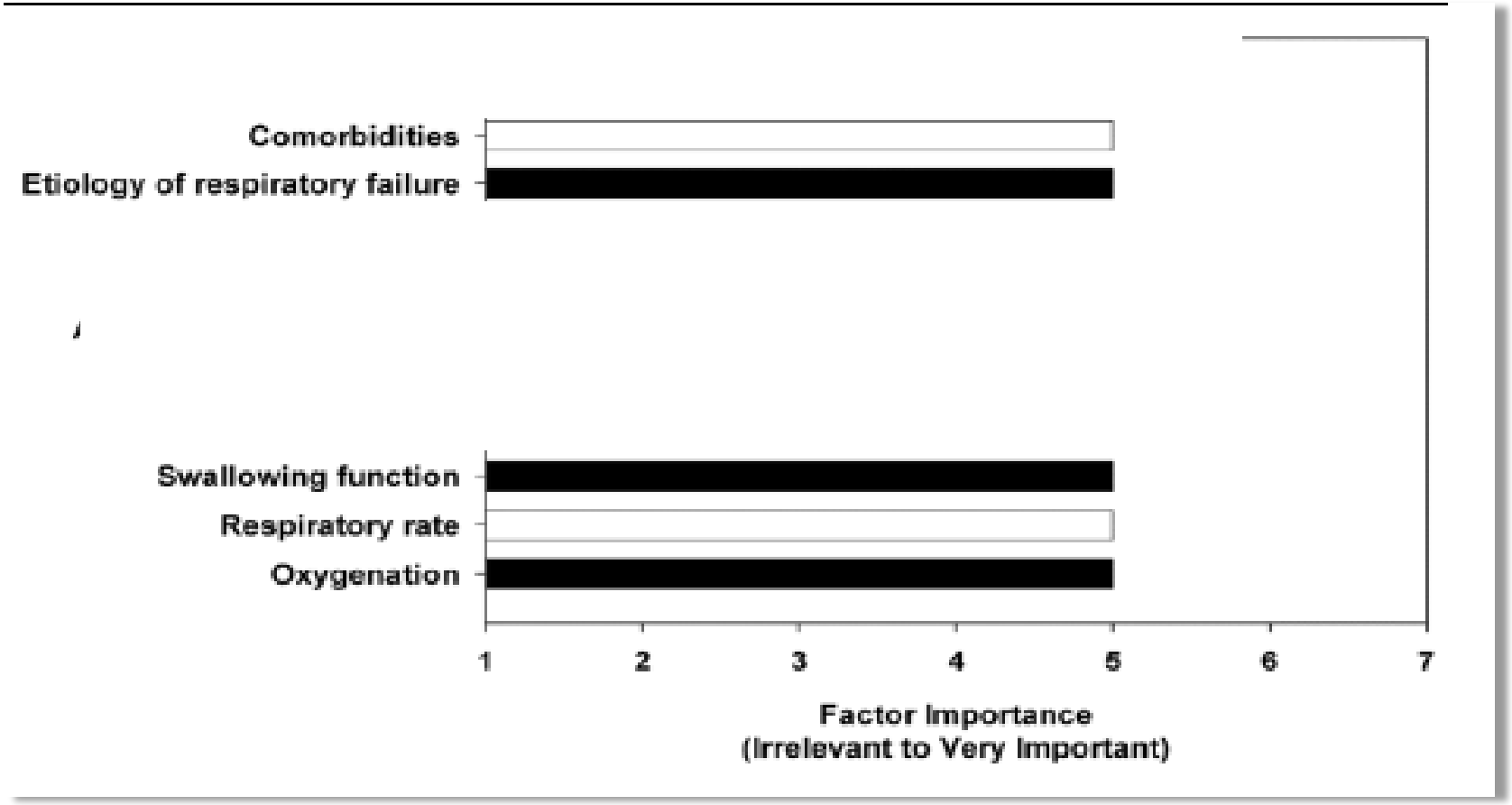
Stelfox H, et al. Determinants of tracheostomy decannulation: an international survey. *Crit Care*. 2008;12(1):R26.

Expert opinion on the determinants of decannulation



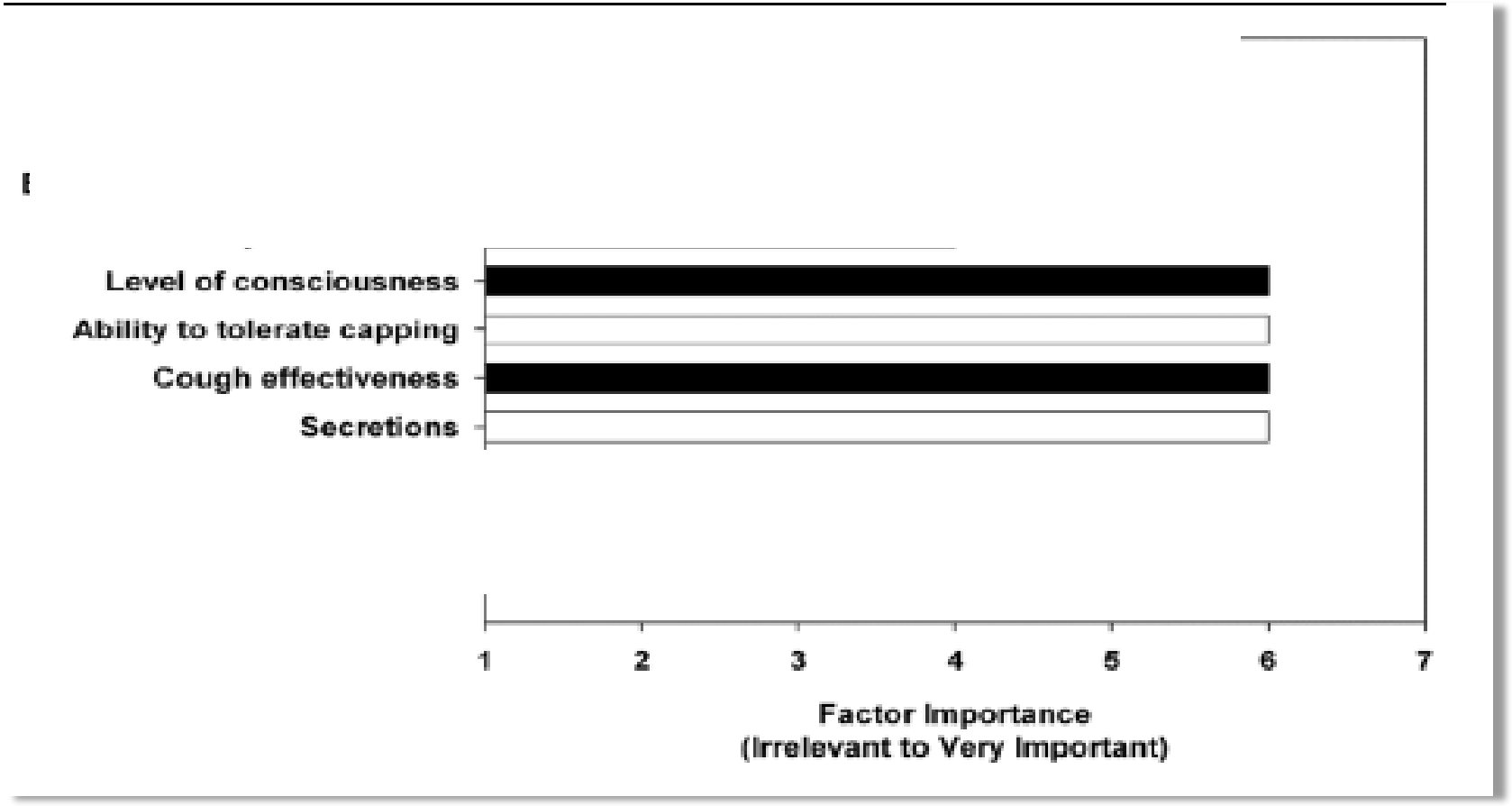
Stelfox H, et al. Determinants of tracheostomy decannulation: an international survey. *Crit Care*. 2008;12(1):R26.

Expert opinion on the determinants of decannulation



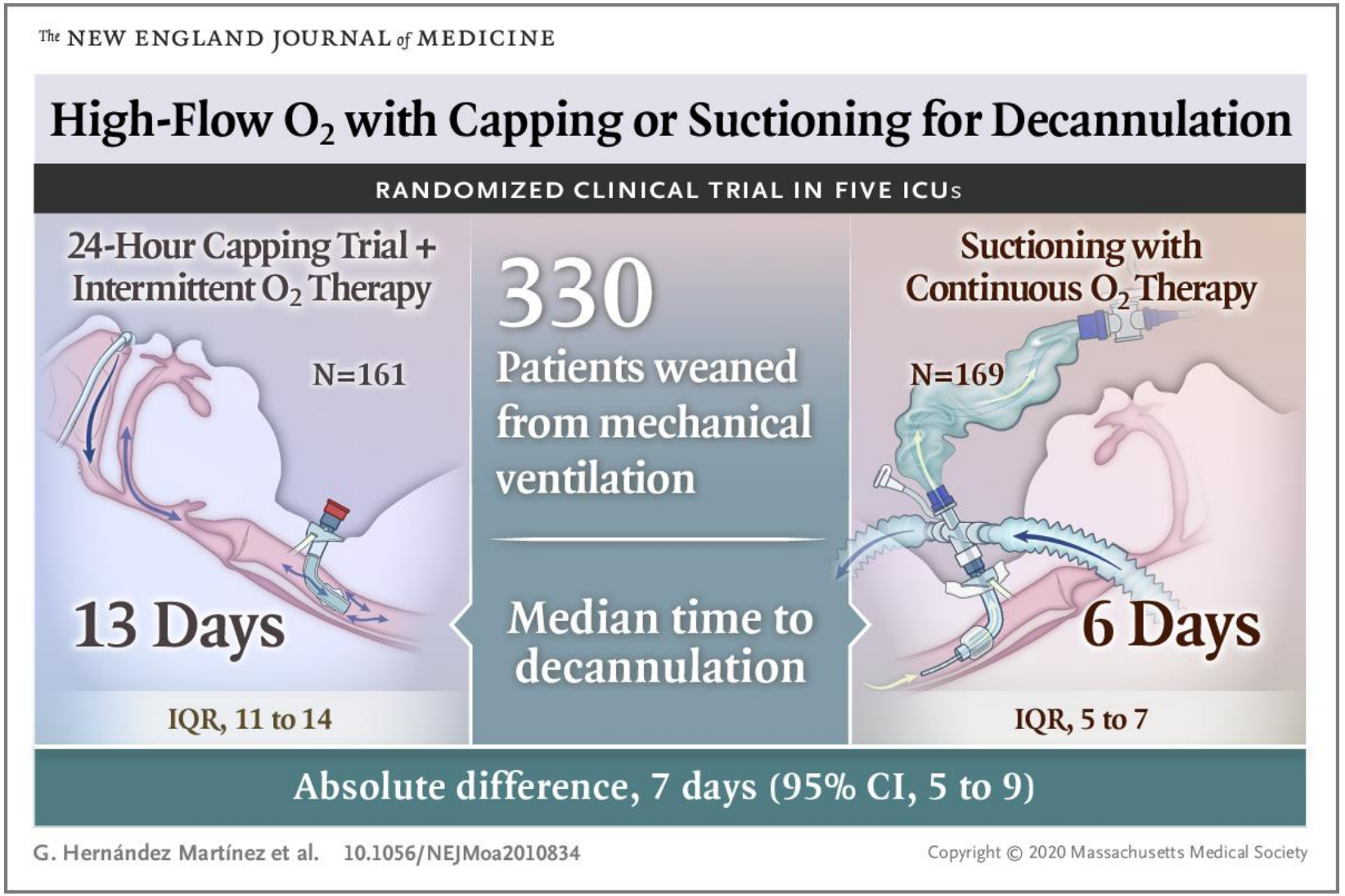
Stelfox H, et al. Determinants of tracheostomy decannulation: an international survey. *Crit Care*. 2008;12(1):R26.

Expert opinion on the determinants of decannulation



Stelfox H, et al. Determinants of tracheostomy decannulation: an international survey. *Crit Care*. 2008;12(1):R26.

RTC on Decannulation



Works in selected patients…

Table 1. Characteristics of the Patients.*

Characteristic	Control Group (N=161)	Intervention Group (N=169)
Age — yr	59.3±14.8	57.3±15.4
Coexisting conditions — no. (%)§		
Body-mass index >25¶	122 (75.8)	126 (74.6)
Heart disease	34 (21.1)	29 (17.2)
Neurologic disease	36 (22.4)	30 (17.8)
Chronic obstructive pulmonary disease	21 (13.0)	18 (10.7)

Exclusion criteria were a contraindication for decannulation at randomization:

- Unconsciousness
- severe swallowing dysfunction
- airway patency problem
- neuromuscular disease other than ICU-acquired weakness
- tracheostomy for airway control

Hernandez-Martinezvet al,N Engl J Med 2020; 383:1009-1017

Complications

Mortality < 2%

Early

- Hemorrhage
- Posteric
  perforati
- Mediast
- Acciden

Late up to 65% (???)

- Tracheal stenosis

stula
ula

1. Under recognized
2. Lost follow-up
3. Lack of standard definitions

- Pneumothorax
- Accidental decannulation
- Tube occlusion
- Aspiration
- Pneumonia

Complications

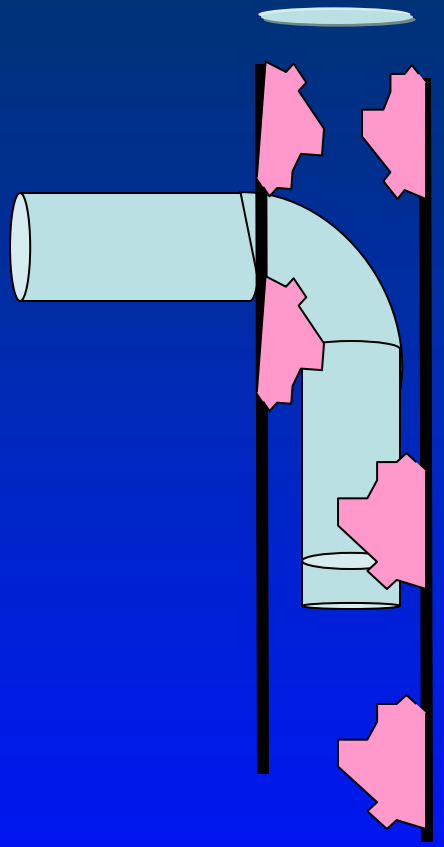
Series of 1,130 patients retrospective single center

Complication	No. of Cases	%
Tracheal Stenosis	21	1.85
Hemorrhage	9	0.87
Tracheocutaneous fistula	6	0.53
Pneumothorax	3	0.26
Tracheoesophageal fistula	1	0.08

Goldenberg D et al, Otolaryngol Head Neck Surg 2000;123(4):495

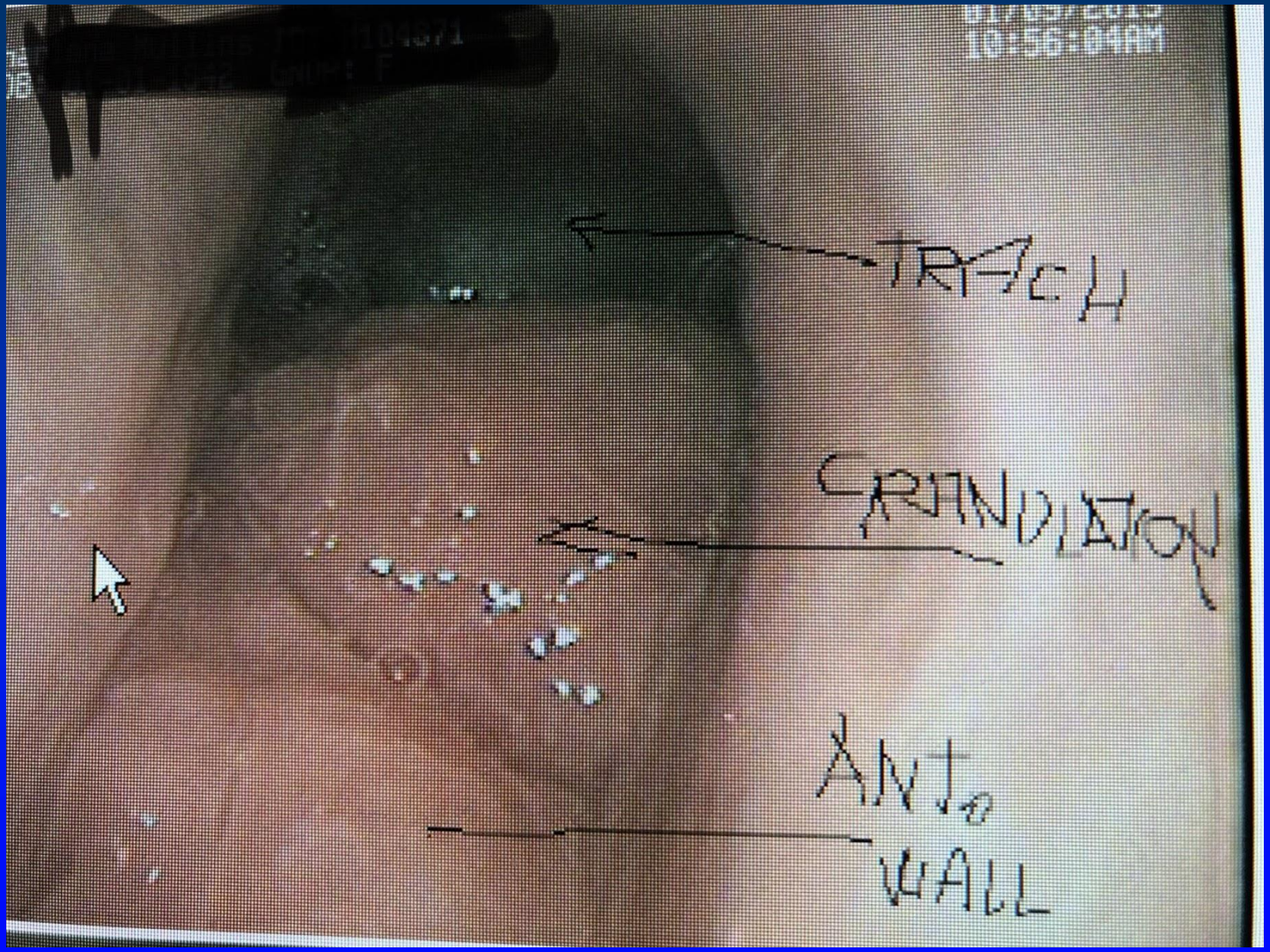
Tracheal Stenosis: S & S

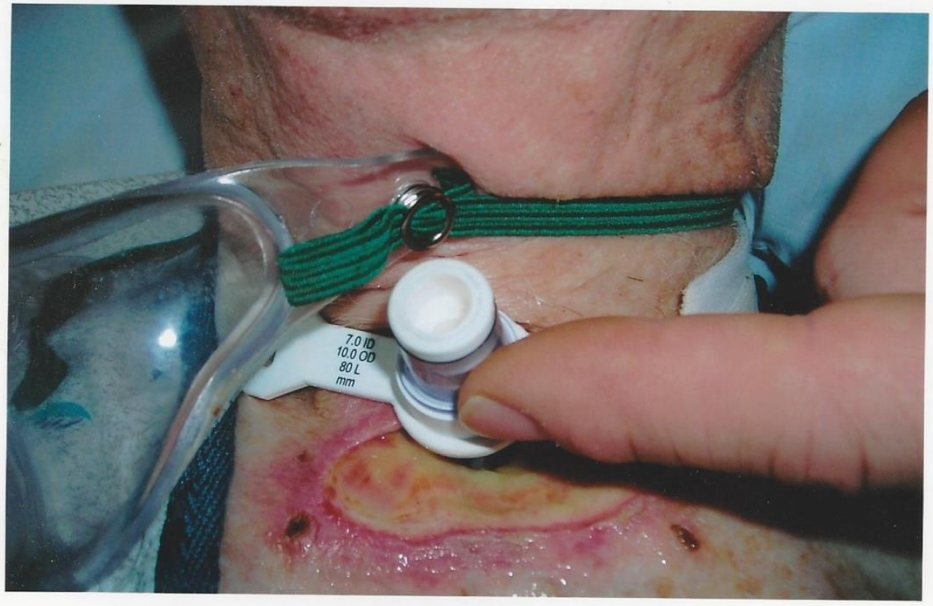
- Difficult to wean
- ↑ PIP
- Unable to advance suction cath.
- Bloody secretion
- Unexplained dyspnea after decannulation need 50-90% stenosis



Overall prevalence 65%
Clinically significant 3-12%

Streitz JM Jr, Surg Clin North Am 1991


TRACH
GRANULATION
ANTRAL
WALL


7.0 ID
10.0 OD
80 L
mm


BIVONA
TTS
10mm

Tracheostomy tubes 101: Objectives

- Who
- When
- Why
- How
- What happens after placement
- Therefore be familiar with this equipment.

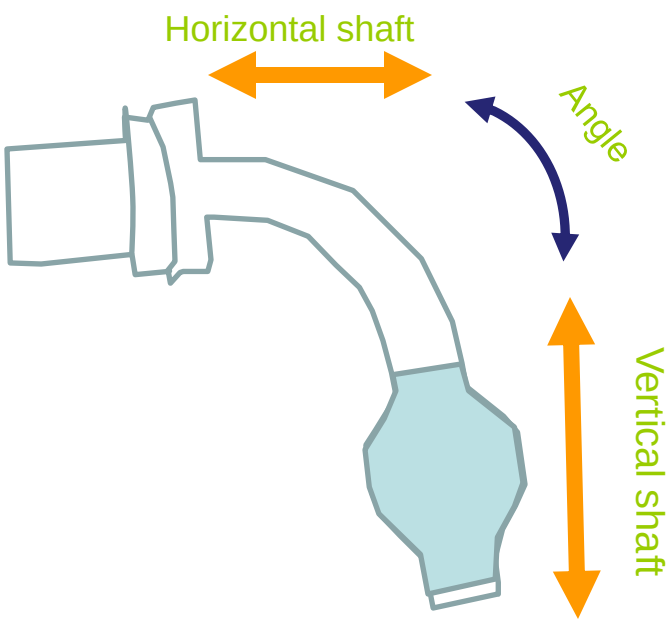
So many trach's too little time…

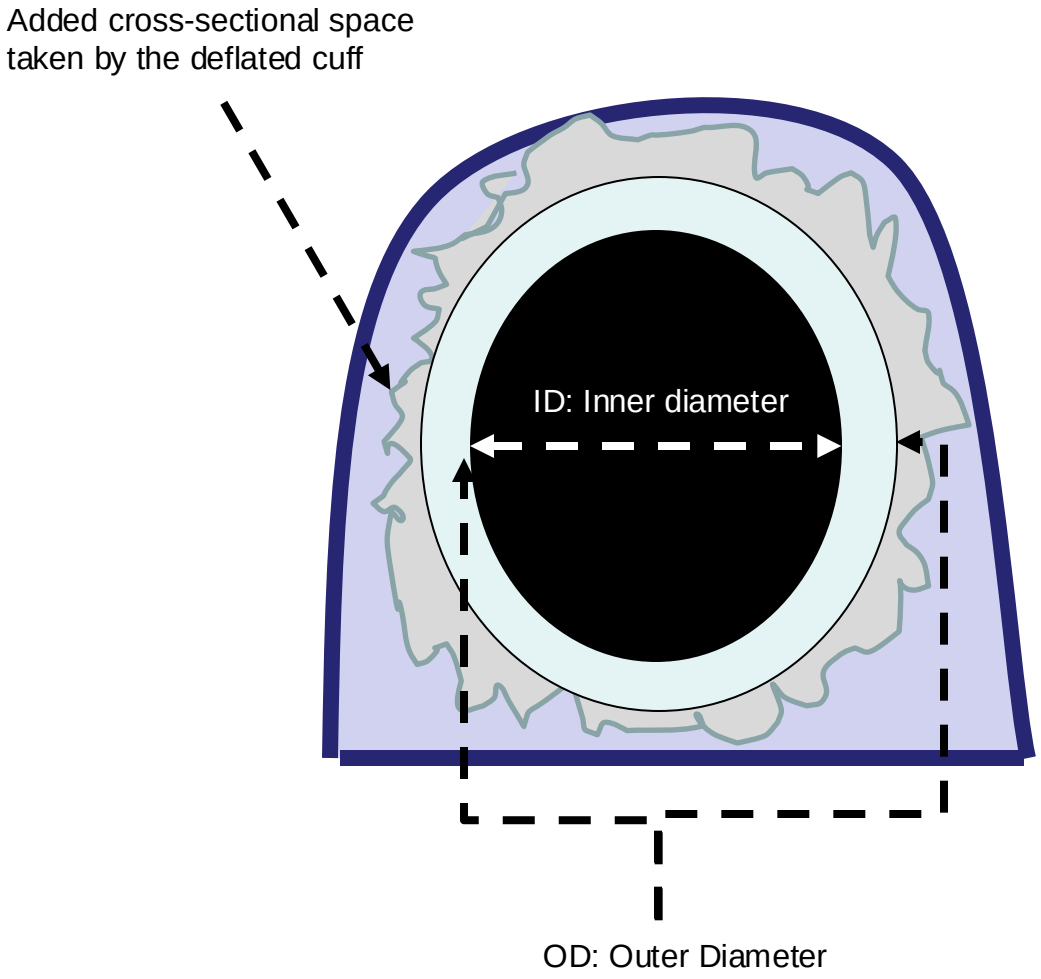
- Material
- Tracheostomy tube dimensions
- Accessories
  - Cuff (types) and uncuffed tubes
  - Inner cannula
  - Fenestration
- Specialized tracheostomy tubes

Material

- Metal : Silver or stainless steel
- Plastic
  - Thermolabile PVC
  - Silicone
  - Silicone with inner metallic coil to increase wall tension

Tracheostomy tube dimensions





Tracheal cross section

Brand and model does matter

A. Open technique tracheostomy tubes						
	Shiley™ SCT	Portex D.I.C®	Bivona® TTS	Portex®Blue Line ultra®	Shiley™ Flex with Taper Guard	Shiley™ LPC & DCT
Cuff	**Air**	**Air**	**Water**	**Air**	**Air**	**Air**
Angle	**75°**	**105°**	**100°**	**105°**	**88°**	**75°**
Material	**PVC**	**PVC**	**Silicone**	**PVC**	**PVC**	**PVC**
I.D.	**O.D**	**O.D**	**O.D**	**O.D.**	**O.D**	**O.D**
6	**8.3**	**8.5**	**8.8**	**9.2**	**10.8**	**10.8**
7	**9.6**	**9.9**	**10**	**10.5**	**11.4**	**-**
8	**10.9**	**11.3**	**11**	**11.9**	**12.2**	**12.2**
I.D.	**Length**	**Length**	**Length**	**Length**	**Length**	**Length**
6	**67**	**64**	**70**	**64.5**	**74**	**76**
7	**80**	**70**	**80**	**70**	**77**	**-**
8	**89**	**73**	**88**	**75.5**	**79**	**81**

Divo et al, Respir Care 2020

Trach sizing comparison open and Percutaneous

A. Open technique tracheostomy tubes						
	Shiley™ SCT	Portex D.I.C®	Bivona® TTS	Portex®Blue Line ultra®	Shiley™ Flex with Taper Guard	Shiley™ LPC & DCT
Cuff	**75°**	**105°**	**100°**		**Air**	**Air**
Angle					**88°**	**75°**
Material	**PVC**	**PVC**	**Silicone**	**PVC**	**PVC**	**PVC**
I.D.	**O.D**	**O.D**	**O.D**	**O.D.**	**O.D**	**O.D**
6	**8.3**	**8.5**	**8.8**	**9.2**	**10.8**	**10.8**
7	**9.6**	**9.9**	**10**	**10.5**	**11.4**	**-**
8	**10.9**	**11.3**	**11**	**11.9**	**12.2**	**12.2**
I.D.	**Length**	**Length**	**Length**	**Length**	**Length**	**Length**
6	**67**	**64**	**70**	**64.5**	**74**	**76**
7	**80**	**70**	**80**	**70**	**77**	**-**
8	**89**	**73**	**88**	**75.5**	**79**	**81**

Divo et al, Respir Care 2020

Brand and model does matter

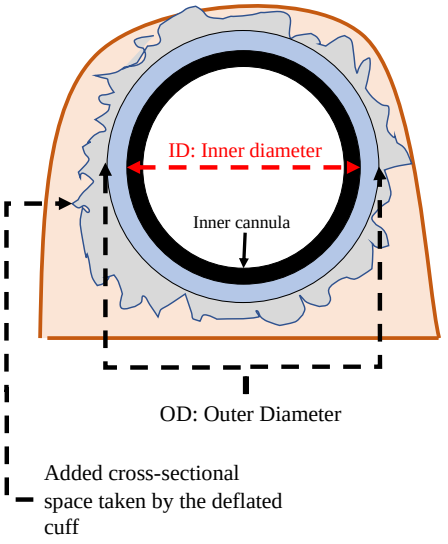
A. Open technique tracheostomy tubes						
	Shiley™ SCT	Portex D.I.C®	Bivona® TTS	Portex®Blue Line ultra®	Shiley™ Flex with Taper Guard	Shiley™ LPC & DCT
Cuff	**Air**	**Air**	**Water**	**Air**	**Air**	**Air**
Angle	**75°**	**105°**	**100°**	**105°**	**88°**	**75°**
Material	**PVC**	**PVC**	**Silicone**	**PVC**	**PVC**	**PVC**
I.D.	**O.D**	**O.D**	**O.D**	**O.D.**	**O.D**	**O.D**
6	**8.3**	**8.5**	**8.8**	**9.2**	**10.8**	**10.8**
7	**9.6**	**9.9**	**10**	**10.5**		
8	**10.9**	**11.3**	**11**	**11.9**	**12.2**	**12.2**
I.D.	**Length**	**Length**	**Length**	**Length**	**Length**	**Length**
6	**67**	**64**	**70**	**64.5**	**74**	**76**
7	**80**	**70**	**80**	**70**	**77**	**-**
8	**89**	**73**	**88**	**75.5**	**79**	**81**

Divo et al, Respir Care 2020

Shiley™ SCT	Portex D.I.C®	Bivona® TTS	Portex®Blue Line ultra®	Shiley™ Flex with Taper Guard	Shiley™ LPC & DCT
					

Portex® Per-fit	Cook™ VersaTube™
	

Tracheal cross section



Cuff types

< 25mmHg

Uncuffed

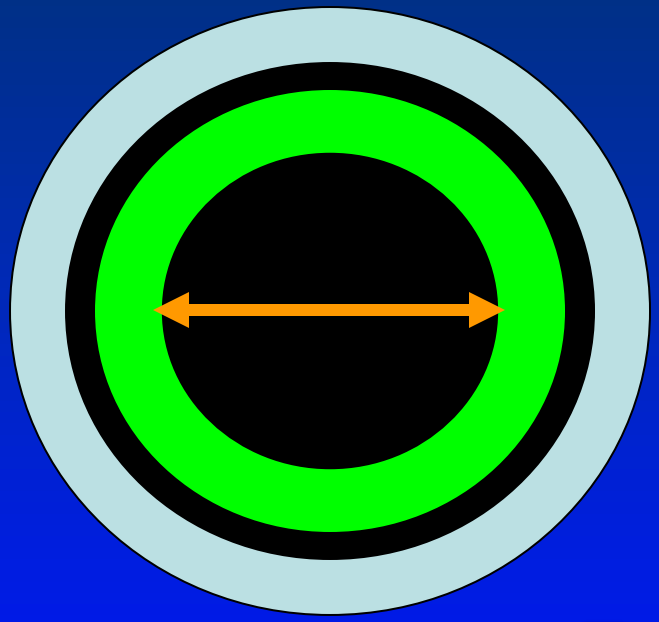
Cuffed:

- Low P, high V
- TTS
- Foam cuff

Cuff types


H
L

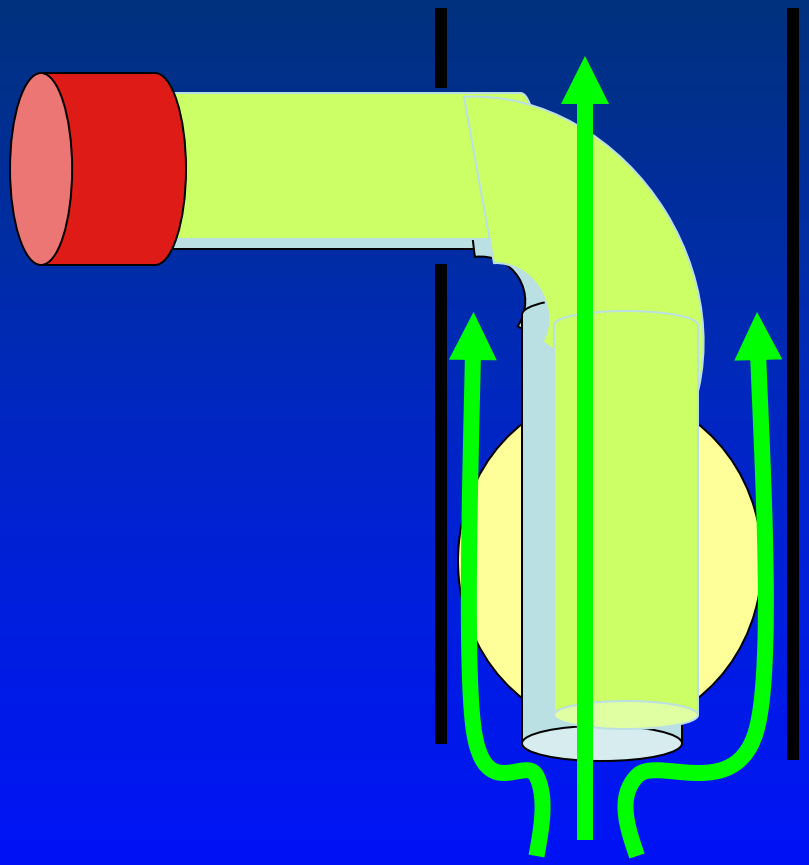
Inner cannula: Think long-term use (going home)

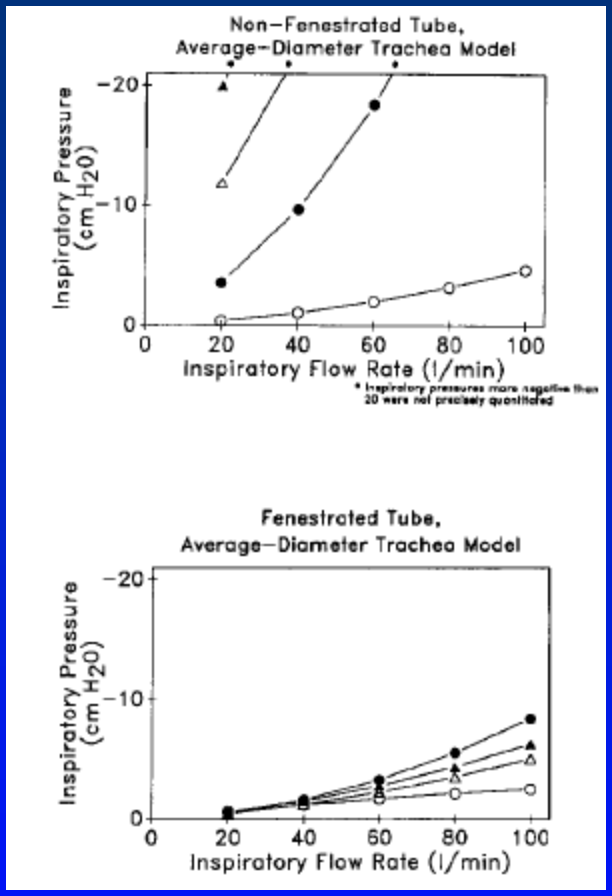


Effective ID - 1mm

$$R \sim \frac{\eta . L}{r^4}$$

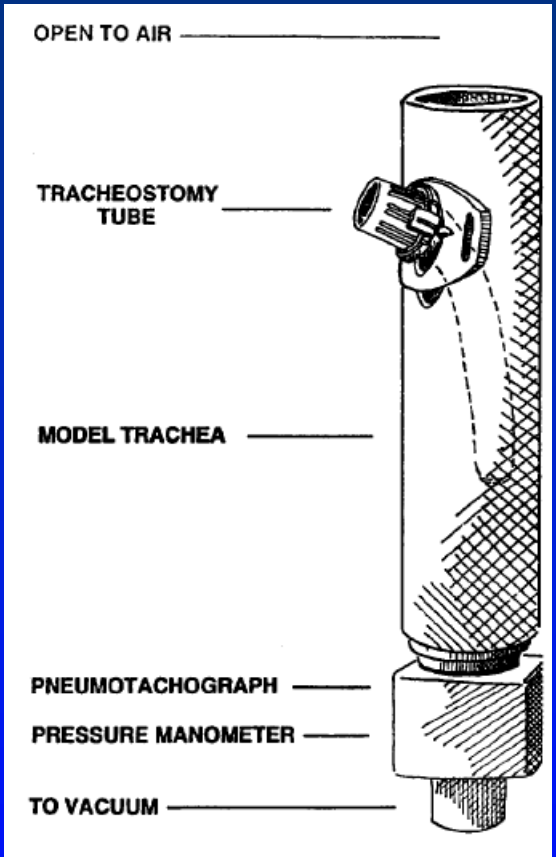
Fenestration

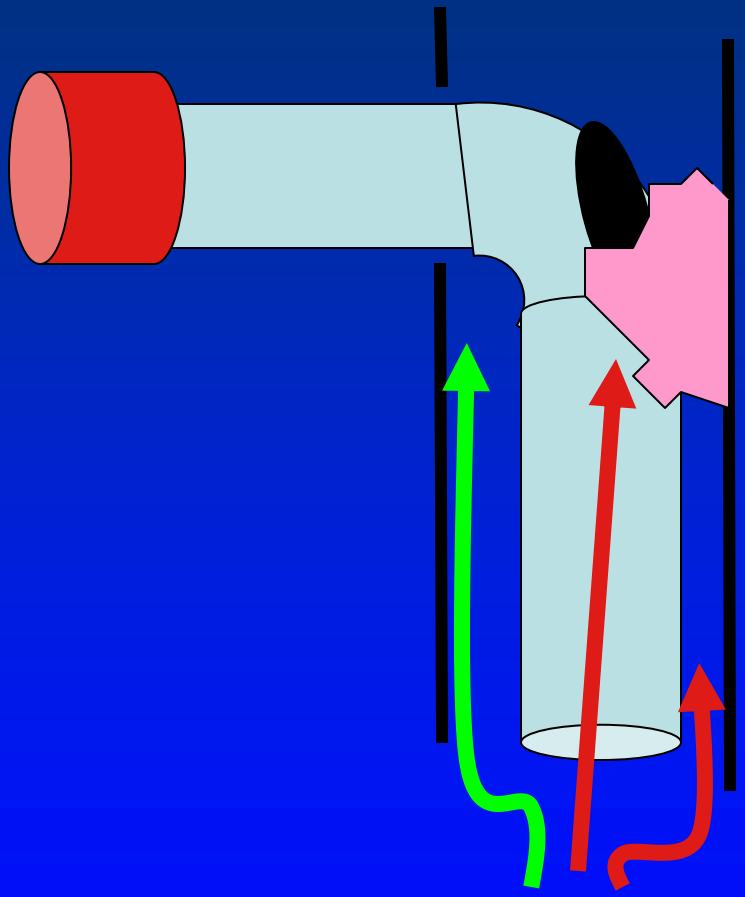




Hussey, J.D. and M.J. Bishop, Chest, 1996. 110(2): p. 494-7

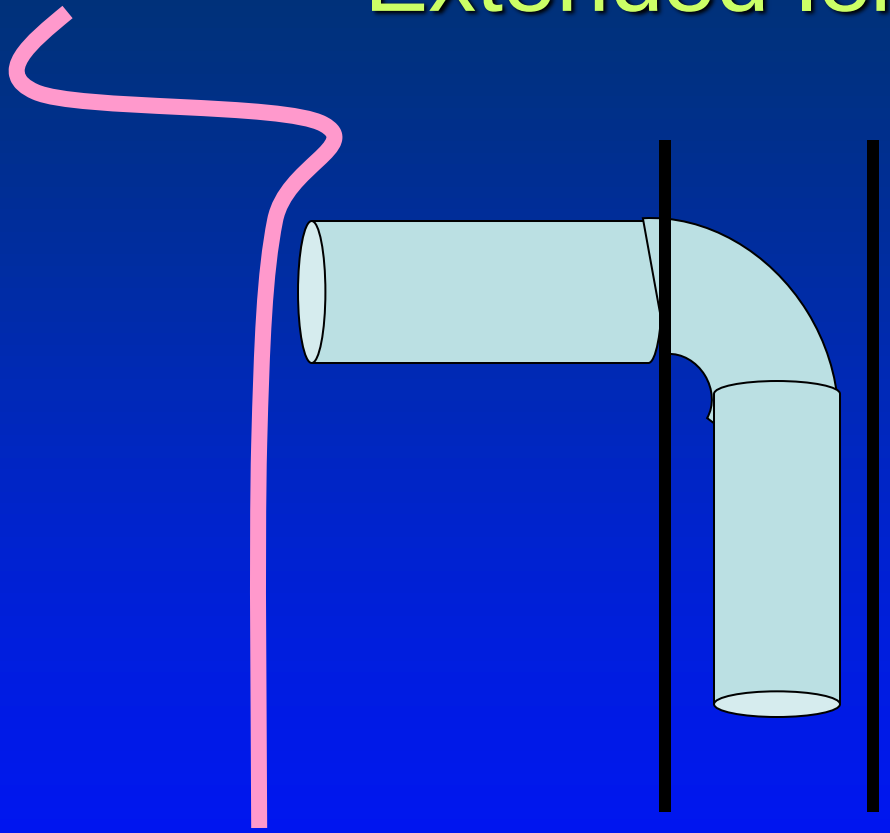
Fenestration: the evidence



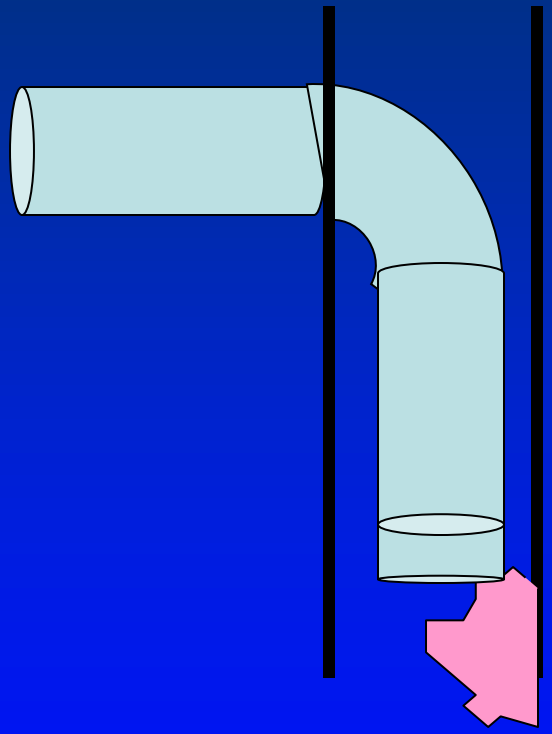


Hussey, J.D. and M.J. Bishop, Chest, 1996. 110(2): p. 494-7

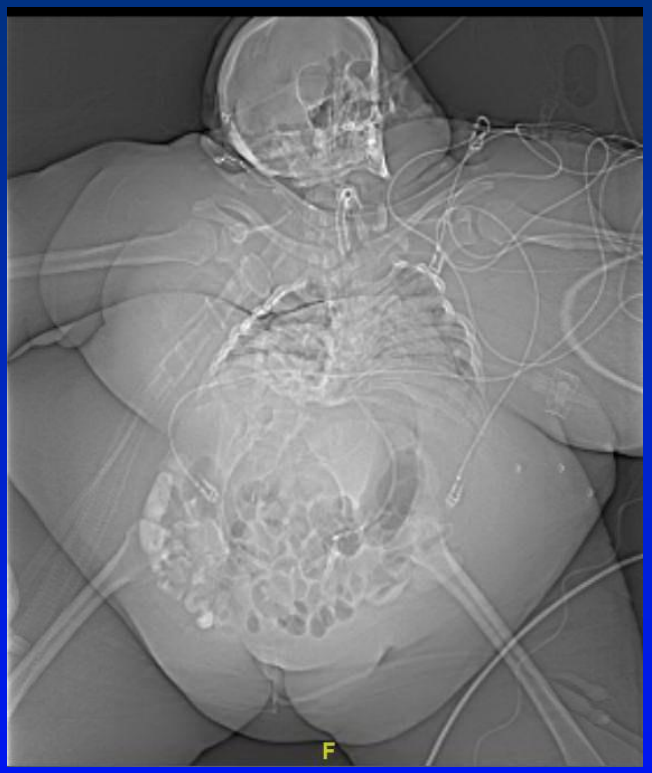
Specialized tracheostomy tubes
Extended length proximal

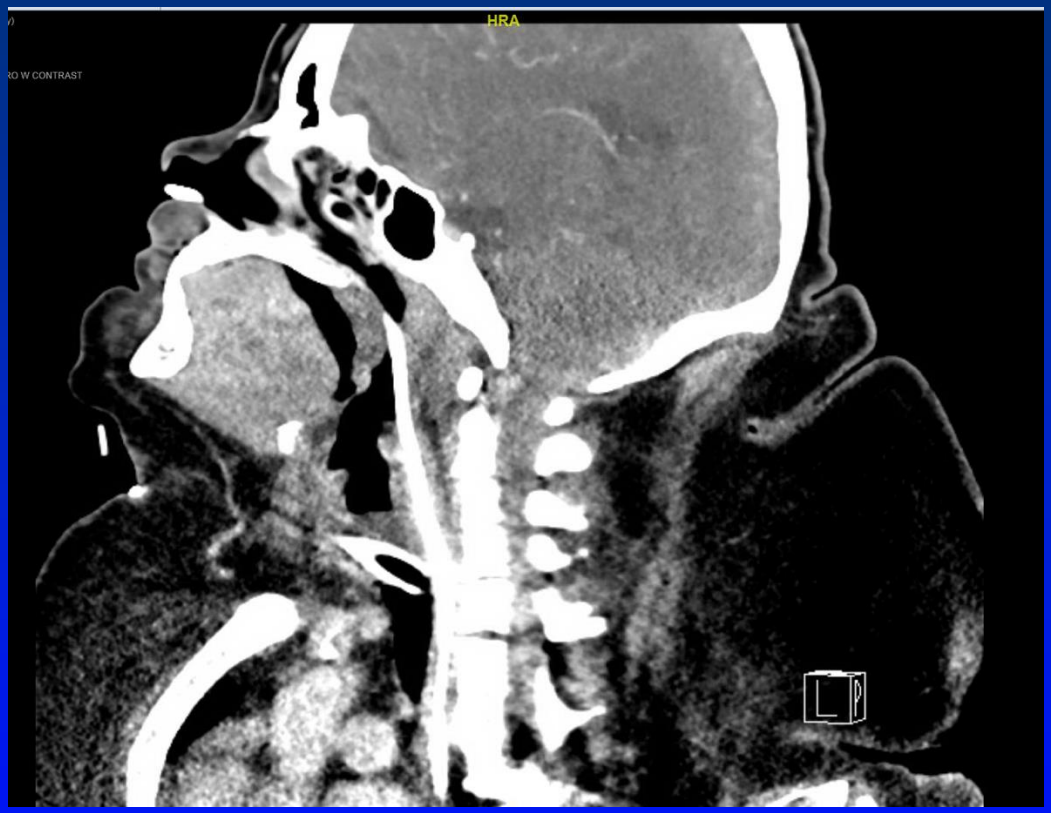


Specialized tracheostomy tubes
Extended length distal

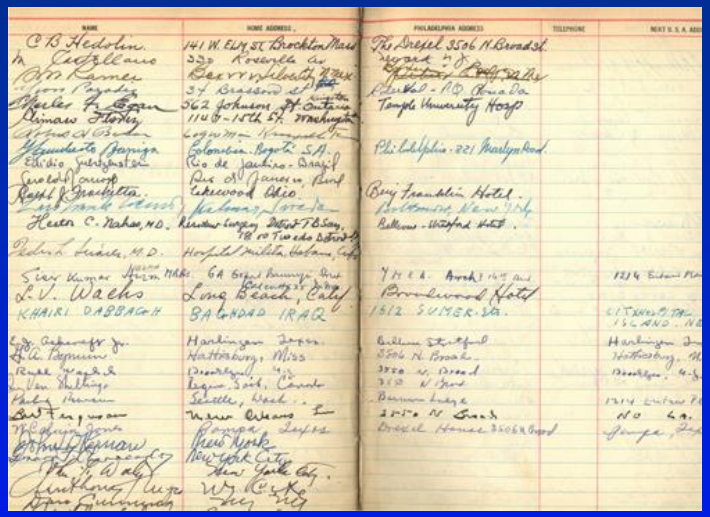


Specialized tracheostomy tubes difficult anatomy


F


HRA
RO W CONTRAST

Thank you



Chevalier Jackson (1865-1958).