Overview of the Paediatric Airway

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A more comprehensive view of the pediatric airway is published in the two articles below:

• Holzki J, Laschat M, Puder C. Iatrogenic damage to the paediatric airway. Mechanisms of scar development. Pediatric Anesthesia 2009, 19 (Suppl. 1): 133–48
• Holzki J, Laschat M, Puder C. Stridor is not a scientifically valid outcome measure for assessing airway injury. Pediatric Anesthesia 2009; 19 (Suppl. 1): 181-98

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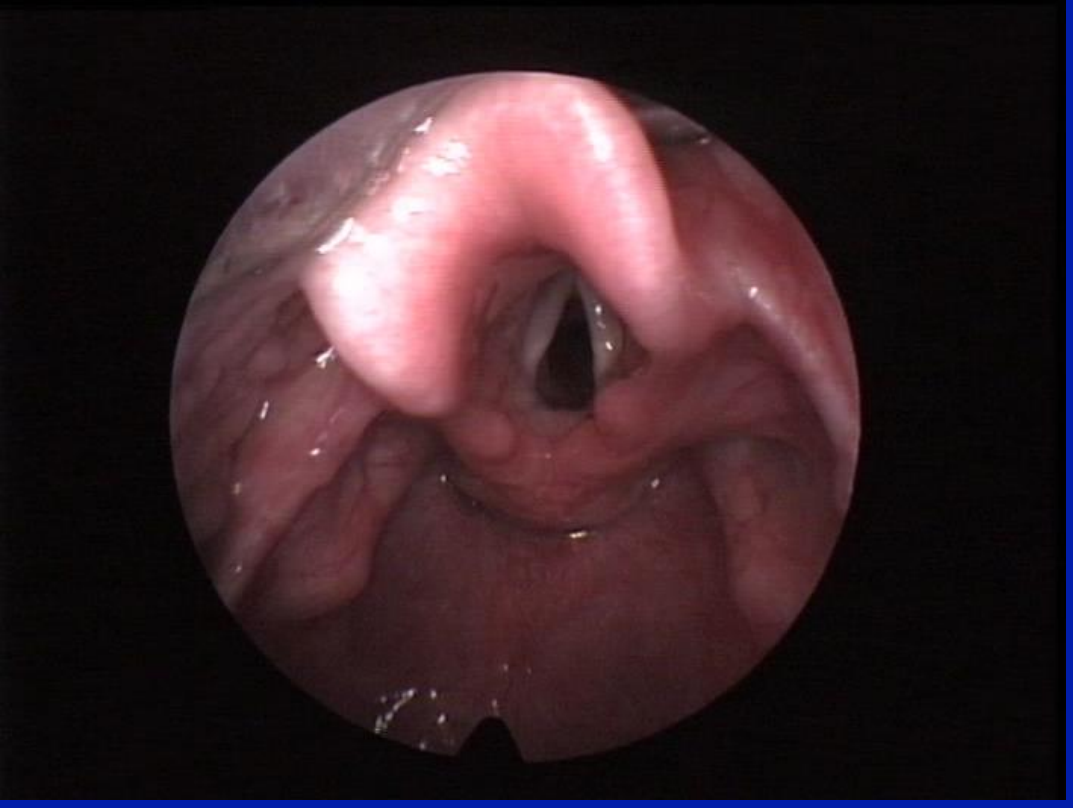
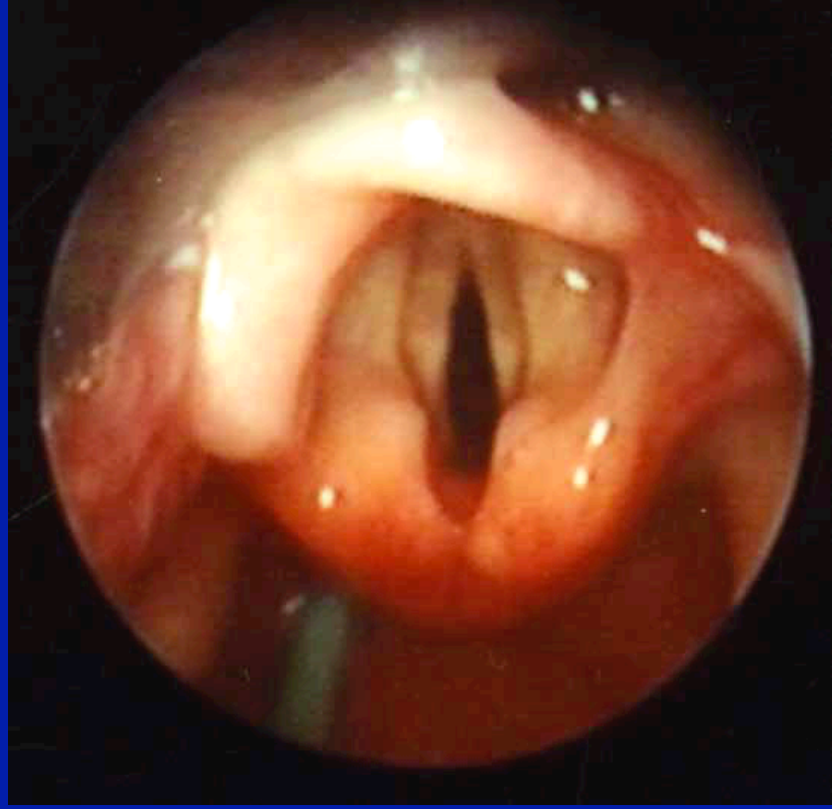
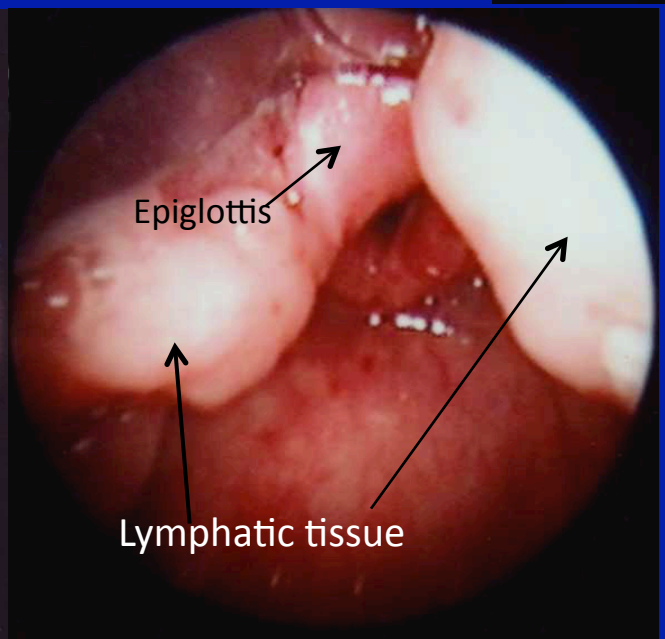
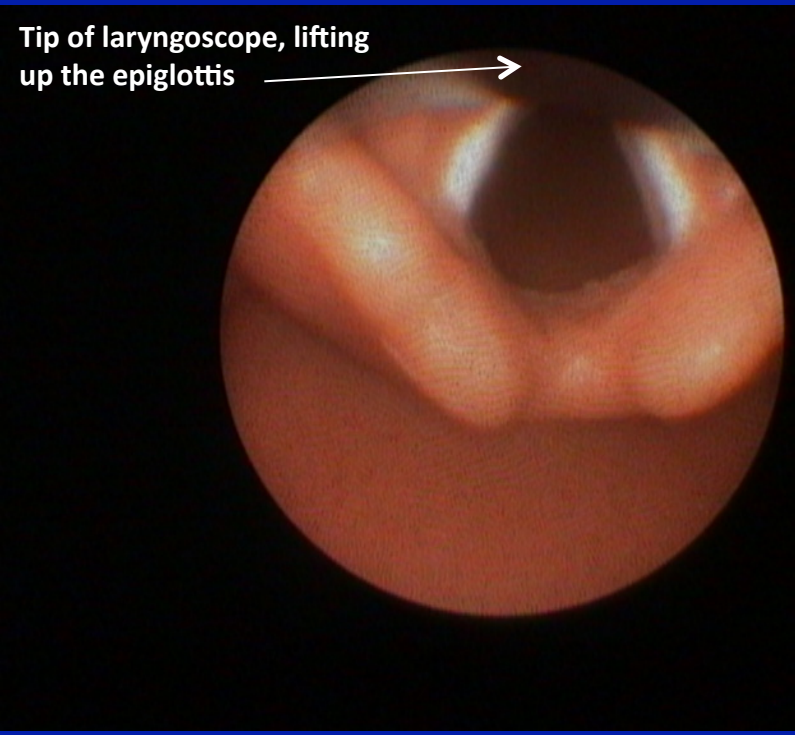




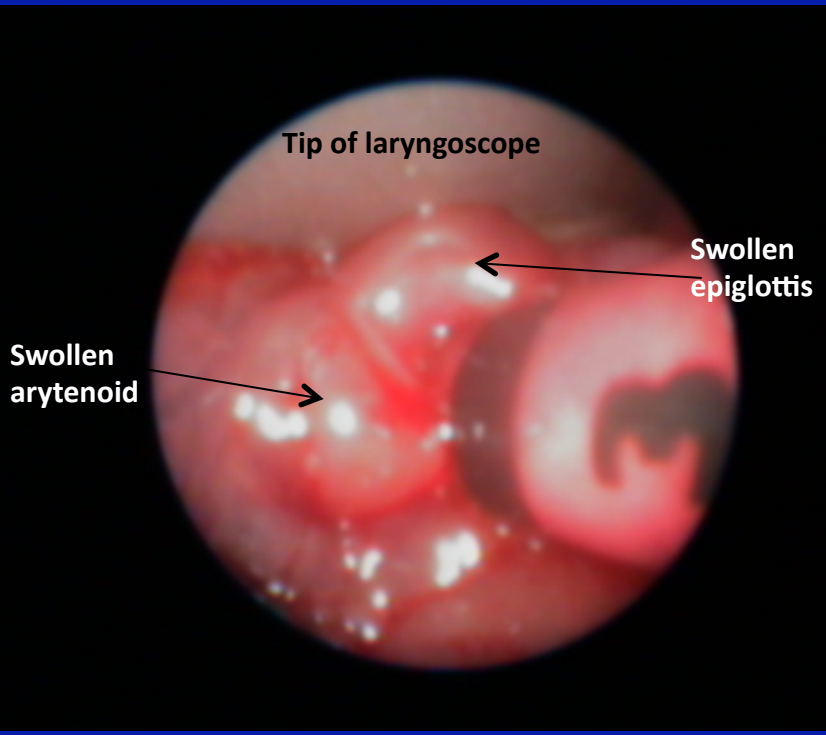


The endoscopist´s perspective:

The aspect of pediatric larynges is as variable as the faces of children



Loading the epiglottis with a straight blade frequently narrows the entrance of the larynx like in this picture

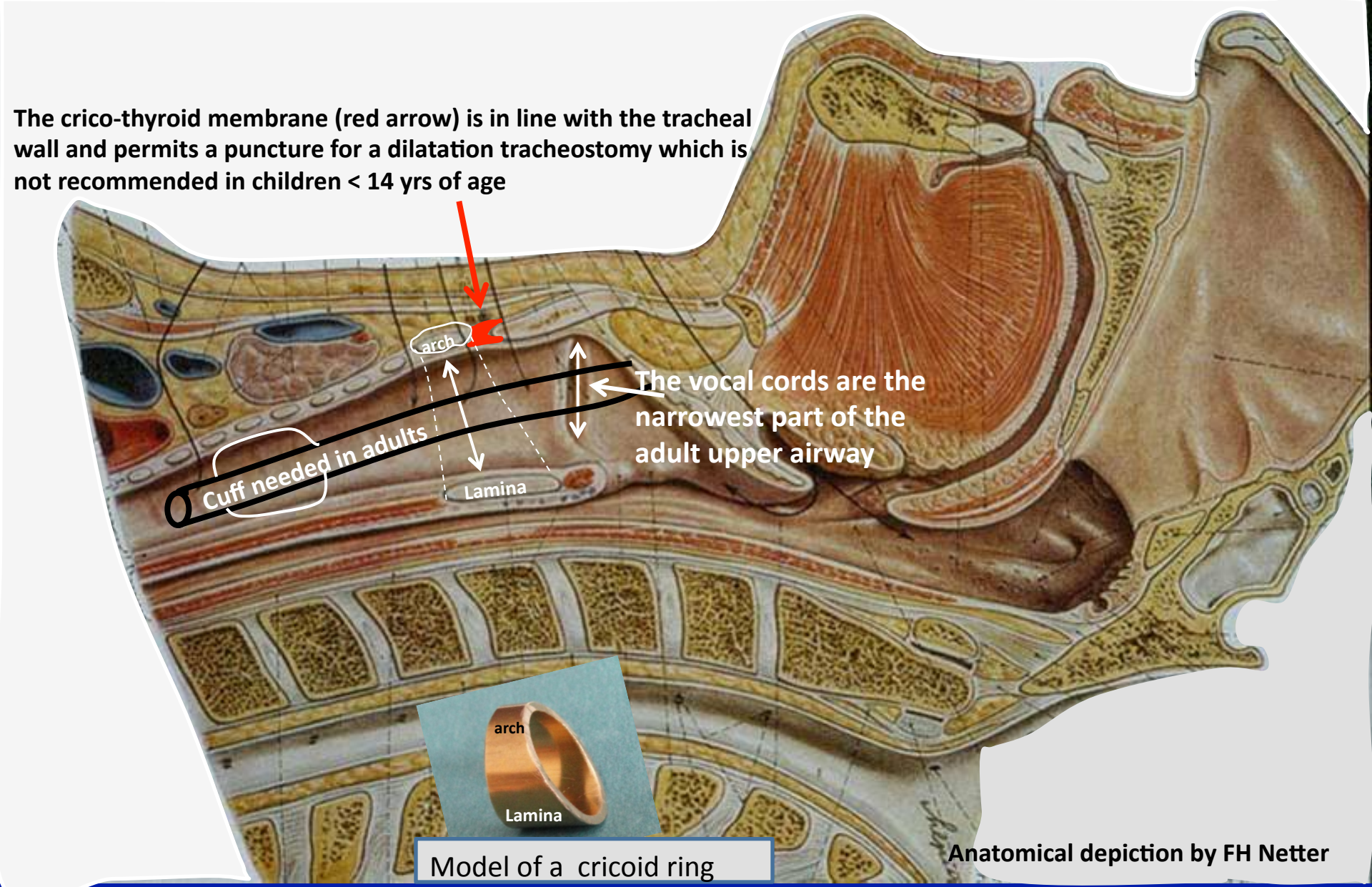


Epiglottis after several attempts at loading it with a straight blade. Extrem swelling of epiglottis and arytenoids. Under the guidance of a Bonfils lens the tip of the blade is placed into the vallecula, permitting a safe intubation

The most conclusive article relating to this topic:

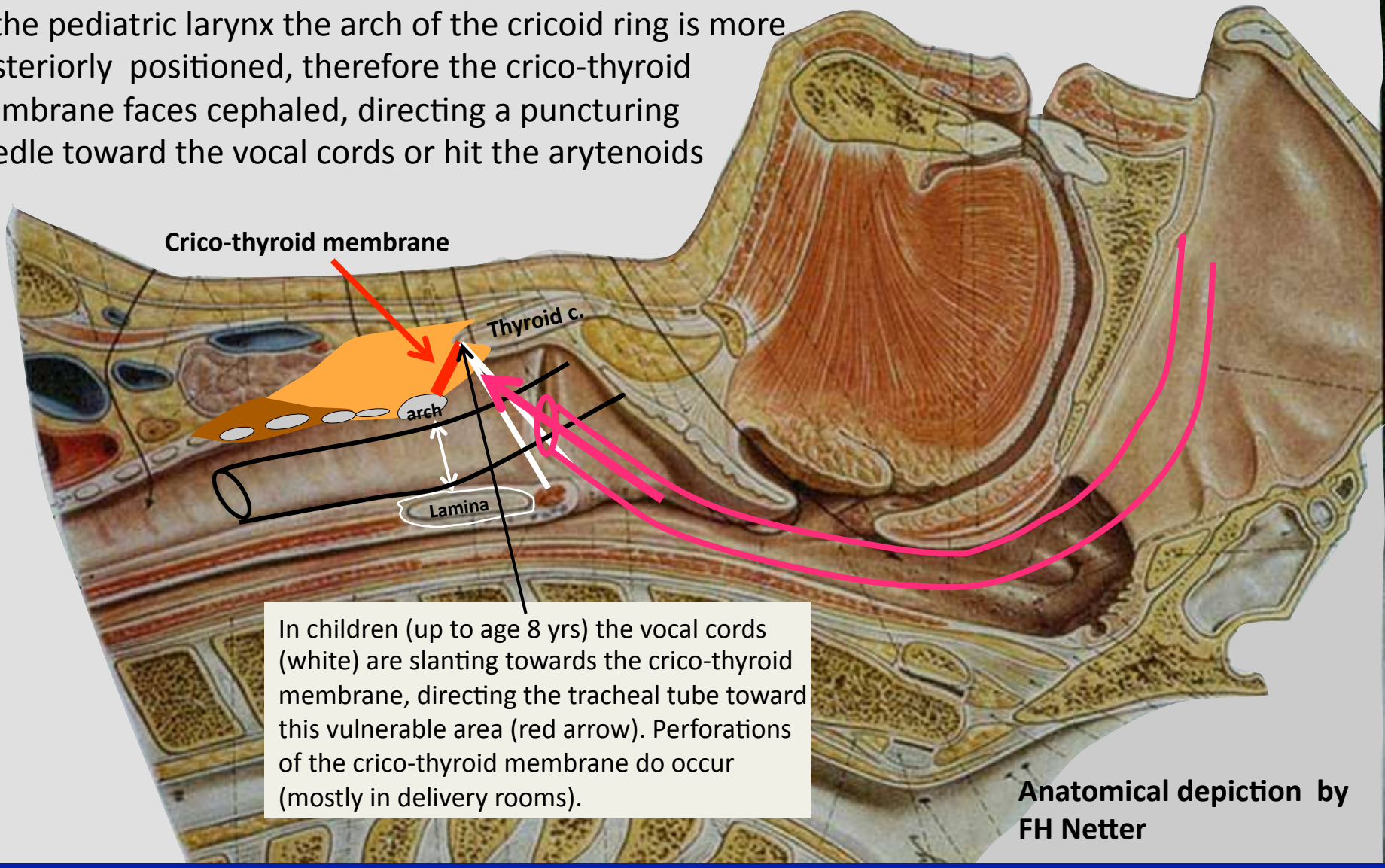
Doherty JS et al. Pediatric laryngoscopes and intubation aids old and new.

Peditr Anesth 2009; 19: (Suppl 1): 30-37



The adult larynx and upper trachea

In the pediatric larynx the arch of the cricoid ring is more posteriorly positioned, therefore the crico-thyroid membrane faces cephaled, directing a puncturing needle toward the vocal cords or hit the arytenoids



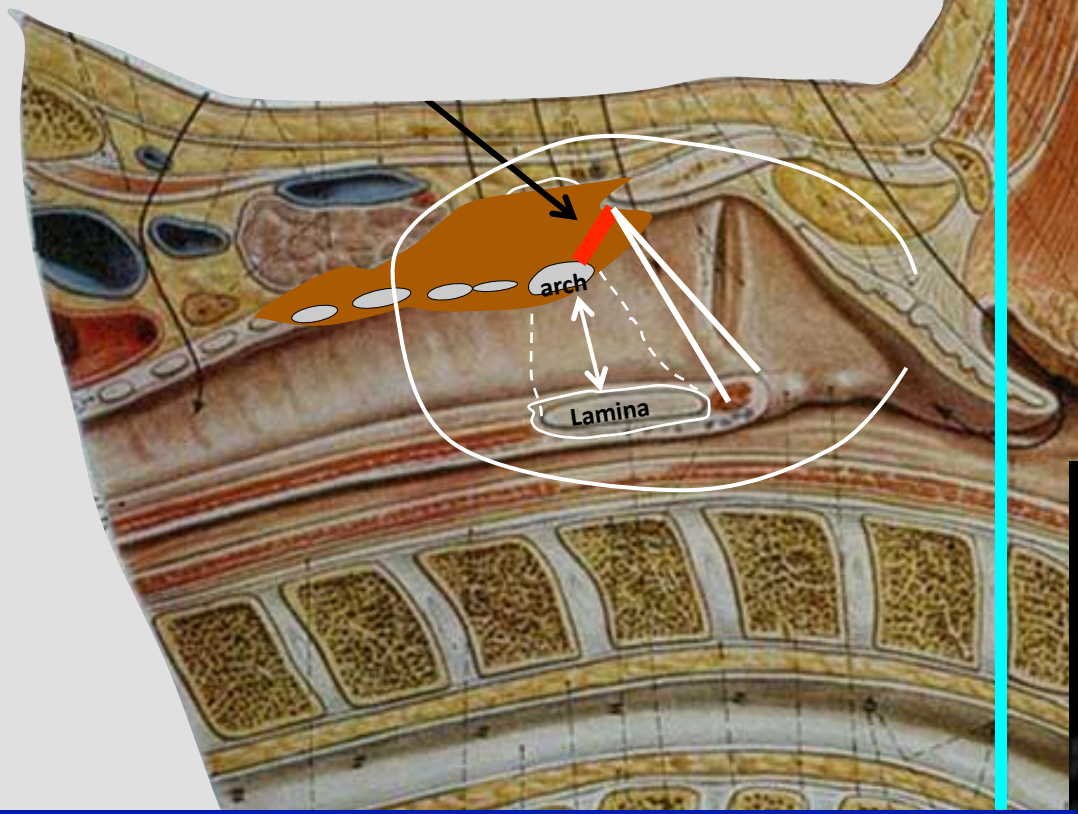
In children (up to age 8 yrs) the vocal cords (white) are slanting towards the crico-thyroid membrane, directing the tracheal tube toward this vulnerable area (red arrow). Perforations of the crico-thyroid membrane do occur (mostly in delivery rooms).

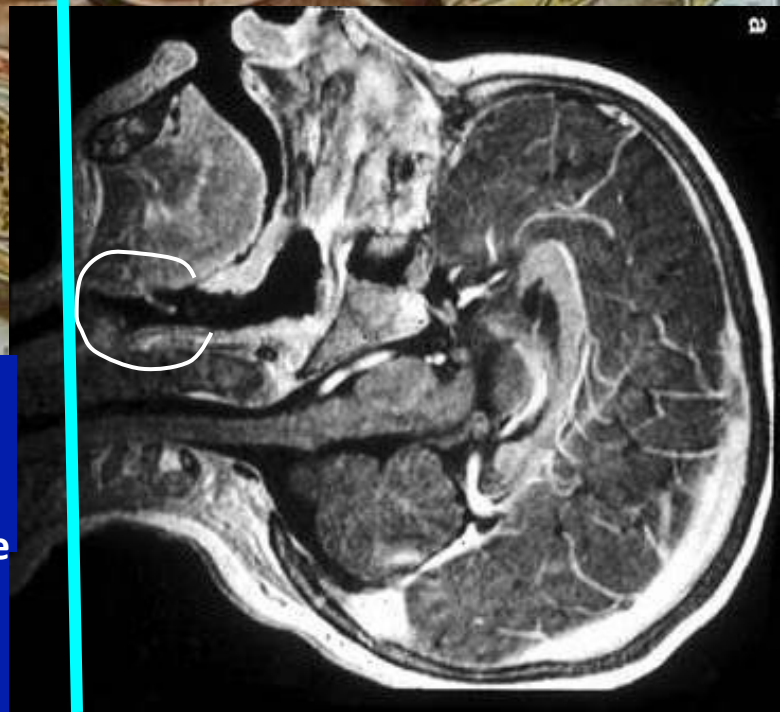
Anatomical depiction by FH Netter

Our knowledge of the pediatric larynx is mainly based on two publications:

- **Bayeux F. Tubage de larynx dans le Croup.** Presse Med 1897; 20: 1-4
- **Eckenhoff JE. Some anatomic considerations of the infant larynx influencing endotracheal anesthesia** Anesthesiology 1951; 12: 401-410

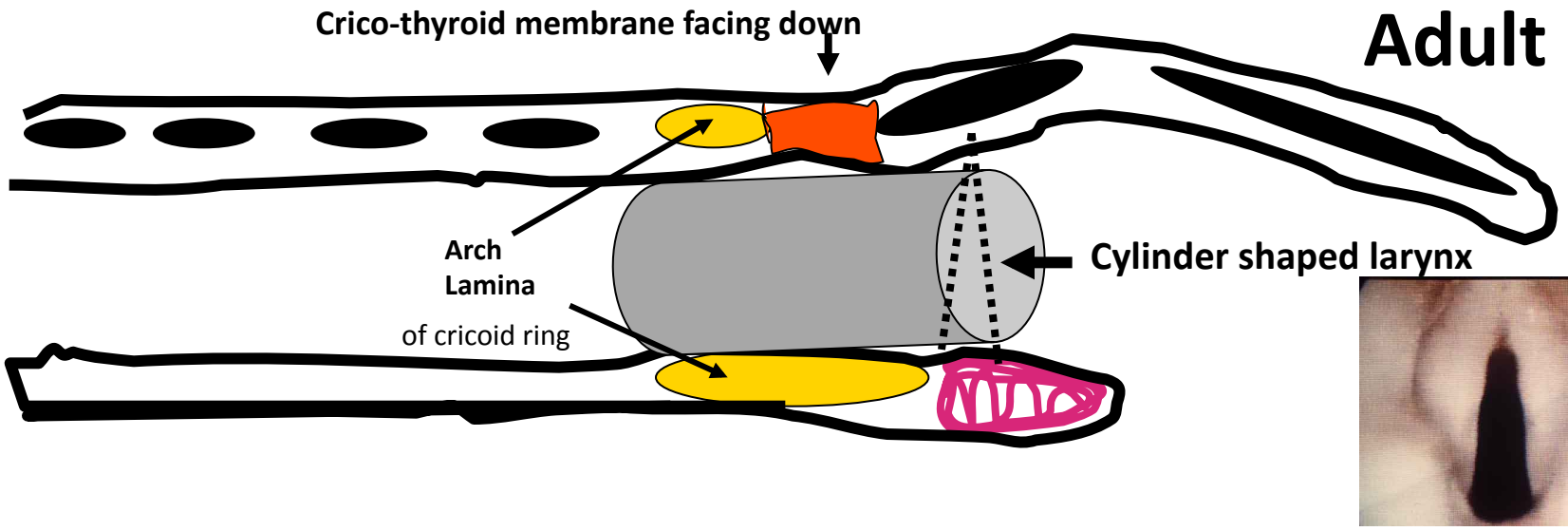
The larynx of the child is in a more cephaled position (above the turquois line) than the adult one (below turqoise line). However, this doesn´t interfere with the ease of intubation.

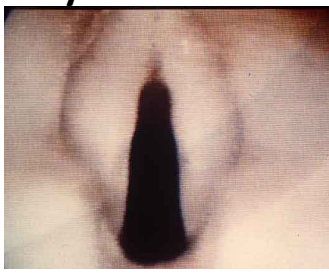


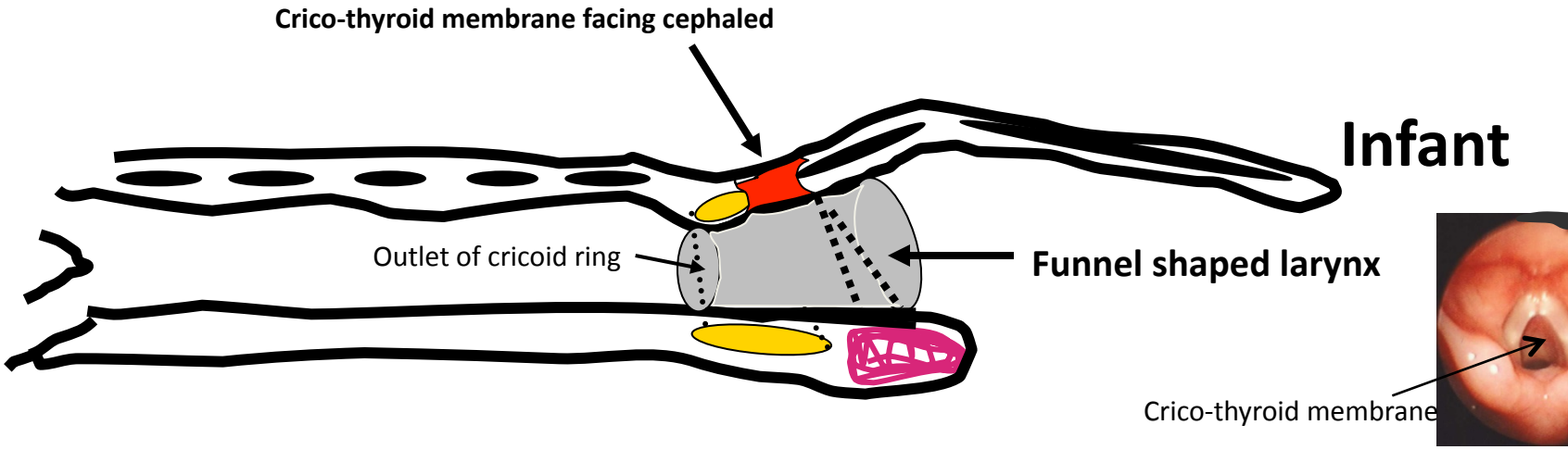


Summary:

1) Cricoid ring is narrowest part of ped upper airway < 8 yrs.
2) Crico-thyroid membrane is facing cephaled
3) The vocal cords are slanting towards the anterior commissure
4) The pediatric larynx (most pronounced in neonates) is in a higher position than the adult one



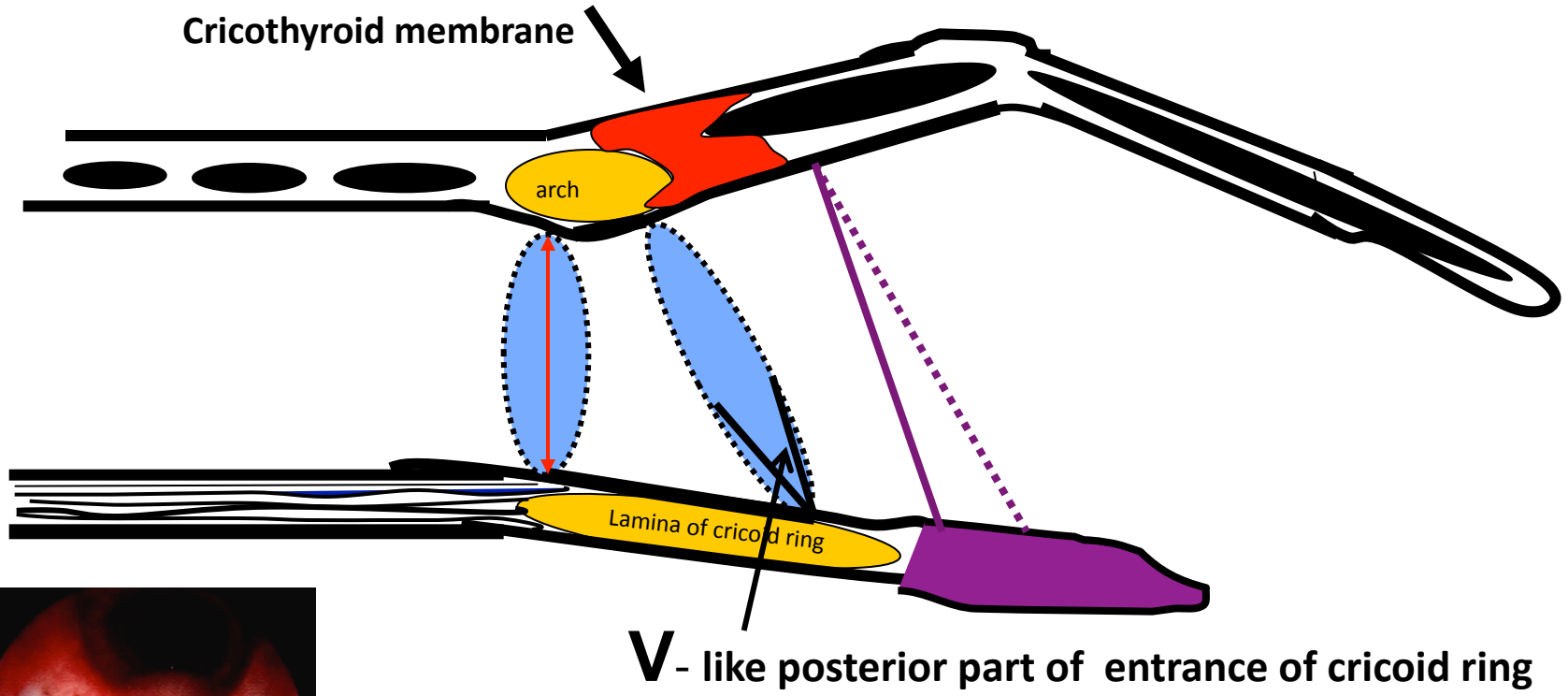


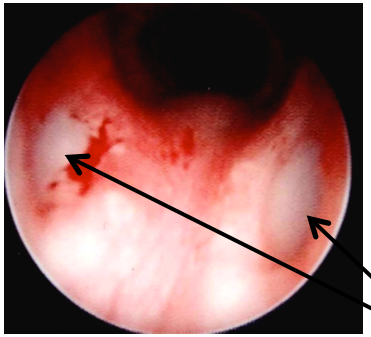


Difference of adult and pediatric larynx according to Bayeux and Eckenhoff

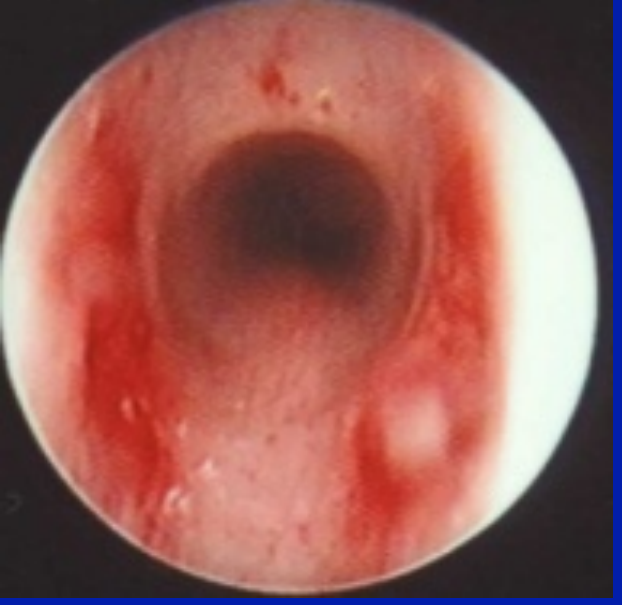
Whole organ autopsy studies of pediatric larynges: Tucker GF et al. Ann Otol Rhinol Laryngol. 1977; 86: 766-9

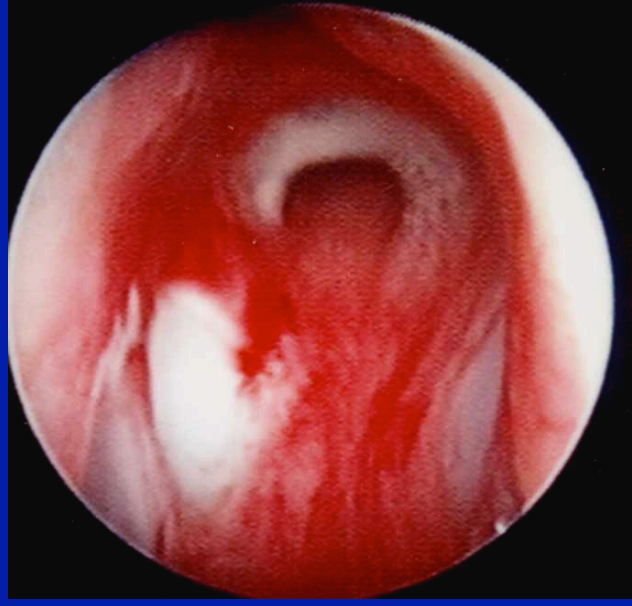
These authors brought the knowledge of an important landmark of the pediatric larynx to the community of pediatric anesthesiologists, the V-like part of the posterior cricoid!



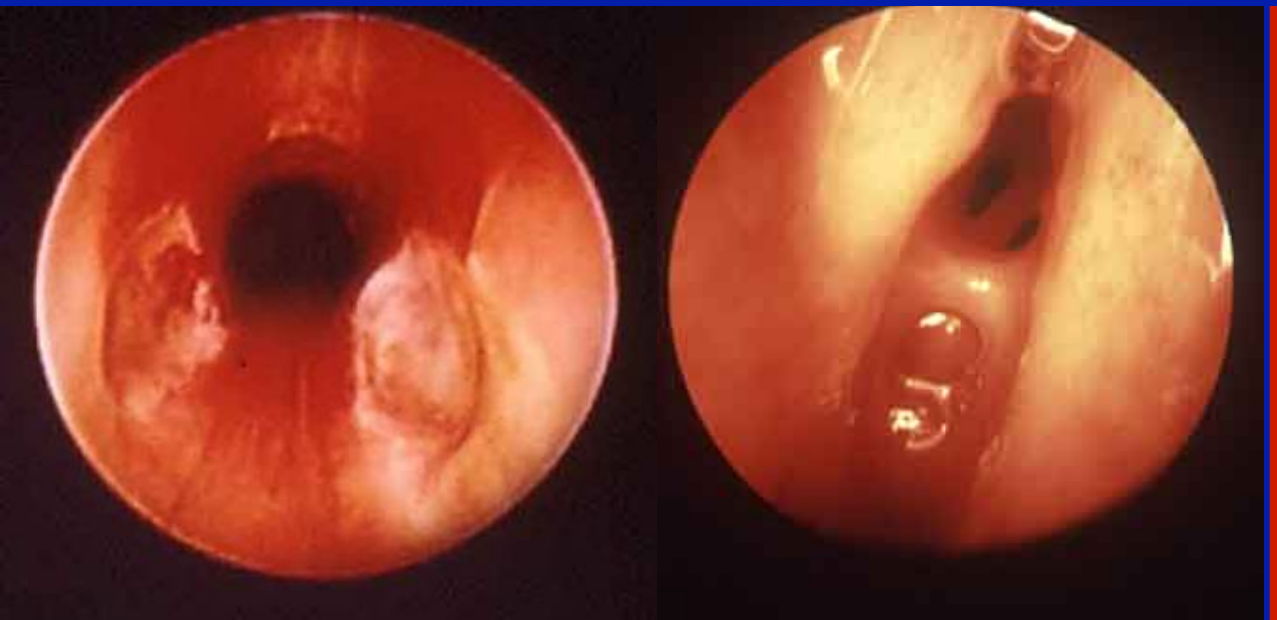


Deep ulcers caused by a too large tracheal tube in the V-shaped posterior part of the cricoid ring. Ulcers cannot be detected by stridor, only by endoscopy!





Is the finding by Tucker et al. of importance for clinical practice? Yes, it explains the mechanism of intubation injury as depicted here. Symmetrical injuries are caused by too large tubes or by cuffed tubes, inflated within the larynx – which happens regularly!



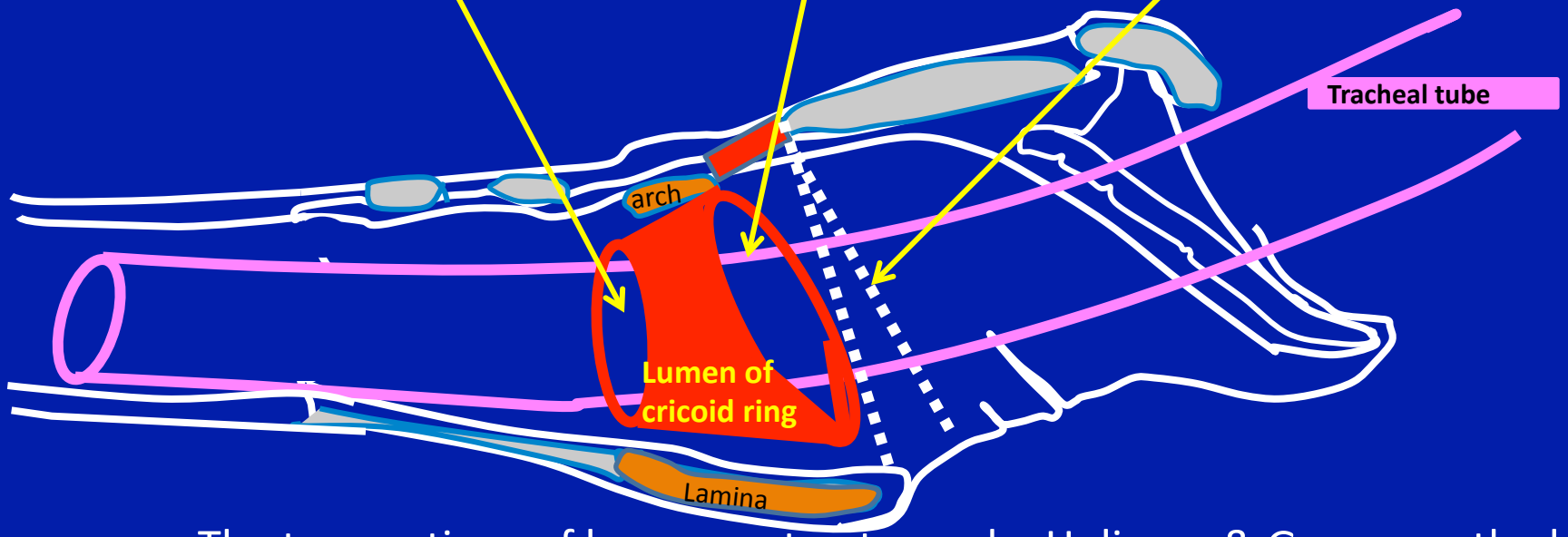
This injury above the glottis stems from too long intubation periods and not from inadaquate tubes!

Cross sections of larynx from: Holinger LD, Green CD. Pediatric Laryngology. Lippincott-Raven, Philadelphia 1997; 21-4

3 Outlet cricoid ring

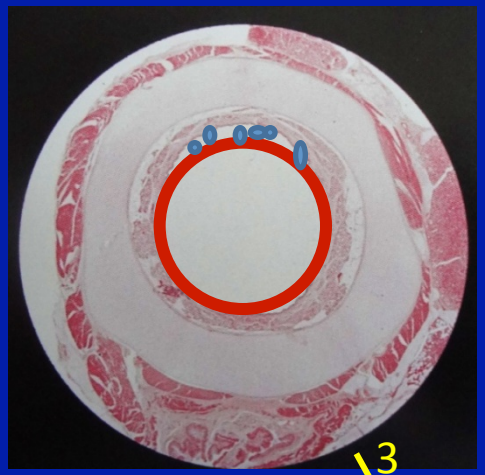
2 Entrance cricoid ring

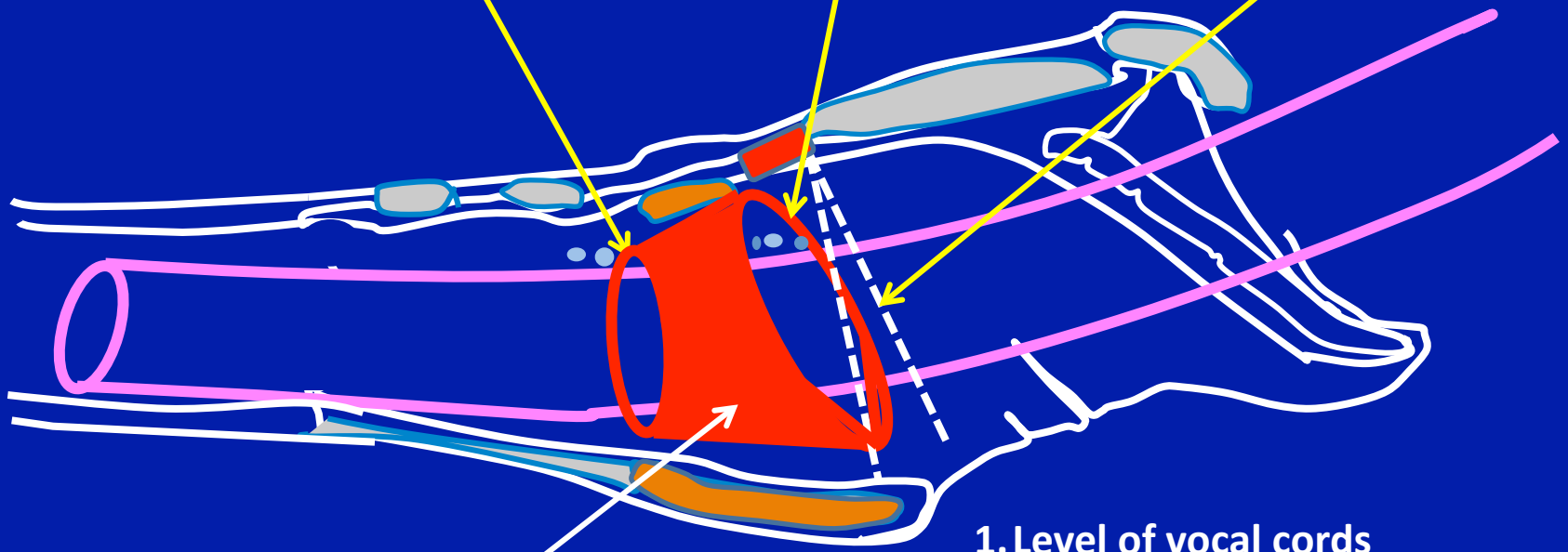
1 Level vocal cords



The transections of larynges at autopsy by Holinger & Green are the best documents to explain the anatomy of the pediatric larynx

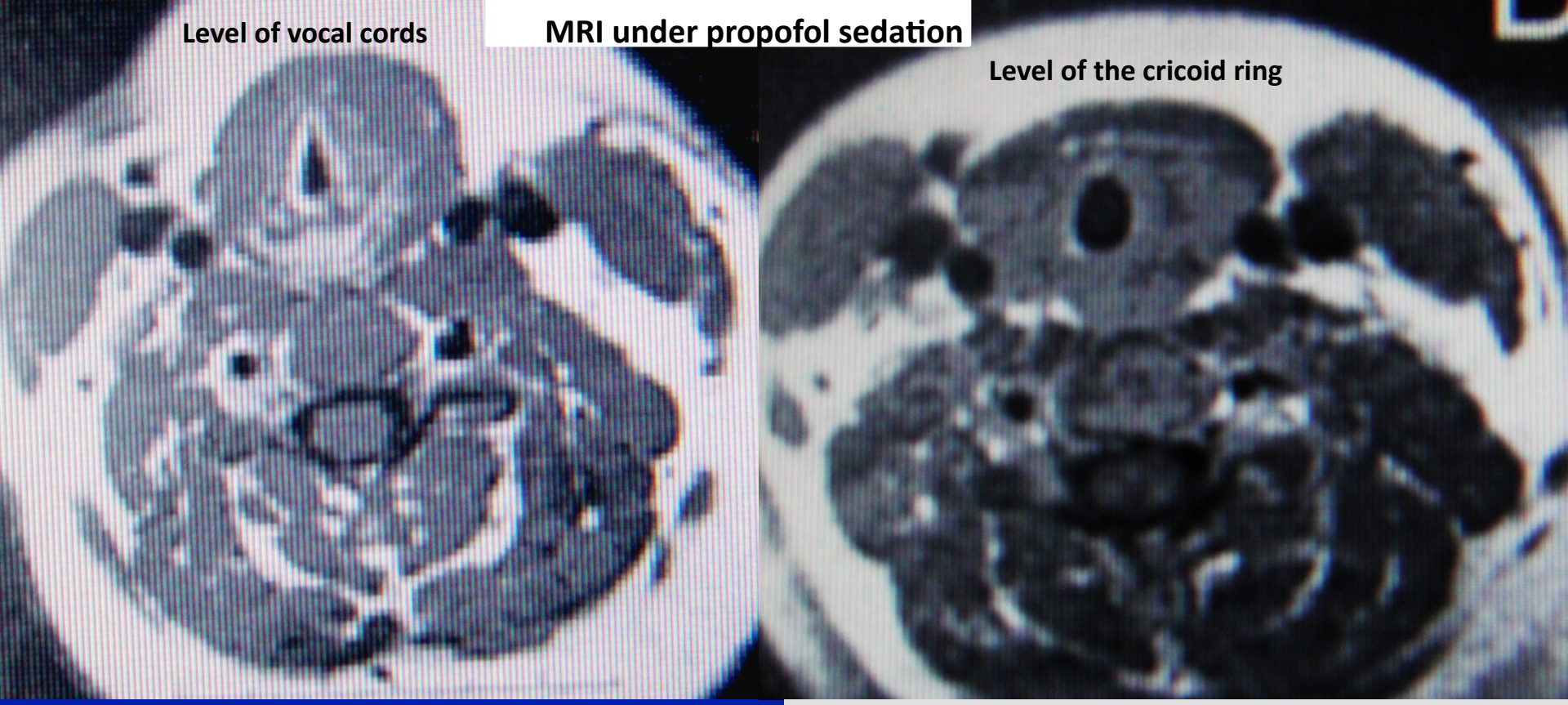
Tracheal tube within the larynx shows that the sealing of the upper airway occurs in the outlet of the cricoid ring (3)





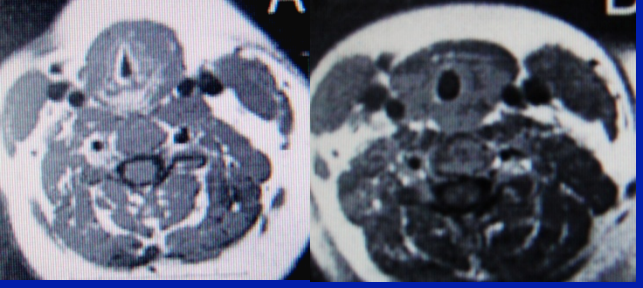
Funnel shaped lumen of pediatric larynx

1. Level of vocal cords
2. Oblique, oval entrance into cricoid ring
3. Almost circular outlet of cricoid ring



Litman RS et al. Developmental changes of larygeal dimension in unparalysed, sedated patients. Anesthesiology **2003**; 98: 41-5

Findings by radiologists: The vocal cords are apparently the narrowest part of the upper airway. However, this interpretation is wrong because the vocal cords are the most pliable structure within the upper airway. This is known since decades. This is the reason why tubes have a bevelled tip.



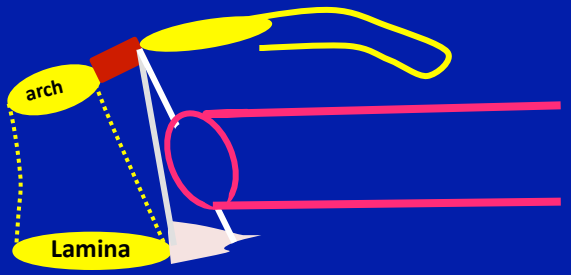
Litman RS et al. Developmental changes of larygeal dimension in unparalysed, sedated patients.

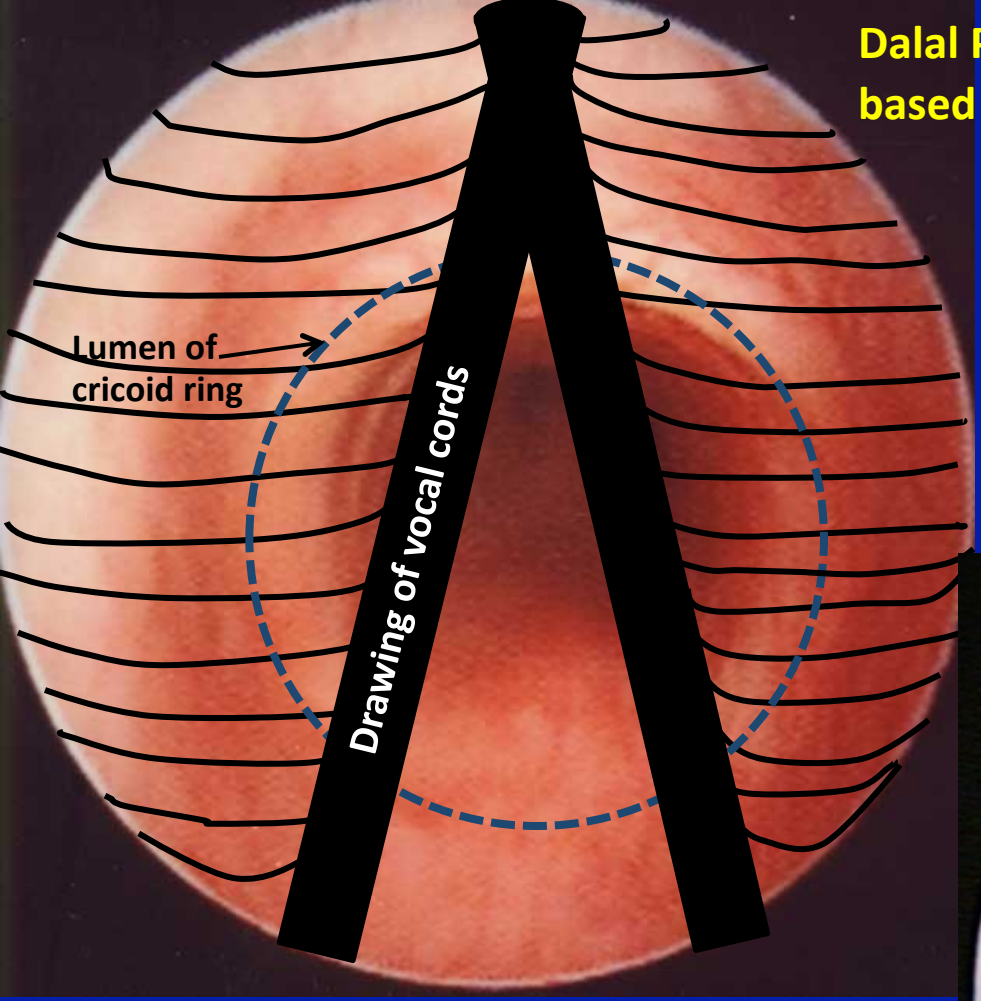
Anesthesiology 2003; 98: 41-5

The findings by the radiologists contain a fundamental error: They compare a highly pliable structure, the vocal cords, with a very rigid, cartilagineous structure, the cricoid ring. In normal intubation the vocal cords never impede the intubation procedure nor do they create a seal, when the patient is mechanically ventilated. This is known since the first intubations decades ago. Therefore tracheal tubes have a bevelled tip.

Tracheal cannulas don´t need a bevel at the tip because they are not inserted through pliable structures

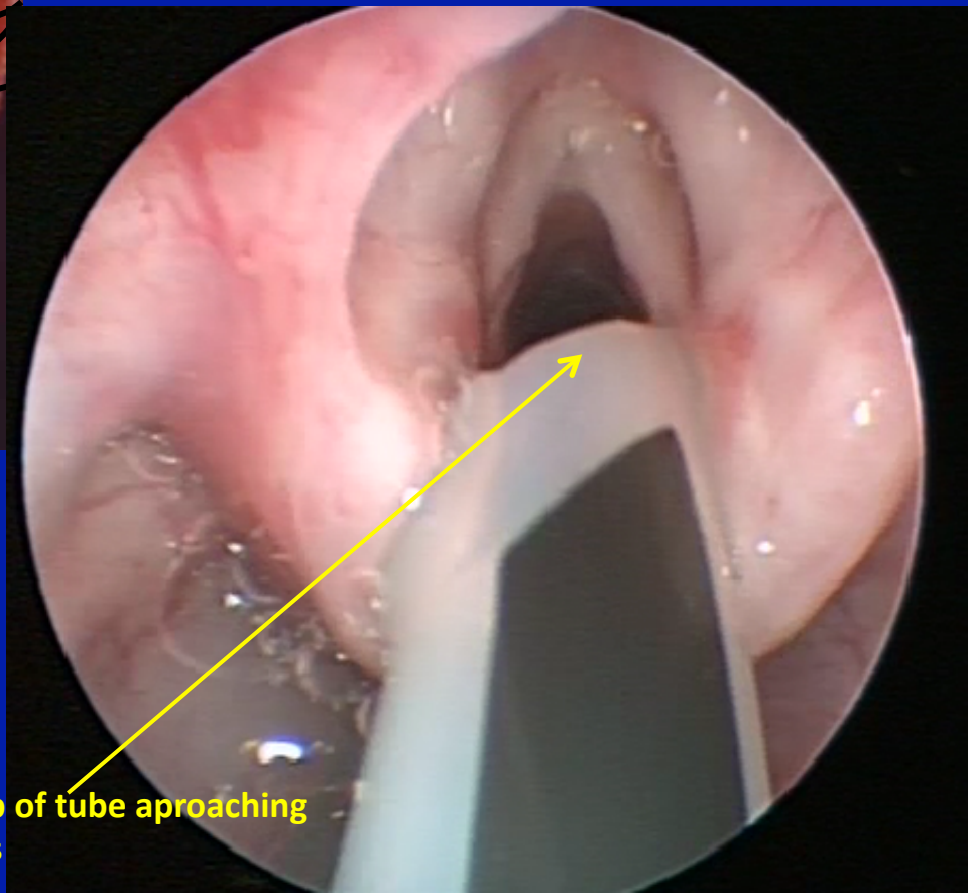
In contrast, the bevel ot the tube has to be pushed through the vocal cords like through a semi-open curtain





Dalal PG et al. Pediatric Larygeal dimensions: An age based analysis. Anesth Analg 2009; 108: 1475-9

Measurements were made in paralysed children. The vocal cords are hanging down like a curtain (para-cadaveric postion)! For this reason all tracheal tubes have a bevel to push the vocal cords apart when intubating a child!



The statement: the vocal cords are the narrowest part of the pediatric upper airway is entirely wrong because this applies to the vocal cords of the adult larynx as well when paralysed

Fortunately, the renowned pediatric ENT-surgeon Dr. RNP Berkovits from Children´s Hospital Rotterdam clarified the situation:

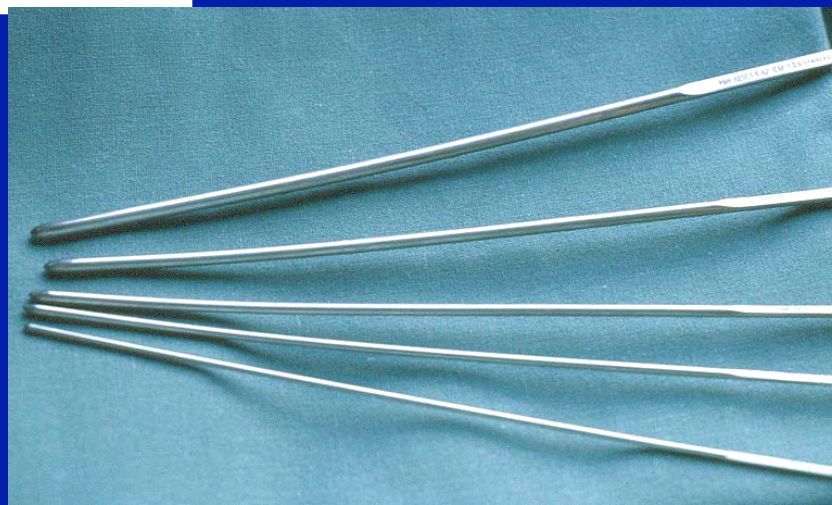
LETTER TO THE EDITOR

Comment on Dalal et al's. study on the Pediatric Larynx:

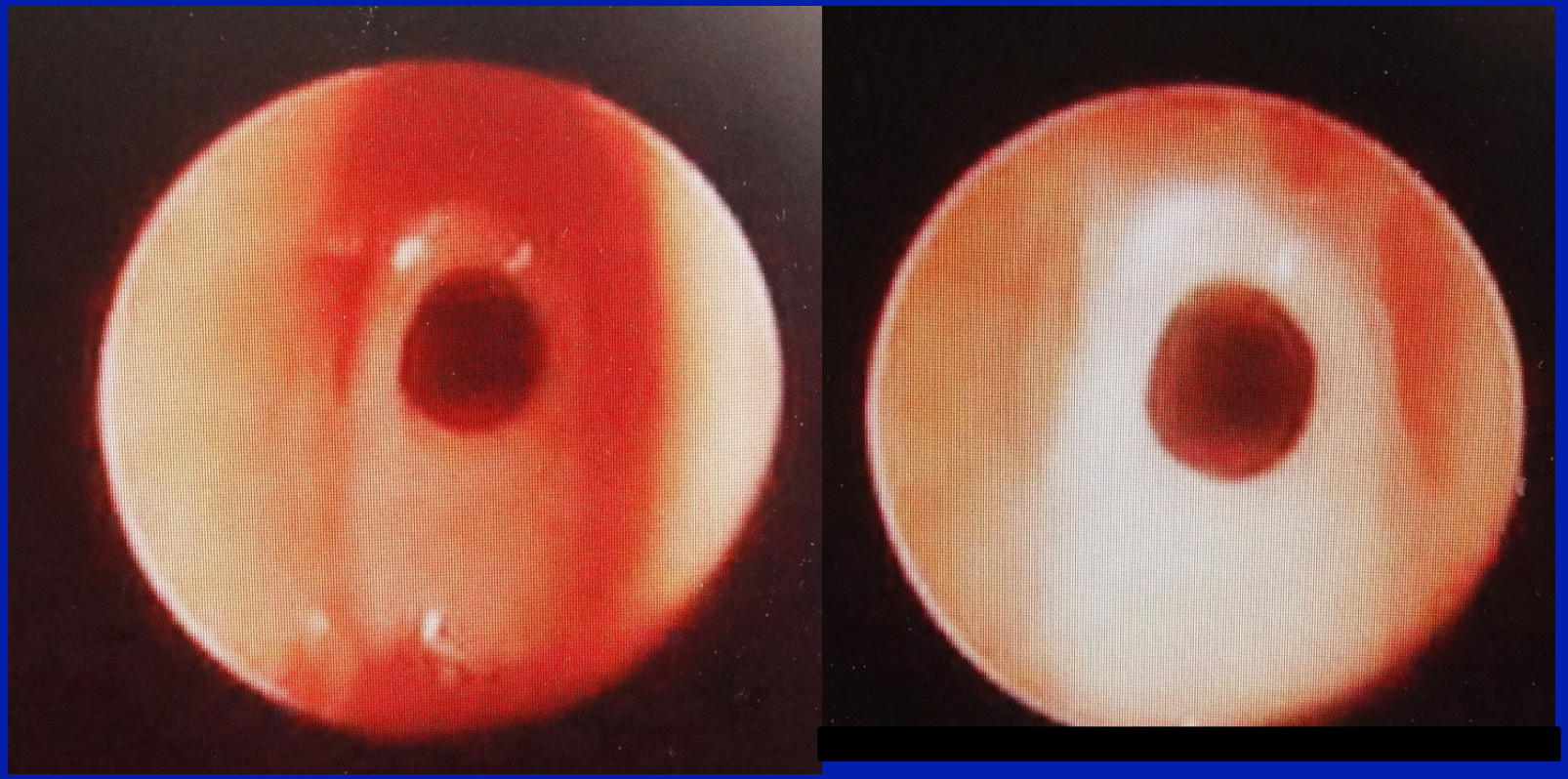
The vocal cords are the most pliable structures of the upper airway.
Accurately measured, the cricoid ring is always functionally and anatomically the narrowest part of the upper airway and the only important rigid site of possible airway damage

Berkovits. Anesth Analg 2010; 110: 1511

Accurately measured means that the diameter of the cricoid ring has to be determined by using measurement rods!

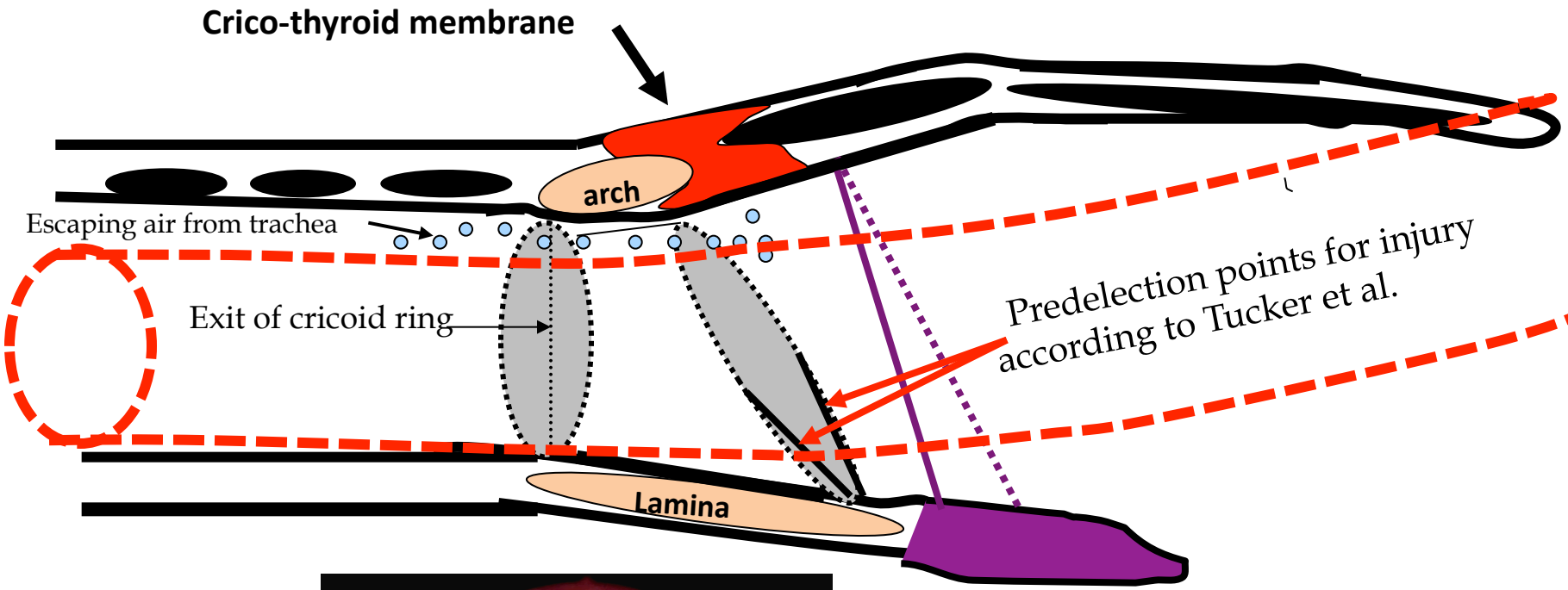


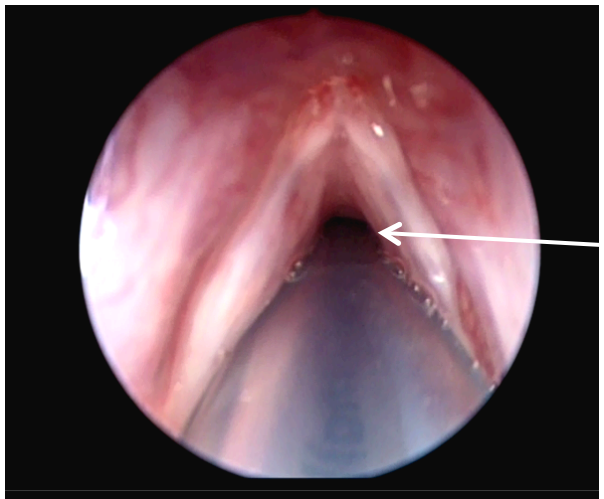
Best evidence that the cricoid ring is really the narrowest part of the pediatric upper airway in a 5 years old child:



An emergency intubation with a too large tube caused necrosis of the entire mucosa within the cricoid ring. The vocal cords are not injured!

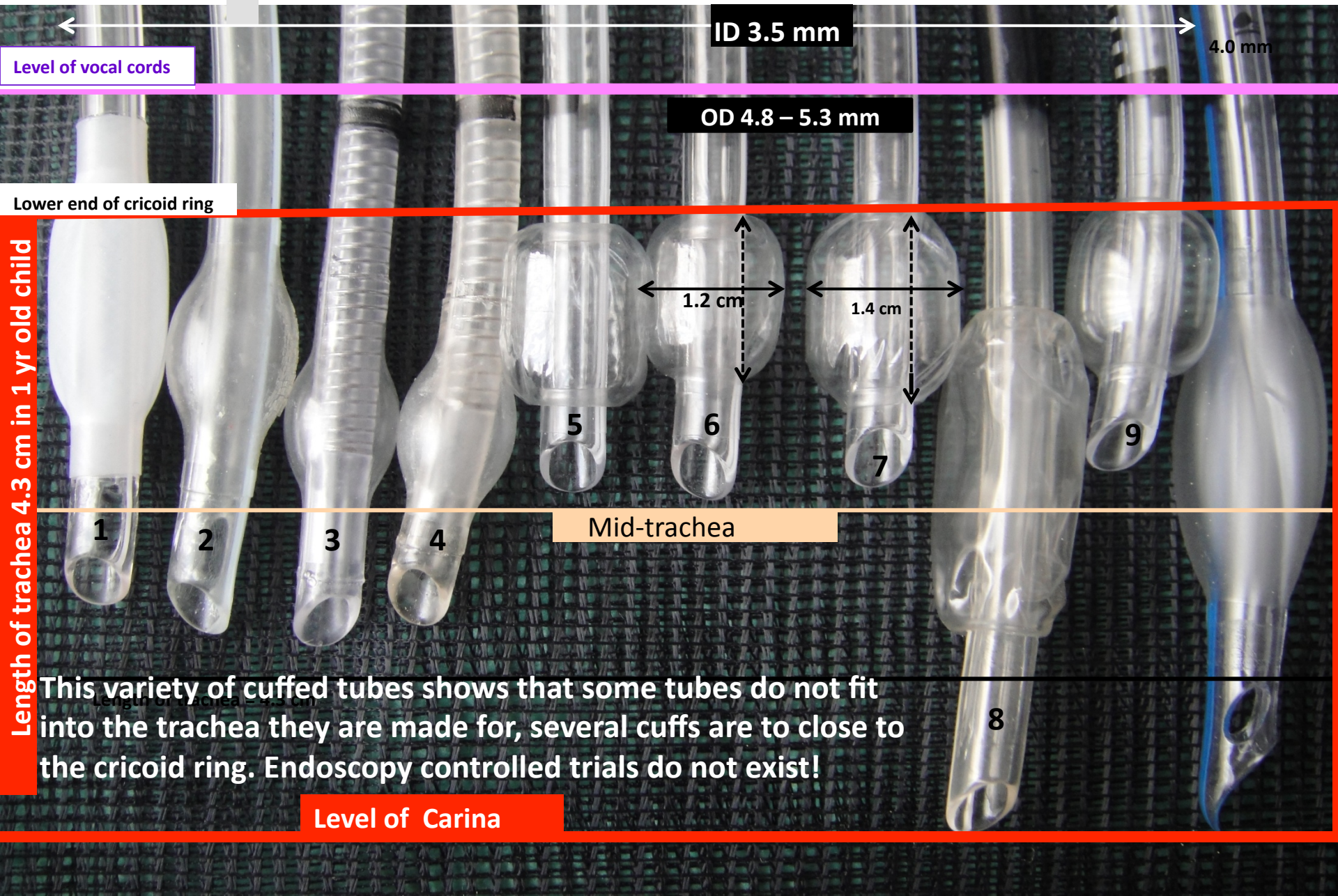
Anatomically the pediatric larynx is predestined to be intubated with an uncuffed tube from prematurity to ~ 8th year of age!



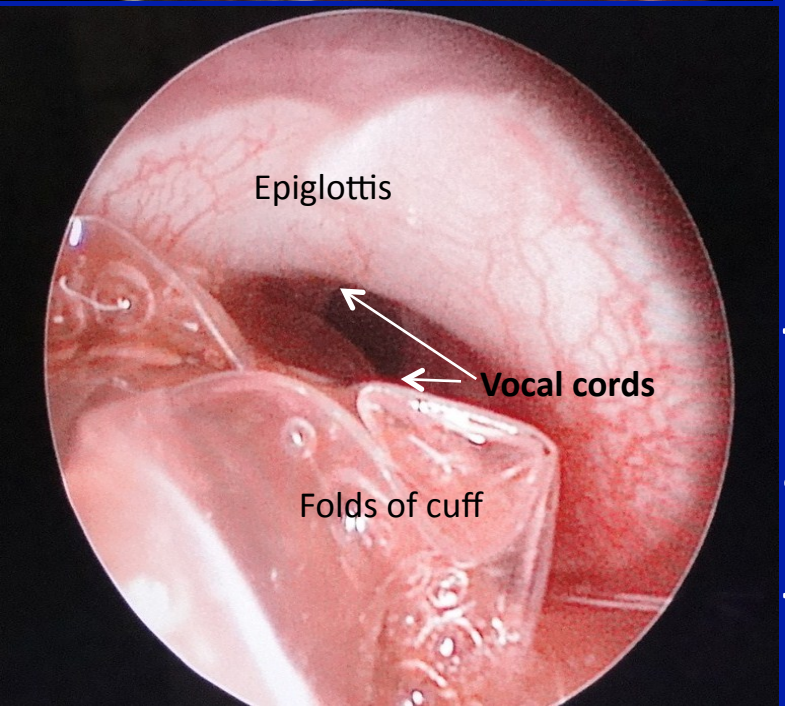


A moderate leak at the anterior face of the tube is the best clinical sign for adequate perfusion of the mucosa within the cricoid ring

What about cuffed tracheal tubes for pediatric patients?
It has never been defined what a „safe“ cuffed tube consists of.!



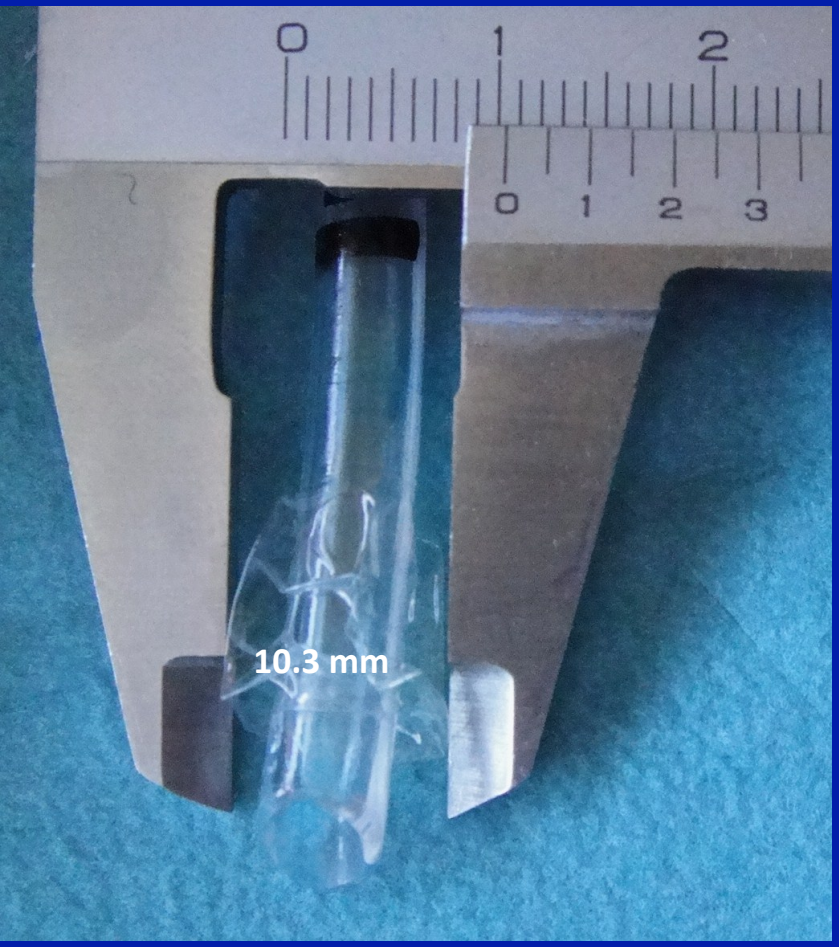
The cuff of a 3.0 mm ID Microcuff° tube has always to be squeezed with force into larynx and trachea of a neonate as well as the 3.5 mm tube into the larynx of an infant.
This can be observed in every single intubation by using a Hopkins lens!



Demonstration in live, anesthetised, young rabbits:

The cuff of an adequately sized Microcuff° tube injures glottis and subglottis by mere intubation and extubation because the over-dimensioned (deflated) cuffs scratch over the mucosa with their extensive folds

3.5 mm ID Microcuff° tube for a1 yr old child



One yr old child:	ID of cricoid ring	5.5 mm
	ID of trachea	~ 6.5 mm
Corresponding cuff (inflated):	OD	11.3 mm
(deflated):	OD	10.3 mm

This cuff, designed for a 1 yr old child causes inevitably mucosal damage in every single intubation, not being inflated!

Do high volume/low pressure cuffs prevent aspiration? → **No!**

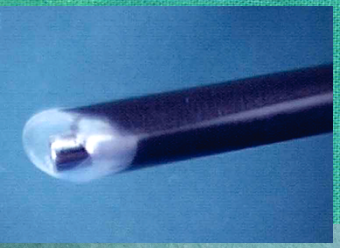
Cuff pressure ~ 40 cm H_2O!

PIP pressures of 50 cm H_2O do not wipe out fluid channels

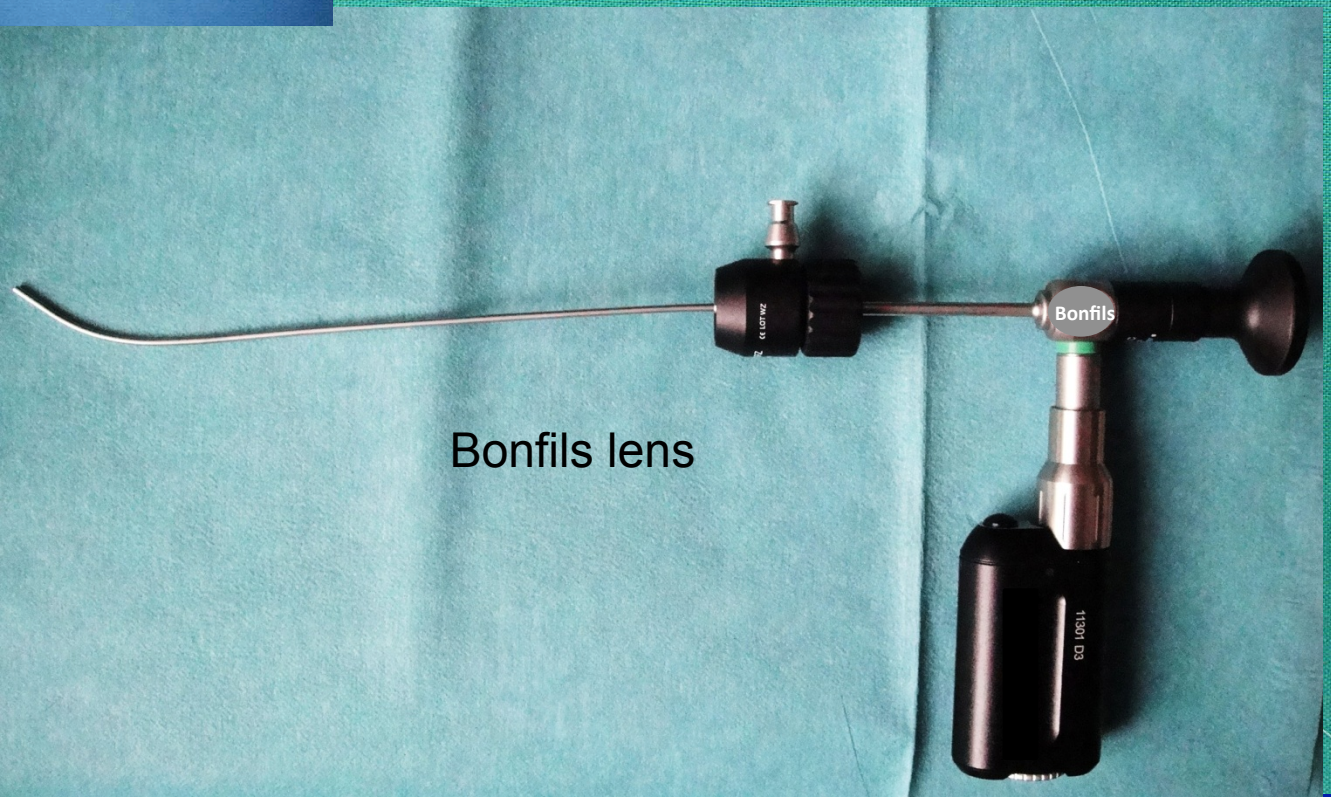
Seegobin RD, van Hasselt GL. Aspiration beyond endotracheal cuffs. Can Anaesth Soc J 1986; 33: 273-9

What is the answer to this chaos of tracheal tubes?

Modern visualizing technology is waiting for being more frequently applied in pediatric anesthesia, giving us all necessary answers!



Hopkins lens



Bonfils lens

End of the presentation