

LARYNGEAL TRAUMA

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ETIOLOGIES

Internal iatrogenic trauma

- > post-intubation, post-tracheotomy
- > post-therapeutic endoscopy

External trauma

- > blunt
- > penetrating
- > inhalation injury
- > caustic ingestion

...DESCRIBED A LONG TIME AGO

**First description :
papyrus of Smith,
Egypt, ~ 600 BC**



ETIOLOGY < XXTH CENTURY

Trauma: open > blunt

Hunting



**War : sword
 gunshot**



PROGNOSTIC...



...FATAL

Respiratory or cardiac arrest

Asphyxy

Hémorragie

Broncho-aspiration

Infection



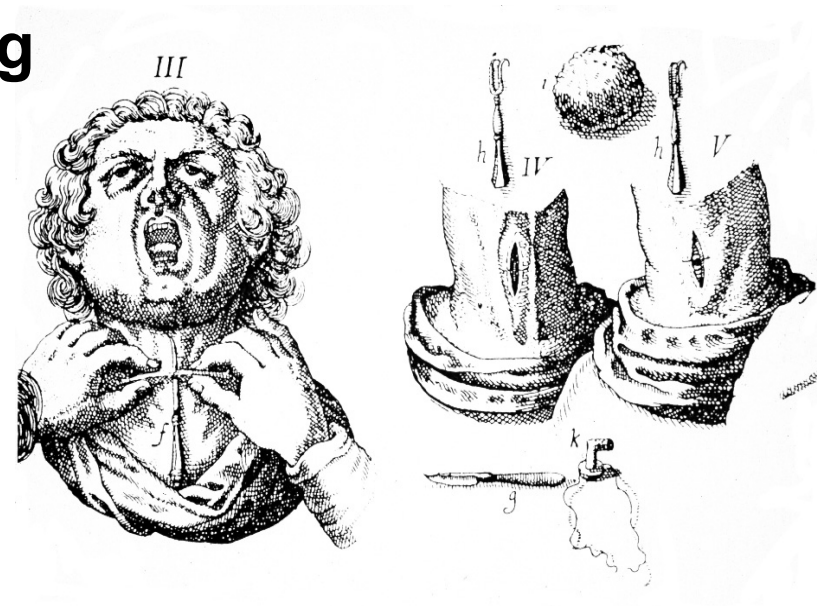
...MISUNDERSTOOD FOR A LONG TIME...

First non specific treatments

Closure of the wound & dressing

tracheotomy (*Habicot, 1620*)

intubation through thr wound
(*Sabatier, 1796*)



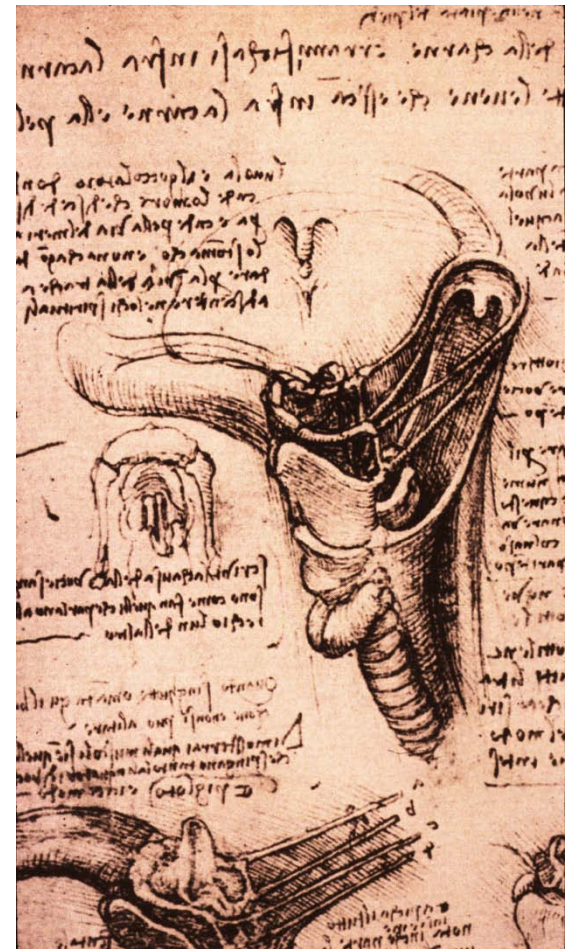
UNDERSTANDING OF THE LARYNX & TRAUMA

~ 500 years

Aristote, Galien, Vésale, Da Vinci, Fallope, Bauhin, Casserius, Santorini, Morgagni,...

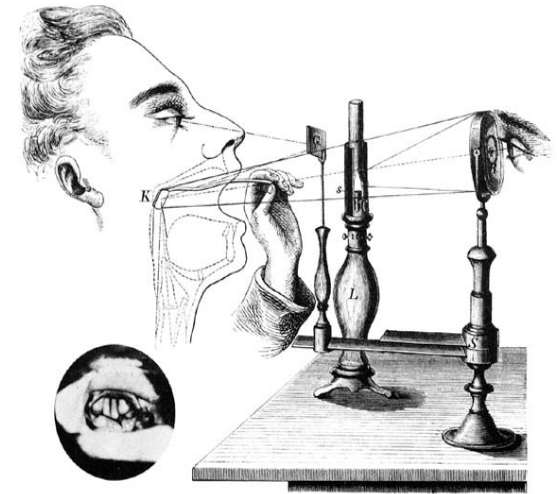
Pathologic anatomy

Morgagni, Laënnec, Albers, Louis, Trousseau, Belloc,...



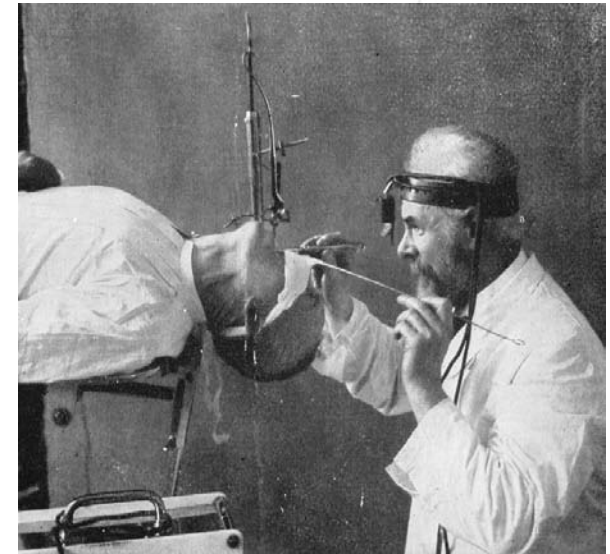
UNDERSTANDING OF THE LARYNX & TRAUMA

Visualisation of the larynx in vivo (*Garcia 1857*)



Laryngology (*Türck 1866*)

Microlaryngoscopy en suspension (*Kierstein 1895, Killian 1911, Kleinsasser 1962*)



FIRST SPECIFIC TREATMENTS

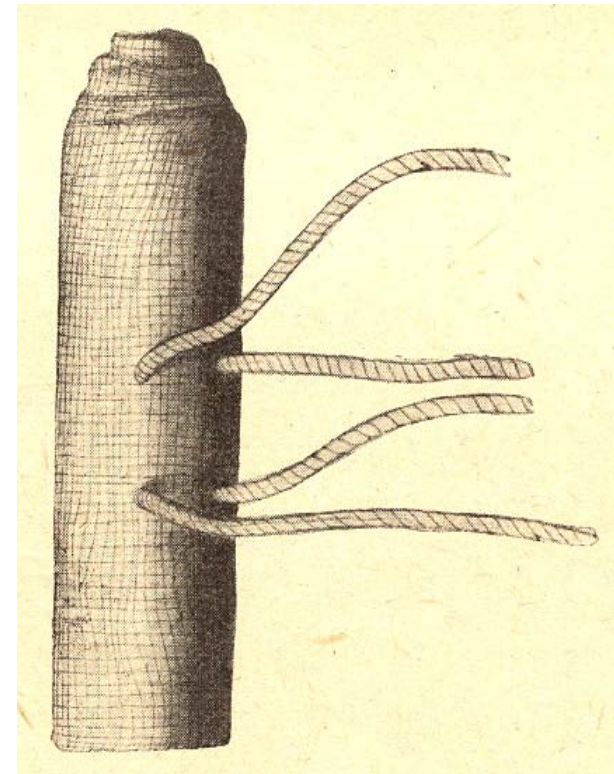
**Laryngofissure for fracture
reposition** *Eichmann* 1850

Surgical treatment of stenosis
 Dobleau 1869

Tracheal resection-anastomosis
 Küster 1885

**Reconstruction with cutaneous
flaps** *Schimmelbusch* 1887

First stents
 Moure 1918



ETIOLOGY

Motor vehicle accidents 60%

> car 37%

> motorcycle 23%

Assault or suicide attempts 20%

> knife wounds, gunshots

> hanging

● Occupational accidents 20%

> sports

> industrial injuries (muffler of factory worker)

PEACETIME PREVALENCE

- ~ 1 in 30'000 emergency room visits (Schaefer 1989)
- ~ 1 in 650 maxillo-facial fractures (Haugh 1992)
- ~ 2 to 5 cases / year / major trauma center (Yen 1994)

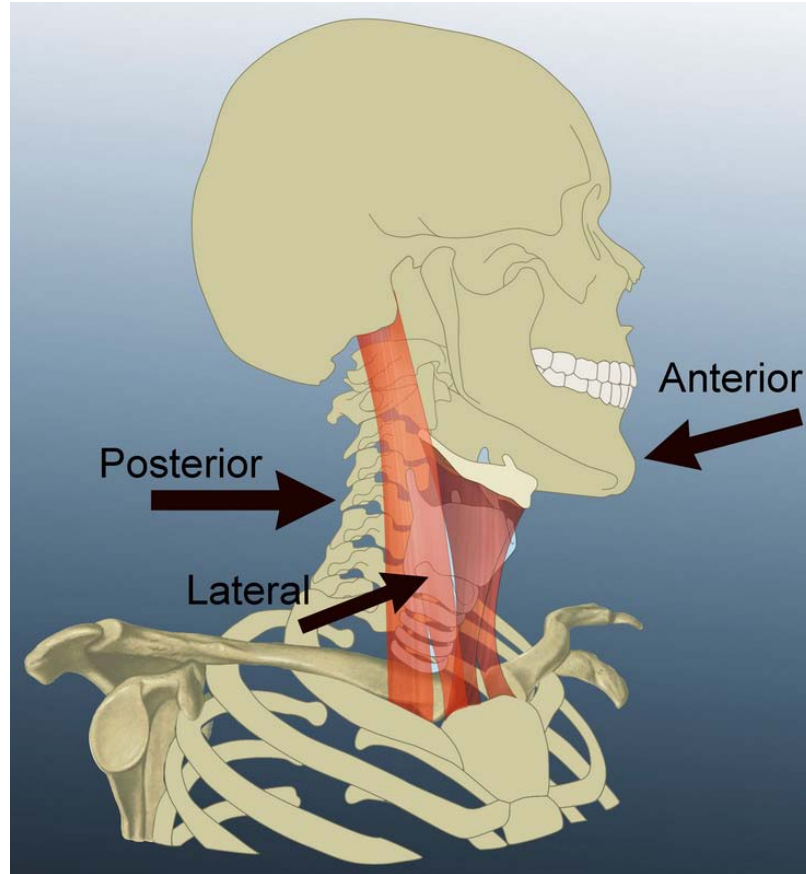
BLUNT INJURIES 83%

PENETRATING INJURIES 17%

> knife wounds
> gunshot } geographic factors

! RARE ENTITY → LIMITED EXPERIENCE !

REASONS FOR RARITY



LARYNX

relatively well-protected
position in the neck

natural shields :

- > SCM muscles laterally
- > cervical spine posteriorly
- > overhanging mandible
cranially (children > adults)



SEAT BELTS + AIRBAGS



EPIDEMIOLOGY

Estimated mortality rate : 2%

- > 40% from blunt injuries
- > 20% from penetrating injuries

Associated injuries

- > craniocerebral trauma ~ 13%
- > open neck ~ 9%
- > cervical spine ~ 8%
- > pharynx / esophagus ~ 3%

EXTERNAL LARYNGEAL TRAUMA

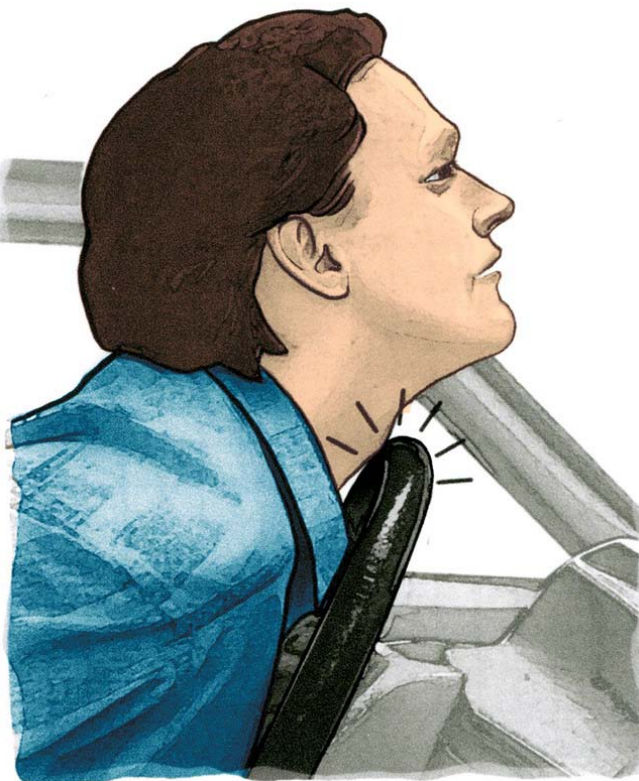
BLUNT

PENETRATING

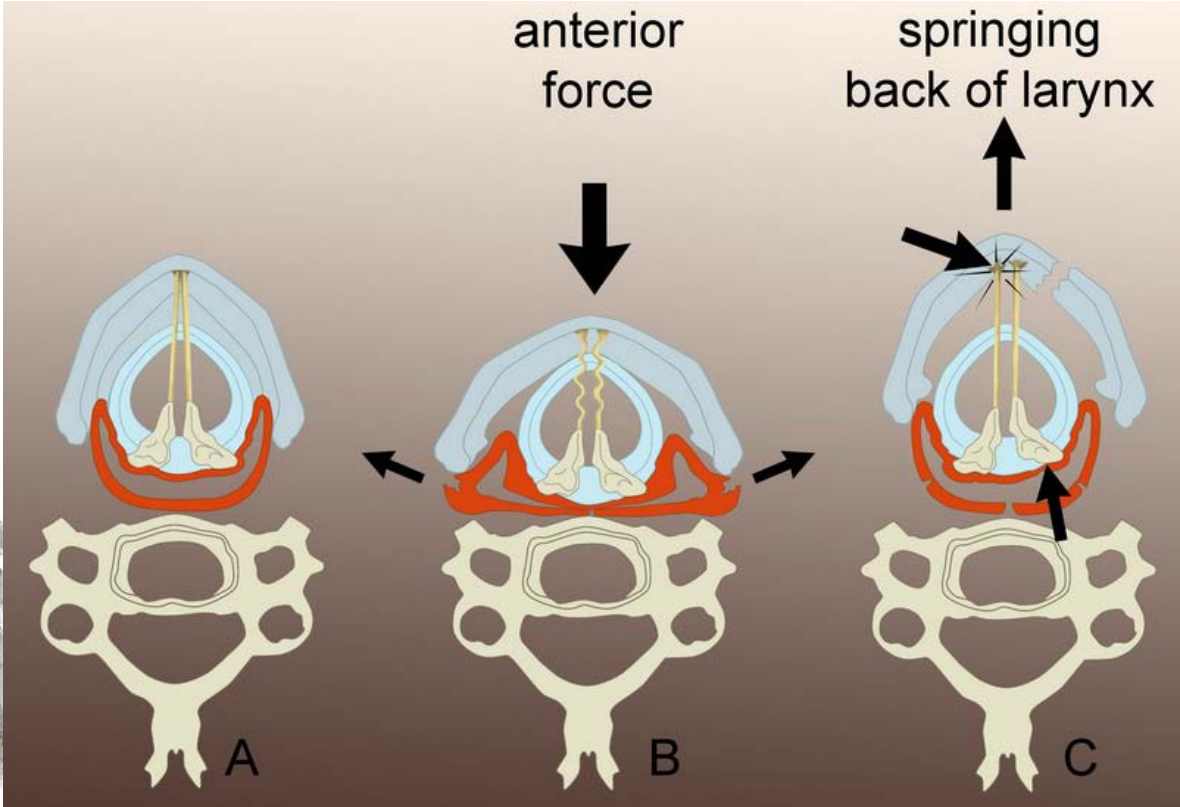
INHALATION

CAUSTIC INGESTION

MECHANISM OF INJURY



crushing forces

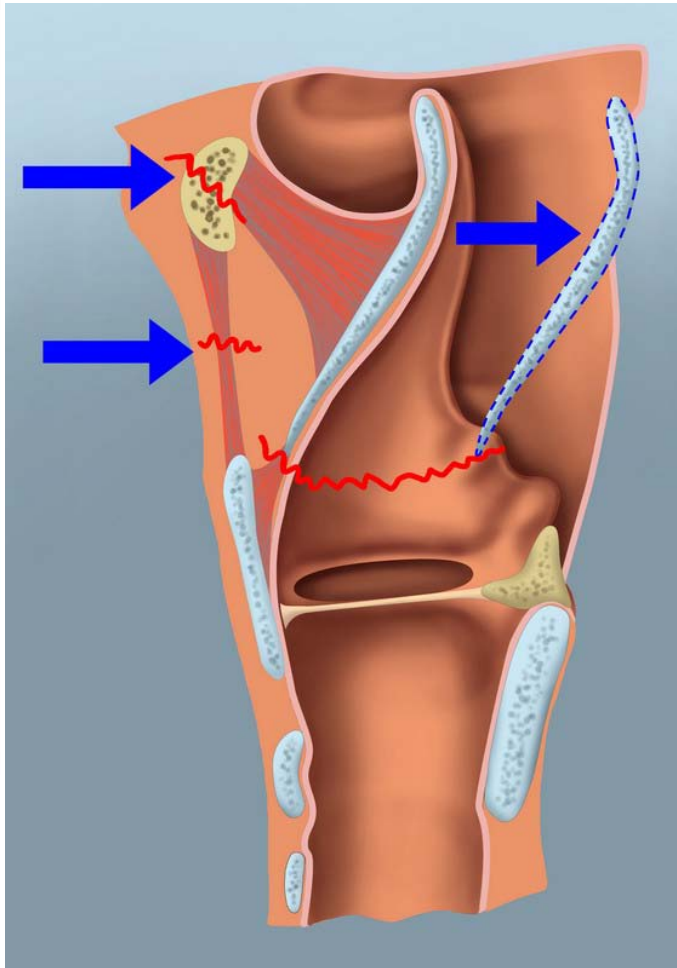


resting state

pharyngeal lacerations

arytenoid dislocation
VC desinsertion

THYROID MEMBRANE HYOID BONE

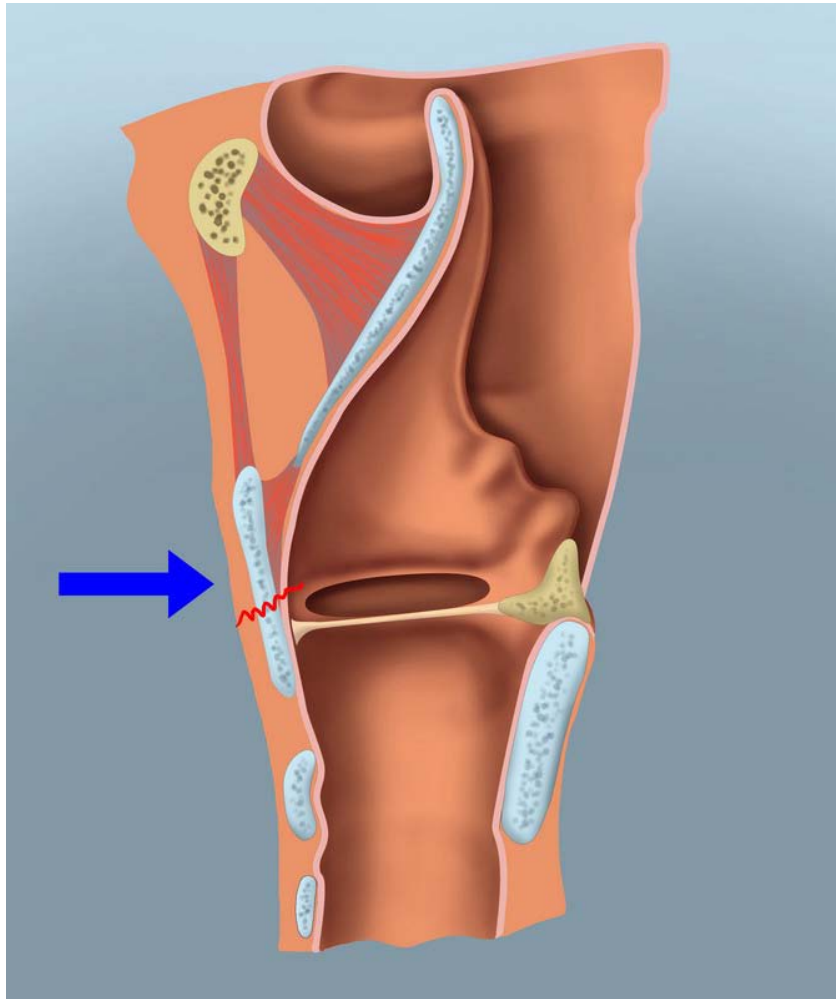


rare event (shielded by mandibule)
except for

> strangulation, hanging

- rupture of thyro-hyoid ligament
- posterior displacement of epiglottis (petiole tear)
- supraglottic lacerations
- possible vascular lesions and pharyngeal tears
- hyoid fracture

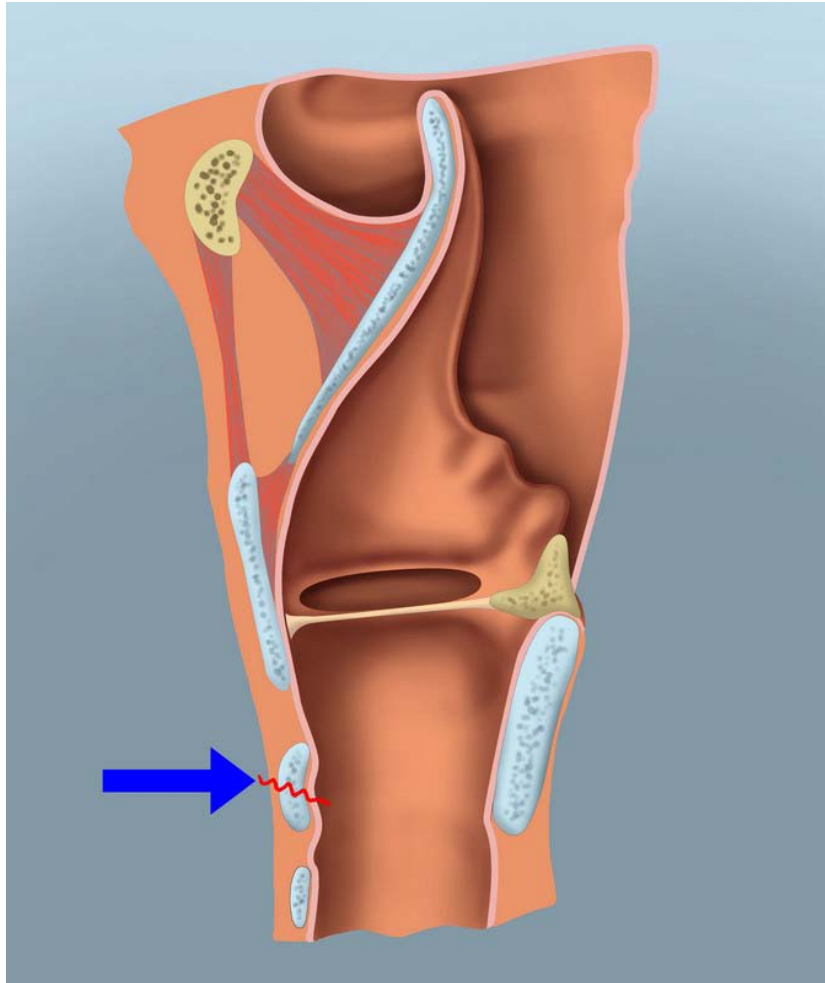
THYROID CARTILAGE



frequent

- paramedian fracture
(risk proportional to calcification)
- ∴ AP diameter of larynx
- possible VC rupture
- possible arytenoid
luxation / avulsion

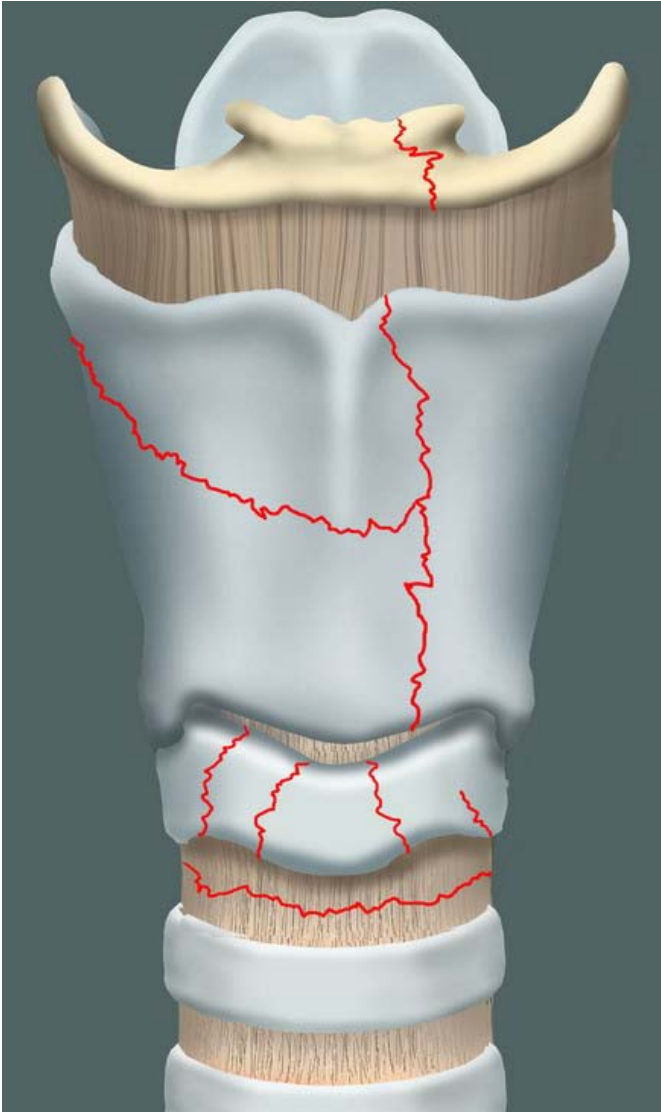
CRICOID CARTILAGE



moderately frequent

- rarely isolated
 - > thyroid cartilage fracture
 - > cricotracheal separation
 - > lacerations of pharynx / esophagus
 - > possible RLN lesion(s)

HYOID TO CRICOID CARTILAGES



Hyoid bone fracture

- Epiglottic posterior displacement
- Arytenoid luxation / avulsion
- Multiple thyroid fractures
- Exposed cartilage
- Cricoid fracture(s)
- Cricotracheal separation

PHYSICAL SIGNS



cutaneous bruises / lacerations

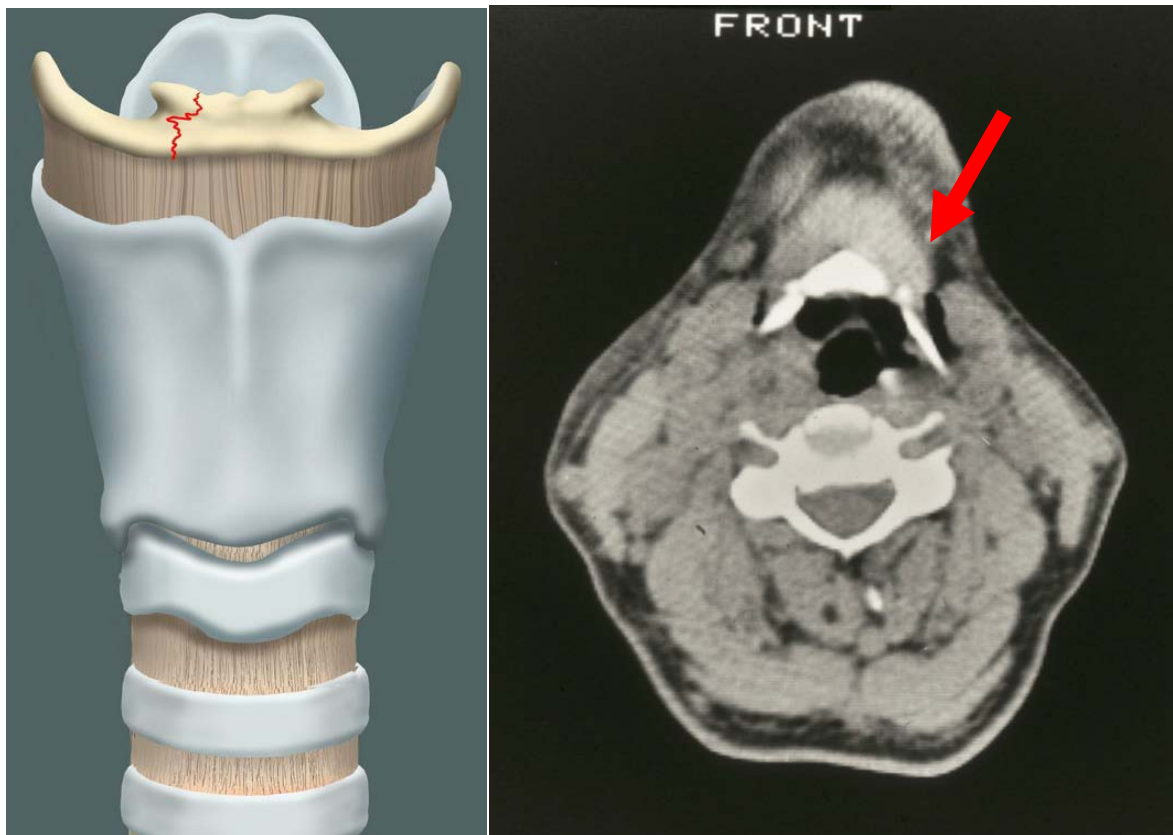
cervical edema / hematoma

subcutaneous emphysema

flattened thyroid notch

false thyroid cartilage mobility

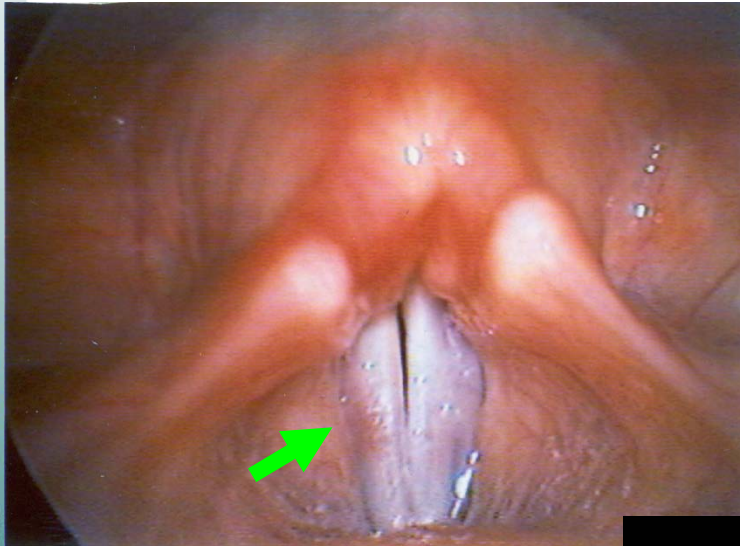
HYOID BONE FRACTURE



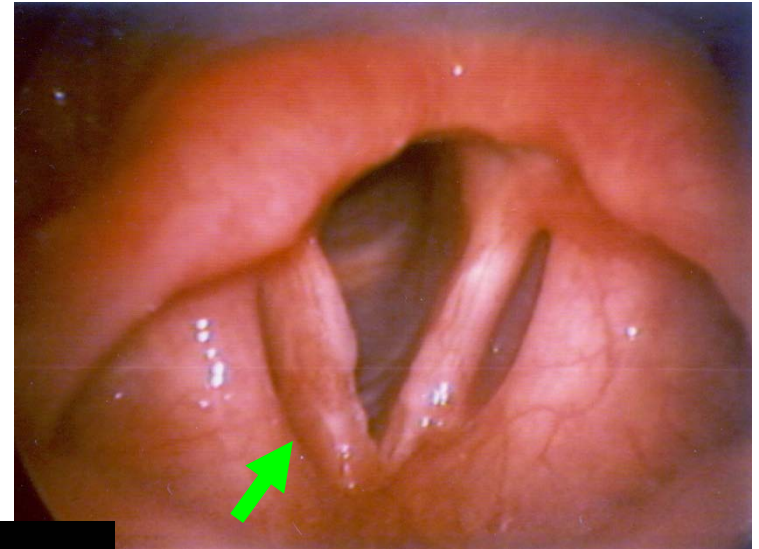
rare

- often combined with thyroid fracture
- strangulation hanging
- pharyngeal tears

THYROID TRAUMA WITHOUT FRACTURE



hematoma

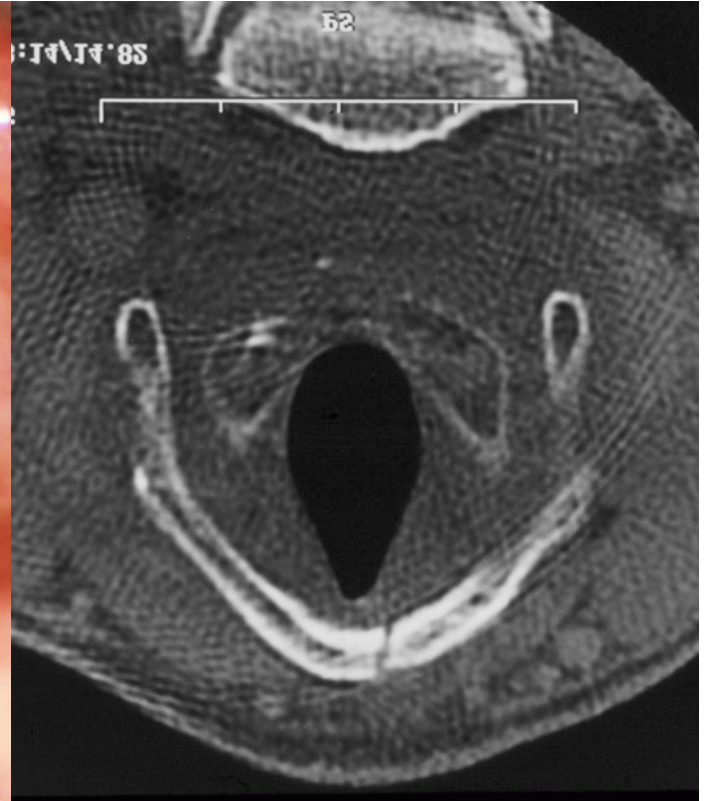
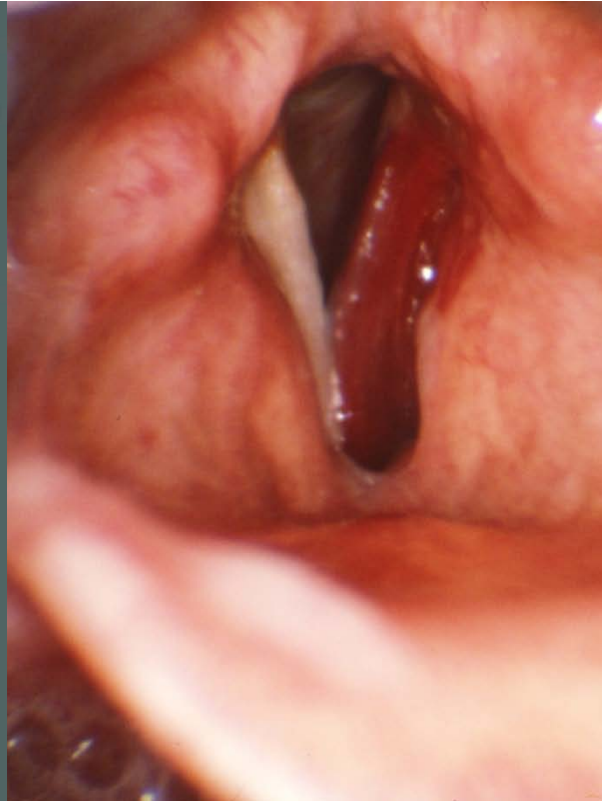
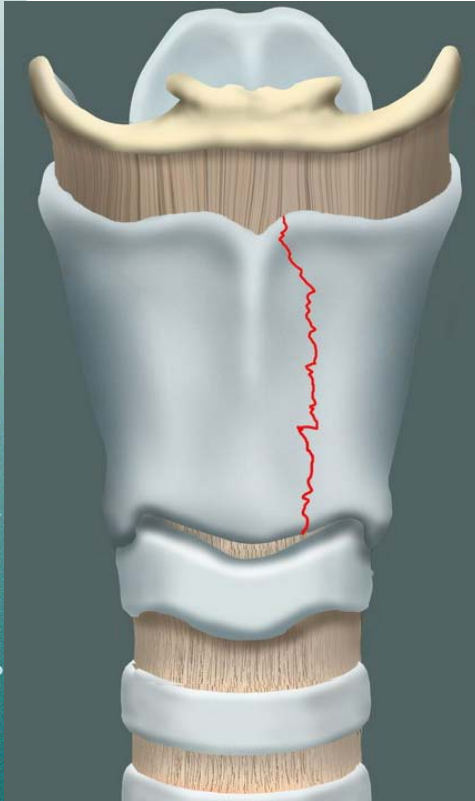


hematoma
+ edema



pharyngeal tear

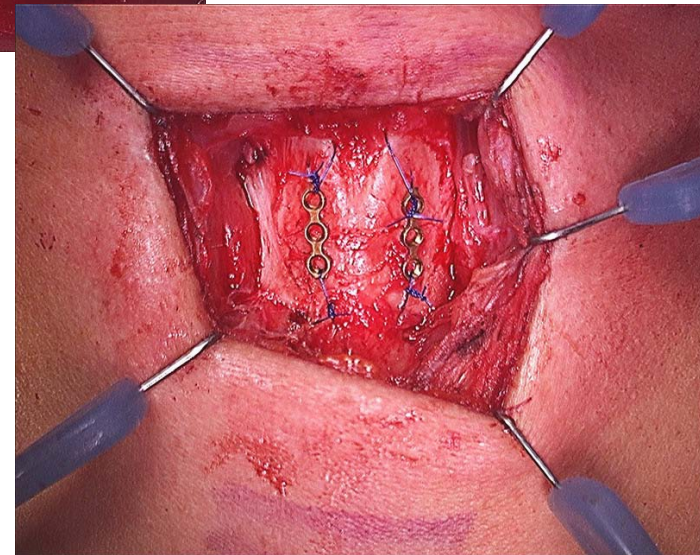
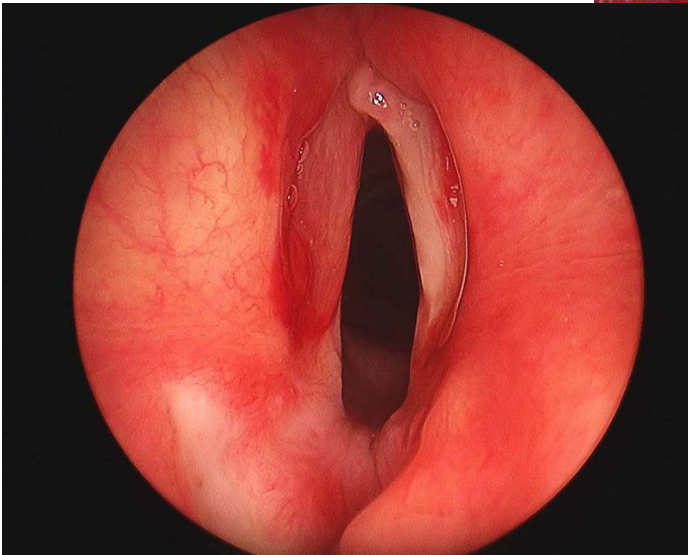
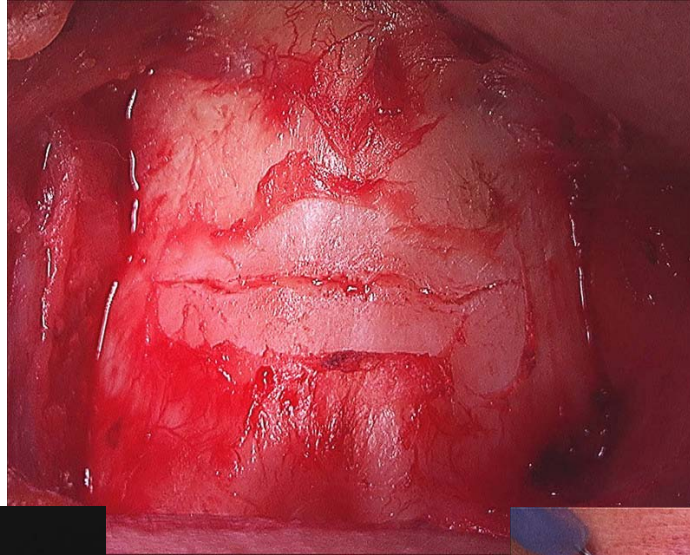
THYROID CARTILAGE FRACTURE



CLASSICAL SITUATION

HORIZONTAL FRACTURE

RARE EVENT

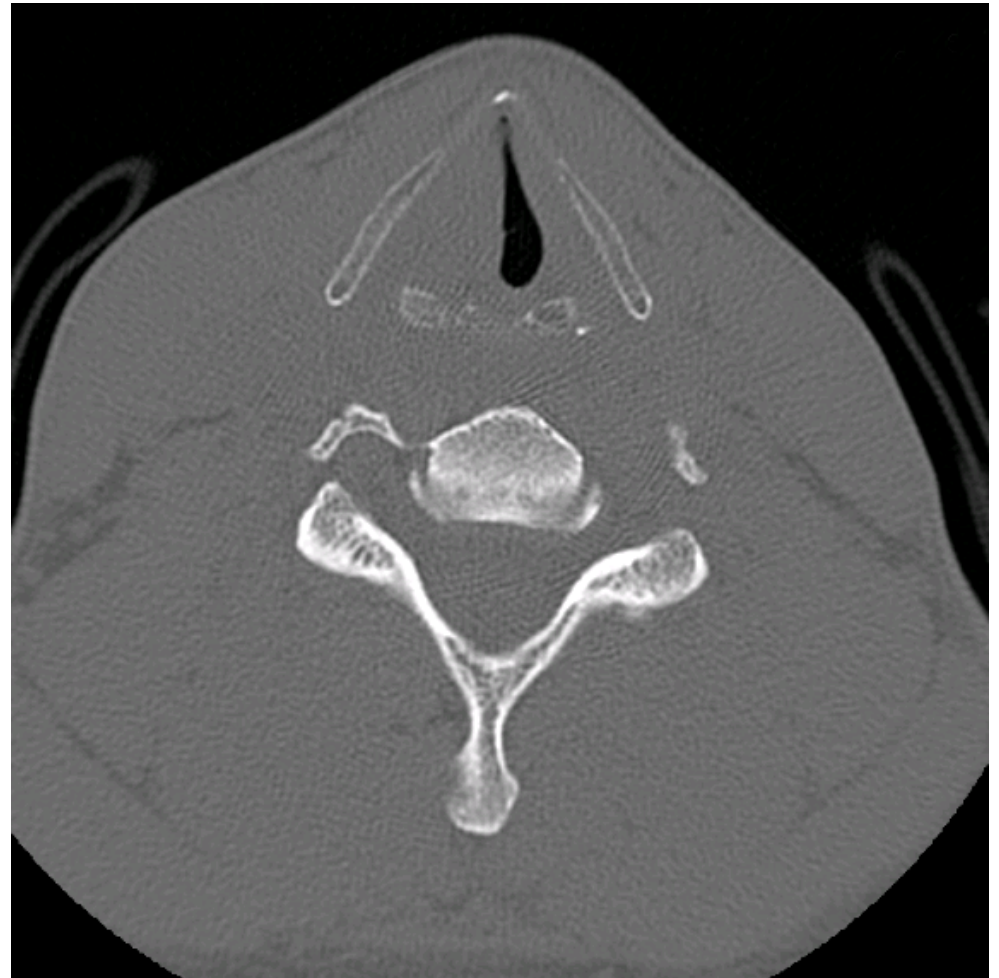


" NORMAL " CT-SCAN

Moderate dysphonia

No visible fracture

Swollen right
arytenoid region

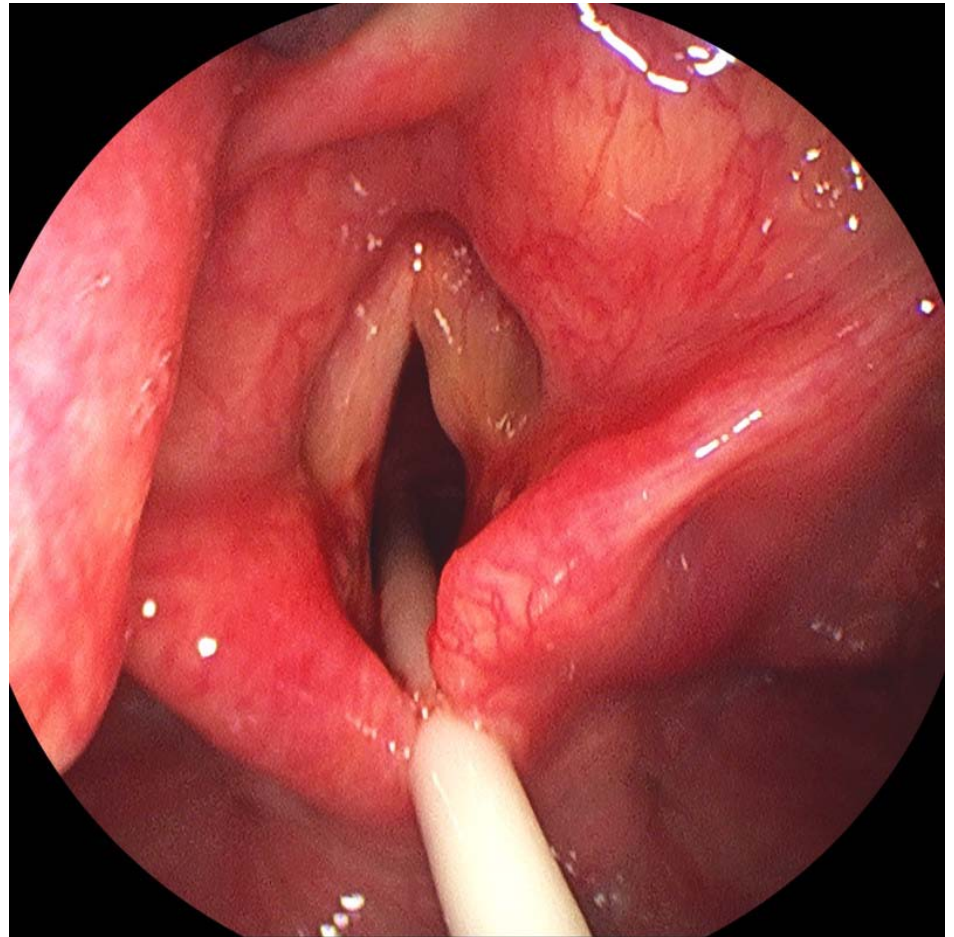


ANTERIOR ARYTENOID LUXATION

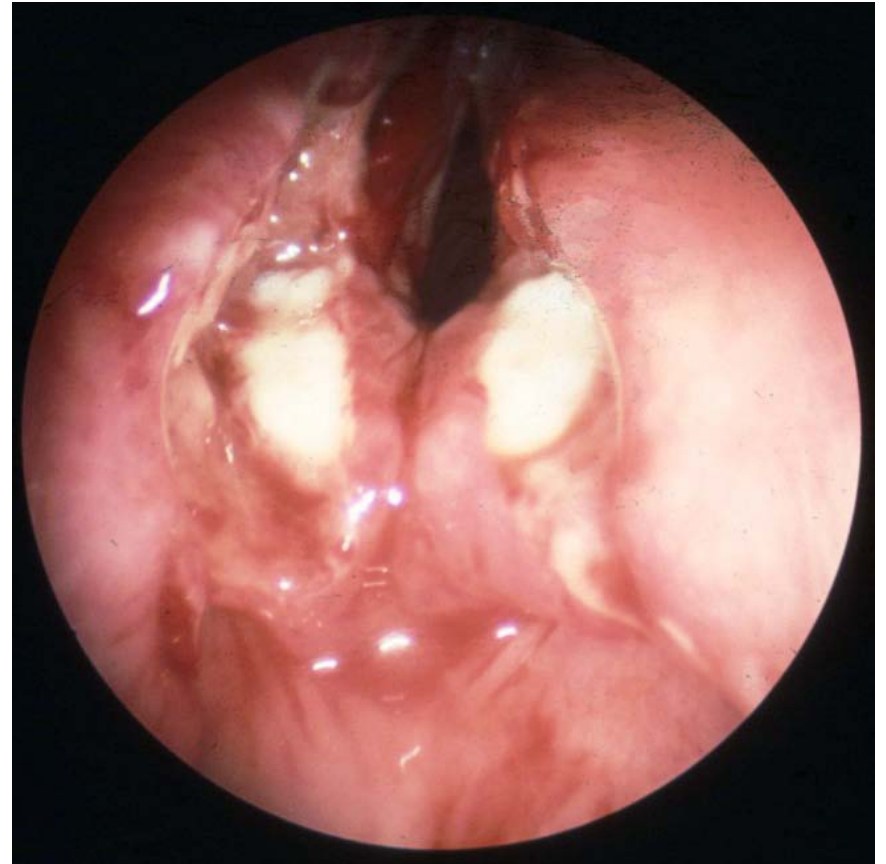
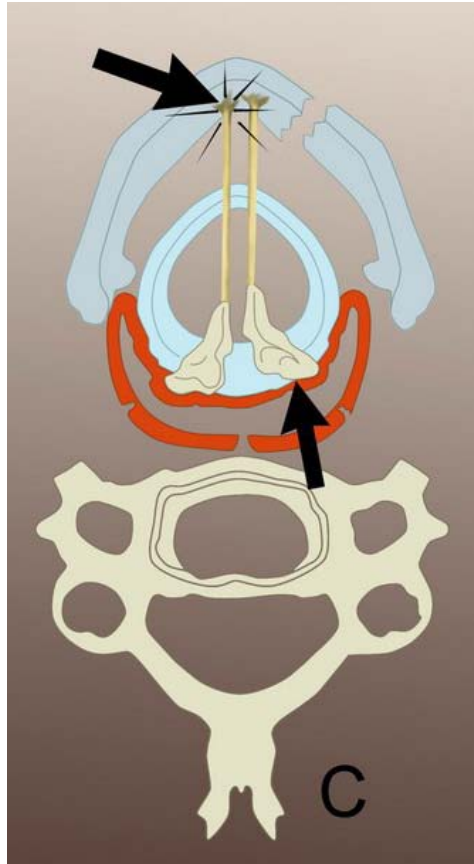
Shortened, lax
right vocal cord

Posterior arytenoid
hematoma

Anteriorly displaced
vocal process

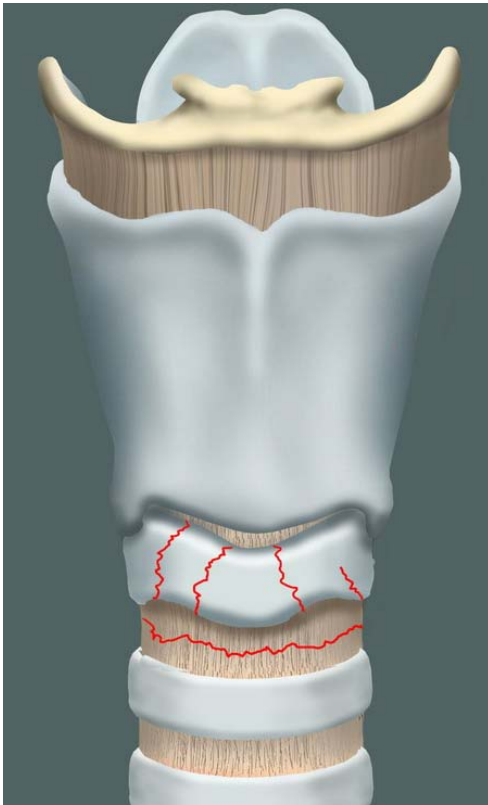


ARYTENOID AVULSIONS

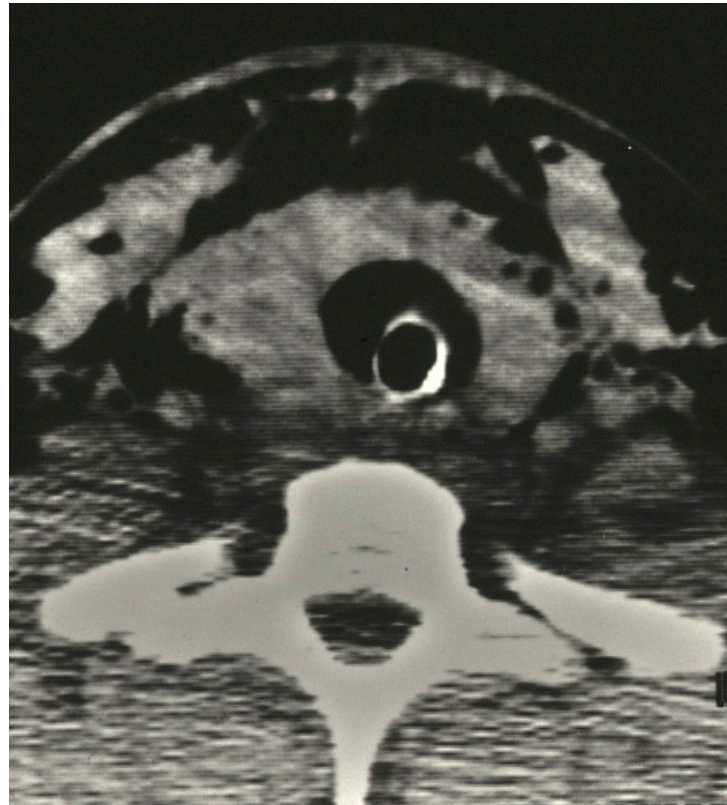


relatively rare event
often associated with thyroid cartilage fracture

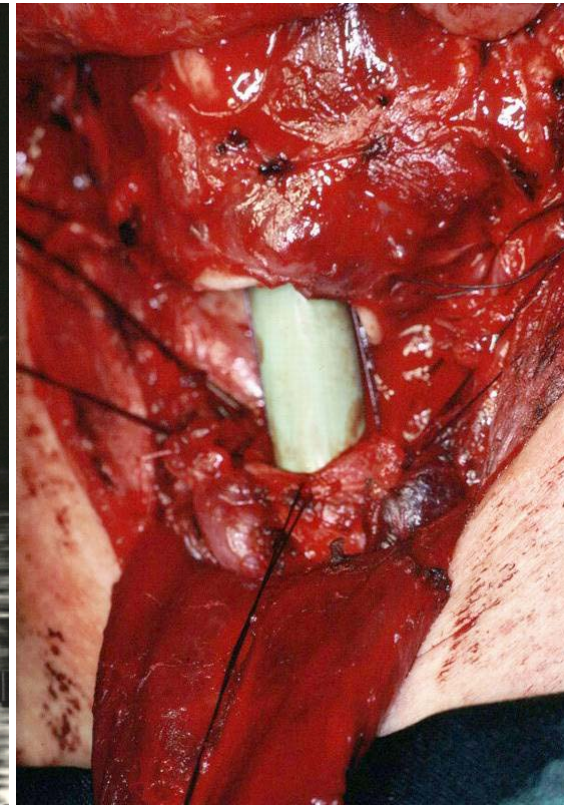
CRICOID CARTILAGE FRACTURE



diagram

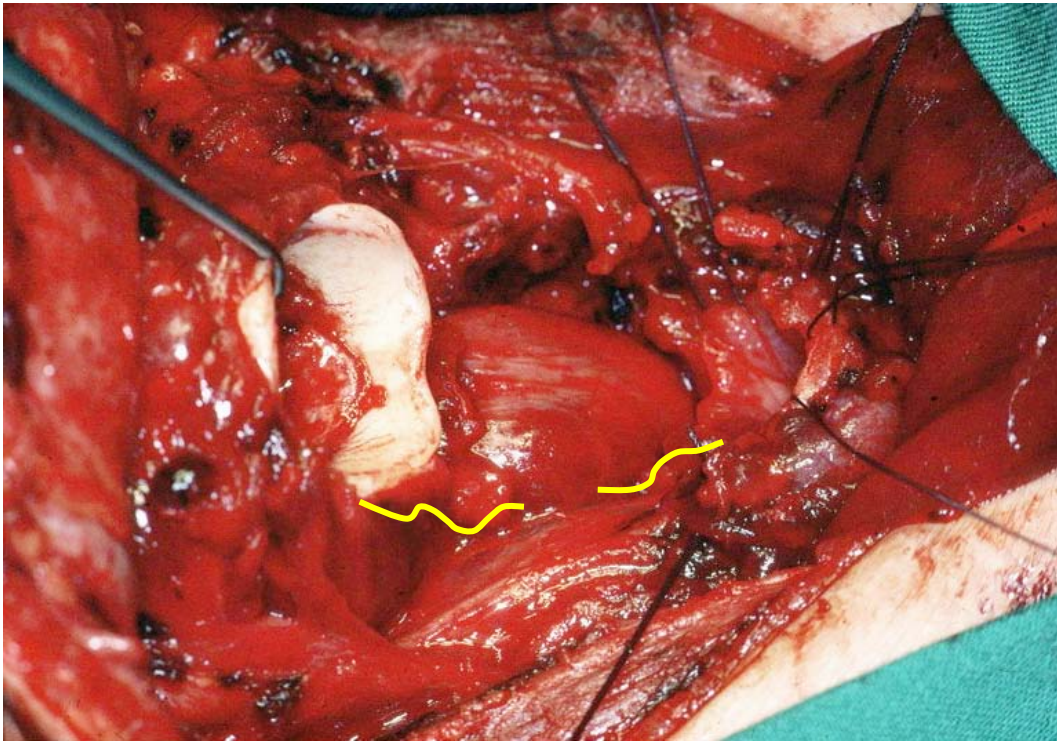


emphysema
around ET tube



cricotracheal
separation

CRICOID FRACTURE + TRACHEAL SEPARATION

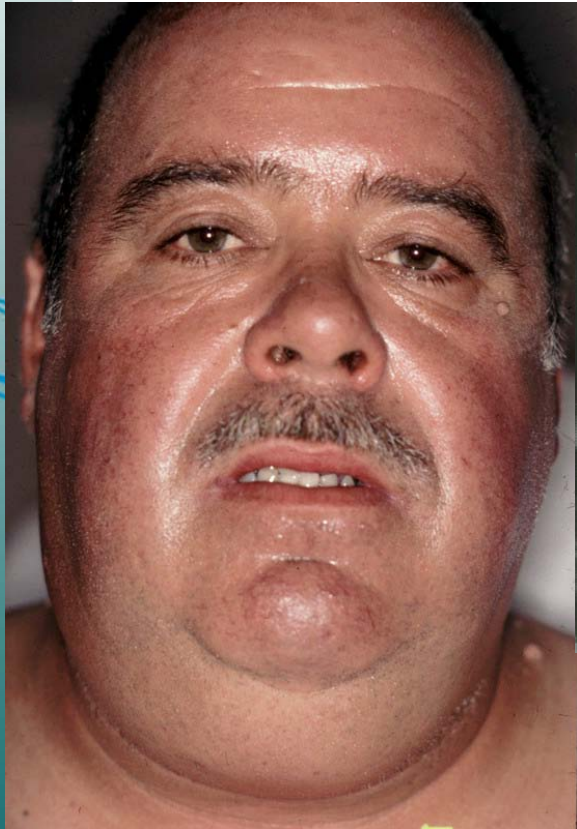


Cricoid fracture

Cricotracheal
separation

Bilateral RLN lesion

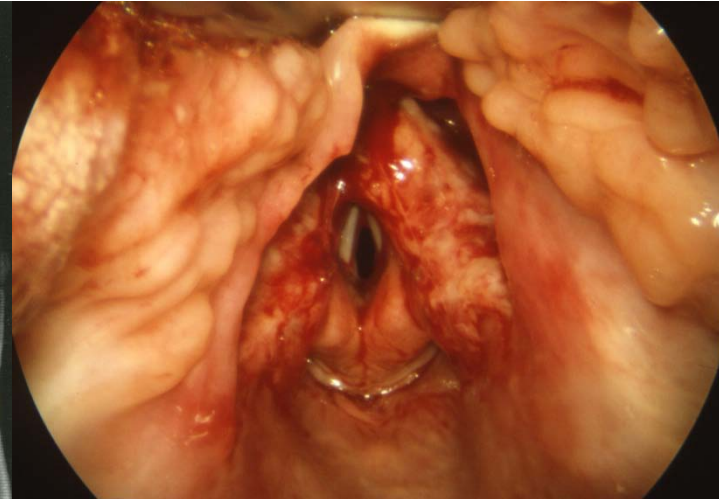
MASSIVE BLUNT TRAUMA



cervical
emphysema



massive
subcutaneous
emphysema

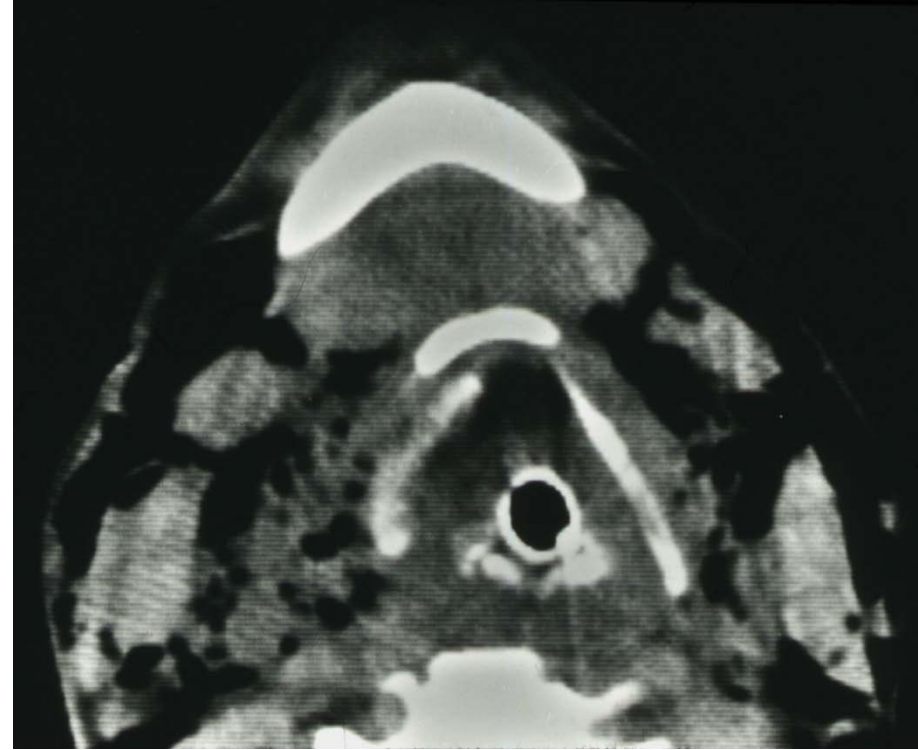


massive
supraglottic
separation

PENETRATING TRAUMA



anterior cervical
wound



cervical emphysema
no fracture

MECHANISM OF INJURY

PEACETIME INJURY

- > knife cuts
- > gunshots

WAR INJURY / TERRORIST ATTACK

- > splinters of mines, bombs
- > gun shells

! DETECTION OF ASSOCIATED INJURIES !

PREVALENCE OF LESIONS

10% larynx

9% pharynx & esophagus

9% jugular vein

7% carotid artery

3% spinal nerve

According to McConnell, Adv. Surg (1994) 27

MANAGEMENT

1. Secure airway : tracheotomy
2. Perform diagnostic endoscopy
 - > larynx, trachea / pharynx, esophagus
3. Envisage radiologic investigations
 - > CT-scan / angio-CT / doppler / angiography
4. Treat surgically (if needed)

TRACHEOTOMY

? **LOCAL** versus **GENERAL** ?
ANESTHESIA



TAILORED DECISION TO INDIVIDUAL CASE
and
EXPERTISE / EQUIPMENT IN ENDOSCOPY

ENDOSCOPY

TNFL = trans-nasal flexible laryngoscopy

Direct laryngotracheoscopy

> bare 0 telescope

Possibly bronchoscopy → intubation

Pharyngo-esophagoscopy

> pharyngoesophageal tears

15% in blunt trauma

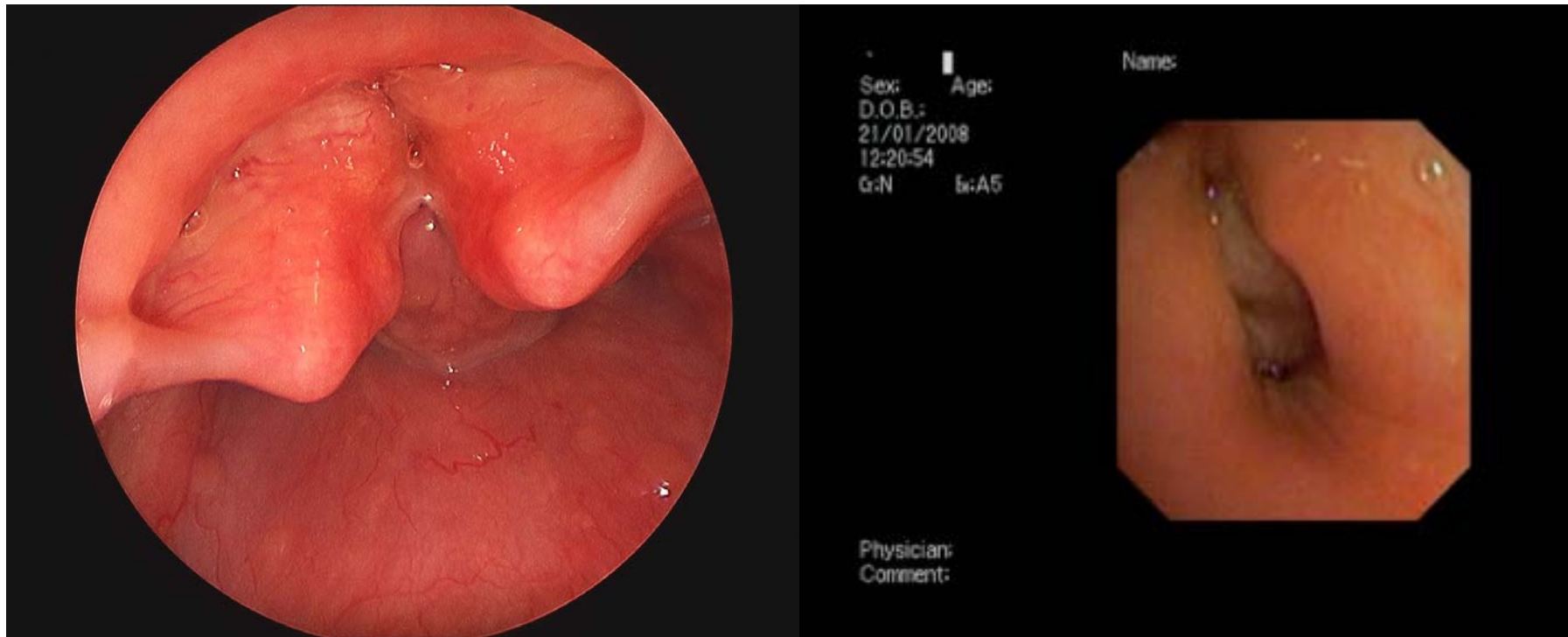
40% in penetrating trauma

! MISSED DIGESTIVE TEARS → DRAMATIC CONSEQUENCES !

DIFFICULT AIRWAY



SUPRAGLOTTIC SYNECHIA



! IMPORTANCE OF RETROGRADE
ENDOSCOPY THROUGH TRACHEOSTOMA !

LARYNGOTRACHEAL INJURY GRADING SYSTEM

- I. Minor hematoma or laceration
No detectable fracture
- II. Mucosal injury without exposed cartilage
No displaced fracture (CT-scan), no ary-dislocation
- III. Exposed cartilage, displaced fractures,
VC immobility
- IV. Same as grade III + disruption of anterior larynx
+ unstable laryngeal framework
- V. Complete laryngotracheal separation

Modified from Schaefer SD, Ann Otol Rhinol Laryngol 98 (1989)

RADIOLOGIC INVESTIGATIONS

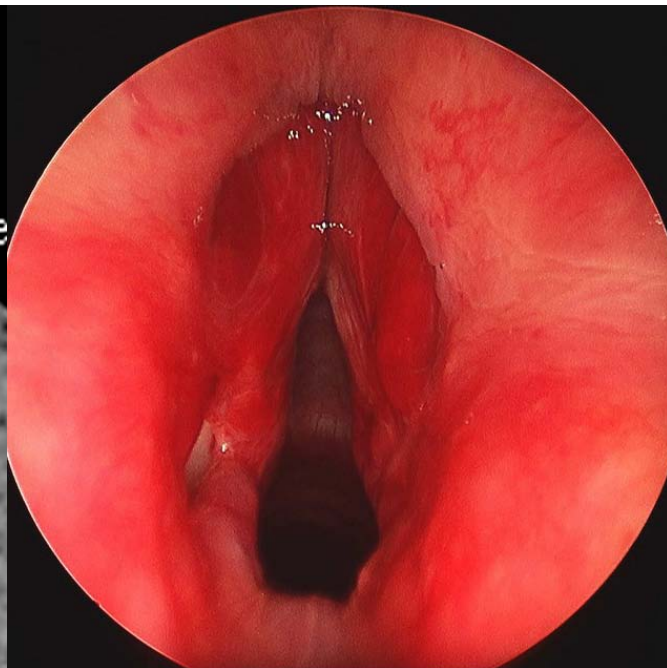
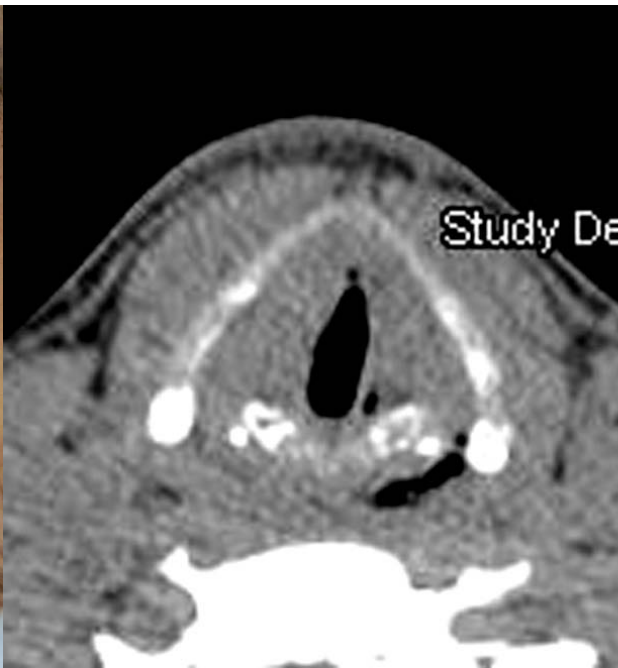
CT-SCAN

- > grade I - II lesions
 - absolute indication
- > grade III - IV lesions
 - relative indication

Angio-CT, DOPPLER, ANGIOGRAPHY

- > vascular lesions {
 - 2% in blunt trauma
 - 38% in penetrating trauma

" NORMAL" CT-SCAN

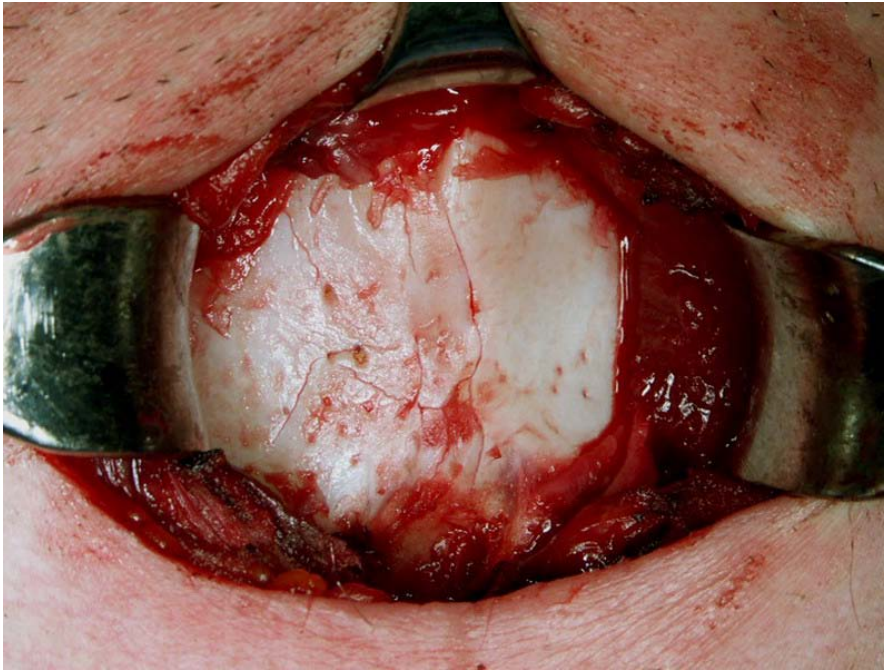


Hockey puck
impact

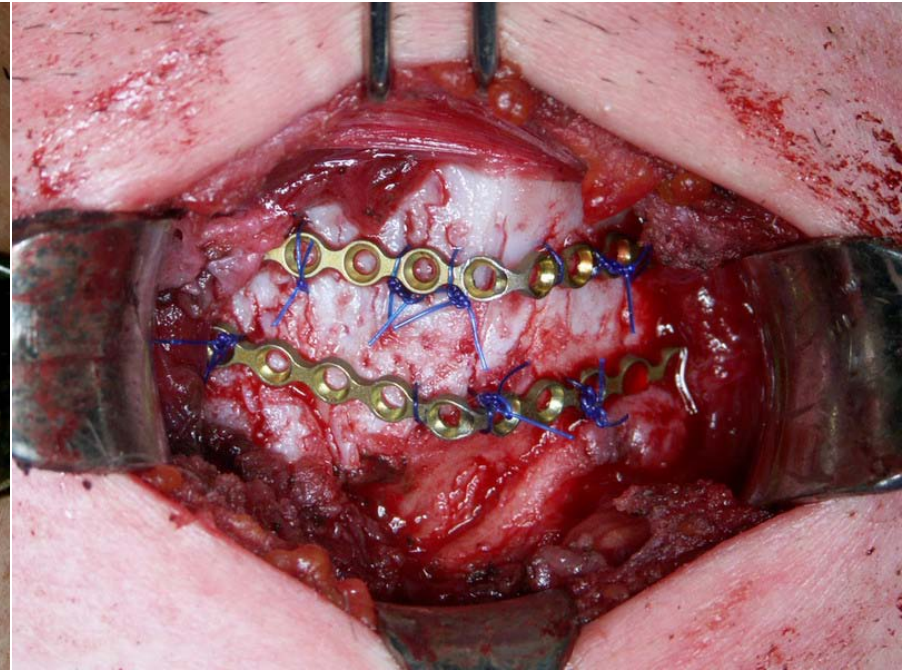
Normal
CT-scan

Bilateral VC
hematoma

SURGICAL FINDINGS



comminutive
fracture



stabilization
with miniplates

CLINICAL PRESENTATION

CONSCIOUS PATIENT

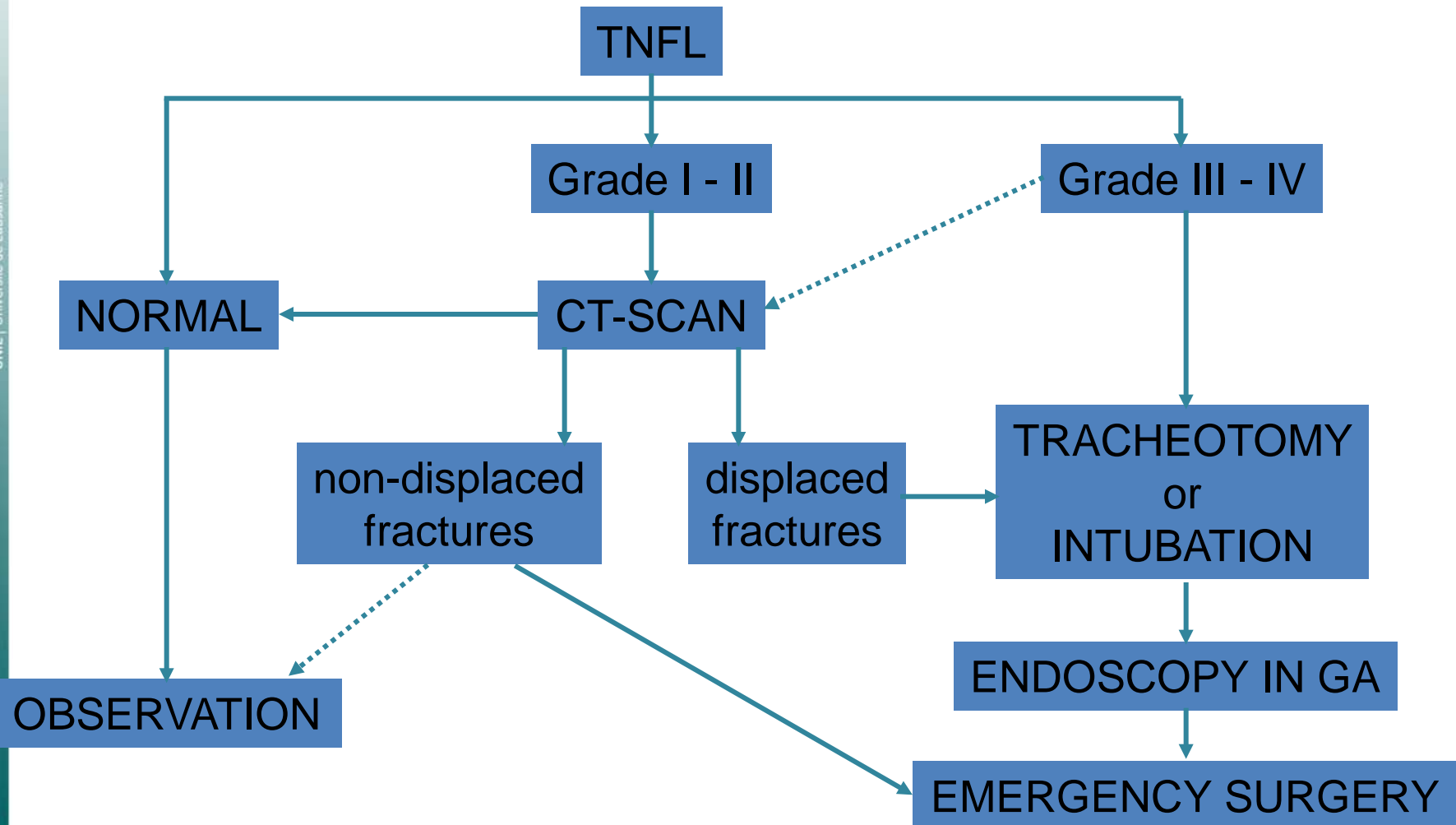
- > airway stable
- > airway obstruction

CAVE : respiratory arrest

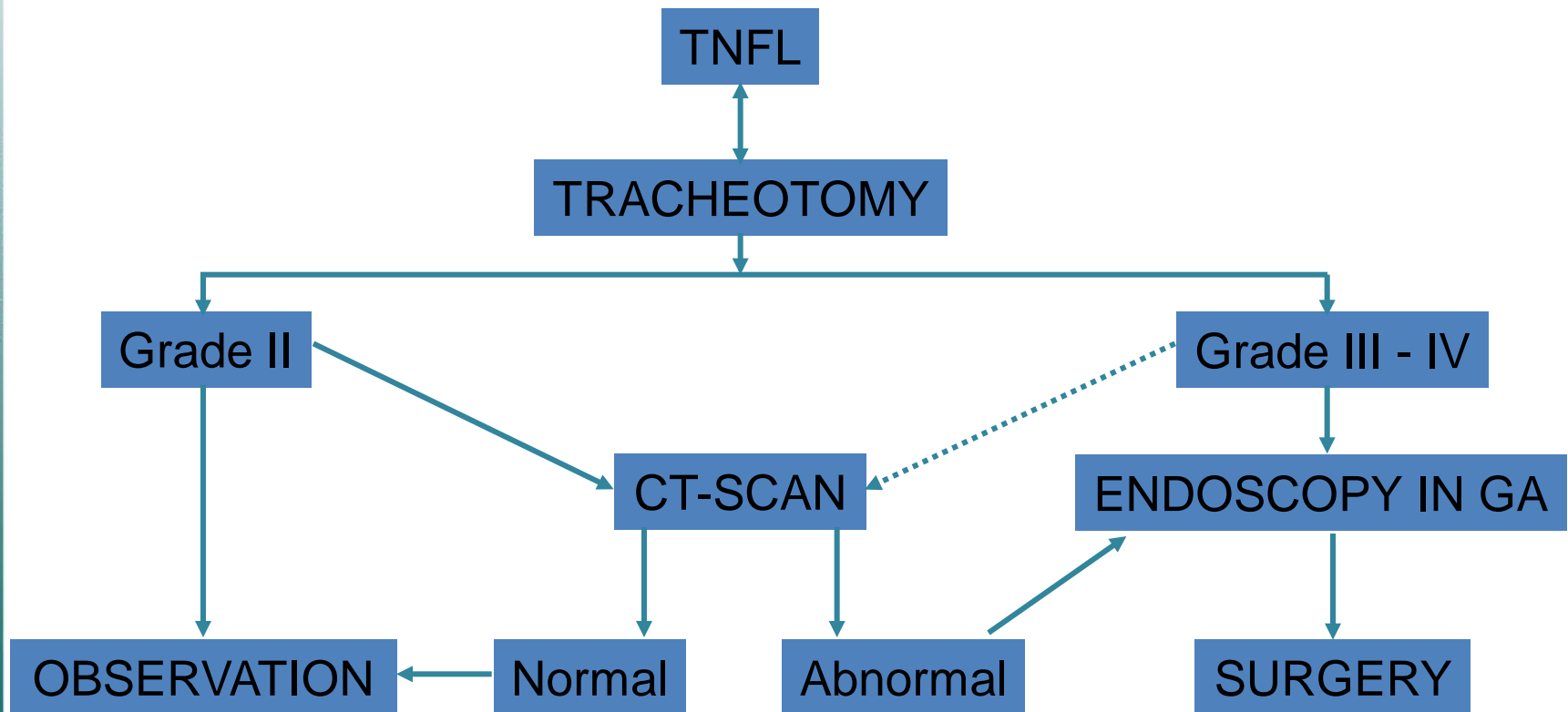
UNCONSCIOUS PATIENT

- > intubated / tracheotomized
- > dead

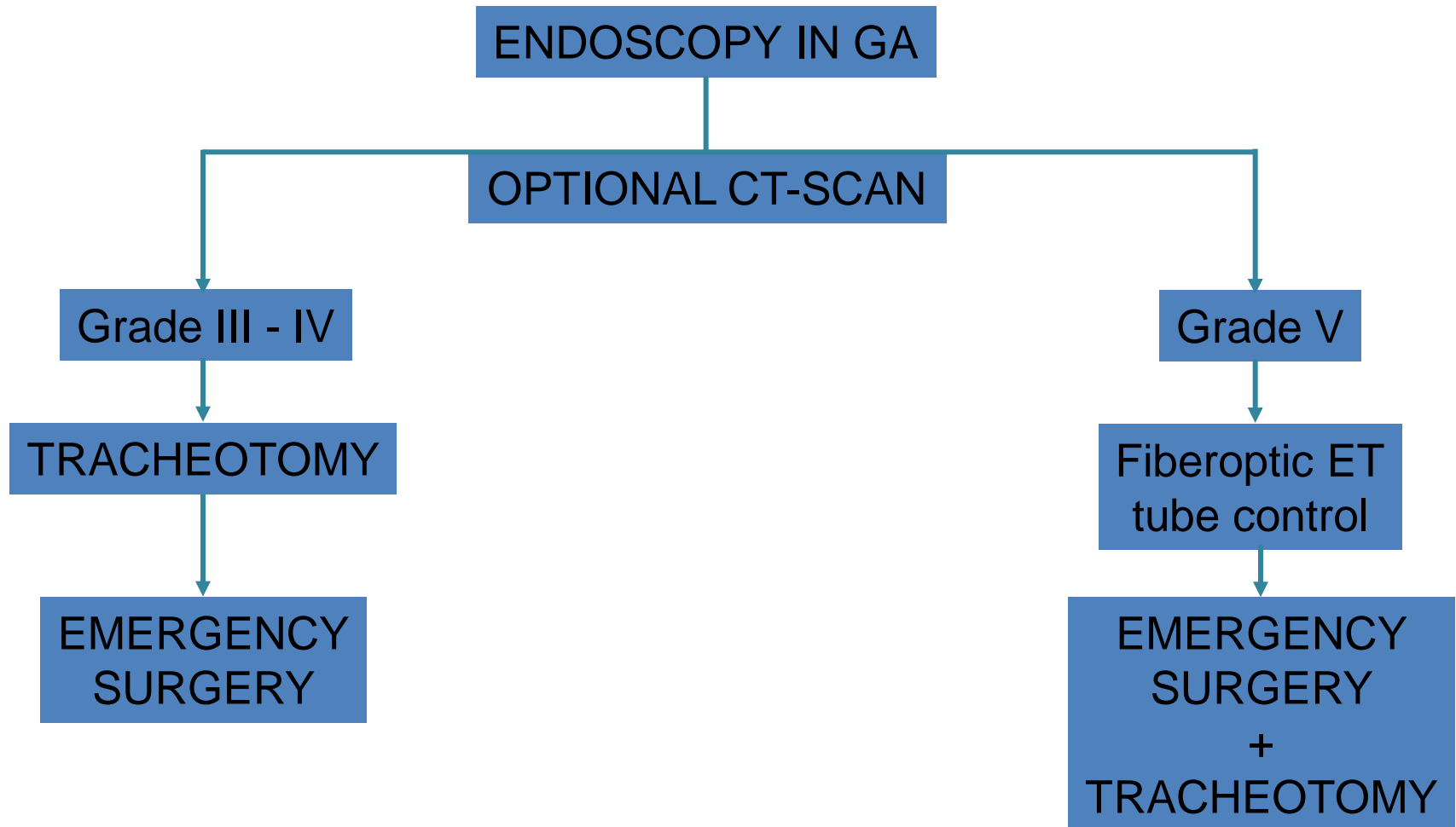
STABLE AIRWAY



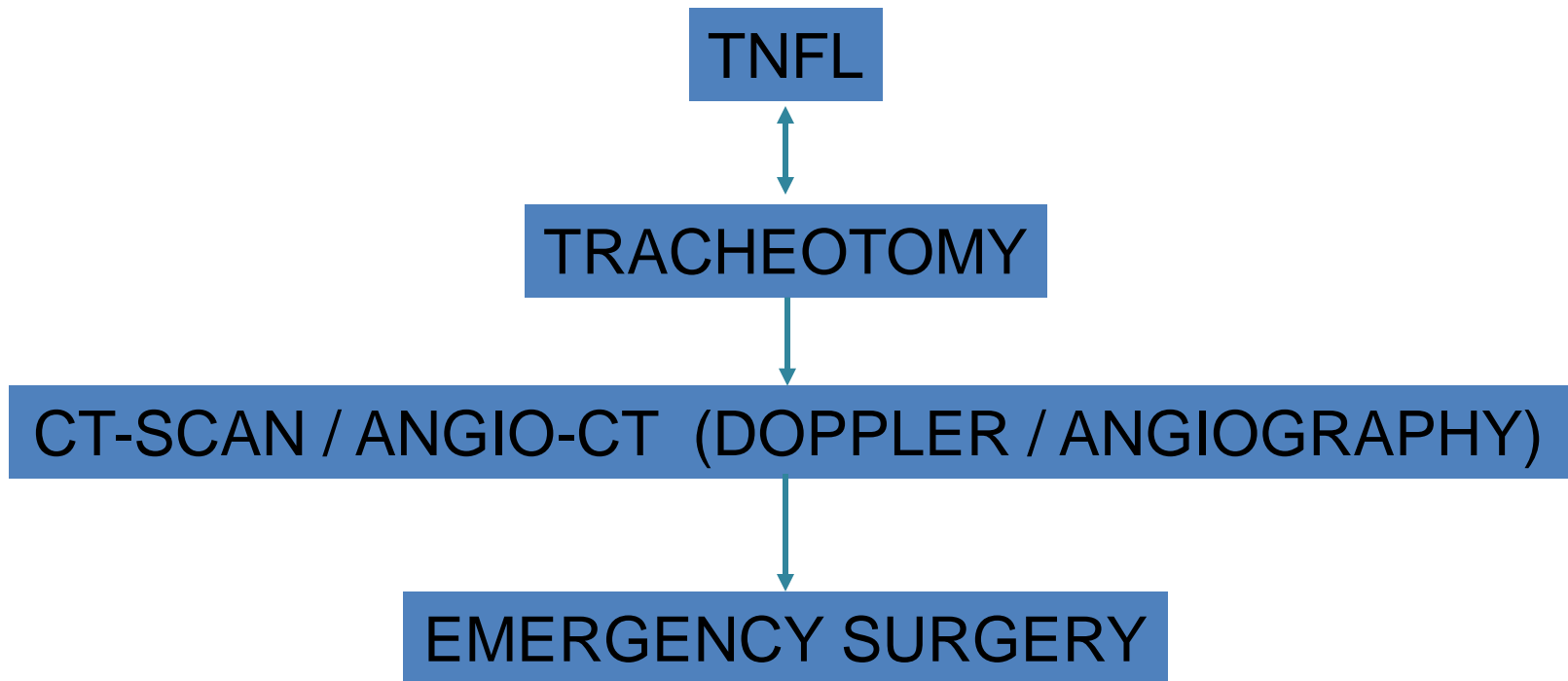
UNSTABLE AIRWAY



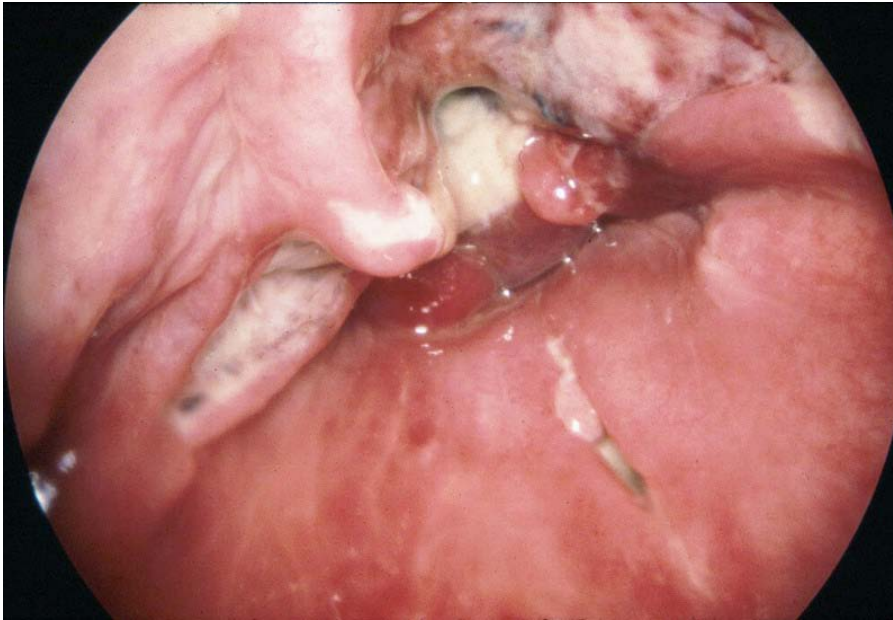
INTUBATED PATIENT



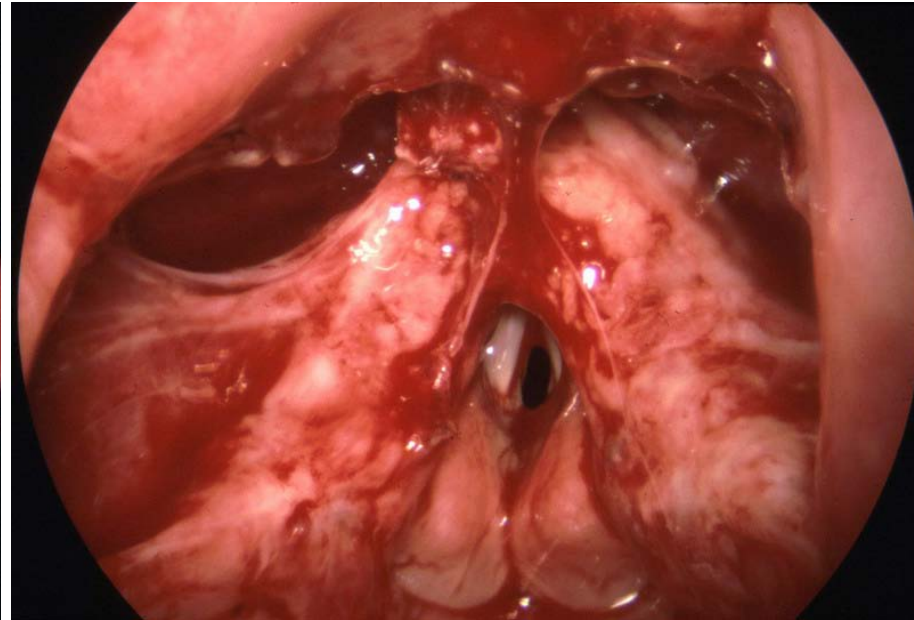
UNSTABLE AIRWAY



SURGICAL TREATMENT



late repair



timely repair

! EMERGENCY SITUATION !

LATE REPAIR

INCREASING WITH TIME

- > edema and hematomas
- > infectious risk
- > cicatricial sequelae

EVERY HOUR COUNTS

- > dramatic impact on final outcome

SURGICAL TREATMENT

Grade II lesions:

- > stabilization of fractures
miniplates / non-resorbable sutures

Grade III, IV, V lesions :

- > reduction / repair of fractures
- > repositioning of epiglottis
- > suturing / grafting of mucosa
- > stenting with LT-mold
- > cricotracheal resection
- > supraglottic laryngectomy

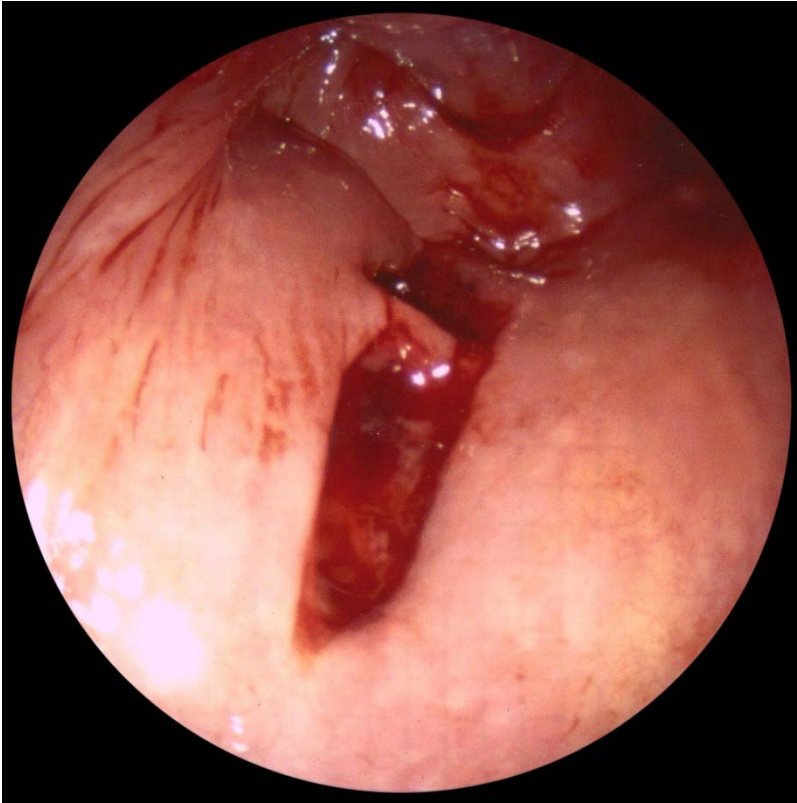
HYOID FRACTURE

CONSERVATIVE TREATMENT

EXCEPT FOR

> PHARYNGEAL TEARS

ISOLATED PHARYNGEAL TEAR(S)



posterior
pharyngeal
laceration



endoscopic
suture

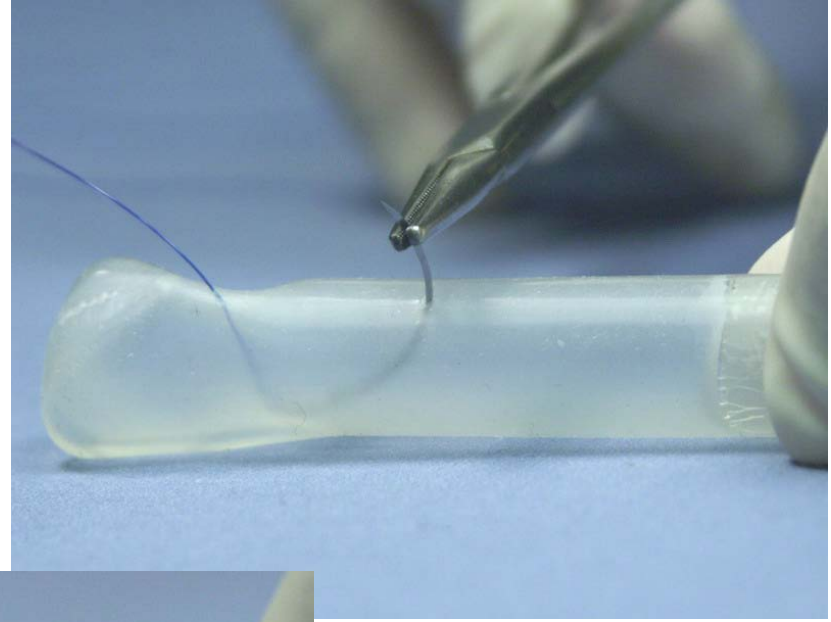
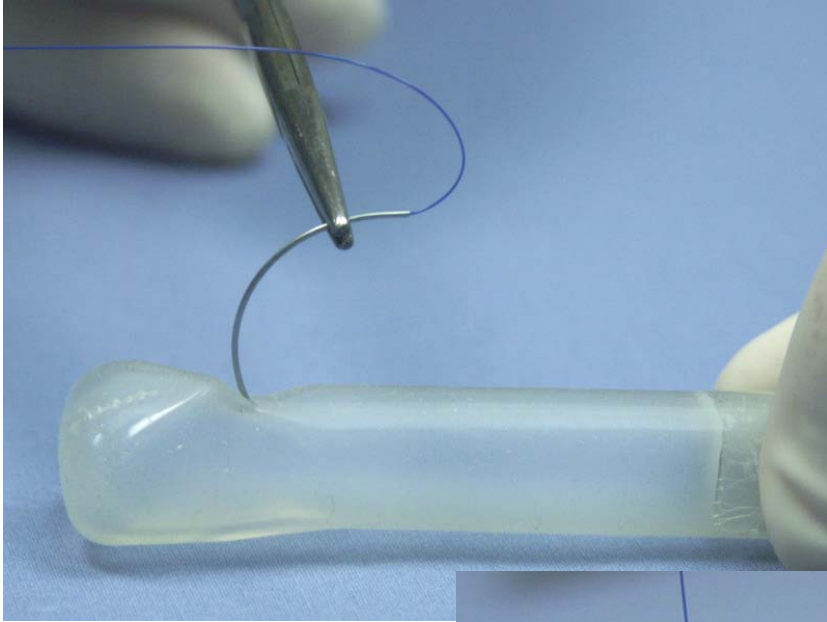
PLACE FOR ENDOSCOPIC TREATMENT

Repositioning of luxated arytenoid

Suture of some laryngeal tears

- Suture of isolated pharyngeal tears
- Stenting with LT-mold

ENDOSCOPIC USE ①



ENDOSCOPIC USE ②

3.0 Prolene® thread mounted onto
Lichtenberger needle-carrier

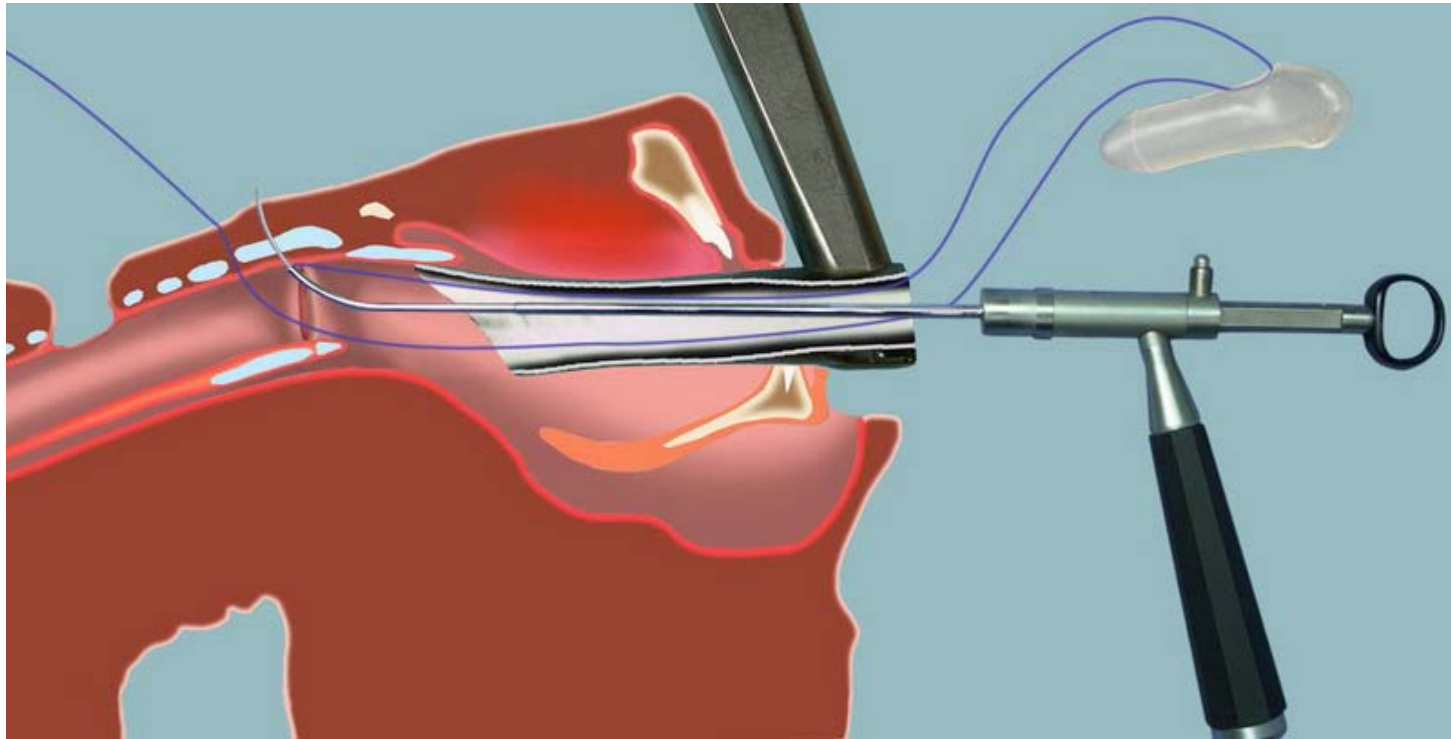
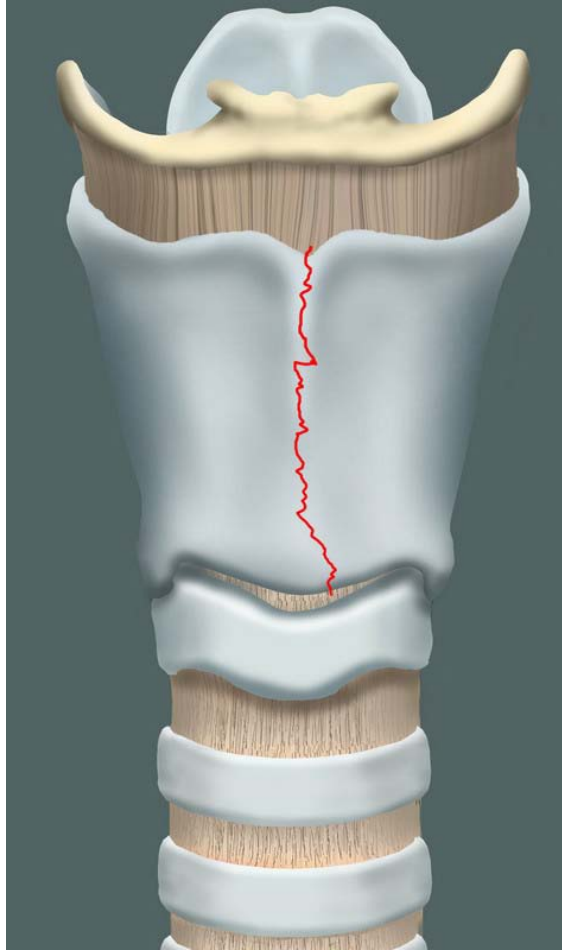
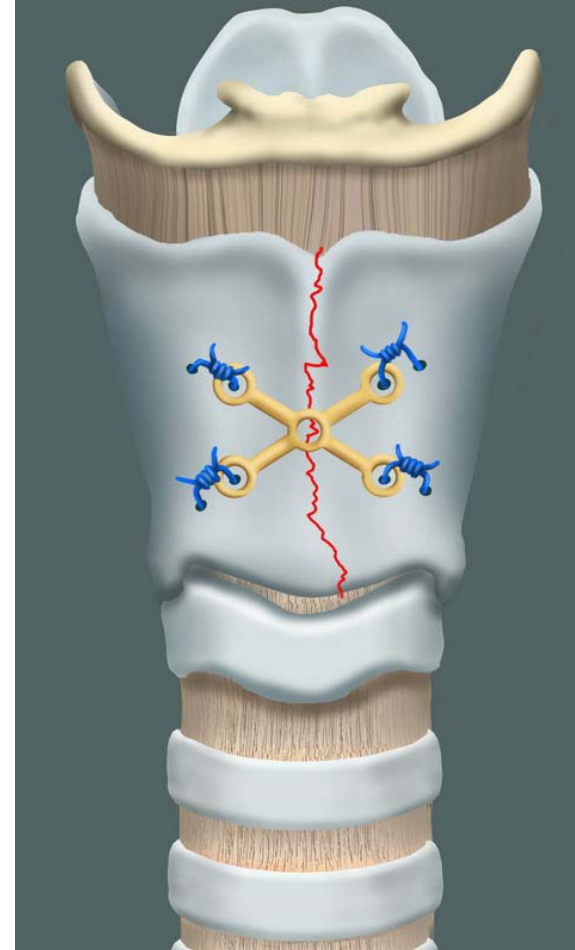


Diagram of endoscopic setting

THYROID CARTILAGE FRACTURE

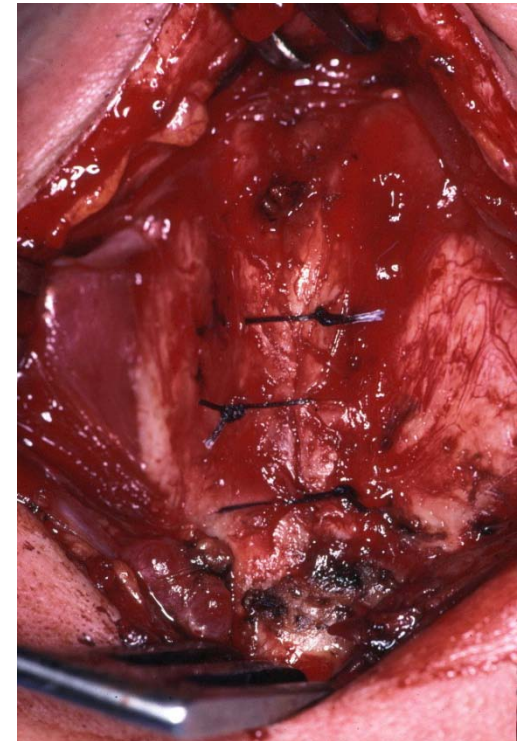
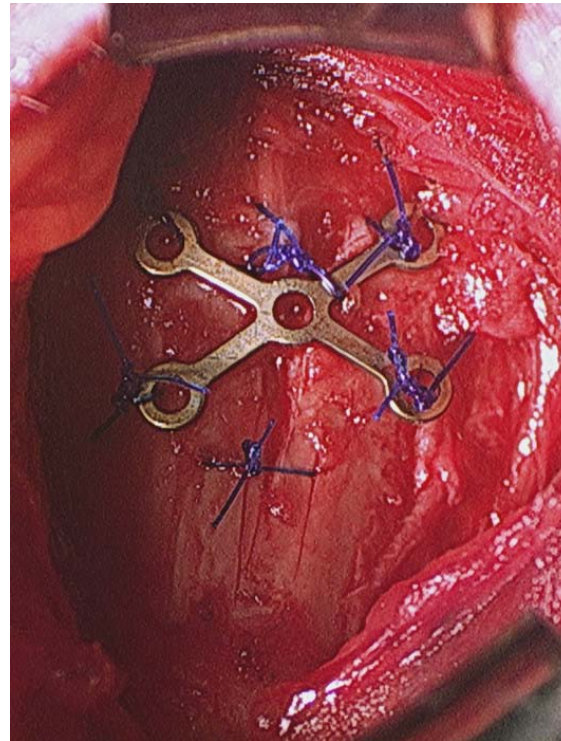
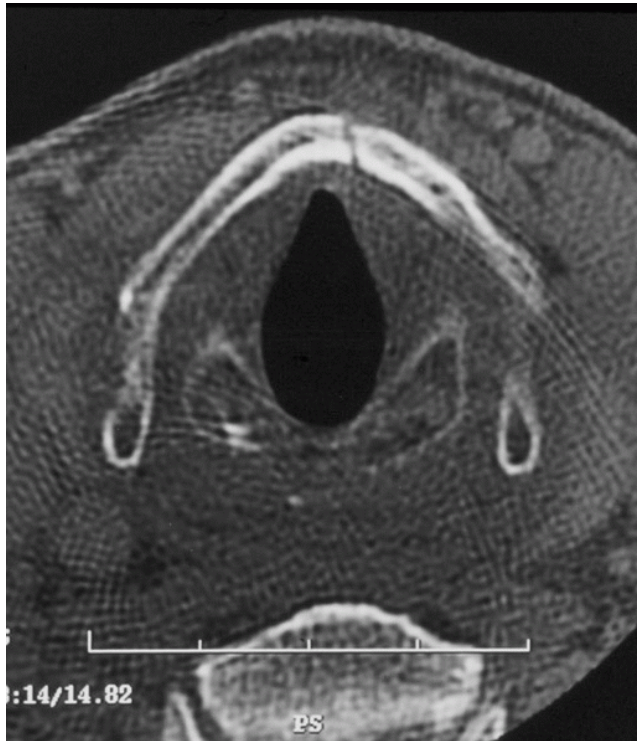


vertical paramedian
fracture



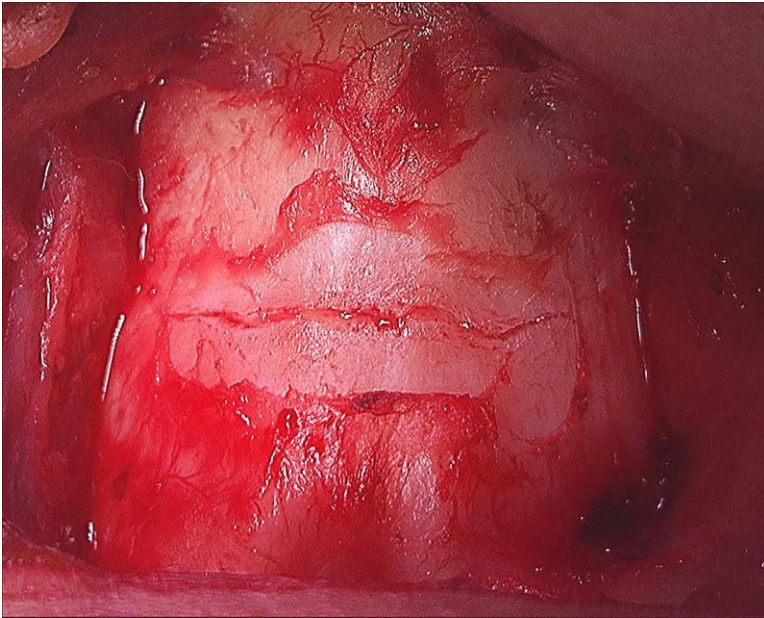
miniplate
= best option

THYROID CARTILAGE FRACTURE

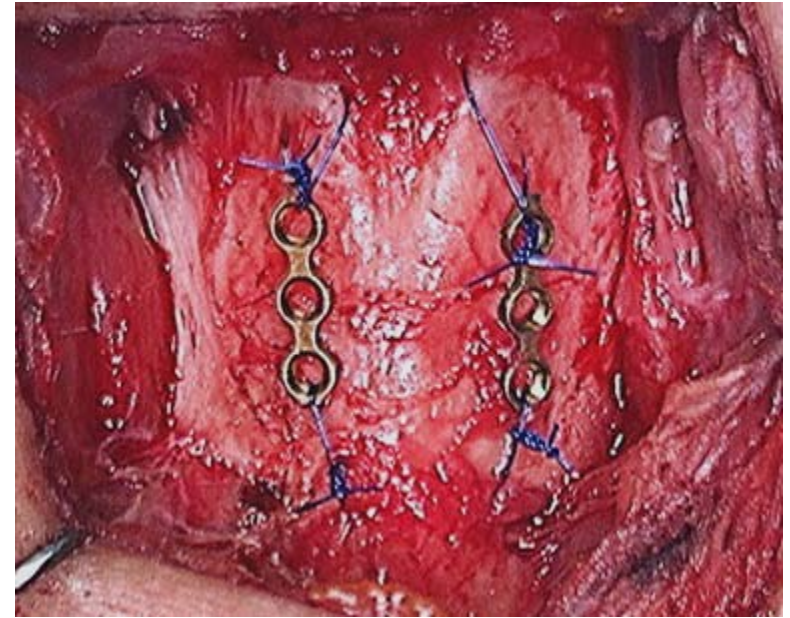


alternative : simple non-resorbable sutures

THYROID CARTILAGE FRACTURE



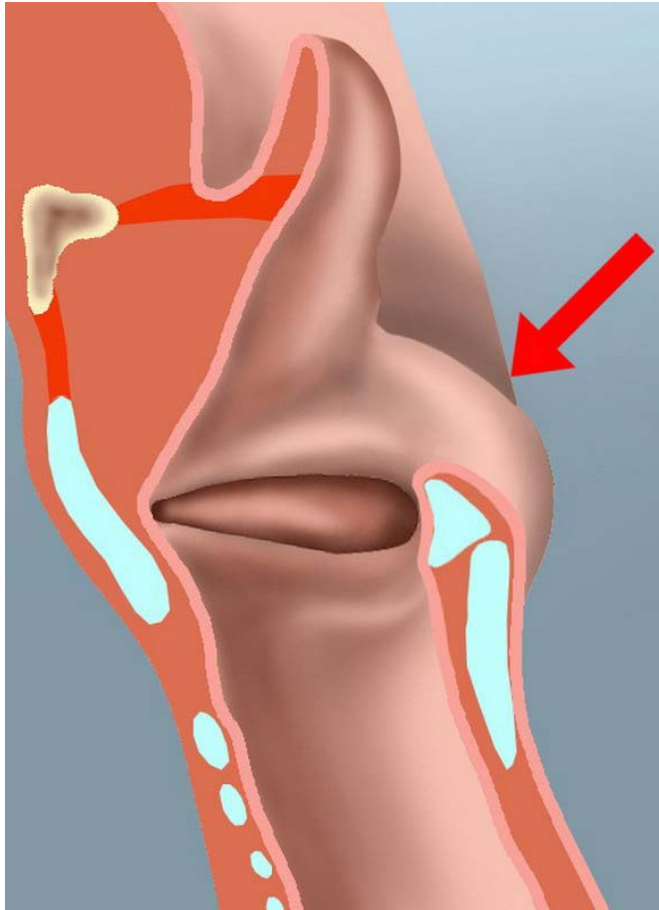
horizontal
thyroid fracture



stabilization
with miniplates

! RARE EVENT !

ARYTENOID LUXATION

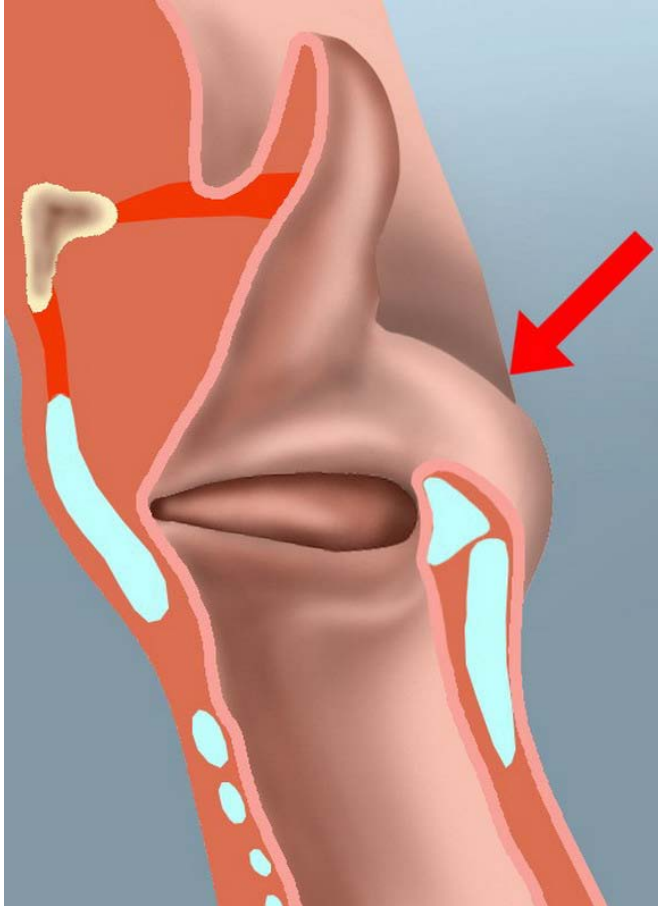


anteriorly tilted arytenoid
+ mucosal edema

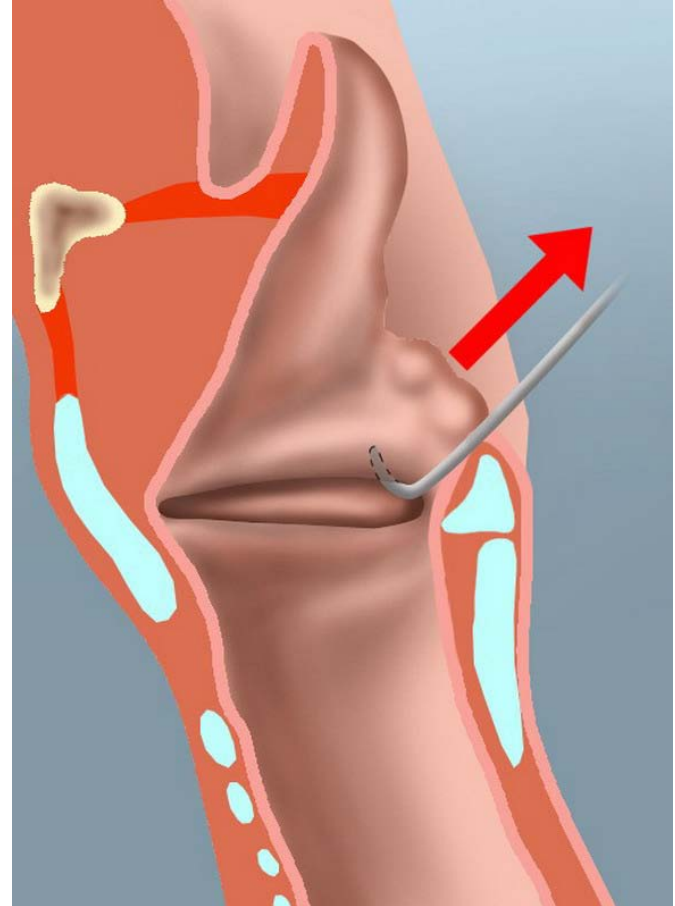


CT-scan

ARYTENOID LUXATION

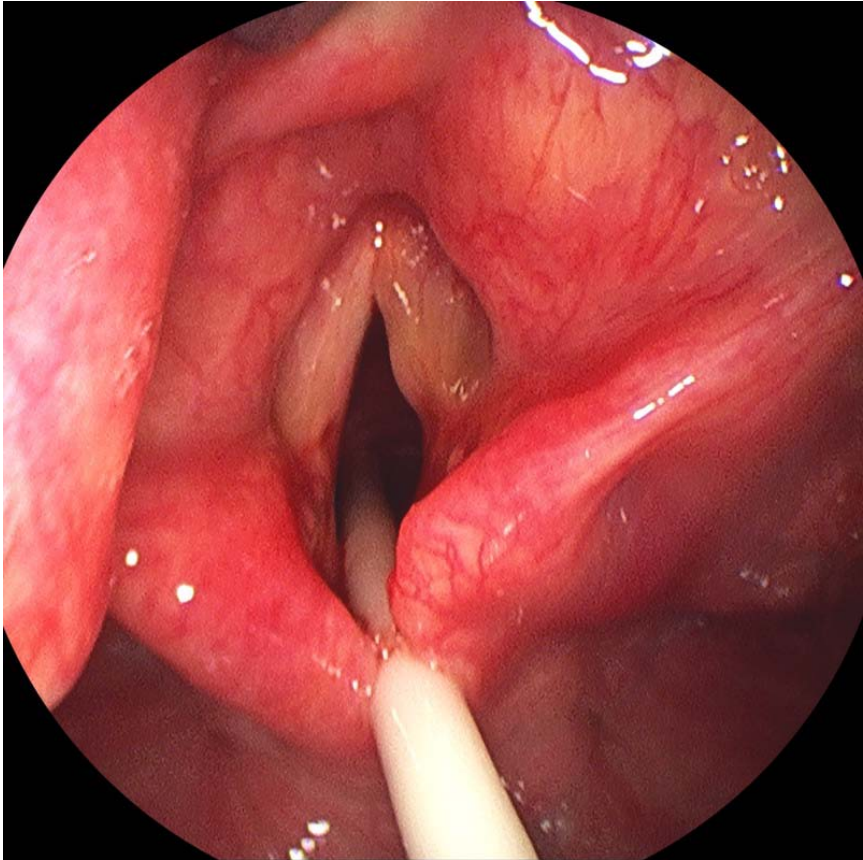


anteriorly
tilted arytenoid
+ mucosal edema

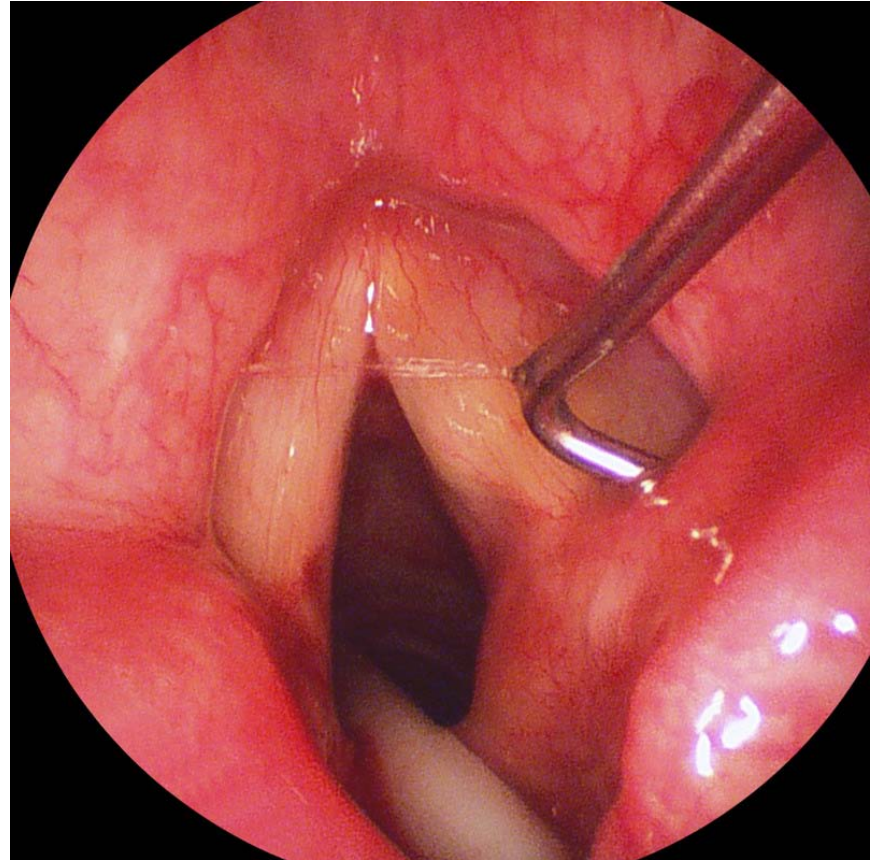


endoscopic
repositioning

ANTERIOR ARYTENOID LUXATION

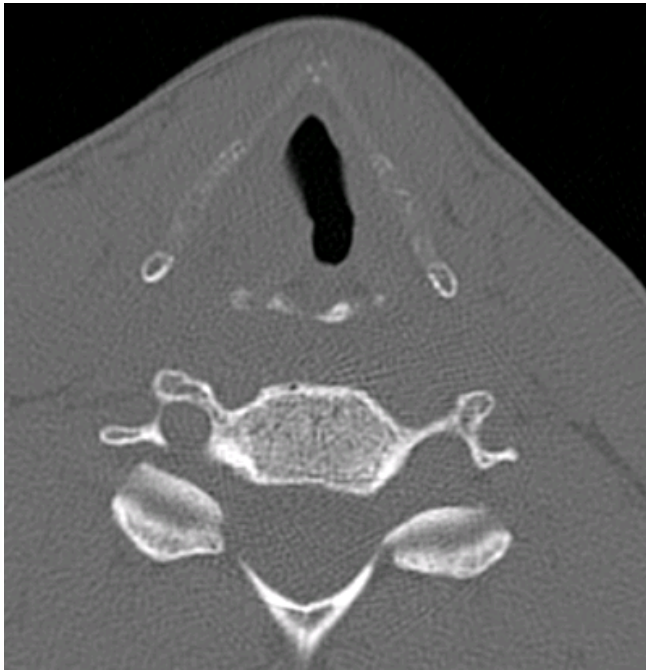


shortened, lax right VC
posterior, arytenoid hematoma

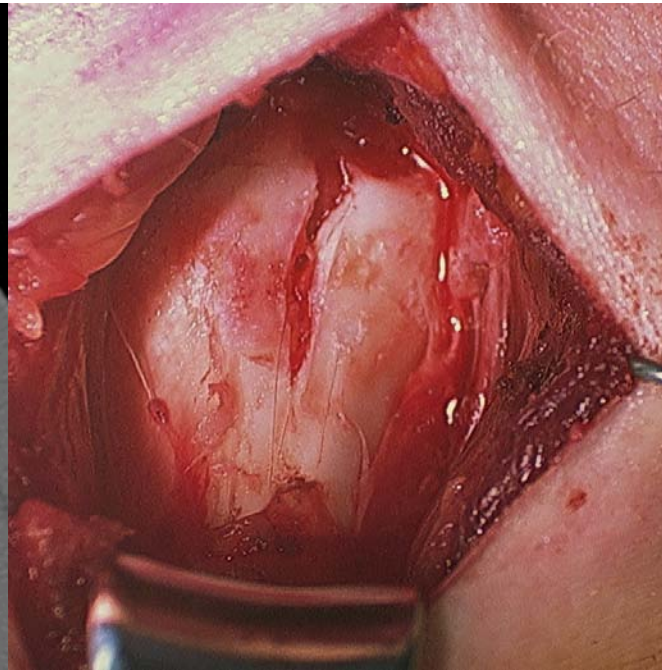


arytenoid
repositioning

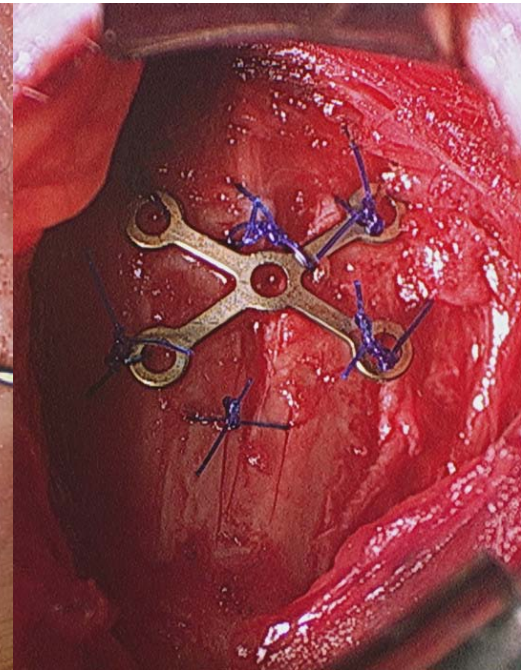
"INVISIBLE" THYROID CARTILAGE FRACTURE



normal
thyroid cartilage



vertical
fracture



stabilization
with miniplate

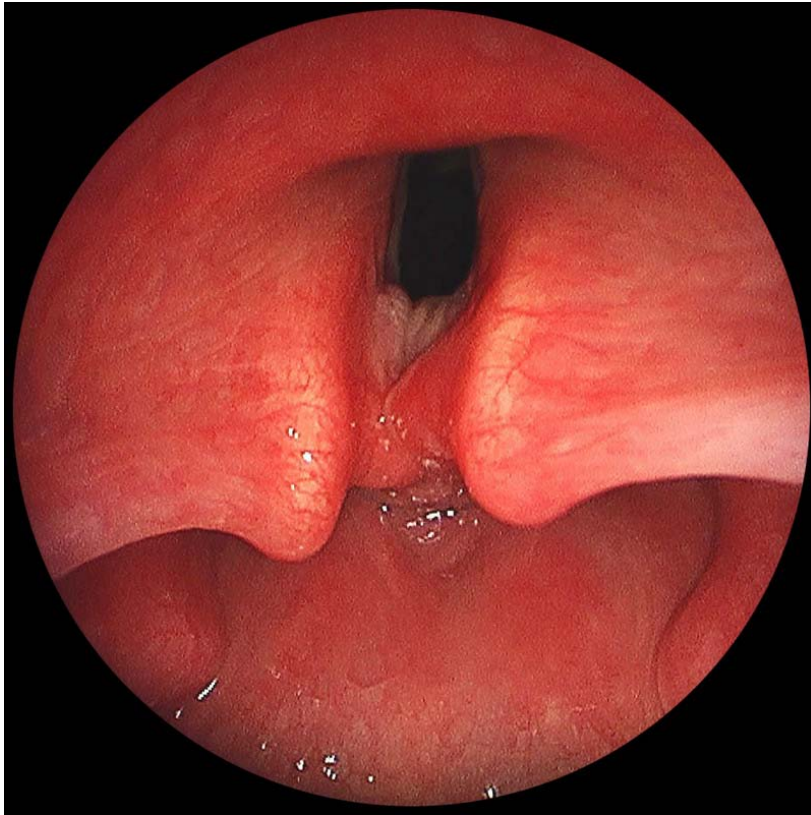
CAUTION AND ADVICES

CT-scan can miss
vertical or comminutive fractures

In case of moderate to severe dysphonia
with suspicion of arytenoid luxation

- > explore the neck : thyroid cartilage
- > stabilize the thyroid cartilage
- > reposition the arythenoid

UNDIAGNOSED ARYTENOID LUXATION



Personal assault
one month ago

Laryngeal strangulation
by hand

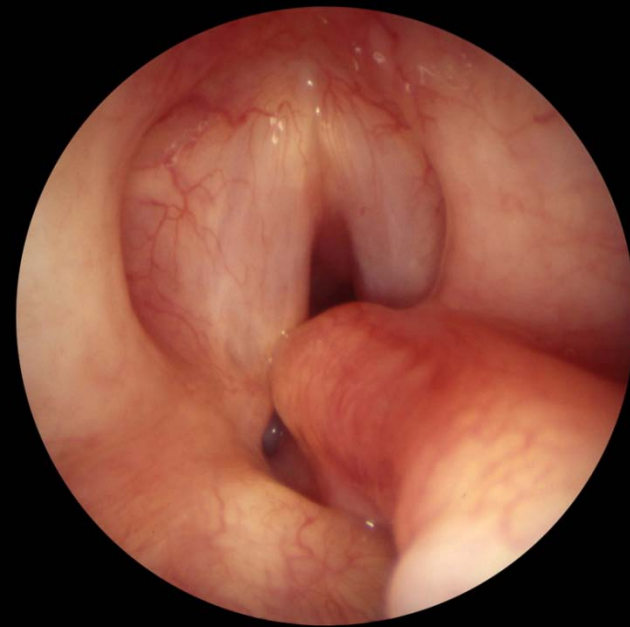
Residual severe dysphonia

No cartilage fracture

LATE ARYTENOID REPOSITIONING

PREOPERATIVE

LATE SEQUELA OF ARYTENOID LUXATION

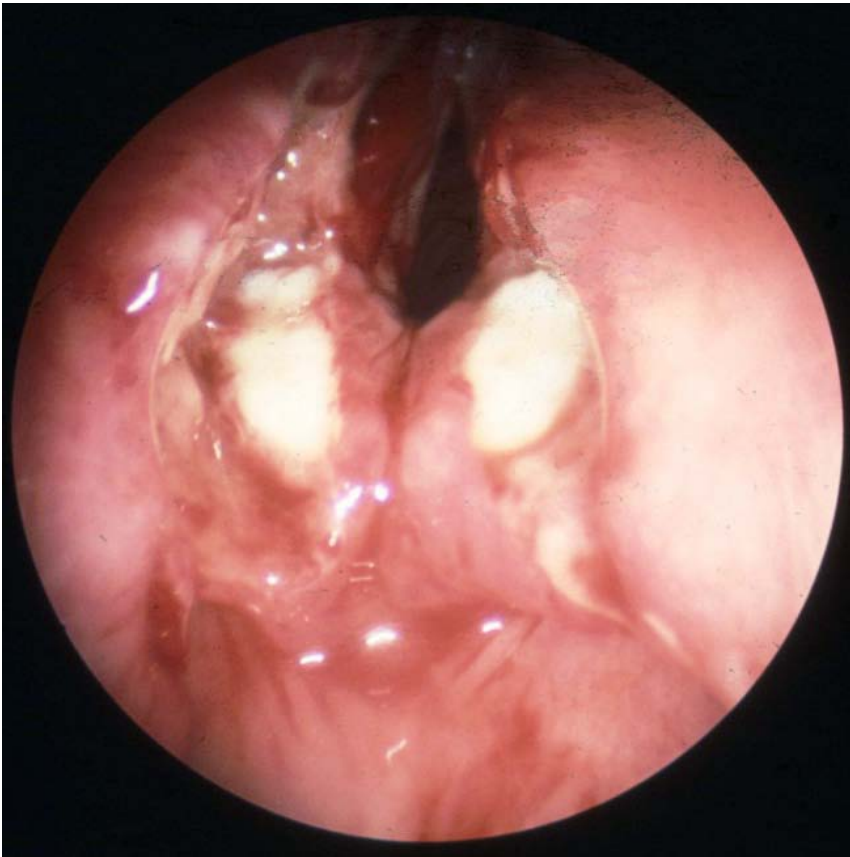


Luxated, fixed
right arytenoid

CO₂ laser
partial resection

Final
result

ARYTENOID AVULSION

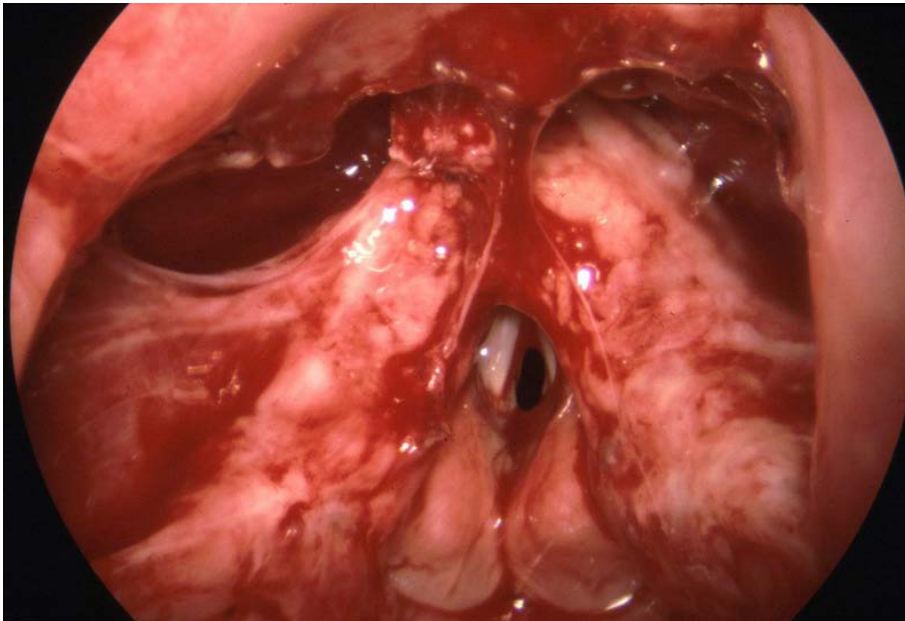


No possible repair

Treatment

- > associated fractures
- > mucosal tears

EXTENSIVE SUPRAGLOTTIC SEPARATION

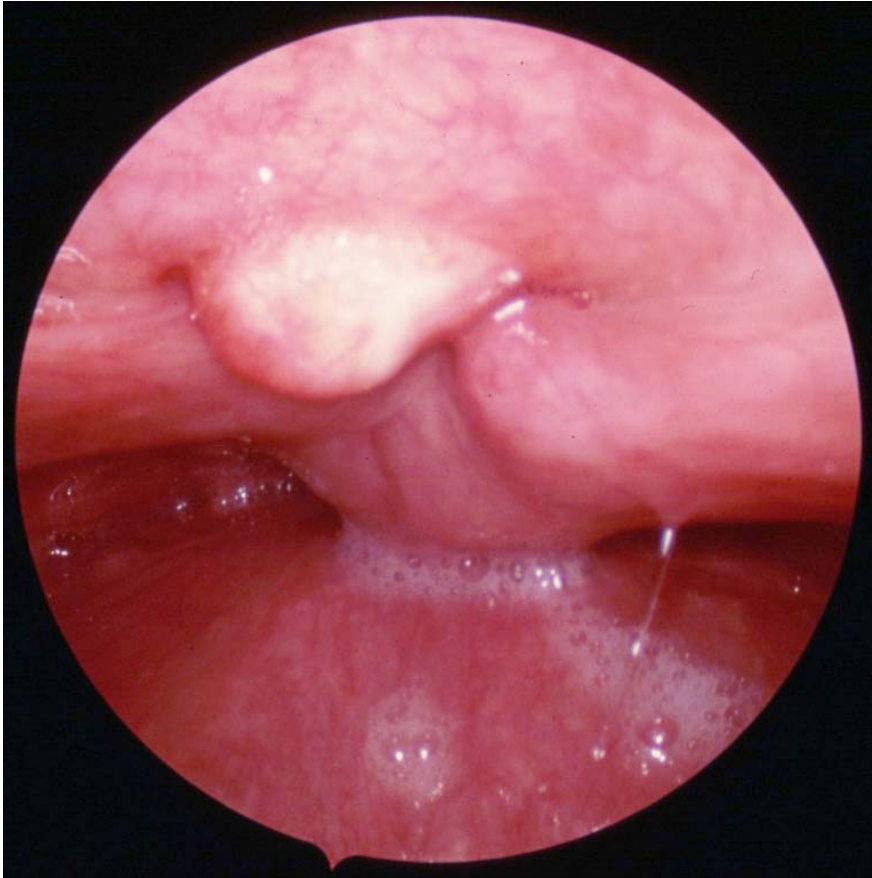


acute stage
laryngeal exposure
with intubation
laryngoscope



final result
with
normal functions

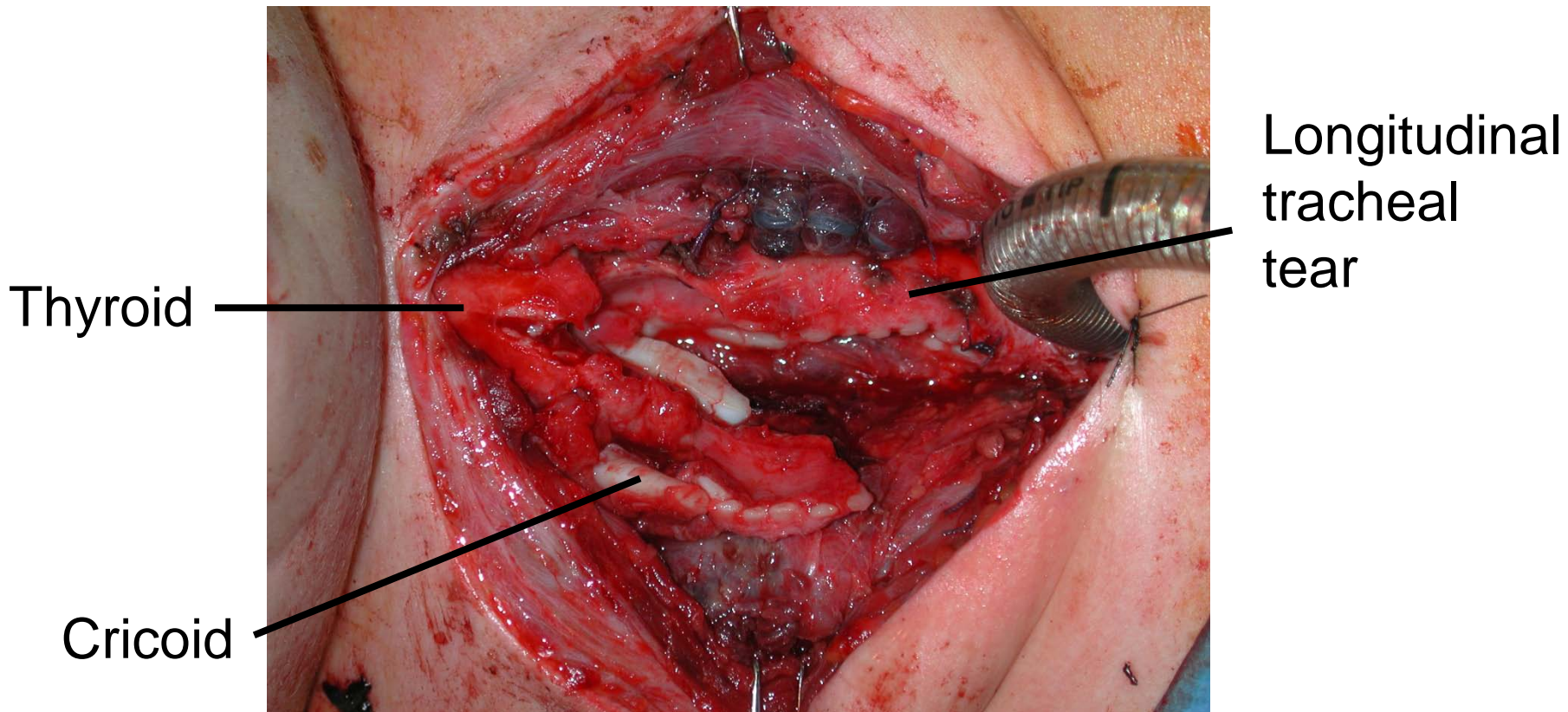
UNTREATED SUPRAGLOTTIC SEPARATION



- > late sequela
- > life time laryngeal cripple
- > difficult rehabilitation
+ decannulation

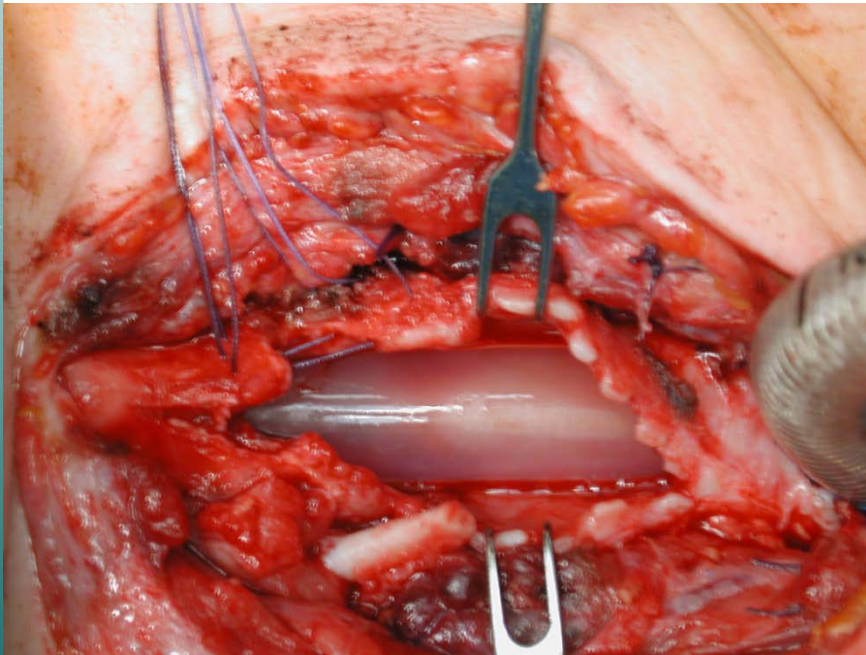
! IMMEDIATE SURGERY AVOIDS SUCH COMPLICATIONS !

THYROID + CRICOID FRACTURES + TRACHEAL TEAR

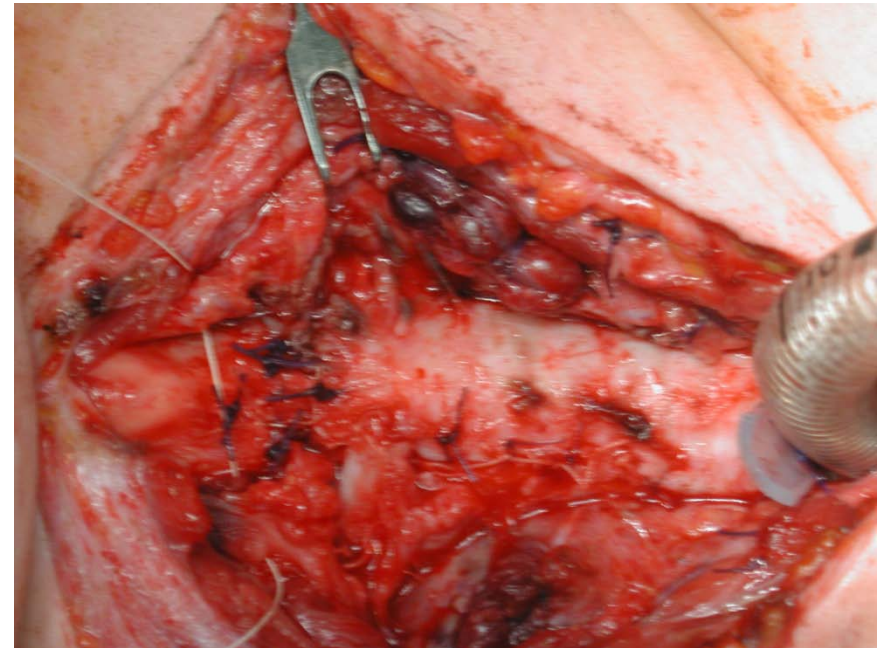


PEROPERATIVE SITUATION

THYROID + CRICOID FRACTURES + TRACHEAL TEAR



Stenting with LT-mold



Suture of torn cartilages
around LT-mold stent

THYROID + CRICOID FRACTURES + TRACHEAL TEAR



Final postoperative result

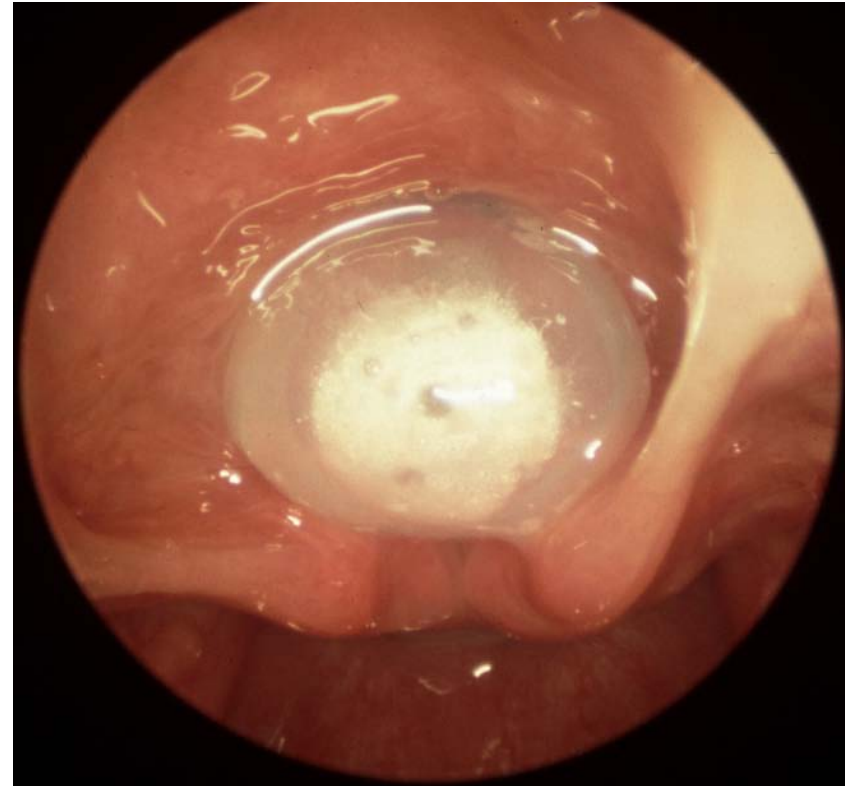
INDICATIONS FOR STENTING

Anterior thyroid cartilage
dislocation

Instable comminutive
fractures

Mucosal defects

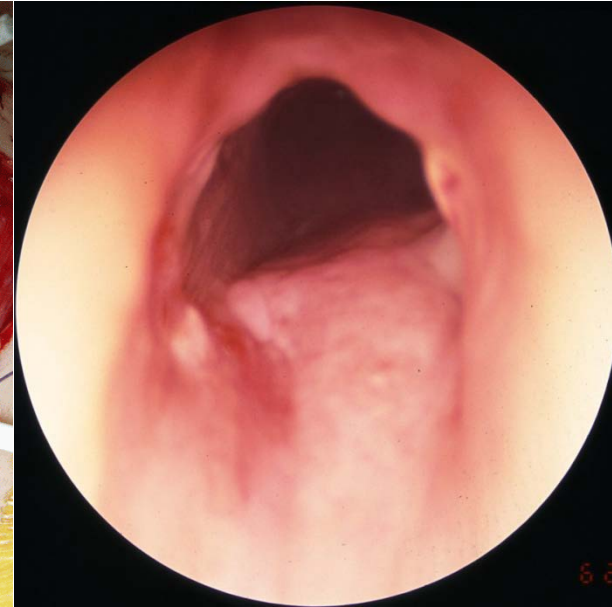
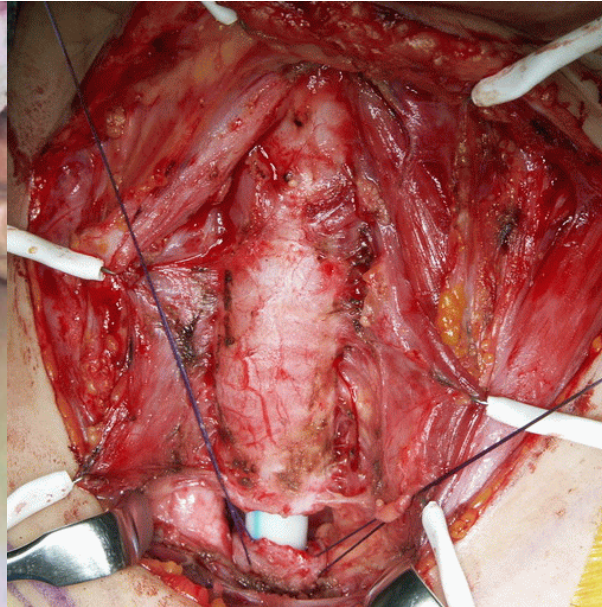
Tear of anterior
commissure



LT-mold

DURATION : DEPENDENT ON SEVERITY OF LESIONS

TRACHEAL RUPTURE



Thoracic compression
by tractor wheel

Tracheal
separation

Surgical repair
at 5th post op day

! RARE EVENT !

SURGICAL RESULTS

- Grade I & II
 - 100% normal breathing
 - 100% normal voice
- Grade III & IV
 - 96% normal breathing
 - 75% good voice
- Grade V
 - correlated to RLN lesion(s)

! POOR PROGNOSIS !

COMMINUTIVE CRICOID FRACTURE
BILATERAL RLN LESION

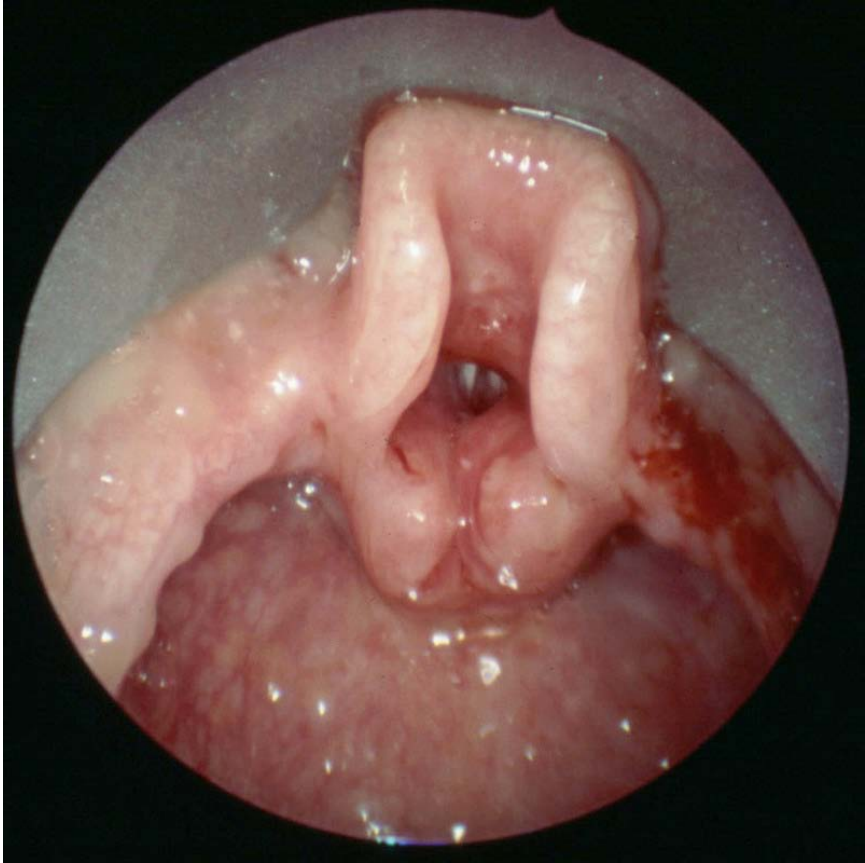
According to Schaefer SD, Am Otol Rhinol Laryngol (1989) 98

INHALATION INJURIES

ACUTE LESIONS

- Hot steam → laryngeal edema
- Smoke → necrotizing tracheitis, bronchitis
→ intra-alveolar hemorrhagic edema
- Ammonia gas → liquefaction necrosis of supraglottis

TREATMENT



Diagnostic / therapeutic bronchoscopy

> cleaning debris, lavage

Secure airway

> intubation / tracheotomy

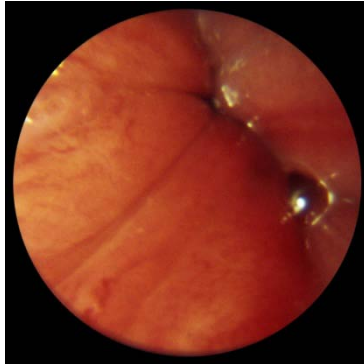
Medical treatment

> antibiotics, corticoids

Treatment of sequelae

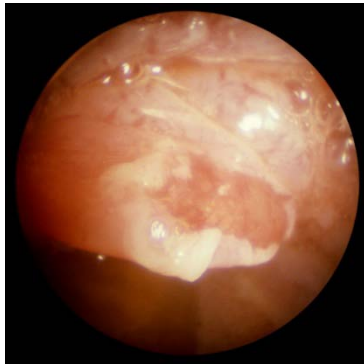
CAUSTIC INGESTION

ACUTE LESIONS



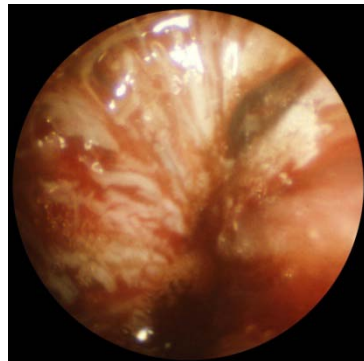
FIRST GRADE

- > erythema, edema



SECOND GRADE

- > epithelial exfoliation, erosion
- > papyrus esophagus / pharynx



THIRD GRADE

- > coagulation necrosis : acids
- > liquefaction necrosis : alkali

MANAGEMENT OF ACUTE LESIONS

Medical stabilization of patient

> hydro-electrolyte balance, pH, etc...

Bronchoesophagoscopy

> demarcation of grade II - III lesions
within 24 - 48 hours

Tracheotomy (if necessary)

Nasogastric tube / PEG

Antibiotics, PPI

SEVERE PHARYNGEAL LESIONS

REFLEX LARYNGOSPASM

- no VC or FVC lesion
- severe burns : laryngeal rim,
pharynx, esophagus

INTUBATION / TRACHEOTOMY

NASOGASTRIC TUBE / PEG

STENTING WITH LT-MOLD (?)



**NO WAY OF PREVENTING
PHARYNGOLARYNGEAL STENOSIS**



MANAGEMENT OF SEQUELAE

AFTER SEVERAL (2 to 3) YEARS

> long-standing inflammatory reaction

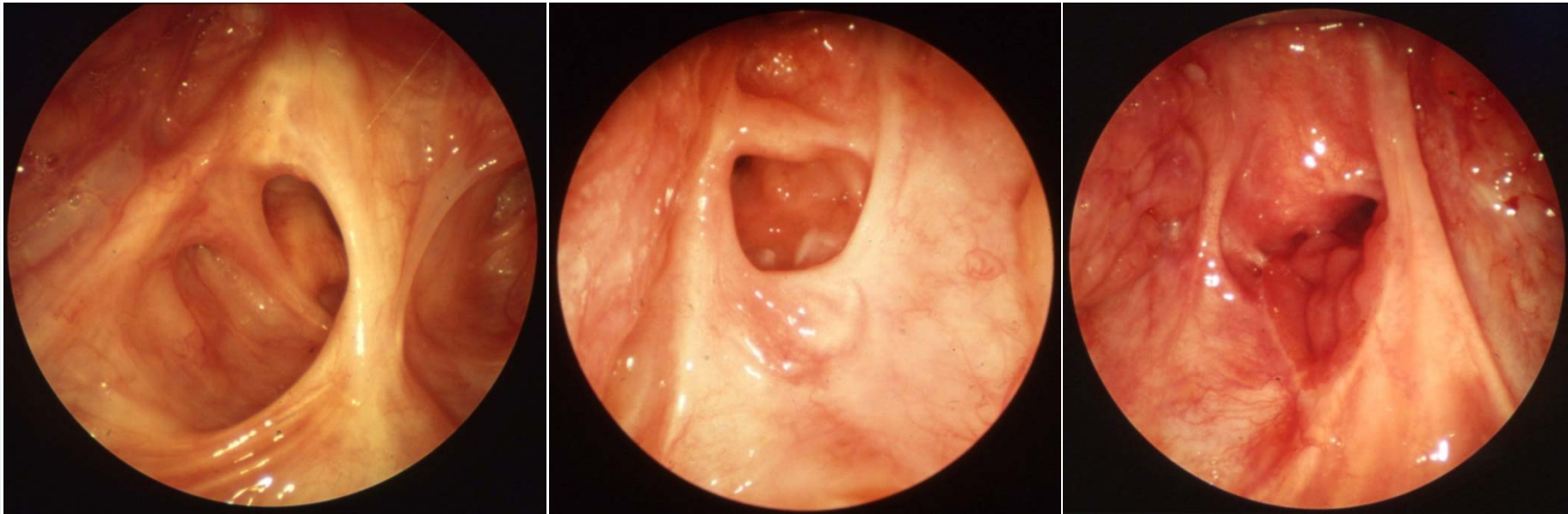
COLON TRANSPLANT TO PHARYNX

TEDIOUS SWALLOWING REHABILITATION

> children much better than adults

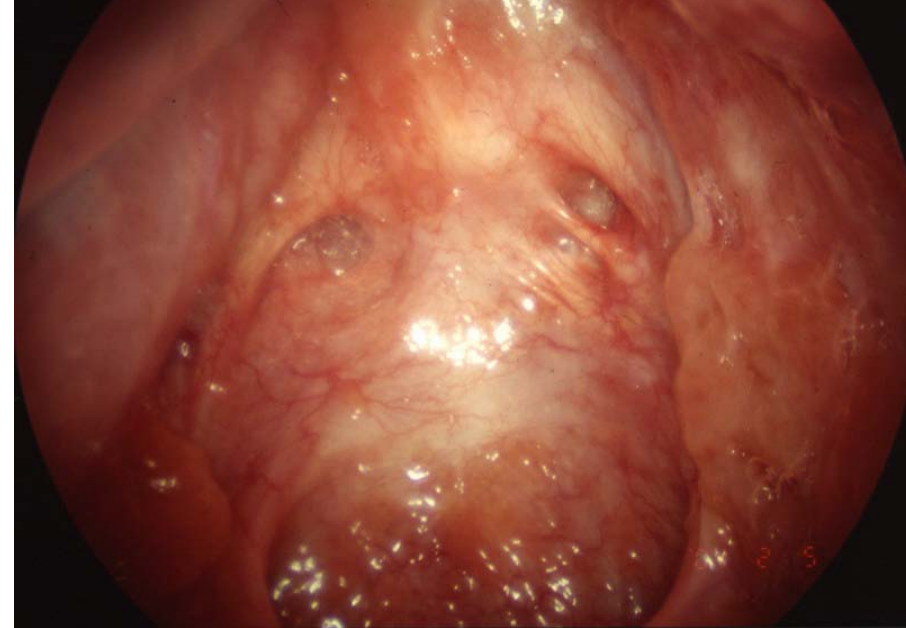
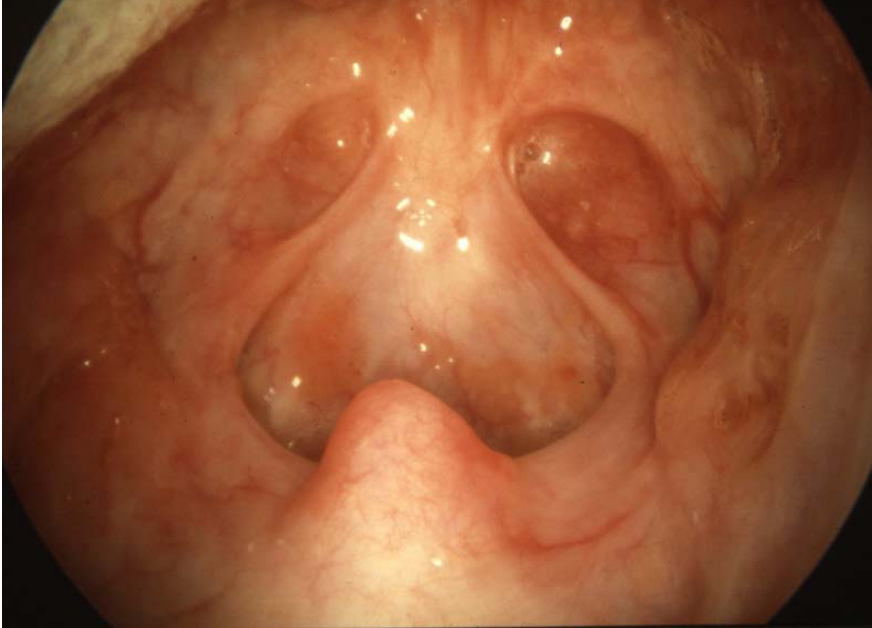
IMPROVED RESULTS WITH LT-MOLD

PARTIAL PHARYNGOLARYNGEAL OBSTRUCTIONS



USUALLY, BANDS OF SCAR TISSUE TETHERING
EPIGLOTTIS + TONGUE BASE TO POST PHARYNGEAL WALL

COMPLETE PHARYNGOLARYNGEAL OBSTRUCTION



ENDOSCOPY WORKUP

Direct pharyngoscopy

Retrograde 70° subglottoscopy
through tracheostoma

> mobility of vocal cords

Retrograde esophagoscopy
or Rx esophagram through
gastrostomy

PHARYNGEAL RECONSTRUCTION

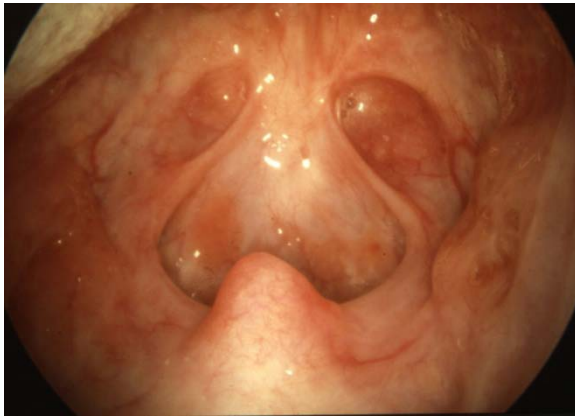
Endoscopic CO₂-laser incision
and excision of scar tissue

Left lateral and anterior pharyngotomy
at the level of the CO₂-laser incision

Suture of colon transplant to
retrocricoid space and pharynx

Stenting with LT-mold

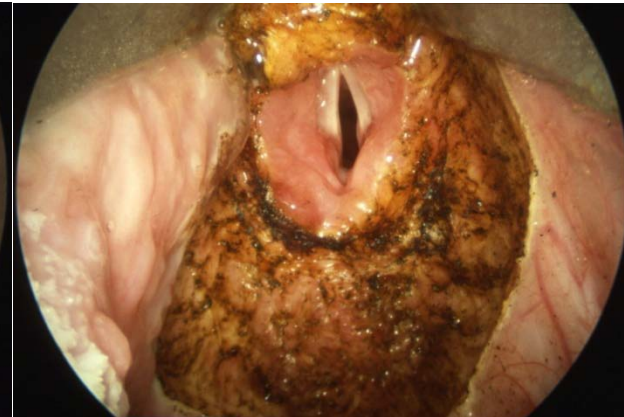
ENDOSCOPIC CO₂-LASER REOPENING ...



fusion of
epiglottis to
pharyngeal wall



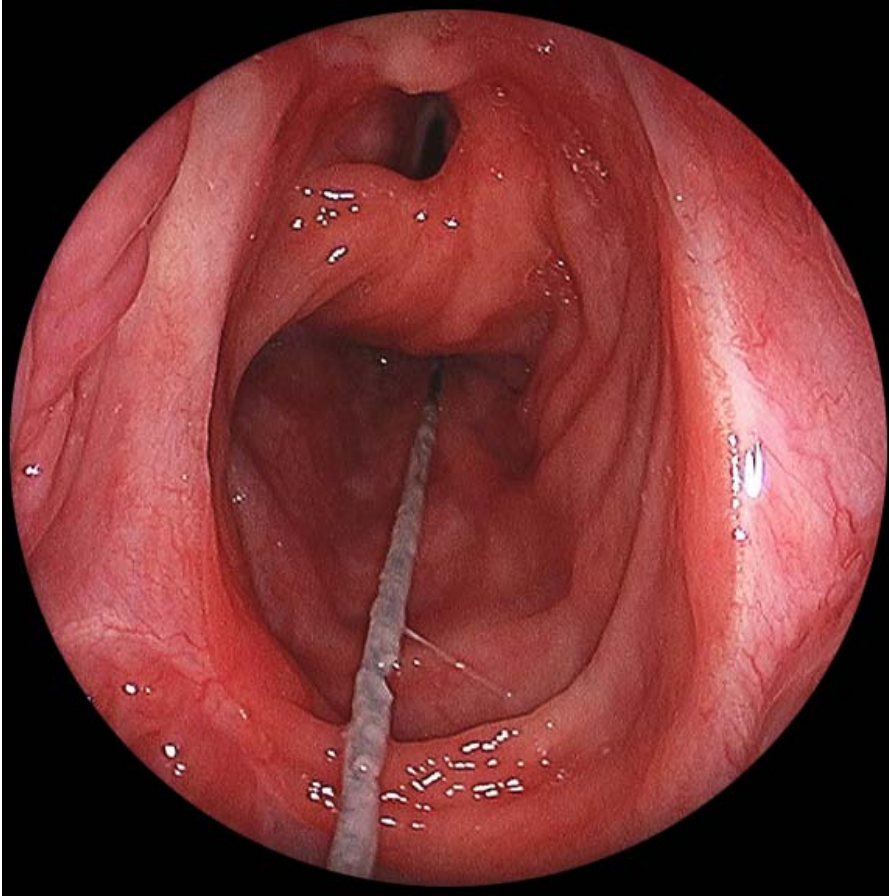
supraglottic
CO₂-laser
reopening



delineation of
pharyngeal
suture line

... AND PHARYNGEAL COLON TRANSPLANT

POST-OPERATIVE RESULT



Normal voice

Normal déglutition

Normal breathing

INITIAL CONDITION

No voice

PEG

Tracheostoma

DEMOGRAPHICS

Number of patients	13
Sex	6 7
Mean age	5 years
> range	2 to 15 years

CLASSIFICATION

- Grade I : - UES + one piriform fossa
(n = 3)
- Grade II : - UES + two piriform fossae
(n = 3)
- intact laryngeal rim
- Grade III : - UES + two piriform fossae
(n = 7)
+ pharyngoepiglottic stenosis
(total obstruction in 3 cases)

! NO GLOTTIC or VENTRICULAR BAND STENOSIS !

RECONSTRUCTION

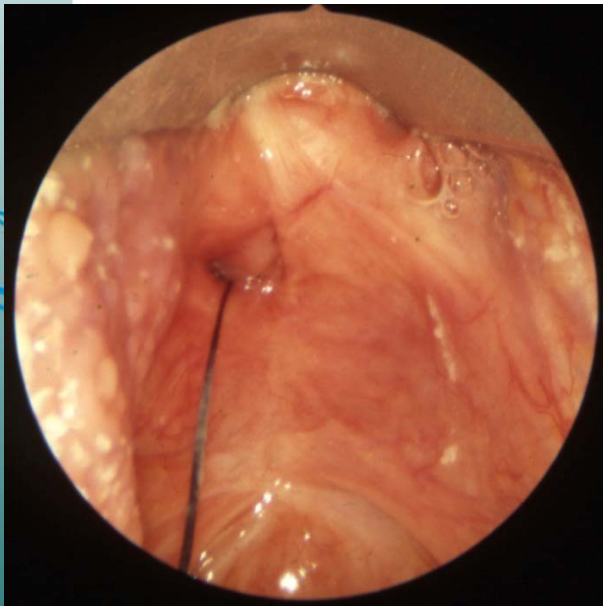
Isoperistaltic colon transplant

n = 10

Gastric tube

n = 3

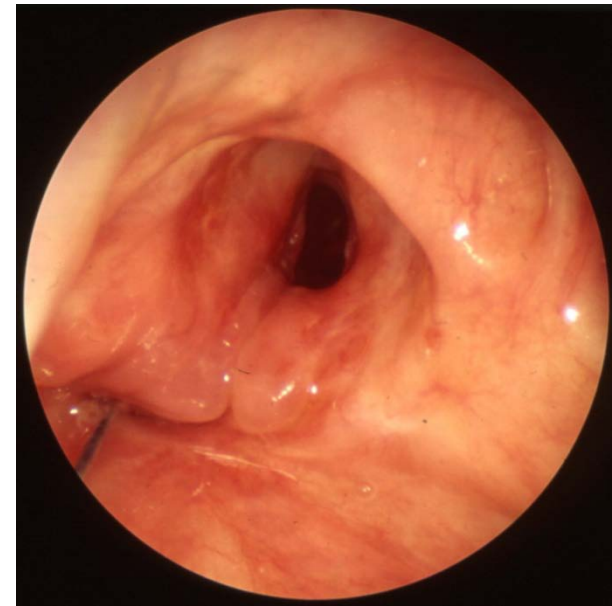
TREATMENT OF SUPRAGLOTTIC STENOSIS



residual
supraglottic
stenosis



LT-mold
after CO₂-laser
reopening



final result

RESULTS N = 13

Decannulation	13 / 13
Exertional dyspnea	0 / 13
Normal voice	13 / 13
Subnormal diet	13 / 13

Mean follow-up 59 months

RESULTS N = 13

Mean hospital stay	36 days (range 16-241 d)
Tracheostoma closure	46 days (range 15-240 d)
Gastrostomy closure	80 days (range 30-240 d)
Additional endoscopic CO ₂ -laser treatment	8 / 13 patients
Pharyngocolic dilatation	7 / 13 patients
Duration of LT-stenting	5 weeks to 3 months

CONCLUSIONS

Efficacious but long
and demanding treatment

Full rehabilitation of most children

- > respiration
- > phonation
- > deglutition

Multidisciplinary team approach

TAKE HOME MESSAGES ①

ETIOLOGY

- > motor vehicle accidents 60%
- > assault / suicide attempts 20%
- > occupational accidents 20%

INJURIES

- > blunt 83%
- > penetrating 17%

TAKE HOME MESSAGES ②

LARYNGEAL LESIONS

- > dependent on level of impacts
- > hyoid to trachea

MANAGEMENT

- > secure the airway { intubation
tracheotomy
- > endoscopy { airway
digestive tract
- > radiologic studies : CT / angio –CT / doppler

EMERGENCY SURGERY

TAKE HOME MESSAGES ③

CT-scan can miss cartilages fractures

Dysphonia + swollen arytenoid region

- > suspicion of arytenoid luxation
- > explore the neck : thyroid cartilage fracture
- > stabilize thyroid fracture first
- > reposition arytenoid next

TAKE HOME MESSAGES ④

! EMERGENCY SURGERY !

**! Same as for open limb fractures
Every post-trauma hour counts !**

HISTORICAL NOTE

- 1620 Habicot : tracheotomy as life-saving treatment
- 1796 Sabatier : intubation through cervical wound
- 19th century : development of anesthesiology
- 1850 Eichmann : reduction of fractures through laryngofissure
- 1885 Küster : tracheal resection + anastomosis
- 1887 Schimmelbush : reconstruction with cutaneous flaps

XXth CENTURY

- 1918 Maure : surgery + stenting
- 1928 Fleming : penicillin
- 1928 Domagk : sulfonamids
- 1939 Canuyt : laryngeal tomography
- 1967 Nahum : laryngeal wound healing
- 1971 Ogura : blunt trauma
- 1974 Alonso : laryngotracheal disruption
- 1985 Hirano : phoniatric sequelae
- 1991 Schafer : CT-scan / treatment algorithm

TREATMENT OF SEQUELAE

1953 Conley : cricotracheal resection

1956 Réthi : posterior cricoid split

1965 Grillo : tracheal resection

1970s Cotton : laryngotracheal reconstruction

1971 Ogura : laryngeal reconstruction

1974 Gerwat & Bryce : CTR with RLN preservation

1975 Pearson : CTR with RLN preservation

1978 Savary : CTR in children