Pediatric Airways - A Surgeon's Perspective

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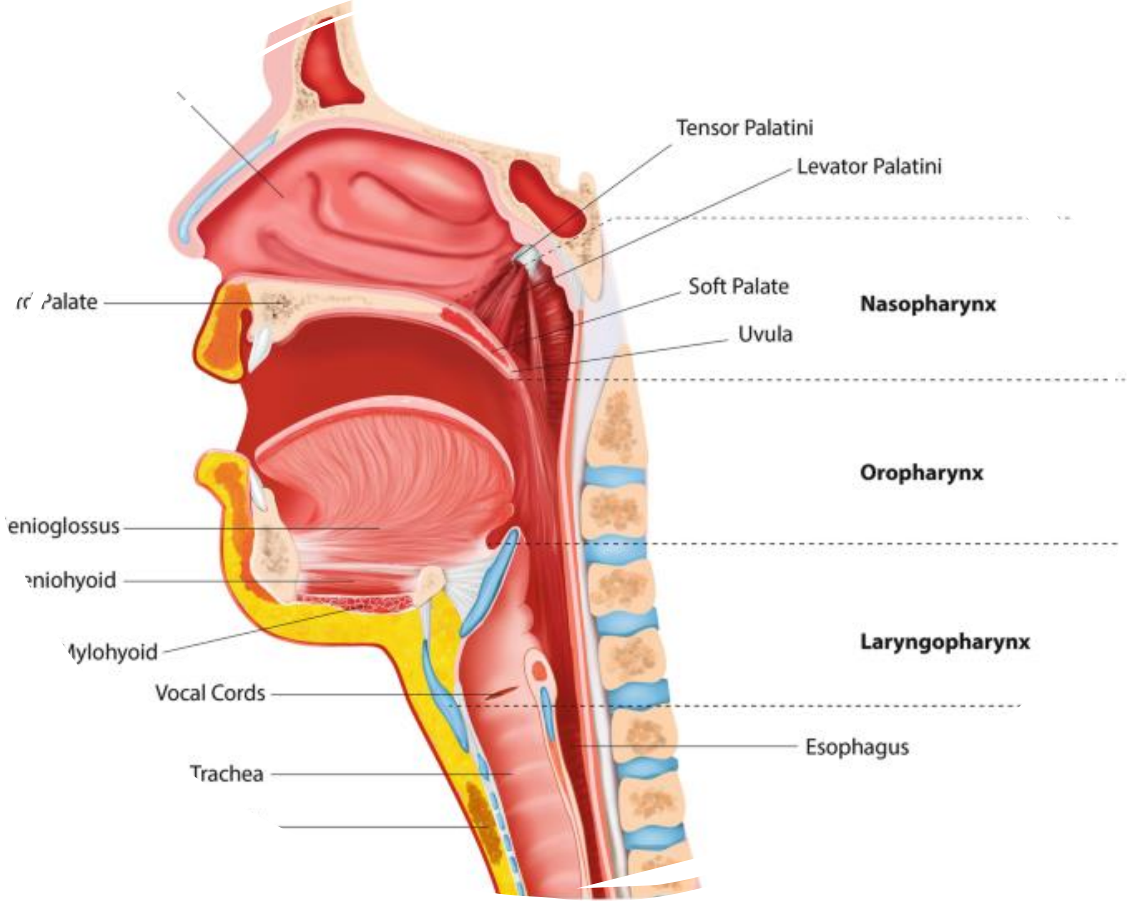
Disclosure Statement

Speaker:

Dr. Taseer Feroze Din

- Has no relevant financial relationships to disclose
- Will not be discussing unlabeled/unapproved use of drugs or products


Tensor Palatini
Levator Palatini
Palate
Soft Palate
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Uvula
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niohyoid
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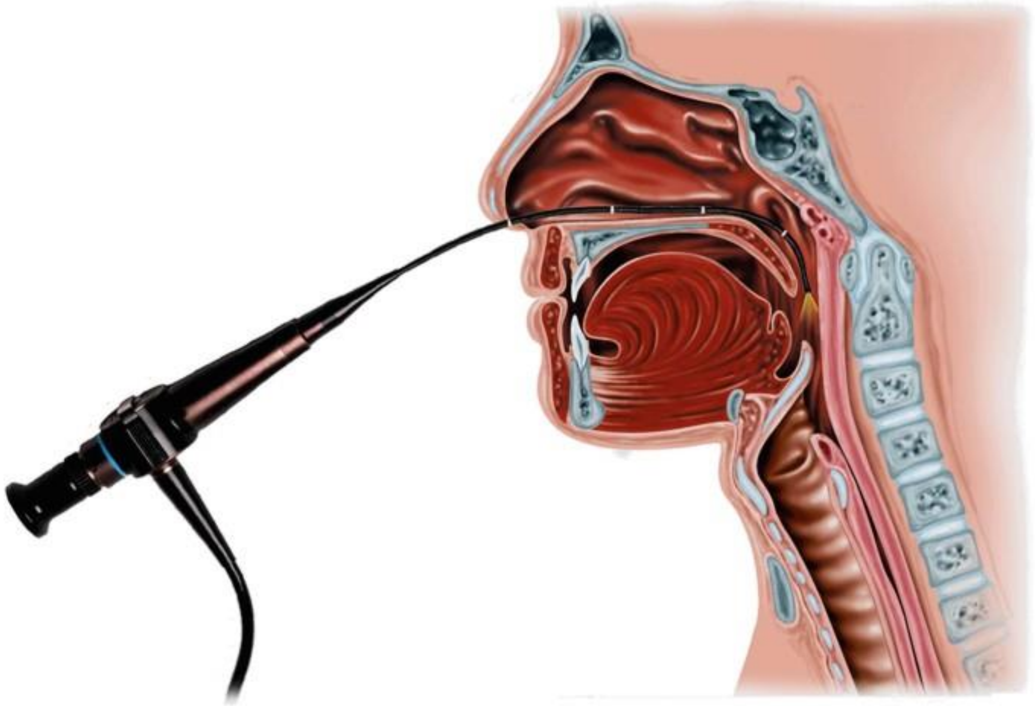
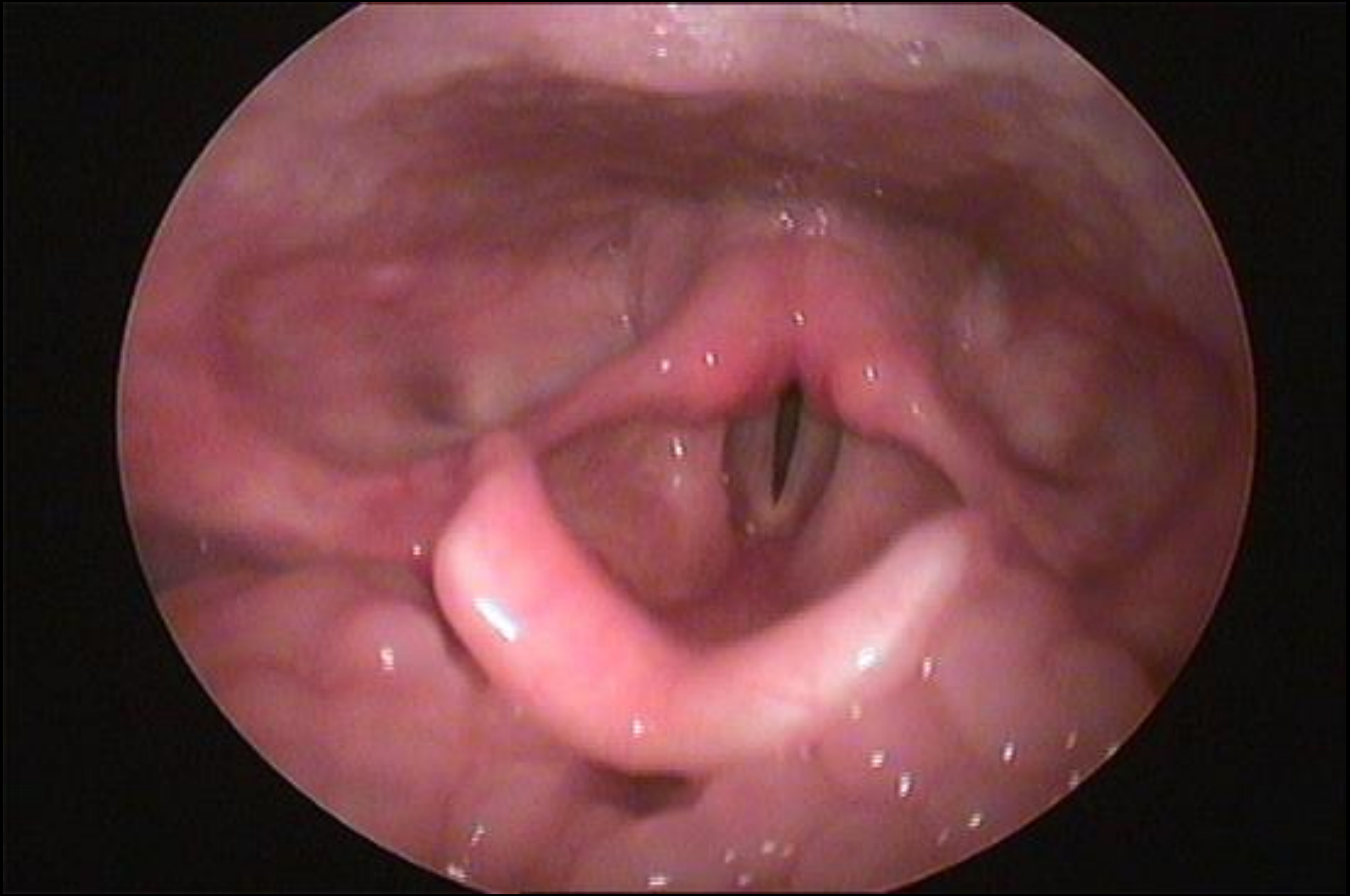
Laryngopharynx
Vocal Cords
Esophagus
Trachea



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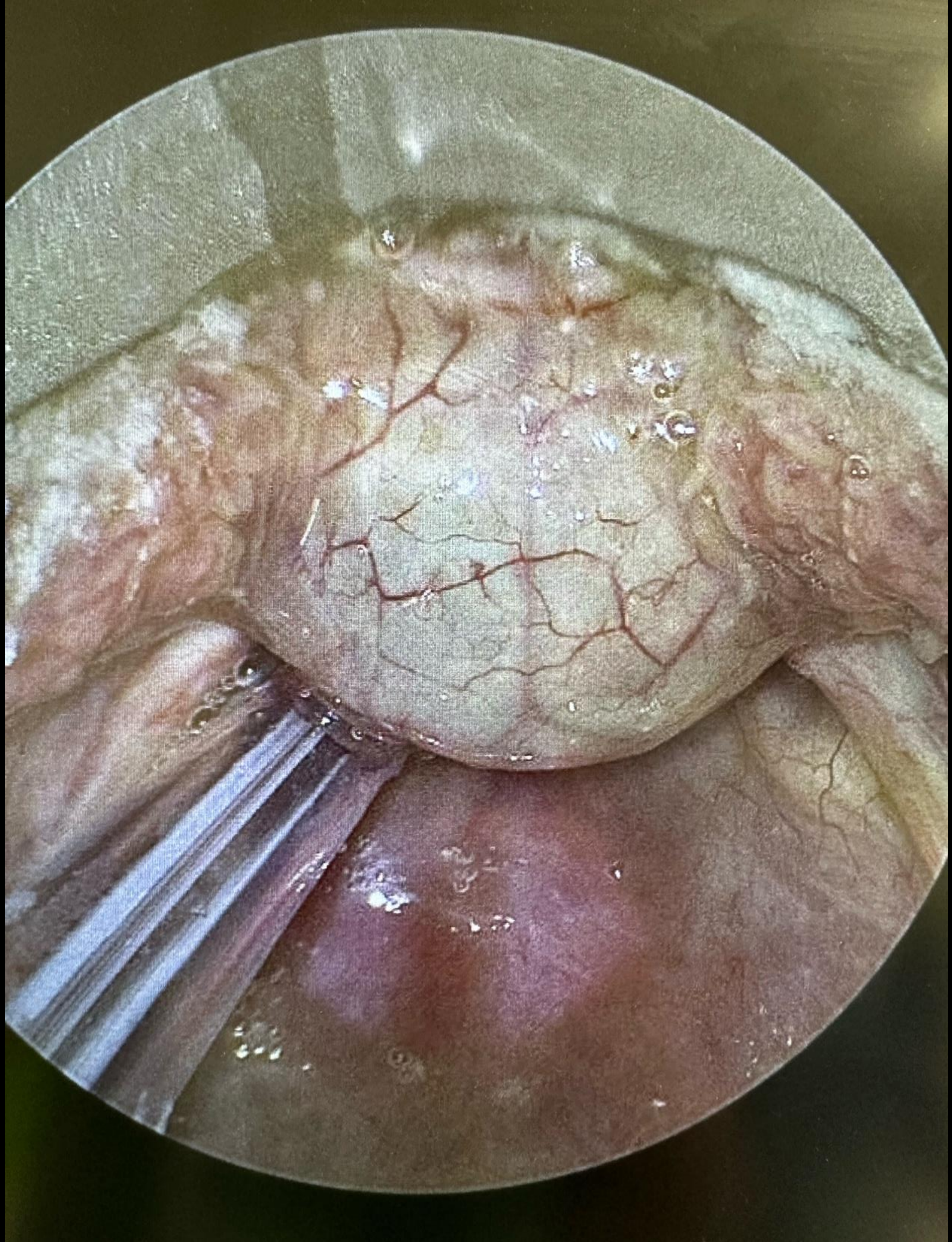
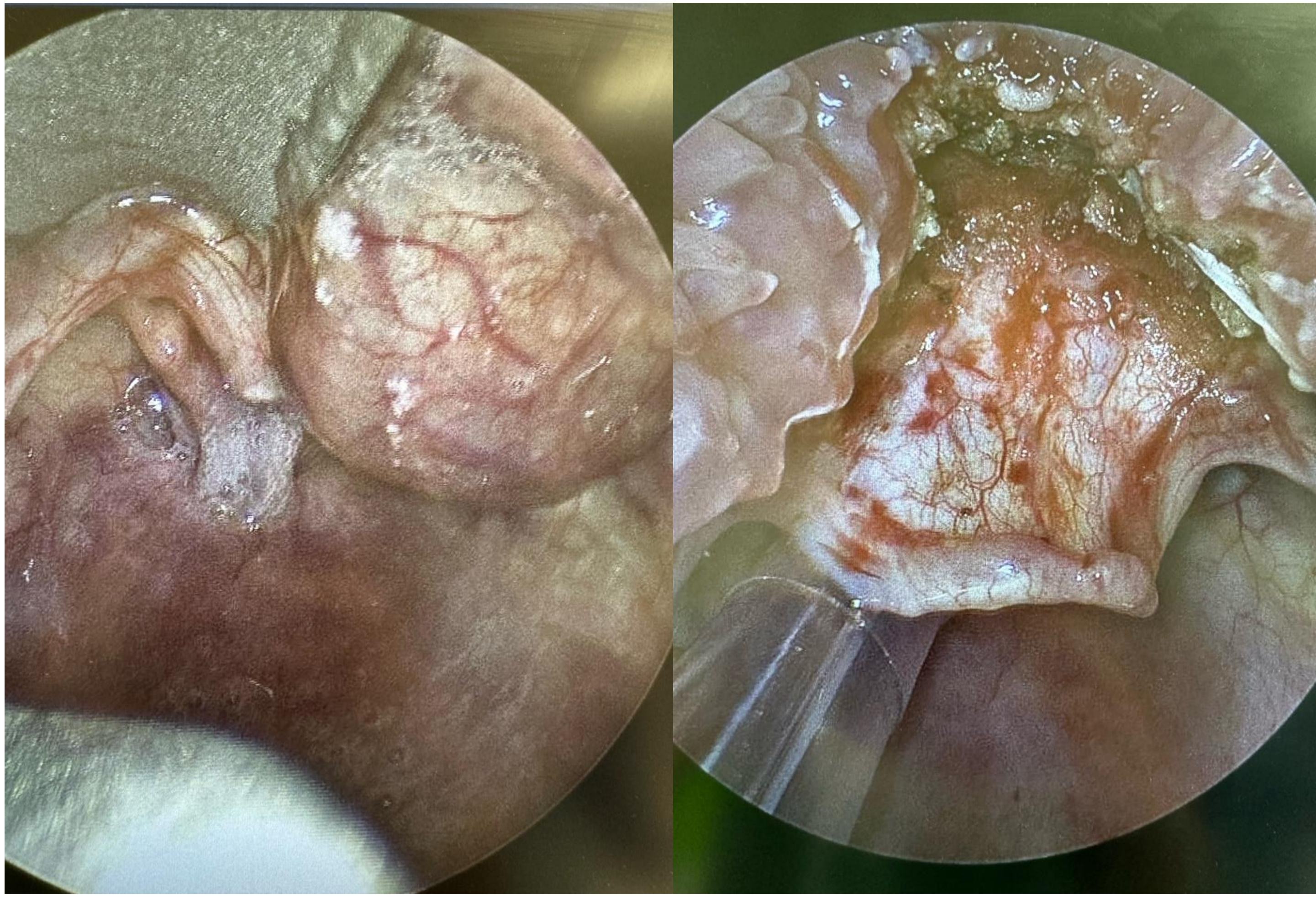
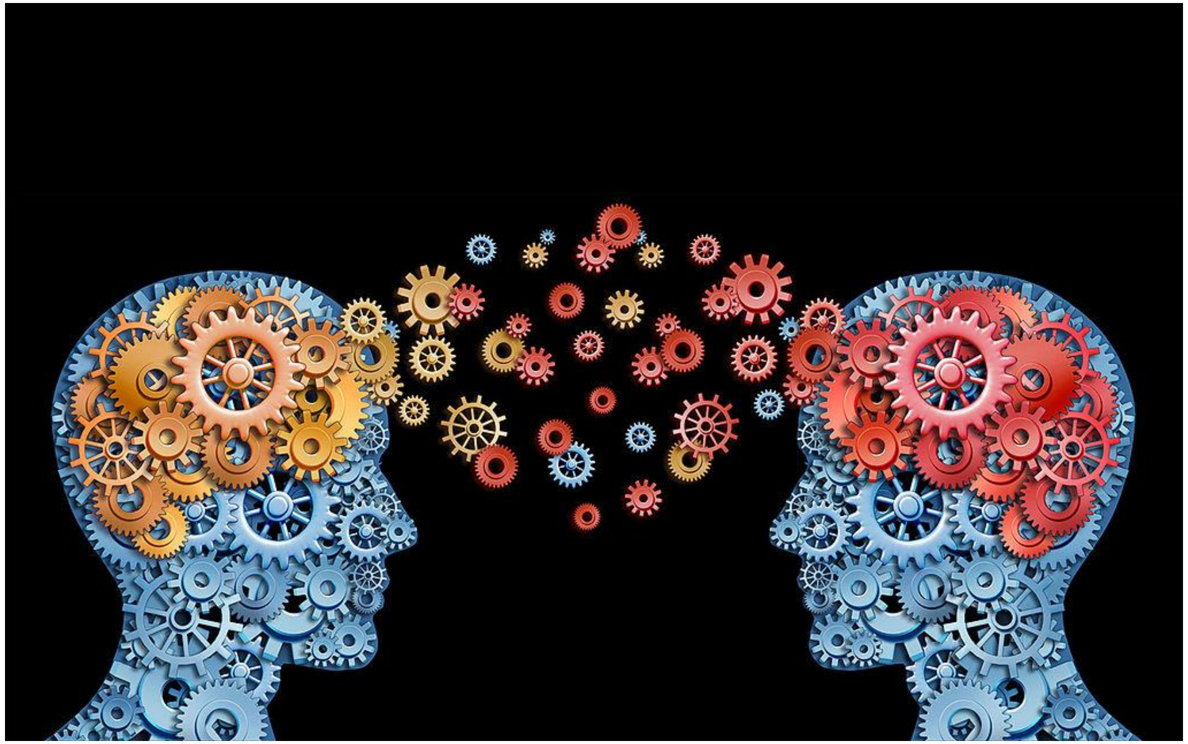


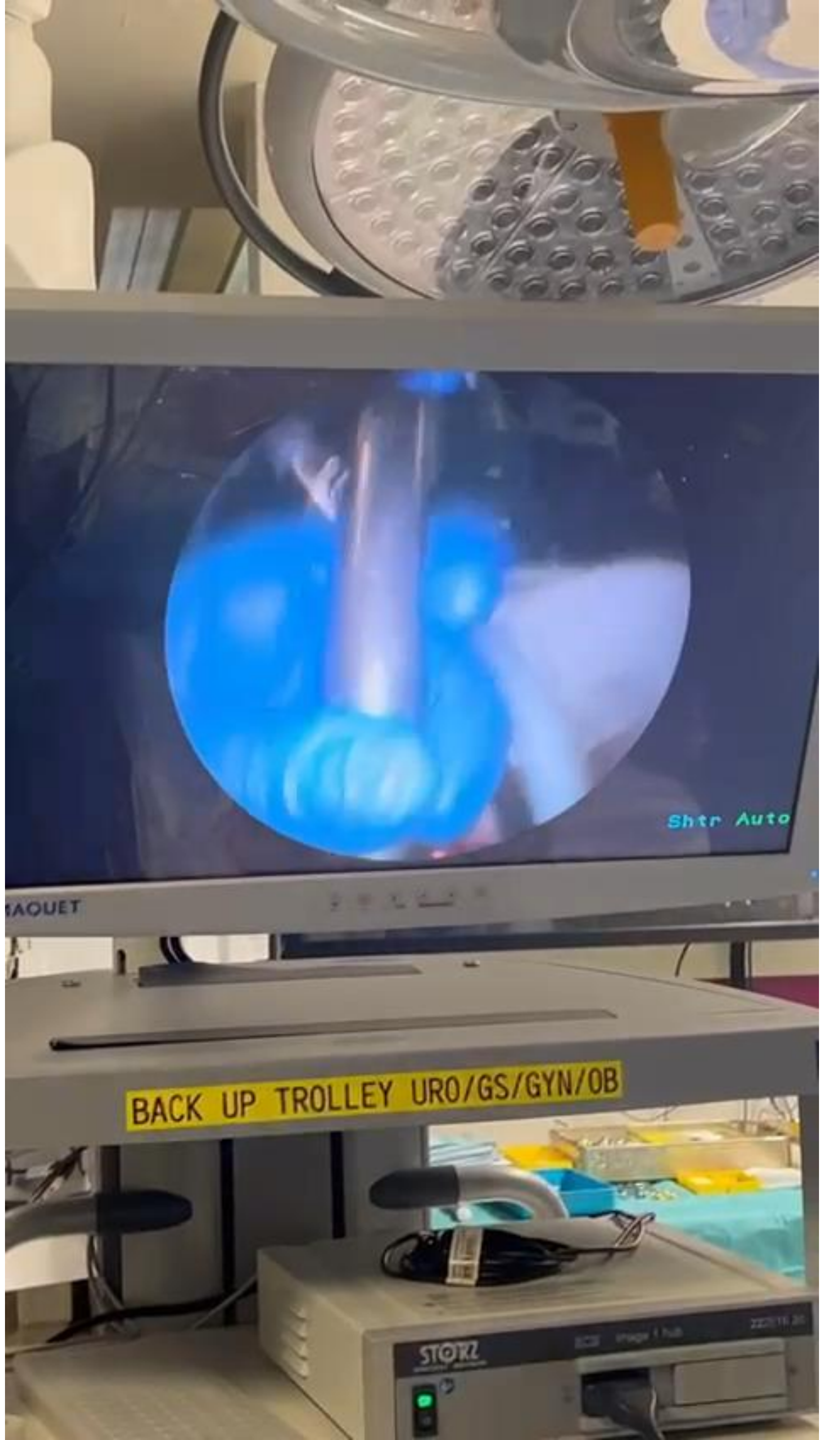
Vallecular cyst

- Intubation challenge
- Surgical excision
  - marsupialization



'Shared airway'

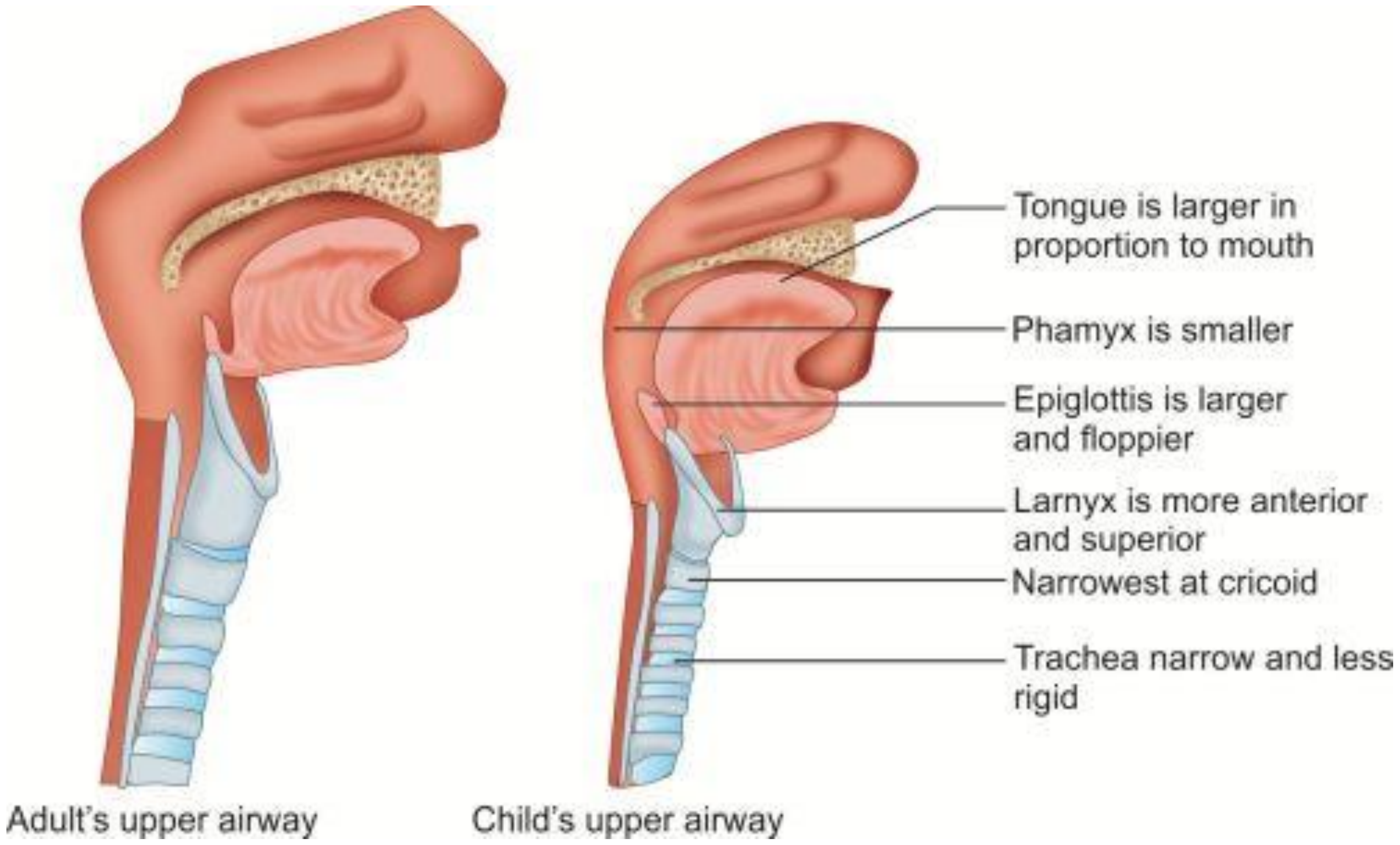



Shtr Auto
BACK UP TROLLEY URO/GS/GYN/OB
STORZ

Objectives

- Recognize the collaborative management of pediatric airways
- Describe the pediatric airway in contrast to the adult
- Recognize common pathologies affecting the pediatric airway, highlighting acquired subglottic stenosis
- Outline equipment for diagnostic airway assessments
- Outline the multimodal management of pediatric airway disease

Pediatric vs Adult airways



Subglottis

- Subglottis - from below true vocal folds (TVF) to the inferior aspect of the cricoid ring
  - Housed within the cricoid cartilage which is a **non-expandable and non-pliable complete ring of cartilage**
- Normal subglottic diameter of a term neonate is 4.5mm or greater
  - *Outer diameter of 3 ETT is 4.2mm*

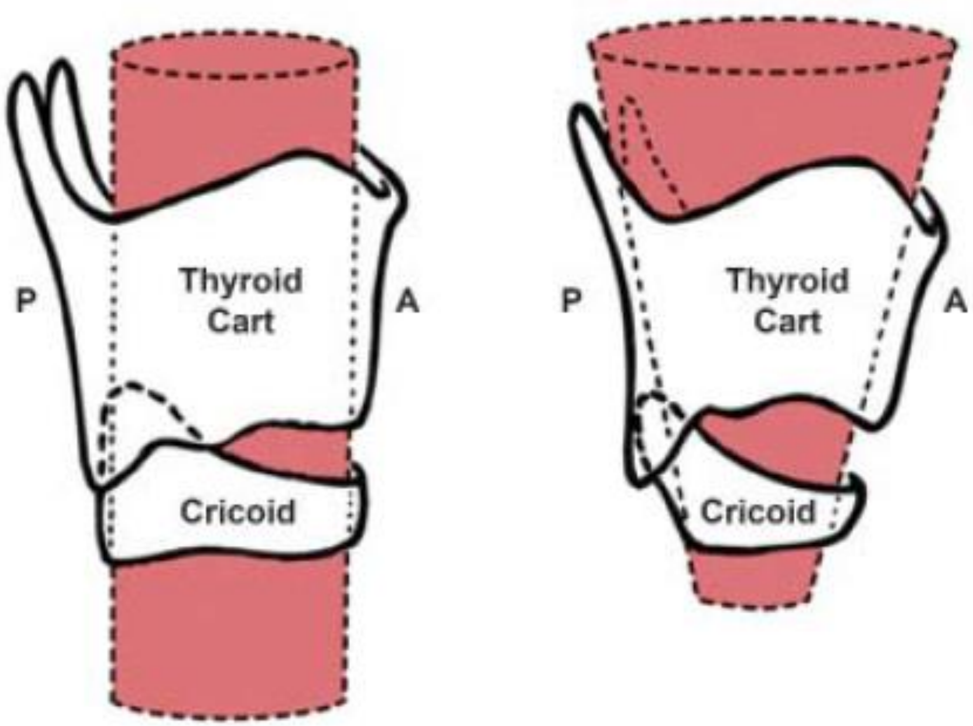
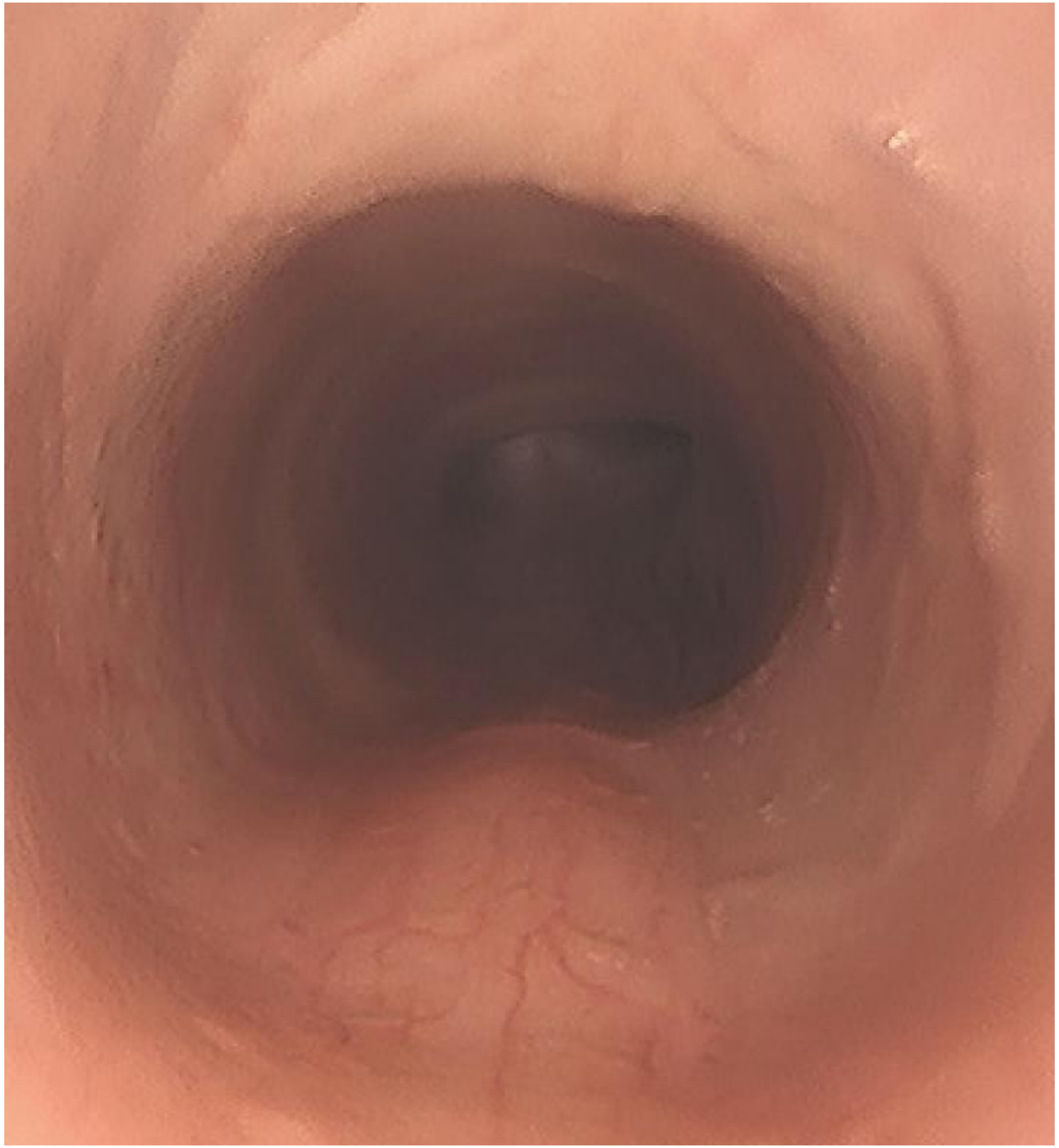
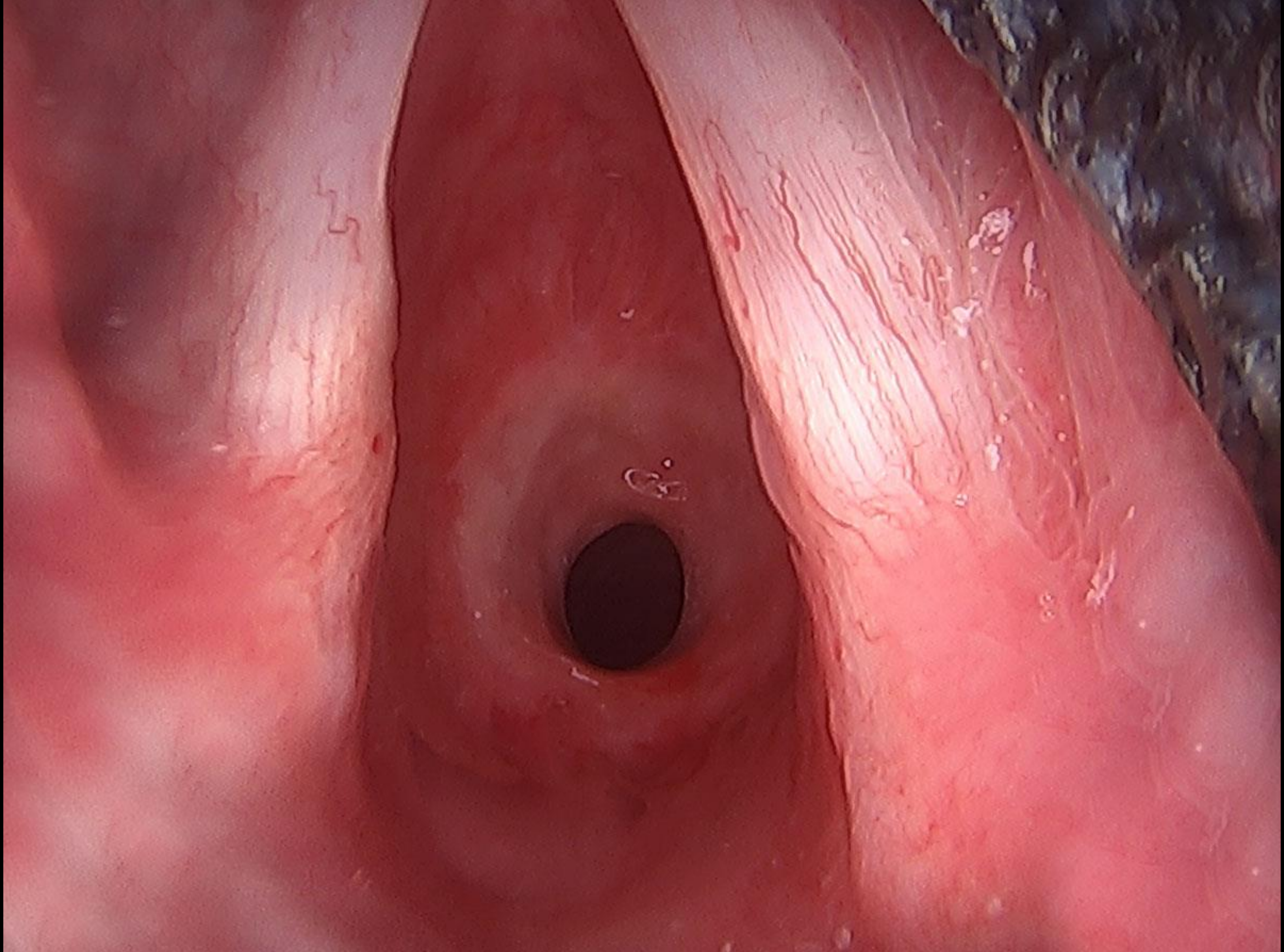
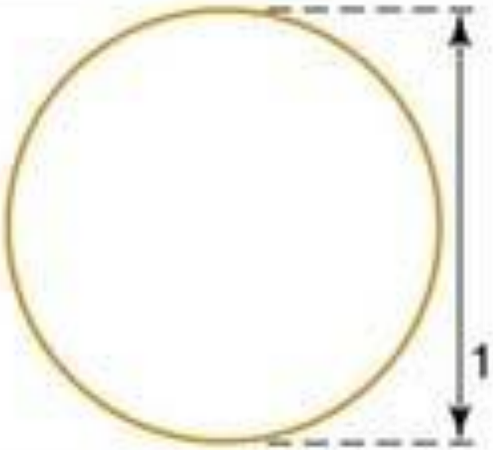
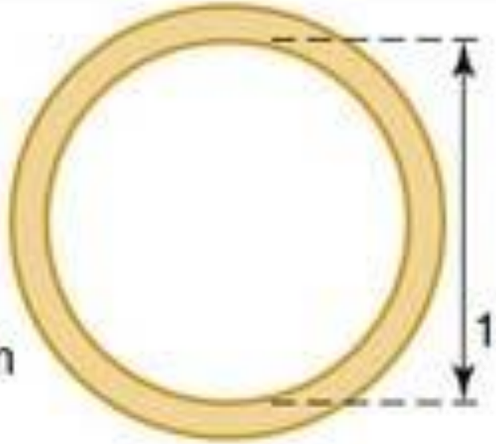


Figure : Anatomy of the adult and infant airway. An infant's airway is conical with the apex of the cone at the level of the cricoid ring, the exit of the larynx while the adult larynx is cylindrical (adapted from Coté CJ, Todres ID[13])

Normal subglottis



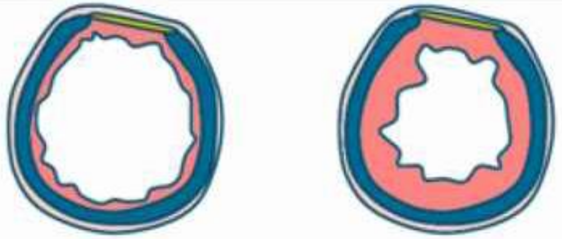
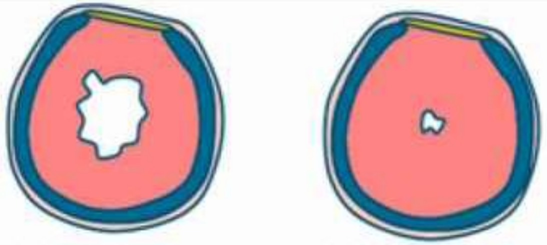


	Normal airway	Airway narrowing by 1 mm	Airway cross-section	Normal resistance
Pediatric airway (4 mm diameter)	 4 mm	 2 mm	75% ↓	16 fold ↑
Adult airway (12 mm diameter)	 12 mm	 10 mm	30% ↓	2 fold ↑

Airway stenosis assessment

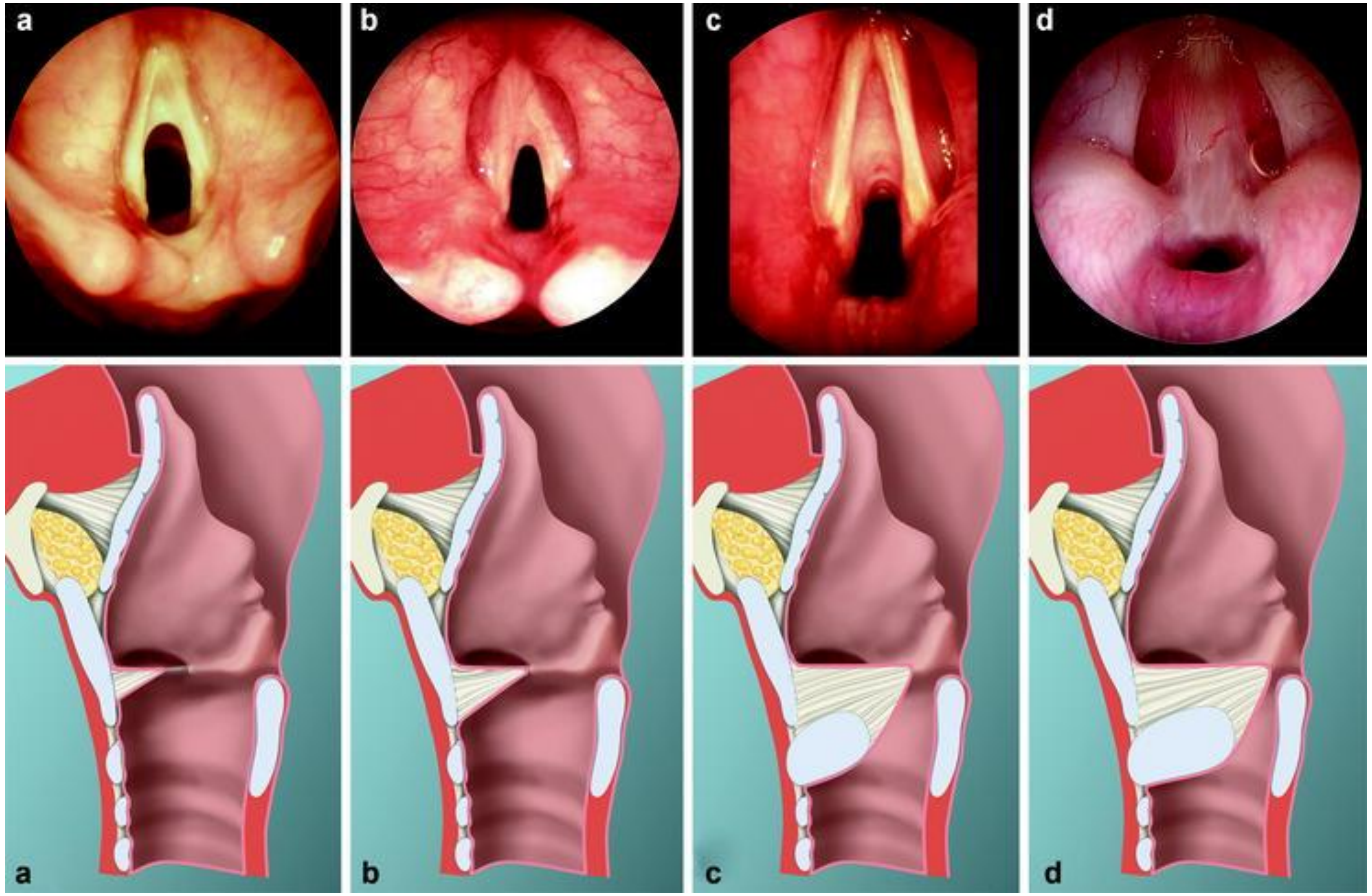
Airway sizing	Assess for leak using a cuffless endotracheal tube
Length and consistency	Soft vs firm
Site	Anterior +/or posterior or circumferential
Maturity	Edema / Active inflammation
Grading	Myer-Cotton Classification
Others	Presence of granulation, fibrosis, scarring

Myer-Cotton Classification

CM 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	

Etiology

- **Congenital**
  - Failure / incomplete recanalization of the laryngotracheal tube during the 3rd month of gestation
  - Spectrum of laryngeal anomalies such as laryngeal atresia, webs and subglottic stenosis
- **Acquired**
  - Vast majority
  - **>90% secondary to endotracheal intubation**



Acquired – Intubation injury

- 1965, McDonald and Stocks popularized the concept of prolonged nasotracheal intubation to manage reversible pulmonary disease in neonates
- Revolutionized neonatal critical care and the management of premature babies
  - *Marked increase in the development of acquired neonatal subglottic stenosis*

Predisposing factors

‘what is the urgency?’

What is the urgency?

THE Laryngoscope FOUNDED IN 1896

Pediatrics

Association Between Length of Intubation and Subglottic Stenosis in Children†

Denise Manica MD, MSc, Cláudia Schweiger MD, MSc, Paulo José Cauduro Maróstica MD, PhD, Gabriel Kuhl MD, Paulo Roberto Antonacci Carvalho MD, PhD

First published: 01 February 2013 | https://doi.org/10.1002/lary.23771 | Citations: 82

† This study was presented at the 41st Congresso Brasileiro de Otorrinolaringologia e Cirurgia Cérvico-Facial, Curitiba, Paraná, Brazil, September 10, 2011, and was considered The Best Original Report in Laryngology.
‡ This study was performed in the Otolaryngology Department and Pediatric Intensive Care Unit of the Hospital de Clínicas de Porto Alegre.
§ The authors have no funding, financial relationships, or conflicts of interest to disclose.

- PI-SGS is an important long-term outcome of intubation, the incidence of which ranges from 0.3% to >11%

Results:

We followed 142 children. In the first FFL, 58 children (40.8%) had moderate to severe laryngeal lesions. During follow-up, 16 children developed SGS, representing an incidence of 11.3% (95% confidence interval, 7.1–17.5). Multivariate analysis showed that for every 5 additional days of intubation, there was a 50.3% increase in the risk of developing SGS, and for each additional sedation doses/day, there was a 12% increase in the same outcome.

Conclusions:

In this first prospective research protocol in children, we found a higher incidence of SGS than in most previous studies. The length of intubation and the need for additional sedation doses appear to be key factors for the development of SGS during endotracheal intubation.

> Arch Dis Child Fetal Neonatal Ed. 2018 Jul;103(4):F349-F354.
doi: 10.1136/archdischild-2017-312962. Epub 2017 Sep 2.

Severe acquired subglottic stenosis in neonatal intensive care graduates: a case-control study

Rebecca E Thomas [1] [2], Shripada C Rao [1] [2], Corrado Minutillo [1], Shyan Vijayasekaran [3], Elizabeth A Nathan [4]

Affiliations + expand

PMID: 28866624 DOI: 10.1136/archdischild-2017-312962

Results: Thirty-seven NICU graduates required surgical intervention for SASGS of whom 35 were <30-week gestation at birth. The incidence of SASGS in surviving children who had required ventilation in the neonatal period was 27/2913 (0.93%). Incidence was higher in infants <28-week gestation (24/623=3.8%) compared with infants ≥28-week gestation (3/2290=0.13%; p=0.0001). On univariate analysis, risk factors for SASGS were: higher number of intubations (4 vs 2; p<0.001); longer duration ventilation (16 vs 9.5 days; p<0.001); unplanned extubation (45.7% vs 20.0%; p=0.007); traumatic intubation (34.3% vs 7.1%; p=0.003) and oversized endotracheal tubes (ETTs) (74.3% vs 42.9%; p=0.001). On multivariate analysis, risk factors for SASGS were: Sherman ratio >0.1 (adjusted OR (aOR) 6.40; 95% CI 1.65 to 24.77); more than five previous intubations (aOR 3.74; 95% CI 1.15 to 12.19); traumatic intubation (aOR 3.37; 95% CI 1.01 to 11.26).

Conclusions: SASGS is a serious consequence of intubation for mechanical ventilation in NICU graduates, especially in preterm infants. Minimising trauma during intubations, avoiding recurrent extubation/reintubations and using appropriate sized ETTs may help prevent this serious complication.

What is the urgency?

PEDIATRICS INTERNATIONAL
Official Journal of the Japan Pediatric Society

Original Article

Post-intubation subglottic stenosis in children: Analysis of clinical features and risk factors

Erkan Cakir, Ayse Ayzit Atabek, Omer Faruk Calim, Selcuk Uzuner, Lina AlShadfan, Hakan Yazan, Orhan Ozturan, Fatma Betul Cakir

First published: 27 December 2019 | https://doi.org/10.1111/ped.14122 | Citations: 11

Methods

A total of 112 patients who had a history of intubation were included. The case group consisted of 50 patients with post-extubation persistent respiratory symptoms for which flexible bronchoscopy (FOB) was conducted and showed SGS. The control group consisted of 62 patient with no post-extubation persistent respiratory symptoms, for whom FOB was not done (n = 54), and who had post-extubation persistent respiratory symptoms and underwent FOB, which did not show subglottic stenosis (n = 8).

Results

No significant differences were detected related to age, gender, and gestational age. The median number of recurrent intubations was 2.5 and 3 in the case group and in control group, respectively (P = 0.14). The median duration of intubation was 20.5 days in the case group, and 6 days in the control group (P < 0.001). The Myer–Cotton classification indicated a degree of obstruction of grade 1 (mild) in 30% (n = 15), grade 2 in 16% (n = 8), grade 3 in 48% (n = 24), and grade 4 in 6% (n = 3) of the case group.

Conclusion

The duration of intubation was found to be a significant risk factor for SGS development. Age at intubation, gender, gestational age, indication of intubation, and the number of recurrent intubations were found to have no significant association. Patients with post-extubation persistent respiratory problems, especially those with prolonged intubations, should be evaluated for SGS.

Predisposing factors for Acquired stenosis

Laryngeal (Intrinsic) – Intubations that are:	Extra-laryngeal (Extrinsic)
Prolonged	Prematurity / Low birth weight
Traumatic	Irritants e.g. GER, meconium aspiration
Repetitive	Systemic factors: malnutrition, anemia, hypoxia
Compressive*	Keloid predisposition

*oversized tubes and hyper-inflated cuffs (microcirculation reduced significantly at 25-30mmHg)

Post-intubation subglottic stenosis: aetiology at the cellular and molecular level

Emma R Dorris[1,2], John Russell[3] and Madeline Murphy[1,2]

Affiliations: [1]National Children's Research Centre, Our Lady's Children's Hospital, Dublin, Ireland. [2]School of Medicine, University College Dublin, Dublin, Ireland. [3]Children's Hospital Ireland Crumlin, Dublin, Ireland.

Correspondence: Emma R Dorris. University College Dublin Conway Institute, Belfield, Dublin 04 V1W8, Ireland. E-mail: emma.dorris@ucd.ie.

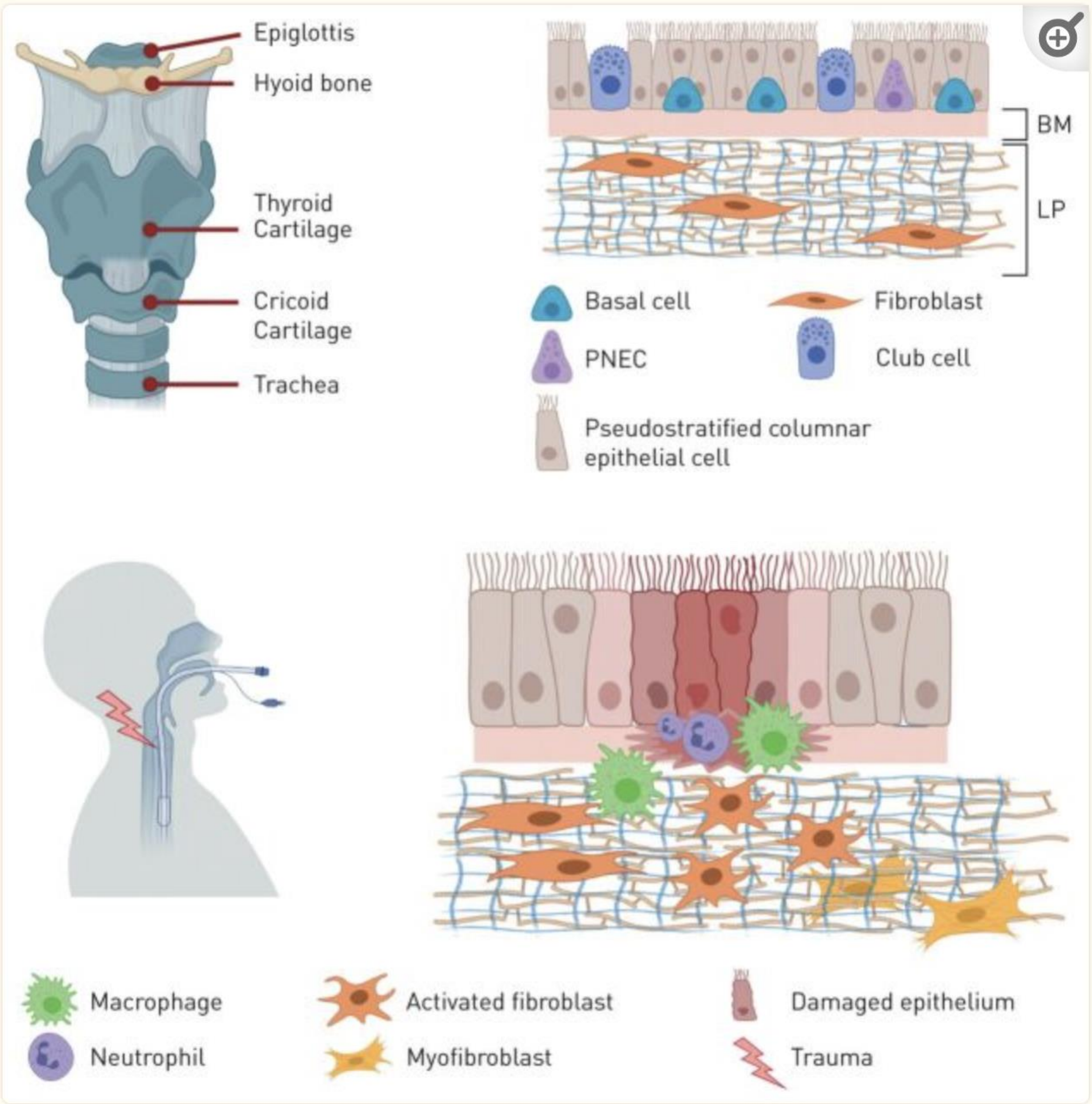
@ERSpublications
COVID-19 may cause an increased incidence of subglottic stenosis (SGS). In this review, the cellular and molecular aetiology of post-intubation SGS is outlined and we discuss how better knowledge of the underlying biology can inform SGS management. https://bit.ly/2RSliRK

Cite this article as: Dorris ER, Russell J, Murphy M. Post-intubation subglottic stenosis: aetiology at the cellular and molecular level. *Eur Respir Rev* 2021; 30: 200218 [https://doi.org/10.1183/16000617.0218-2020].

Inflammation → Proliferation → Remodelling

Pathophysiology

- An exaggerated wound healing response is central to an acquired stenosis
- Initiated by high compressive forces of the ETT causing pressure necrosis, mucosal edema and ulceration
- Resultant granulation formation causes luminal narrowing and stenosis, and eventually scar formation



International Journal of Pediatric Otorhinolaryngology
Volume 151, December 2021, 110931

Prognostic factors in the management of pediatric subglottic stenosis ☆

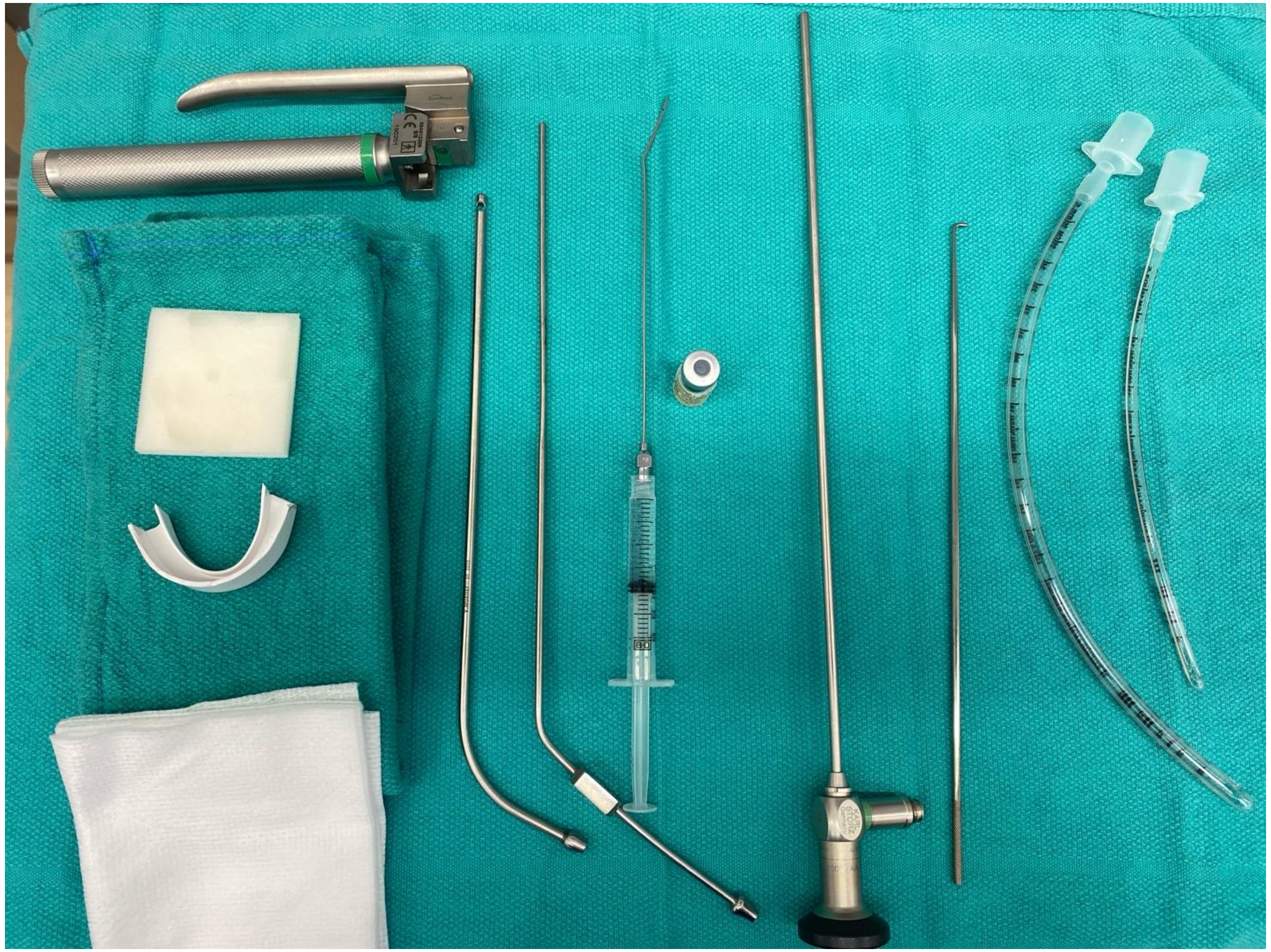
Sarah Debs [a], Aasif A. Kazi [a], Dustin Bastaich [b], Leroy Thacker [b], Rajanya S. Petersson [a] [c]

3. Results

A total of 47 patients were included in the study, of which 51% (n=24) were female. The average gestational age was 31±6.14 weeks (range 26–41 weeks), and prematurity, defined as gestational age <37 weeks, was seen in 66% (n=31) of patients. The most common comorbidities were bronchopulmonary dysplasia (60%, n=28) followed by the presence of reflux (55%, n=26). The average intubation length was 61.5 days±57.2 days (range 0–180 days). The average grade of stenosis on initial direct laryngoscopy was 1.94±0.92. The average number of interventions performed per patient was 3.93±2.81. Laryngotracheal reconstruction was performed on 49% (n=23) of patients (Table 1). The following comorbidities were not found to have a significant association with requiring LTR: bronchopulmonary dysplasia, chronic lung disease, chromosomal abnormalities, reflux, and pulmonary hypertension. Interestingly, the length of intubation was also not found to be associated with a significantly higher rate of LTR (Table 1).

Diagnostic workup

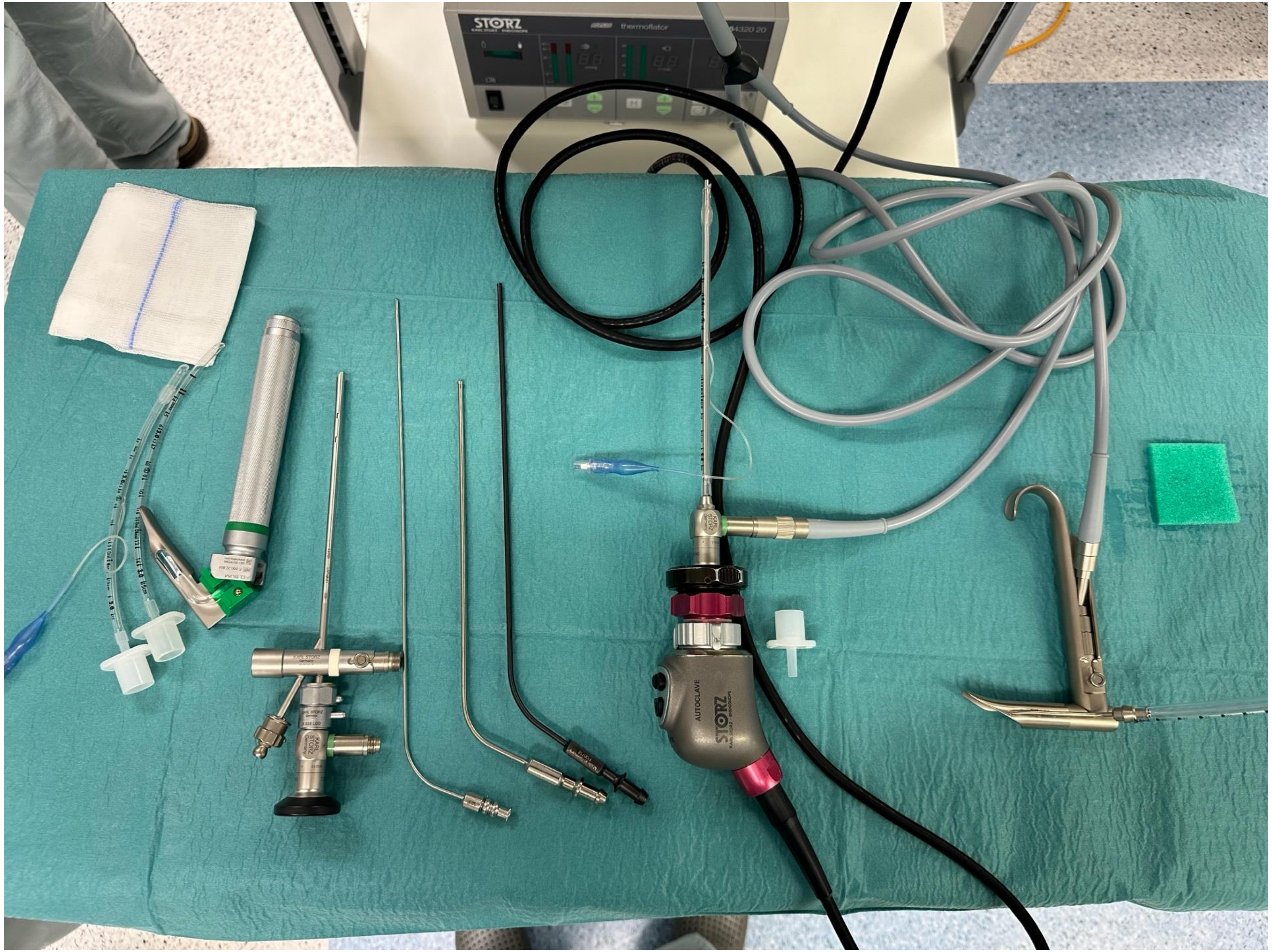
- **Flexible laryngoscopy**
  - Supraglottic and glottic pathology
- **Rigid endoscopy**
  - Laryngoscopy, tracheoscopy, bronchoscopy gold standard
  - Under spontaneous ventilation



Left to Right: Laryngoscope, anti-fog, dental guard, rigid suctions (pharyngeal, laryngeal), weight-based local anasthesia with atomizer, Hopkin's telescope, right-angled probe, appropriate ET tubes

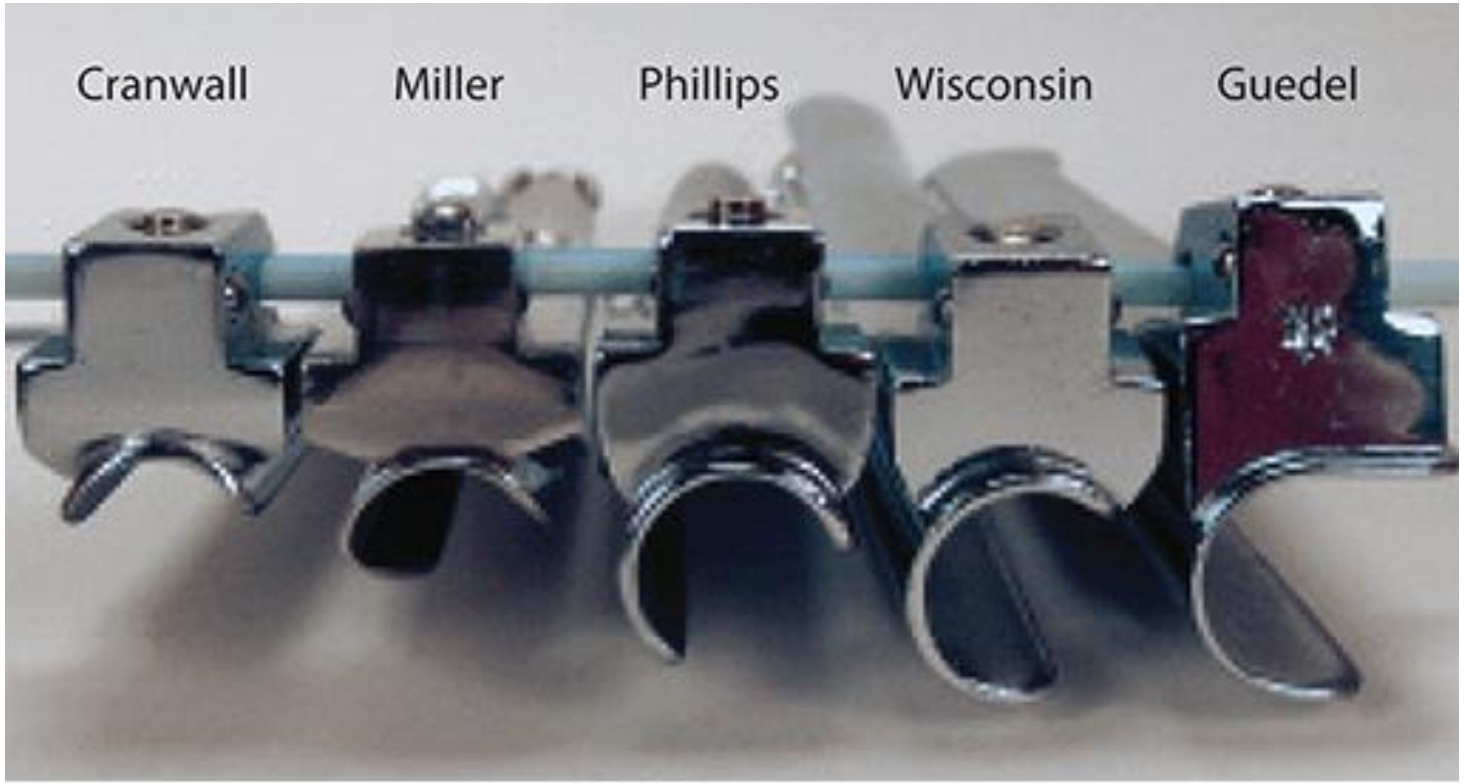
ETT over a Hopkins rod

Set-up



Laryngoscopes

Laryngoscopes



Source: Orlando R. Hung, Michael F. Murphy: *Hung's Difficult and Failed Airway Management*, 3rd edition

Laryngoscopes

Suspension micro-laryngoscopy

Management

Primary aim is to avoid a tracheostomy

Medical - adjunctive

- Treatment of any underlying conditions
- Infection
- Gastro-esophageal reflux
    - Would hinder laryngeal recovery
    - No surgery in an ‘active larynx’ - wait at least 6 months on PPI/H2RA
- Steroids
- Adrenaline nebulisers

Surgical

- Tracheostomy
- Endoscopic balloon dilatation
- Laryngotracheal reconstruction

Avoid tracheostomy if you can

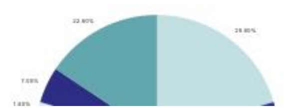
AIRWAY SURVEILLANCE IN PEDIATRIC TRACHEOSTOMY PATIENTS IN QATAR

Niveen Mukhtar[1]; Larkin Accinelli[1]; Faisal Abdelkader[1,2] Taseer F Din [1,2]
1. Division of Pediatric Otolaryngology-Head & Neck Surgery, Sidra Medicine, Qatar
2. Department of Otolaryngology-Head & Neck Surgery, Weill-Cornell Medicine - Qatar

INTRODUCTION

Our pediatric ENT team in Qatar serves a unique patient population with high rates of genetic disorders and consanguinity in the community, with a large number of tracheostomized children. In addition, the COVID-19 pandemic disrupted routine patient monitoring and surveillance. Post-pandemic, we have noted an increase in tracheostomy-related bleeding emergencies, obstructive tracheal granuloma formation, obstructive tracheal crusting secondary to poor hydration and stoma complications amongst various other challenges. In response, we are establishing a national pediatric tracheostomy surveillance program as a standard of care for Qatar's tracheostomized children. The purpose of this program is to centralize care for pediatric tracheostomies and enhance its safety. Our team's first goal was to establish routine airway evaluations in tracheostomized children.

Figure 2. Erosion over innominate artery.



METHODS AND MATERIALS

Retrospective-prospective study from October 2023 to September 2024. Our aim was to assess the pick-up rate of surveillance micro-direct laryngotracheobronchoscopies (MDLBs) in tracheostomized patients <18 years old cared for by Sidra Pediatric Otolaryngology, Qatar.

Figure 1; Airway crusting

DISCUSSION

Our goal as a regional pediatric airway center is to create a system that provides pro-active management to prevent complications and optimize safe care for all tracheostomized patients. In establishing routine airway evaluations in tracheostomized children nationally, we have seen our rate of initial pickup was much higher that what is reported in the literature: 71.2% vs 55.1% from the group at Boston, USA[1], with some of our pro-active interventions potentially preventing life-threatening complications like a trachea-innominate fistula. With the aforementioned results, our next step is to expand our outreach into the community to establish optimal routine pediatric tracheostomy care.

RESULTS

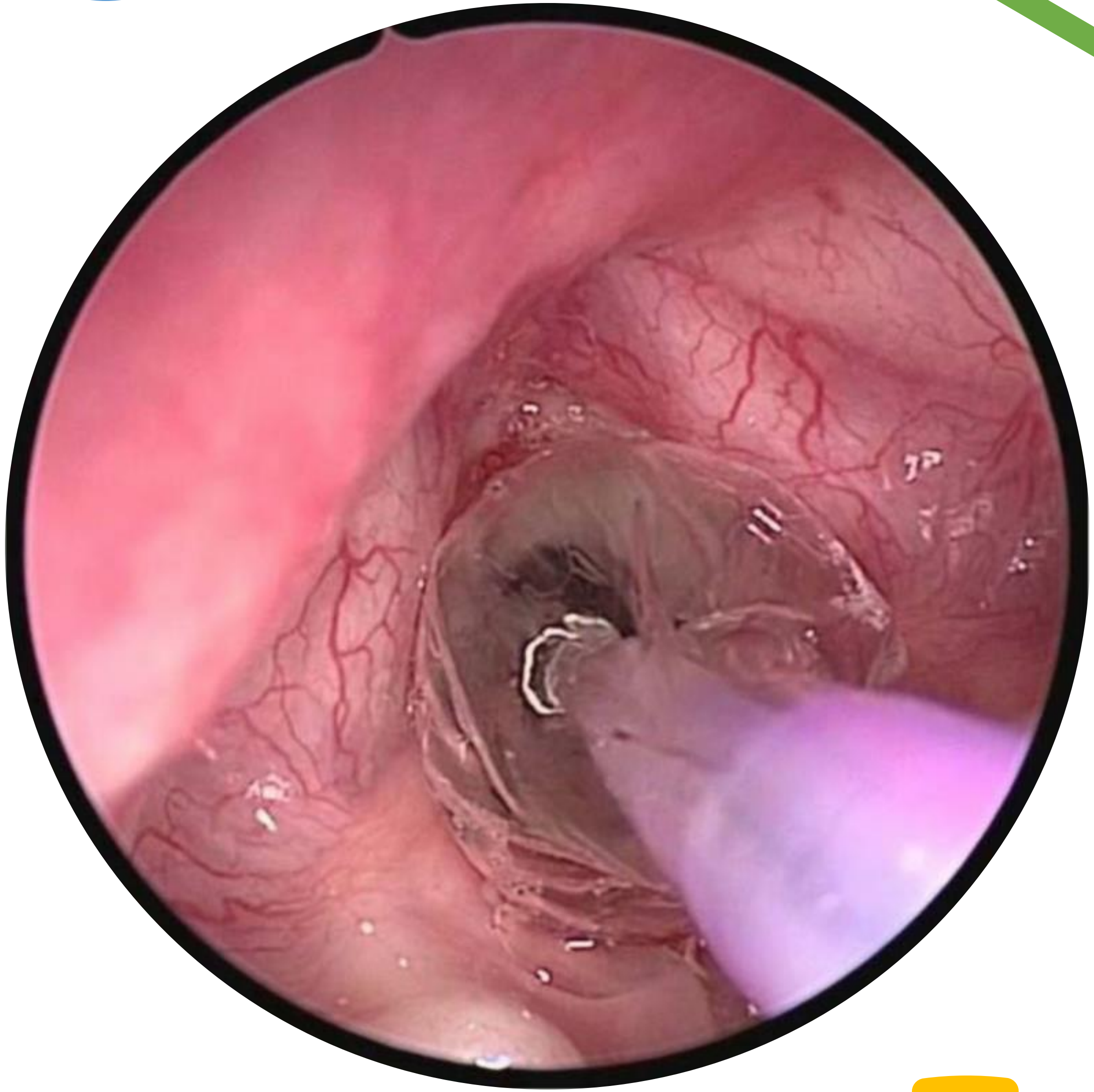
Establishing routine airway evaluations in tracheostomized children nationally has been a joint effort between our tracheostomy care team, the chronic care facilities that care for majority of these children and our operating room staff. 56 patients were included.17 (29.8%) had reassuring MDLBs, requiring no acute intervention. 36 (63.2%) had obstructive granulomas requiring surgical intervention. Notably, 7 (12.5%) of patients had significant tracheal granuloma obstruction with increased ventilatory settings over the past months that reversed after surgical intervention. 5 (8.8%) of patients were found to have mucosal sloughing over where the innominate artery crosses the trachea, that prompted further imaging and adjustments to tube and cuff position for safety. 1 (1.8%) had a megatrachea and 4 (7%) had obstructive airway crusting that needed removal. Lastly, 13 (22.8%) had newly diagnosed structural pathology like subglottic stenosis impacting ability for decannulation or necessitated altering tracheostomy tube style.

Figure 3. Suprastomal granuloma.

Figure 4; Tracheal granuloma.

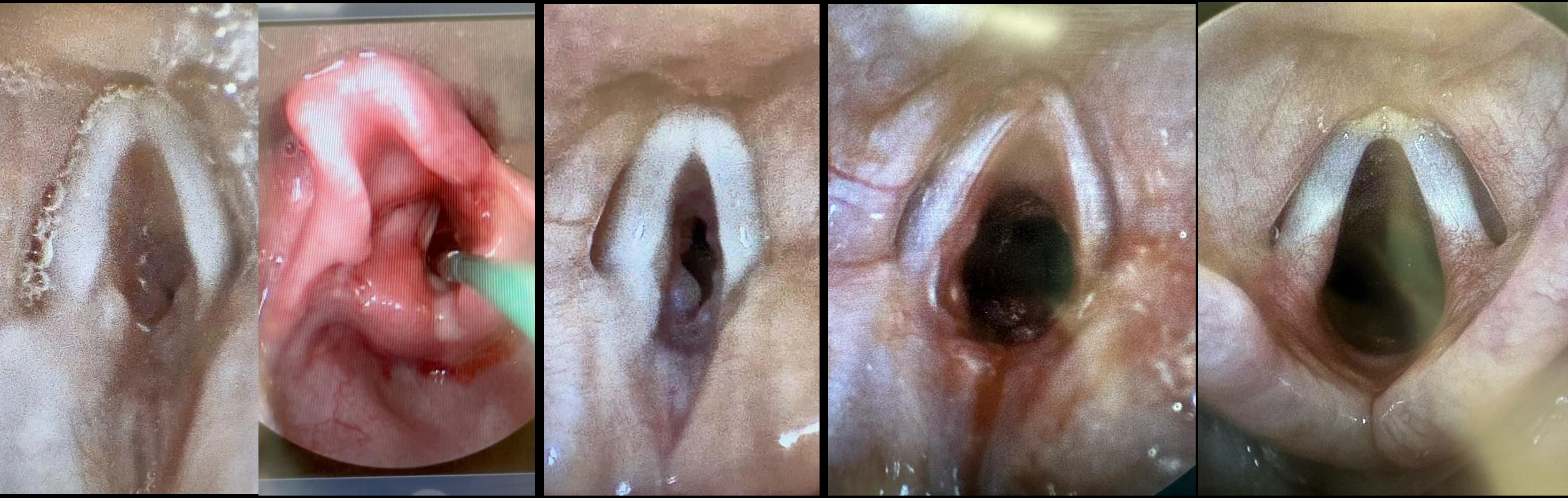
National Tracheostomy Surveillance Program

- Pick up red flags
- Prevent complications
- Assess for decannulation potential

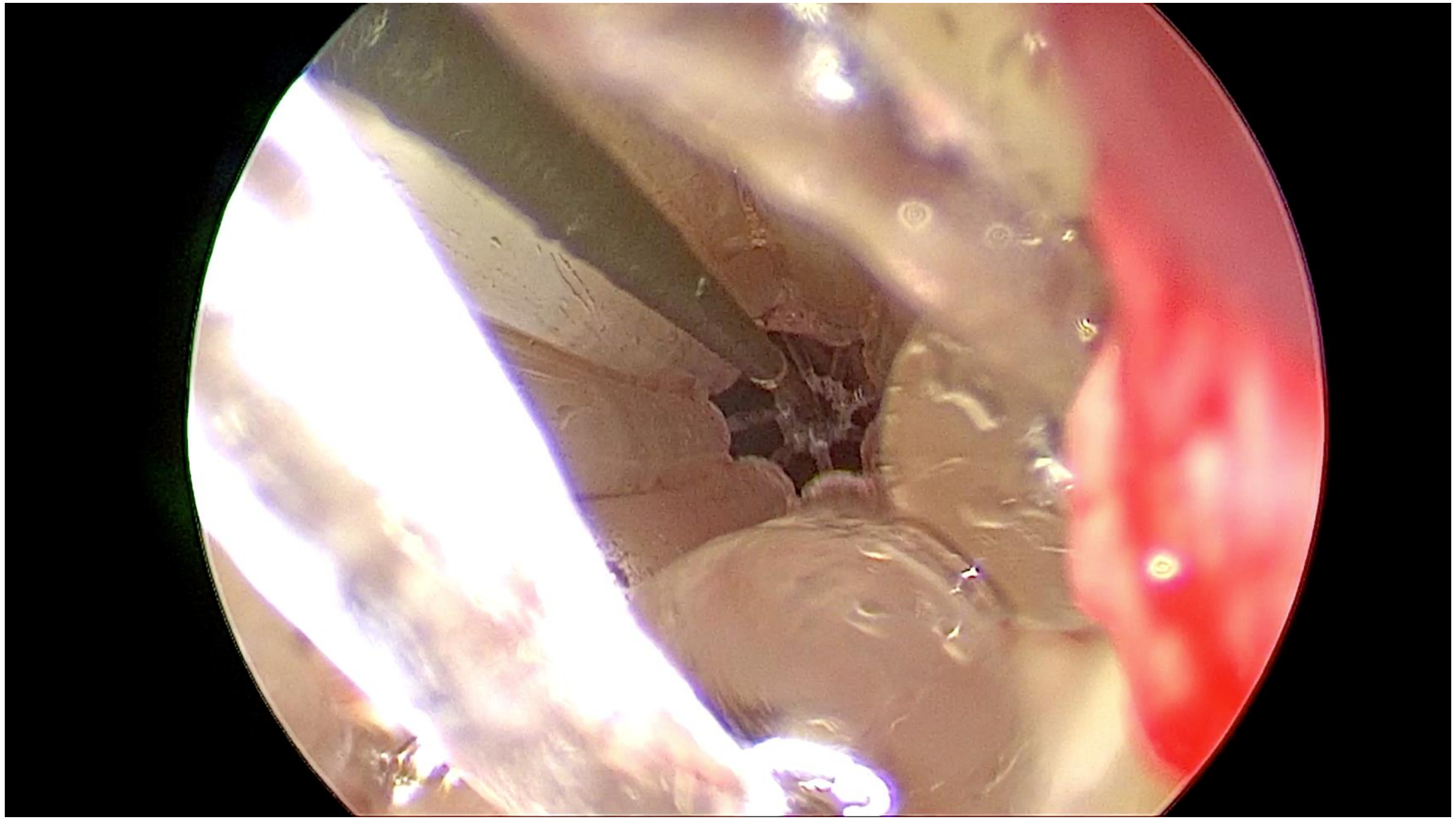


Endoscopic airway surgery

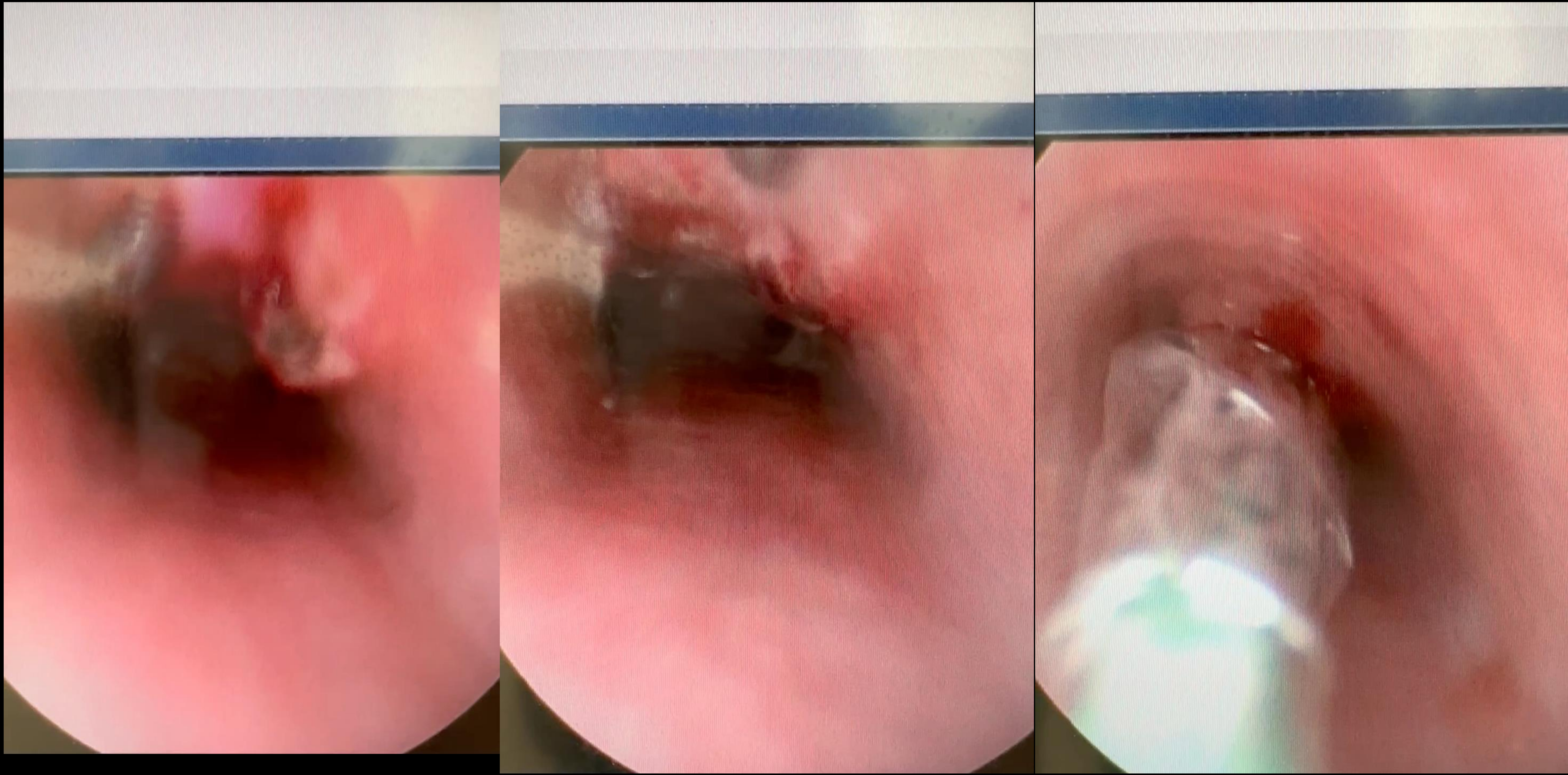
Balloons

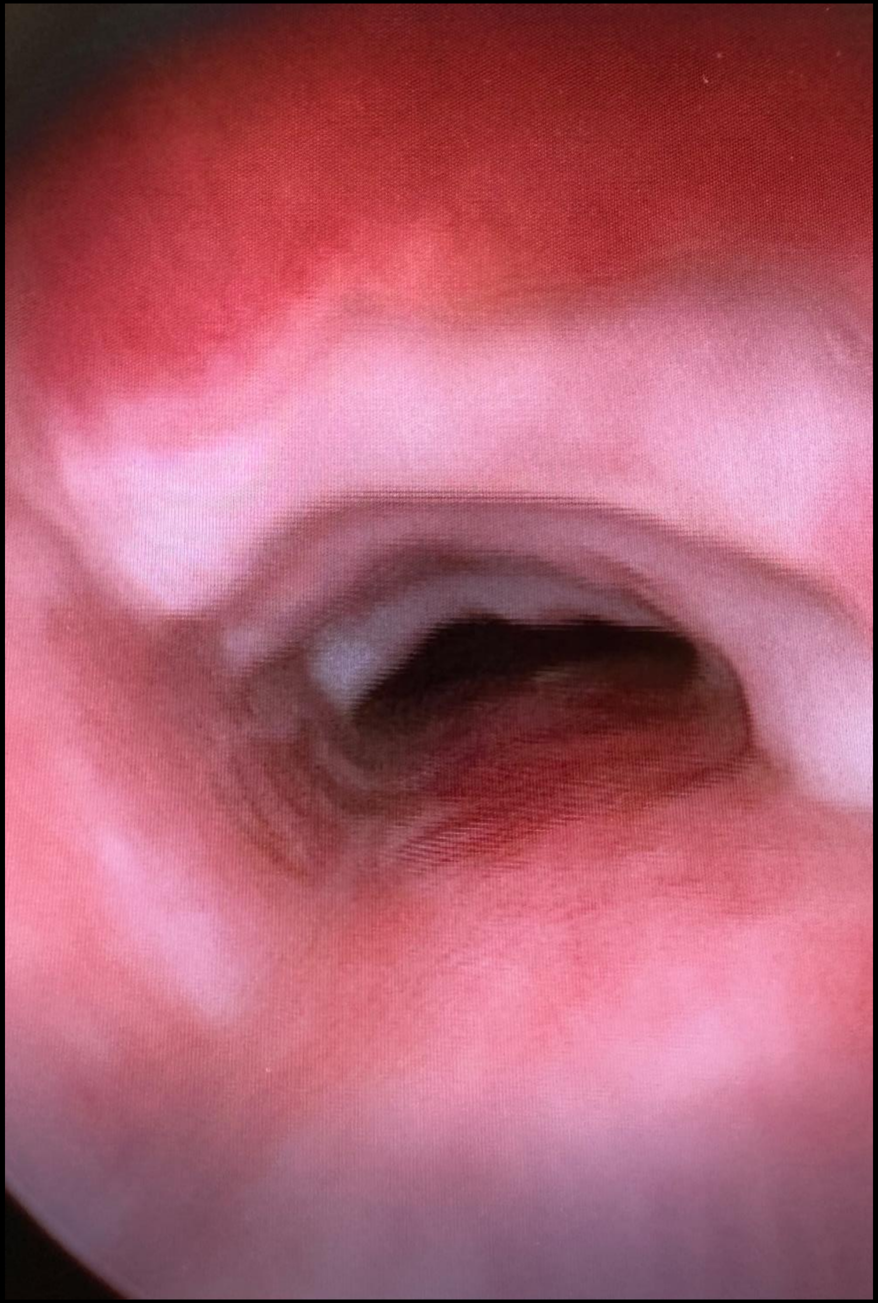


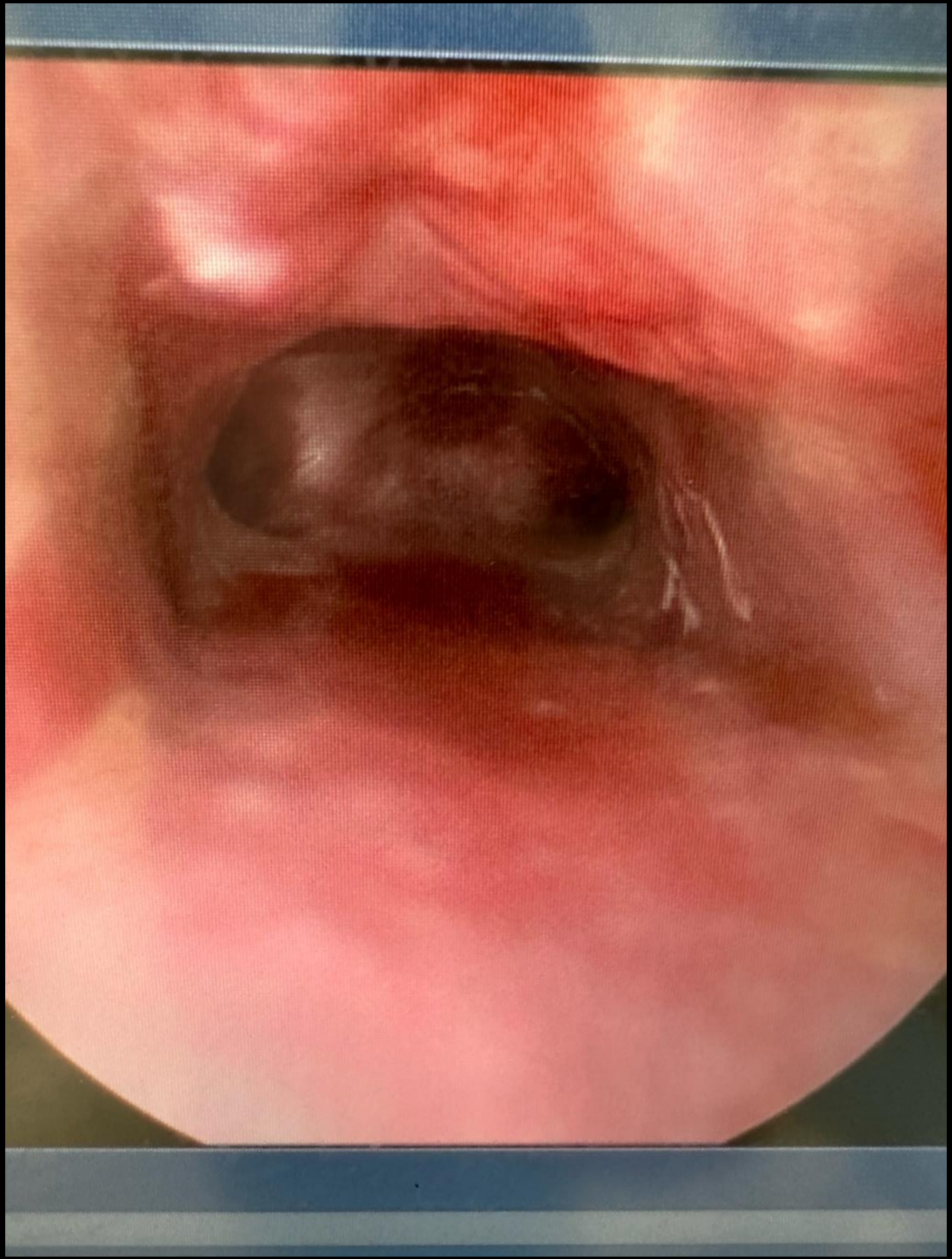
Ventilating balloons



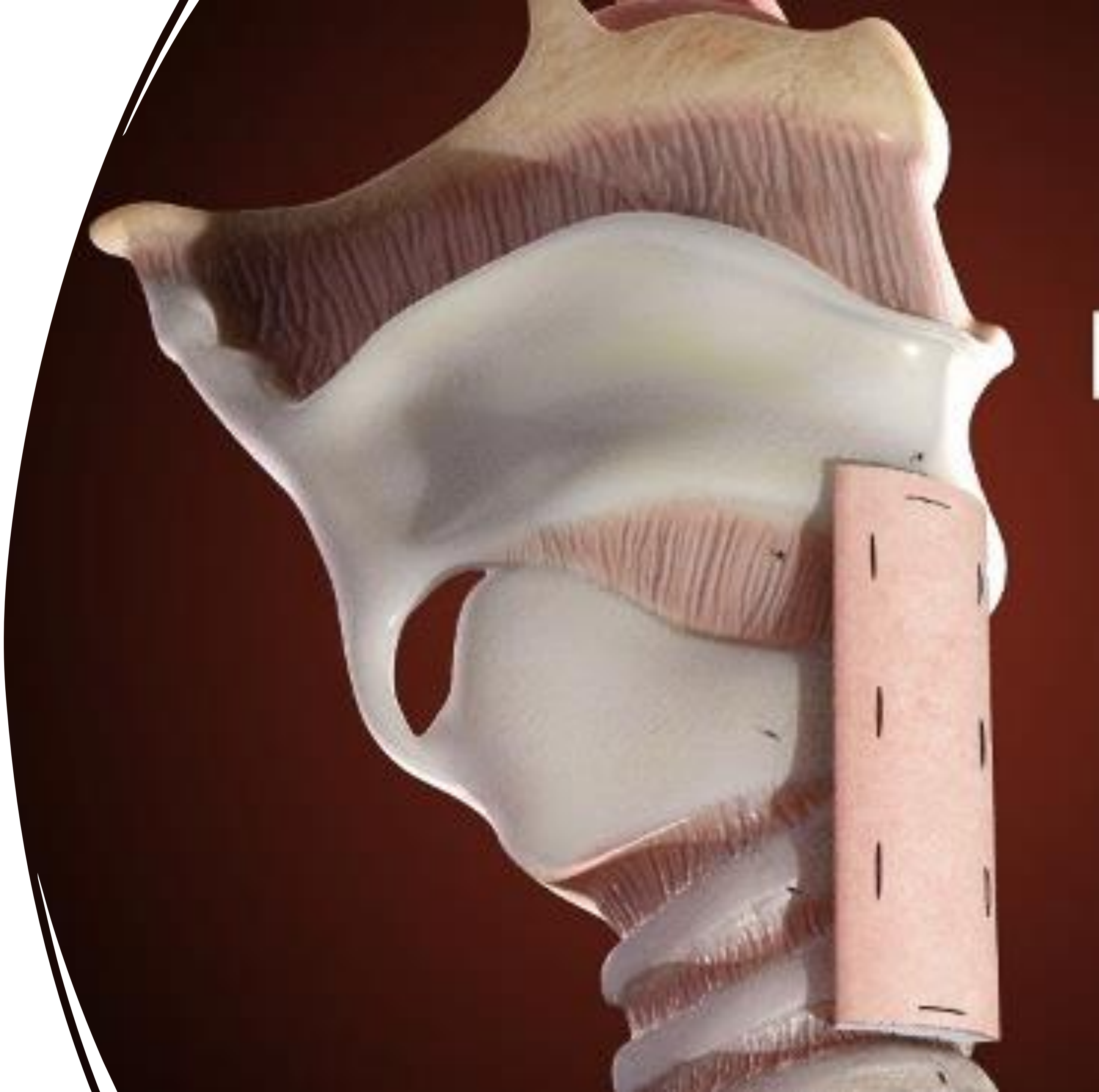
Lasers

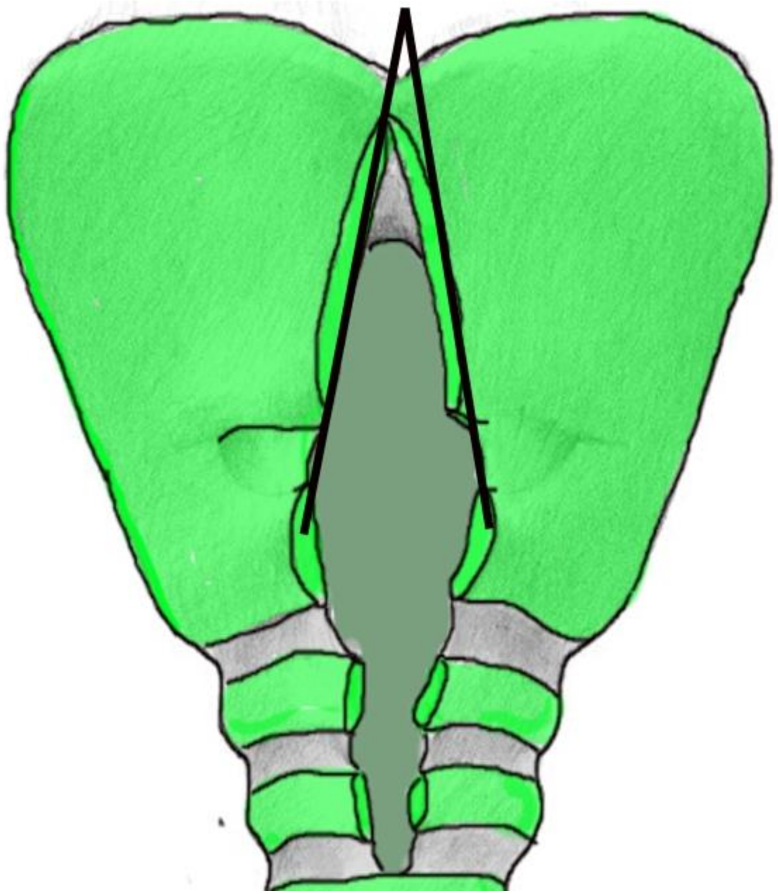


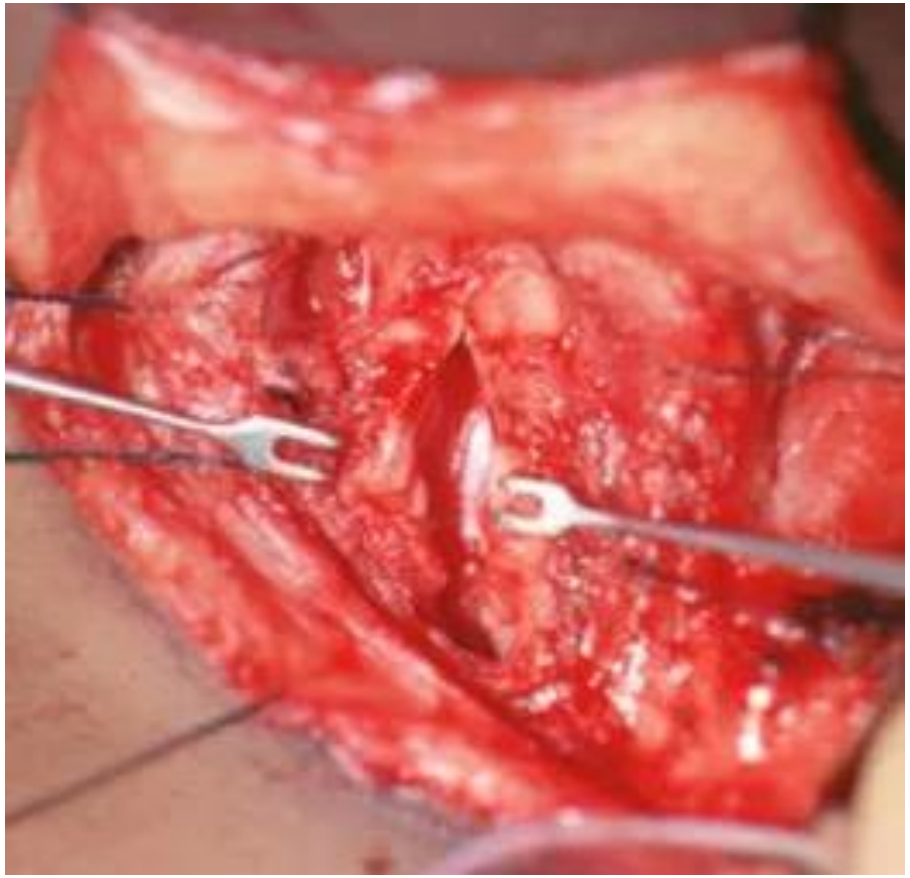




Open airway surgery





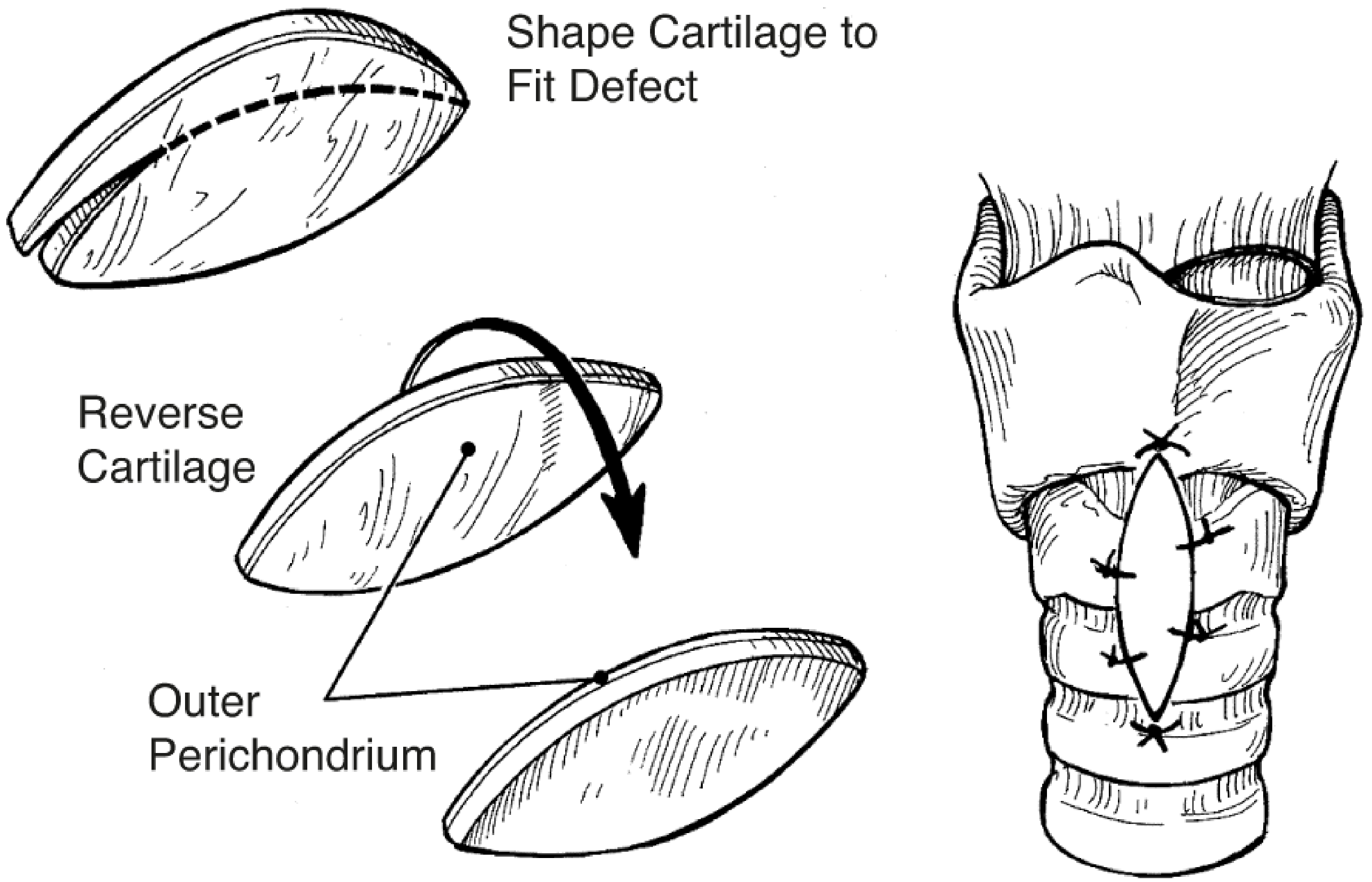


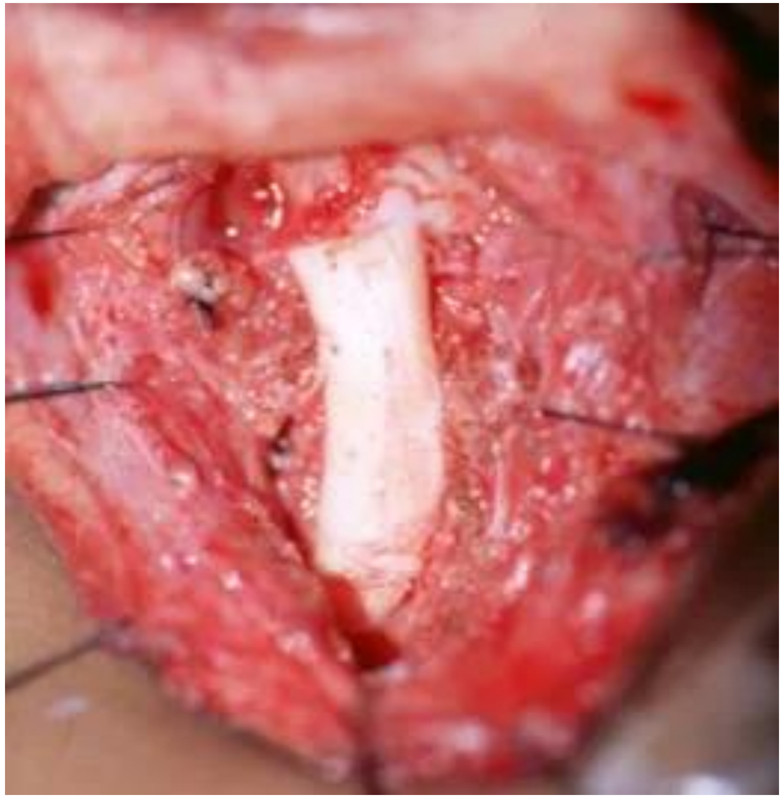
- Anterior incision of the trachea from the 2nd tracheal ring up through the cricoid and into the lower third of the thyroid ala

Augmenting the split?

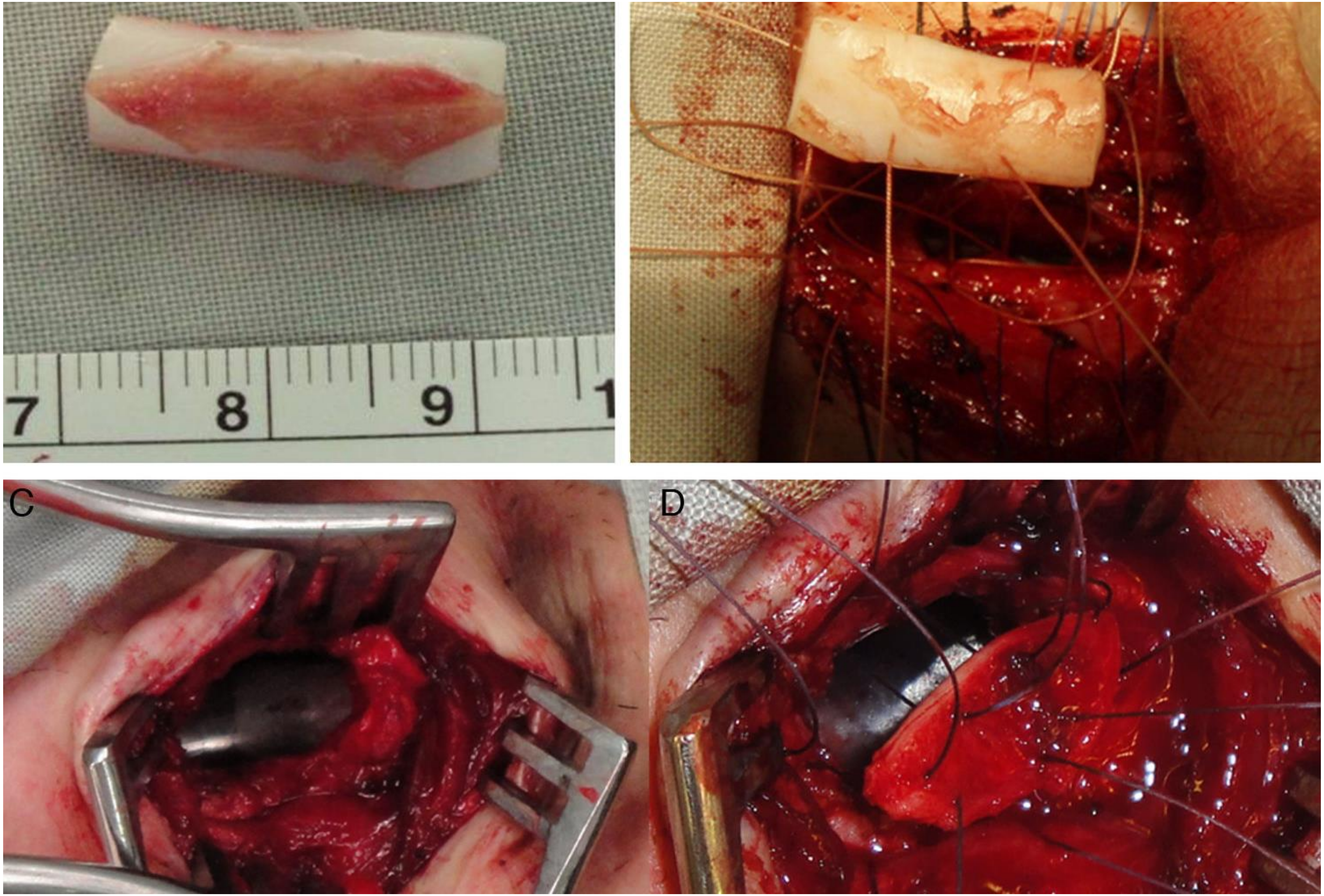
- Improved the likelihood of success

Thyroid alar graft





Costal cartilage



7
8
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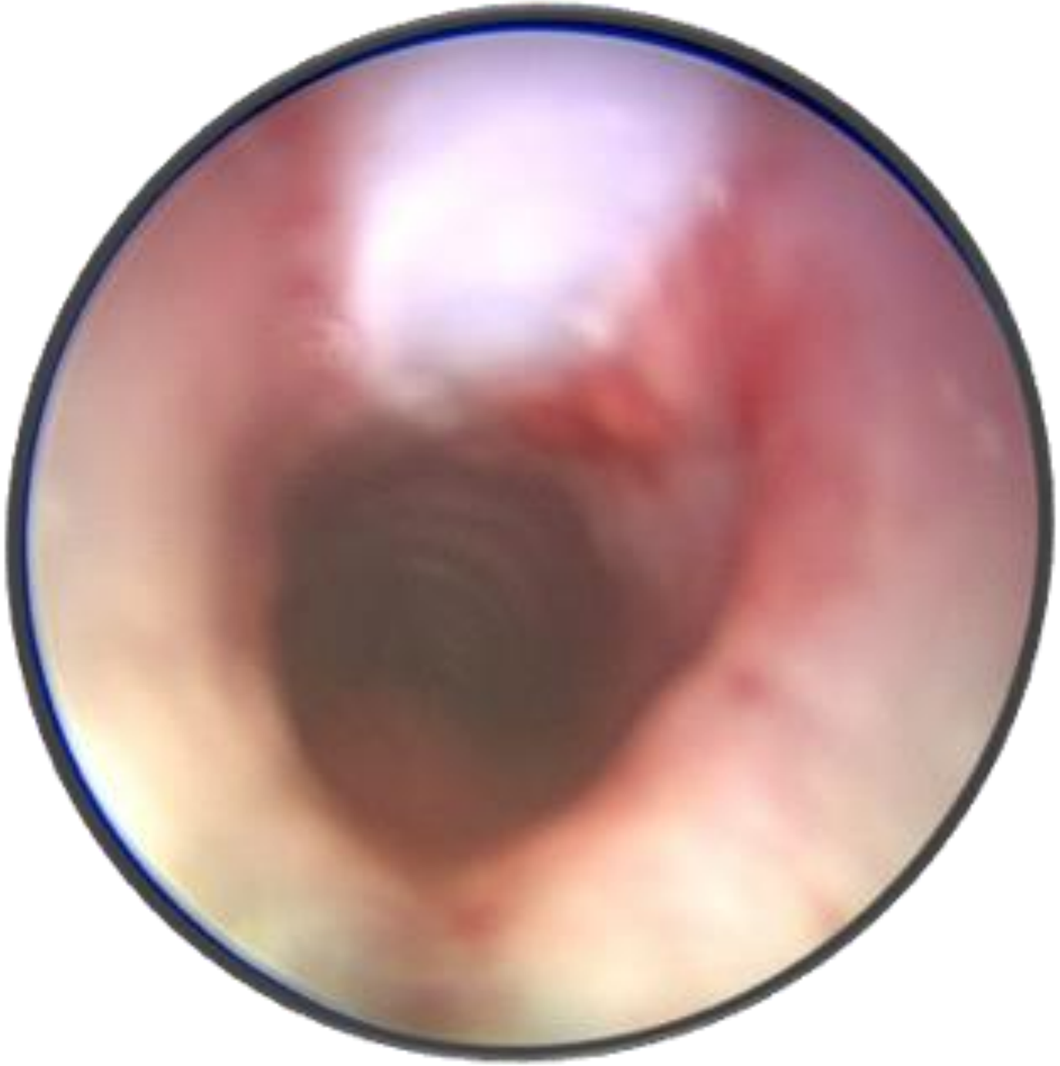
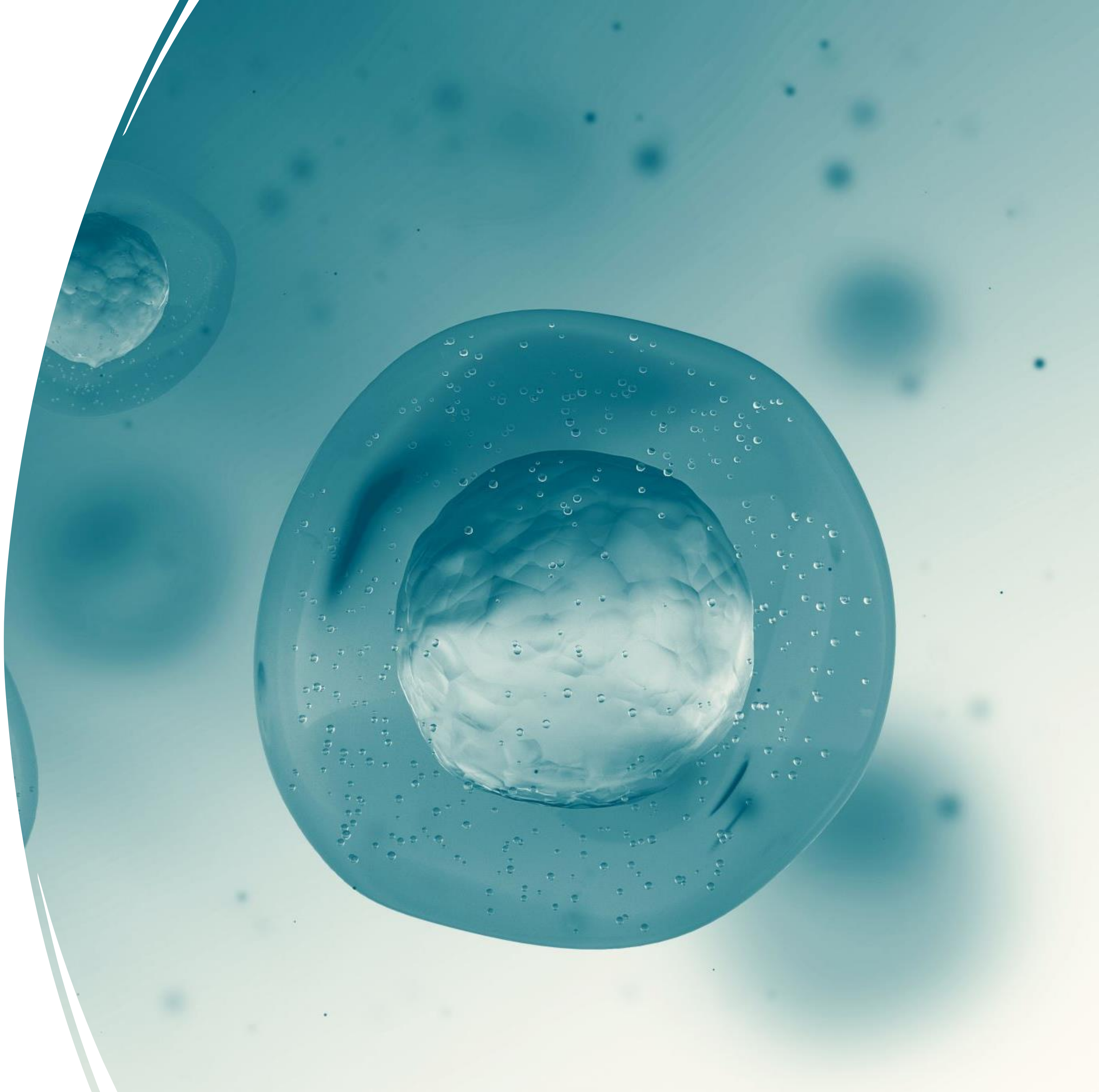
6 weeks post-op…



Complications

- *Intraoperative*
  - Pneumothorax
  - Loss of the airway / hypoxia
- *Early postoperative*
  - Wound infection
  - Subcutaneous emphysema
  - Loss of the graft
  - Accidental extubation
- *Long term*
  - Failure and restenosis - Incidence of 10-20%



Complex Airway Team

1. ENT
2. Anasthesiologist
3. Pulmonologist
4. General Surgeon / Thoracic Surgeon
5. Intensivist

Summary

- An airway is best managed by sharing and caring
- Pediatric airways are small and tenuous
- Beware of intubation-related airway injury!
- Plan extubation as soon as intubated
- Avoid tracheostomy if you can

Questions?

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