

Cavity, Muscles and Mucosa of Larynx

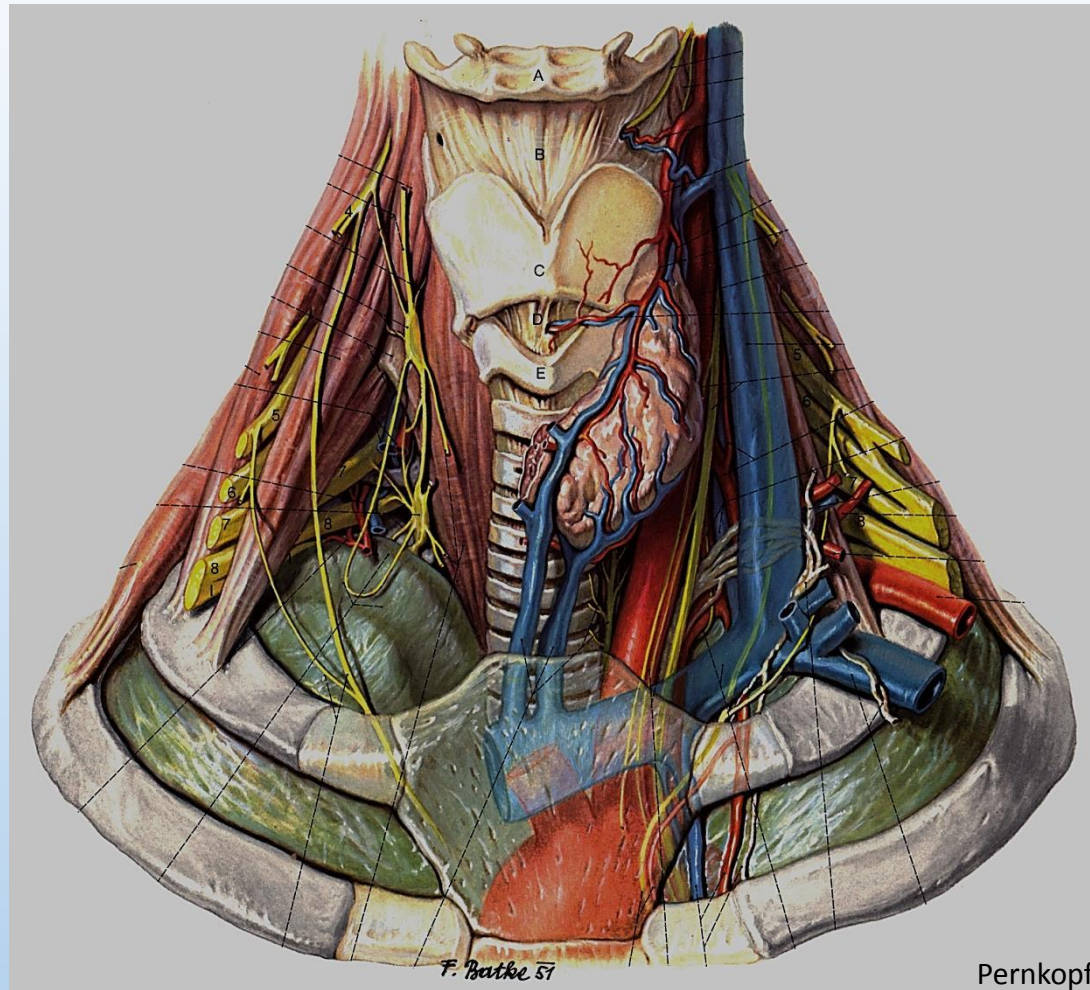
Maxillofacial aspect

compiled by

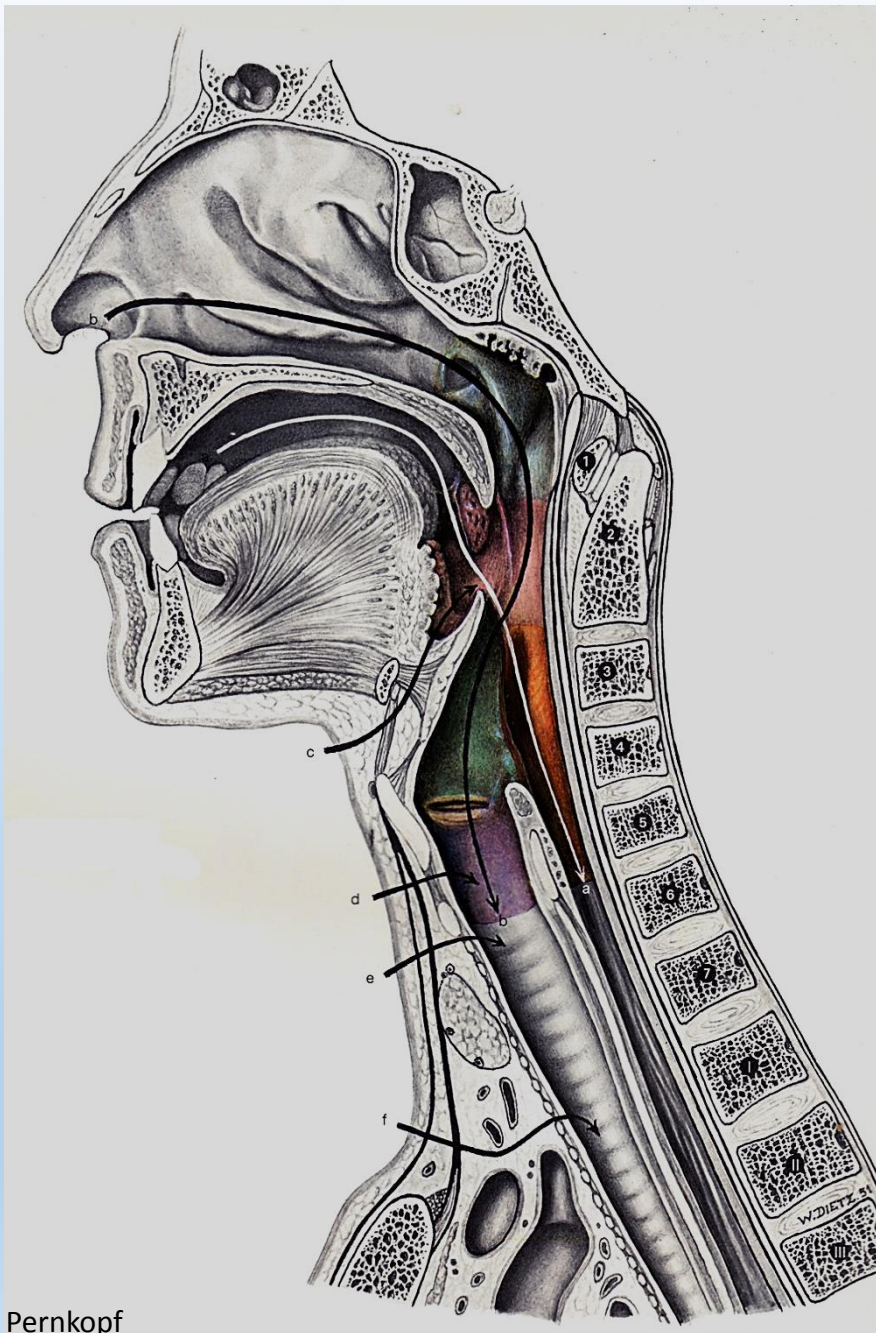
András Csillag

collaborators

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Close proximity of thyroid gland:
common fascia, innervation and blood supply (see pharyngeal pouches)
Laryngeal nerves must be spared at thyroid surgery!!



Larynx:

Separation between airways and food passage

First part of lower airways

- Phonation
- Respiration
- Cough
- Abdominal pressure

Multiple medical relevance

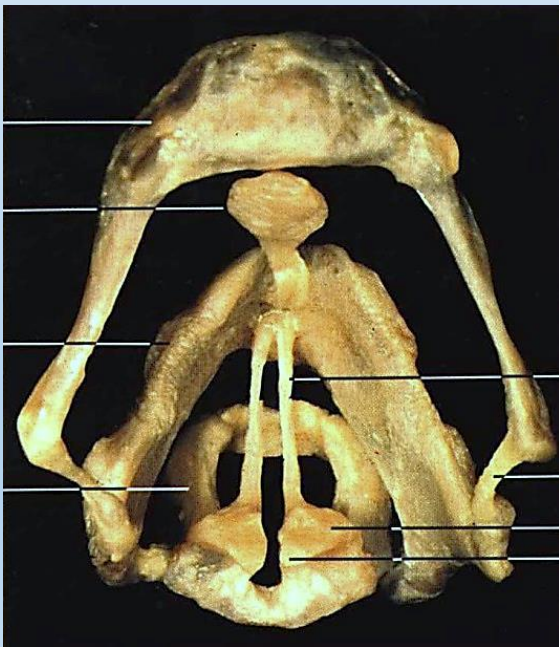
e.g.:

- loose submucosa (oedema!)
- Oncology
- Assisted respiration of patients (coniotomy, intubation etc)

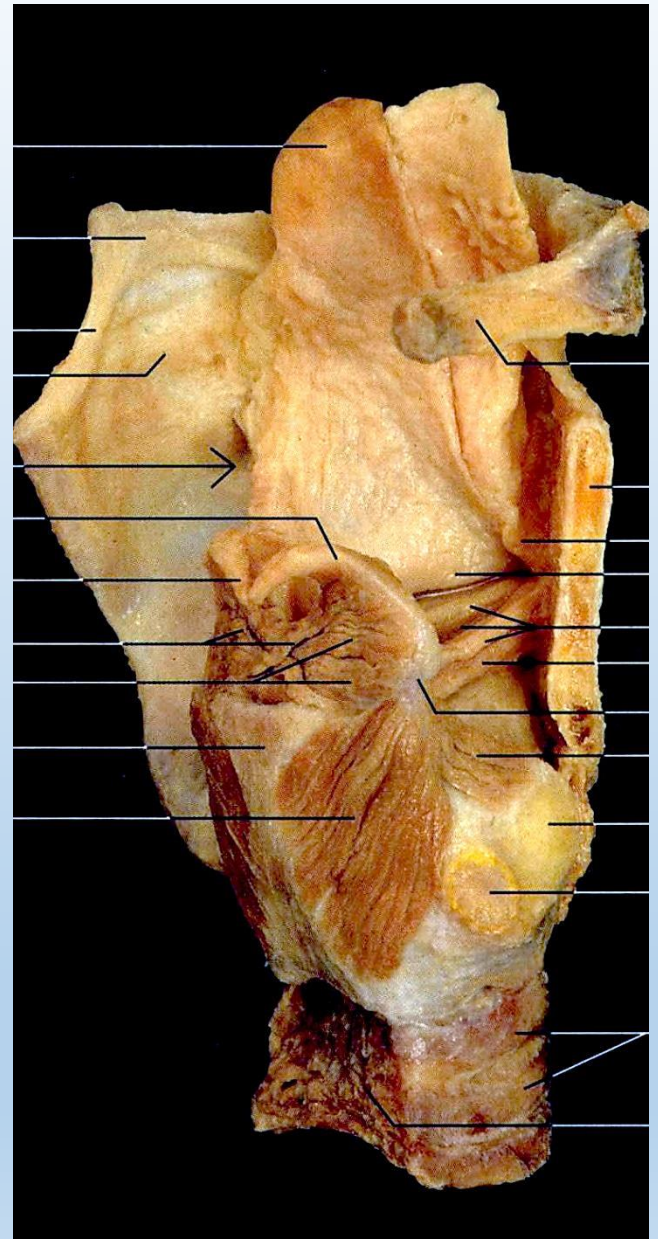
Components:

- **Skeletal** (cartilages)
- **Muscles**
- **Ligaments**
- Fibroelastic membranes
- Mucosa
- Nerves, blood vessels, lymph vessels

} **Joints,
Movements**



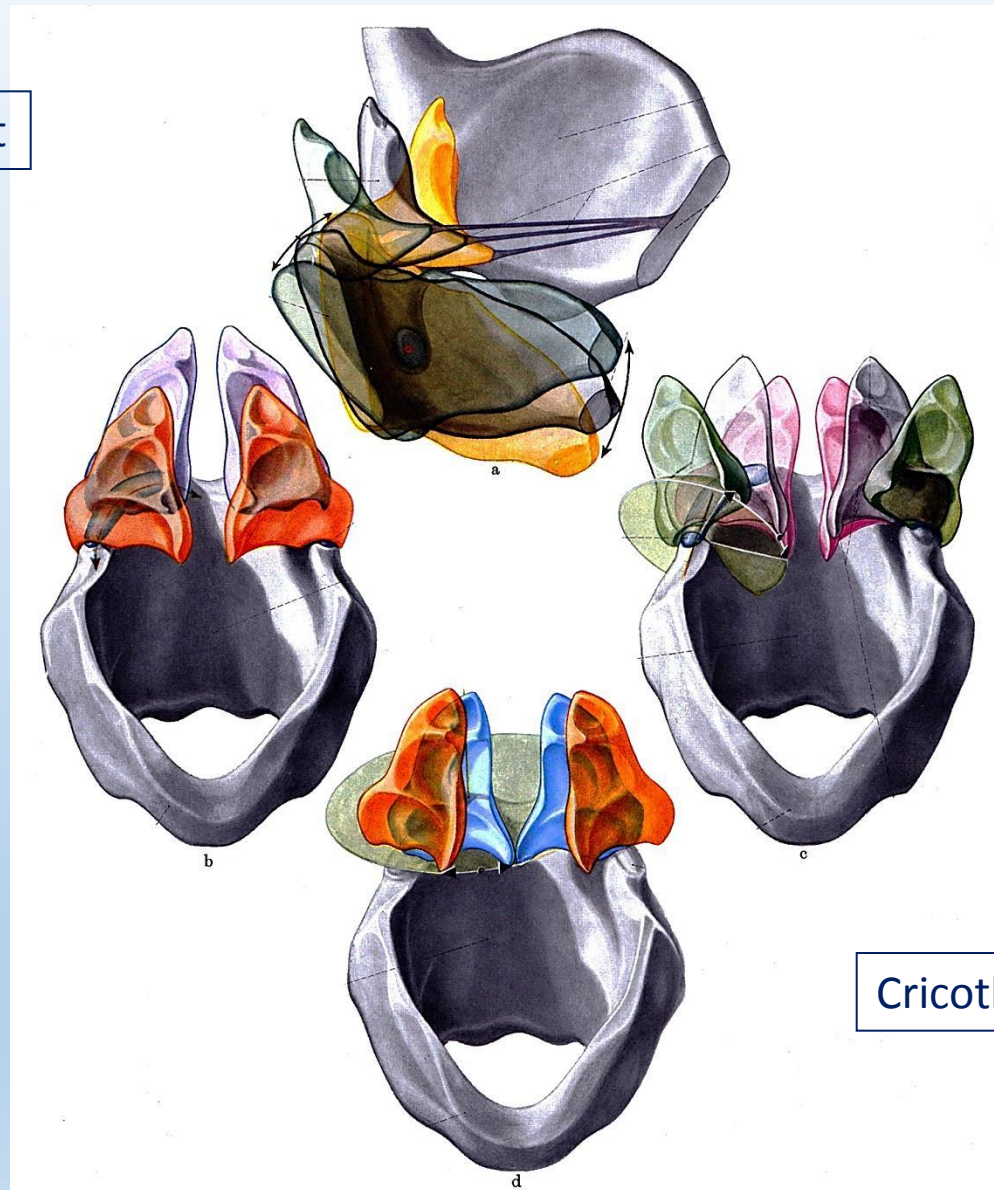
Yokochi



Yokochi

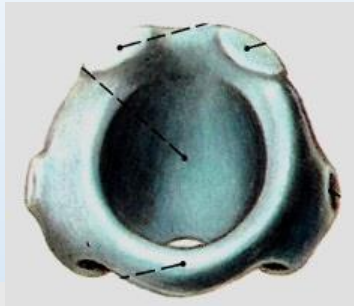
Joints and movements

Cricoarytenoid joint

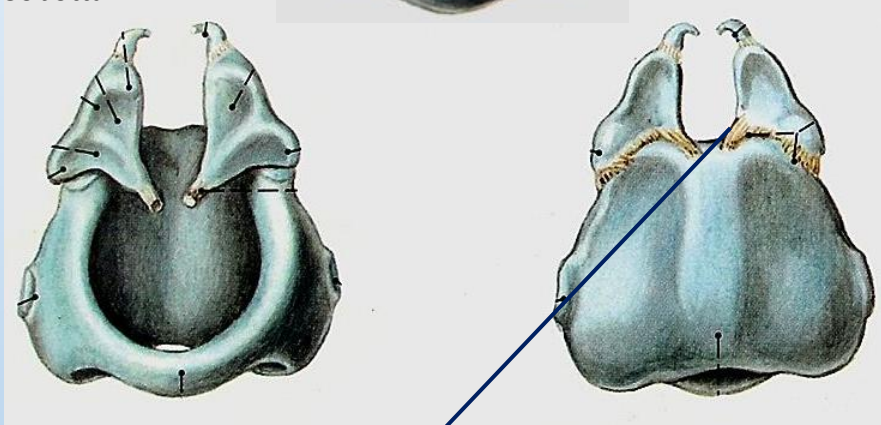


Cricothyroid joint

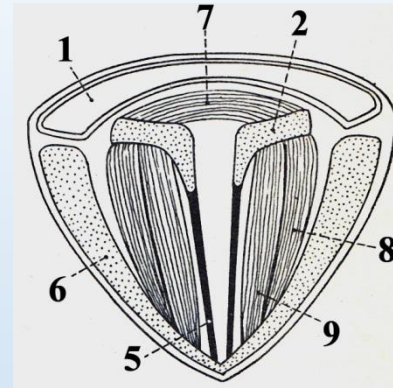
Cricoarytenoid joint



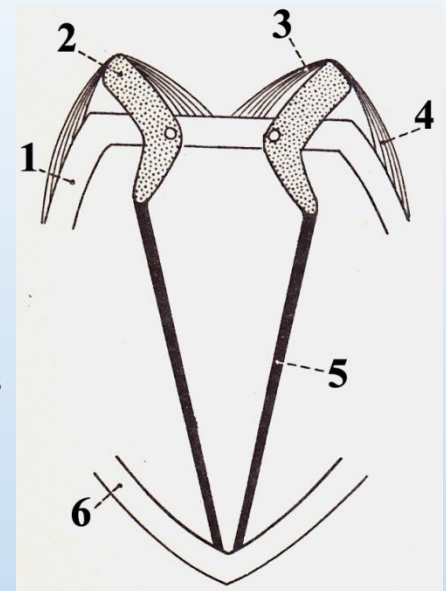
Sobotta



Posterior cricoarytenoid lig.



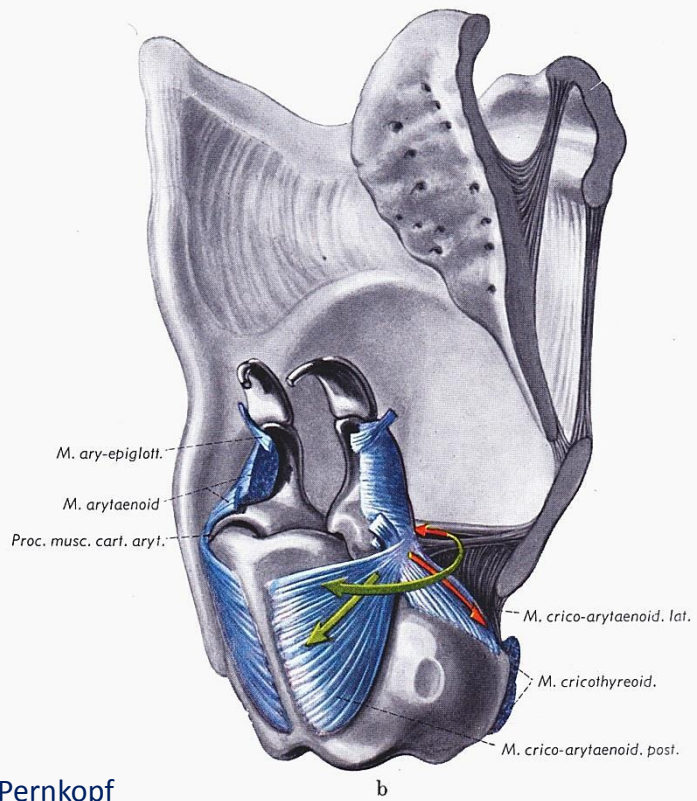
Kiss



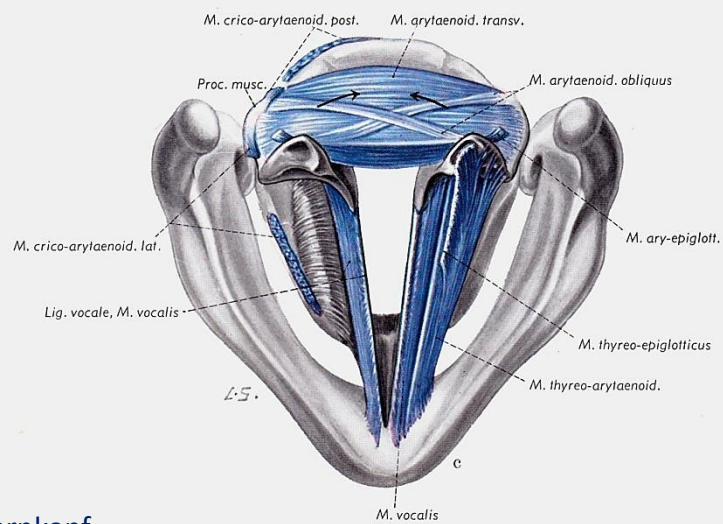
1. Cricoid cartilage
2. Arytenoid cartilage
3. **Posterior cricoarytenoid m. („Posticus”)**
4. Lateral cricoarytenoid m.
5. Vocal ligament
6. Thyroid cartilage
7. Arytenoid muscles
8. Lateral thyroarytenoid m.
9. Medial thyroarytenoid m. (M. vocalis)

Plane joints: Rotation and sliding

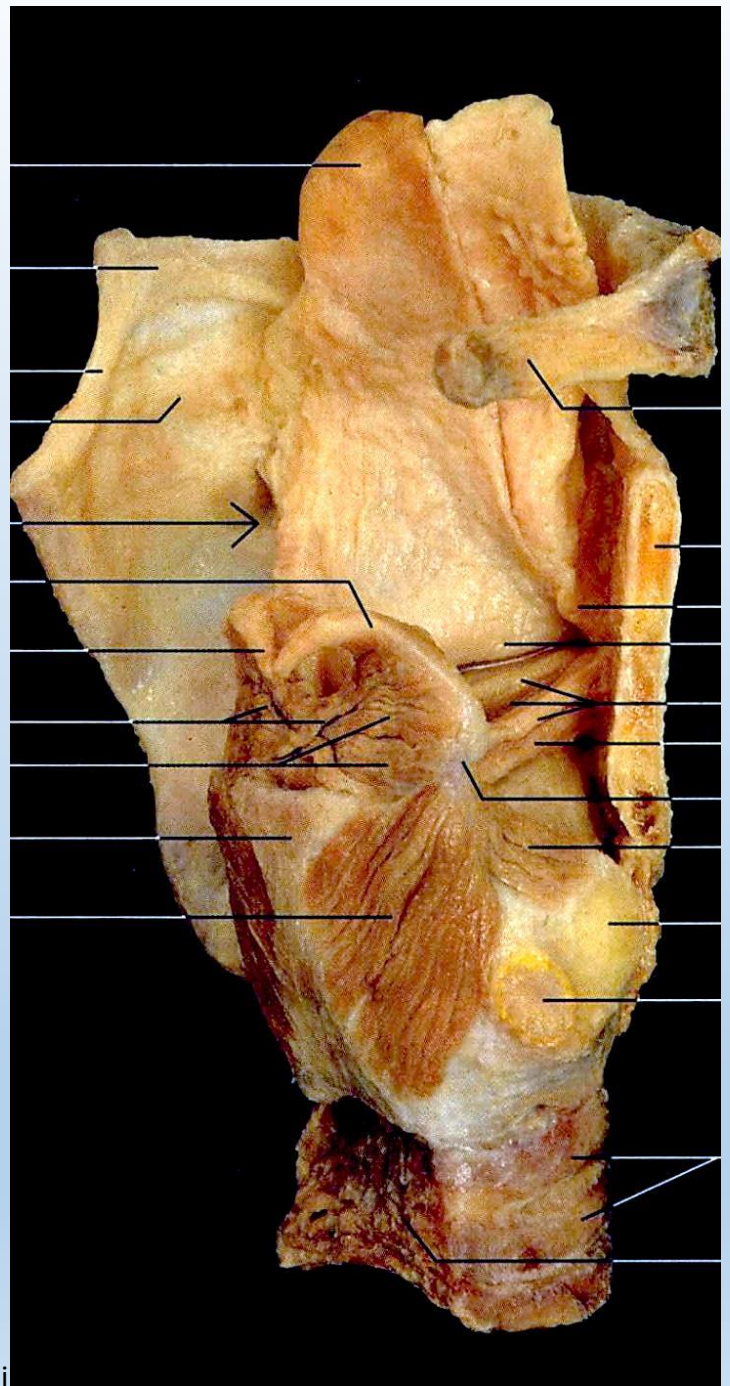
Posterior cricoarytenoid m.:
The only opener of glottis! (breathing!)



Pernkopf



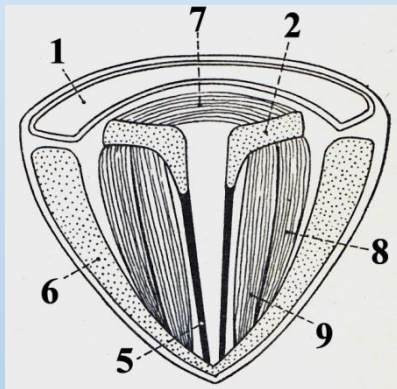
Pernkopf



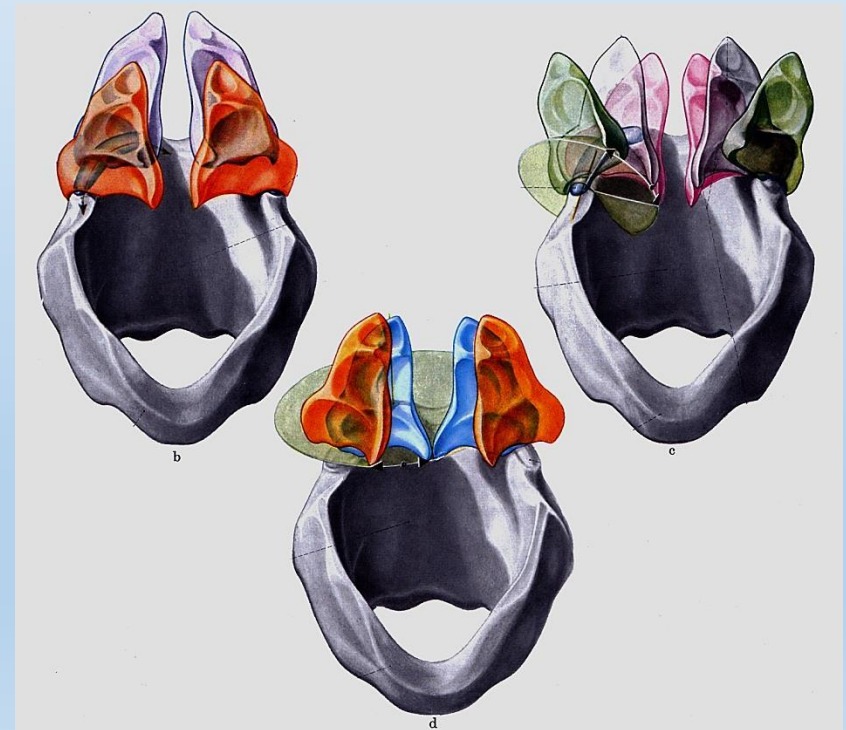
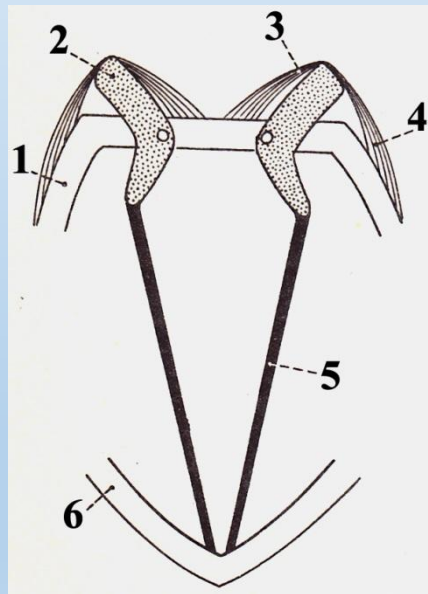
Yokochi

Cricoarytenoid joint

- (3) Posterior cricoarytenoid m. („Posticus“): **The only opener of glottis! (breathing!)**
- (4) Lateral cricoarytenoid m.: closes the intermembranous part of glottis
- (7) Arytenoid muscles: close the intercartilaginous part of glottis
- (8) *Lateral thyroarytenoid m.*: closes the intercartilaginous part of glottis
- (9) *M. thyroarytenoideus medialis (M. vocalis)*: closes the intercartilaginous part of glottis, fine adjustment of vocal ligaments

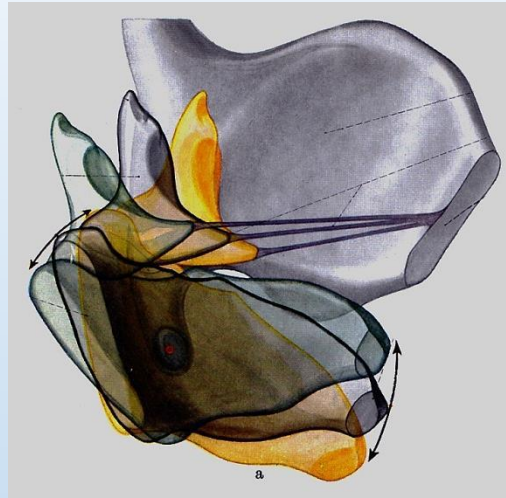
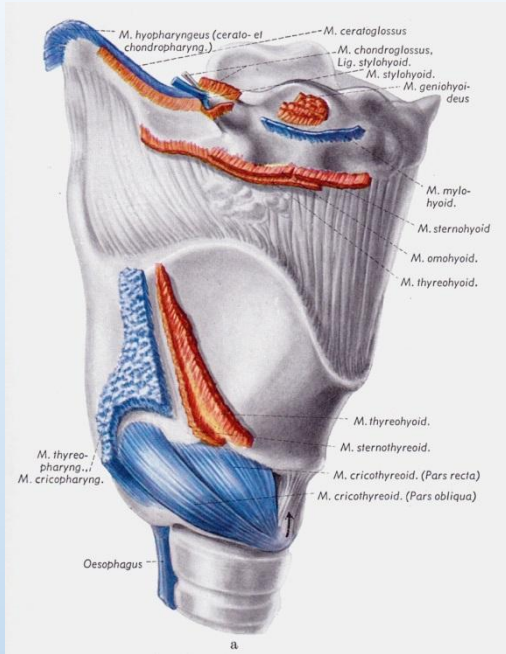


Kiss

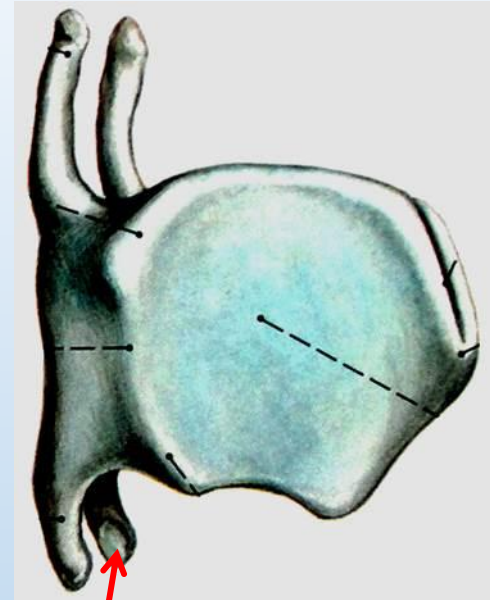


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Cricothyroid joint



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Sobotta

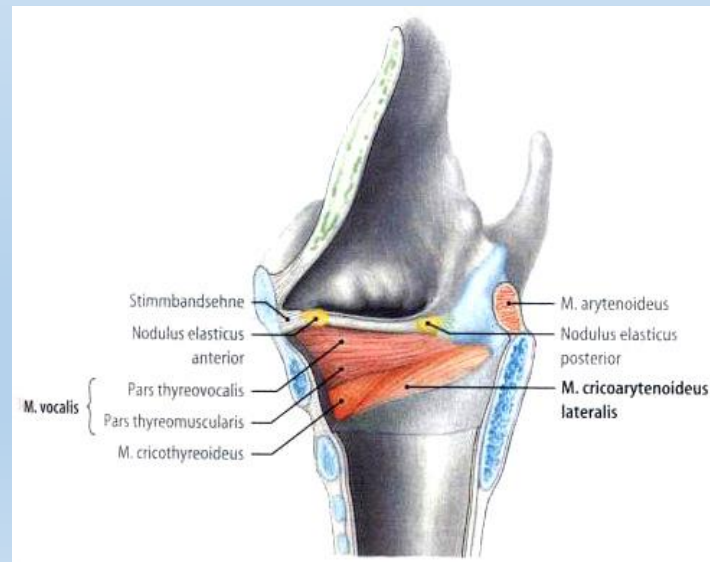
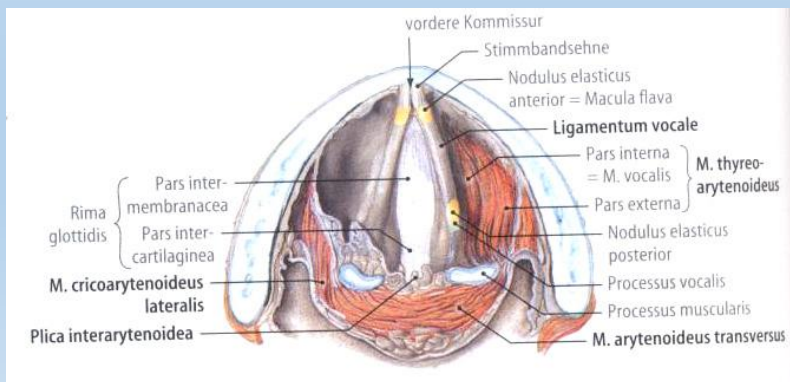
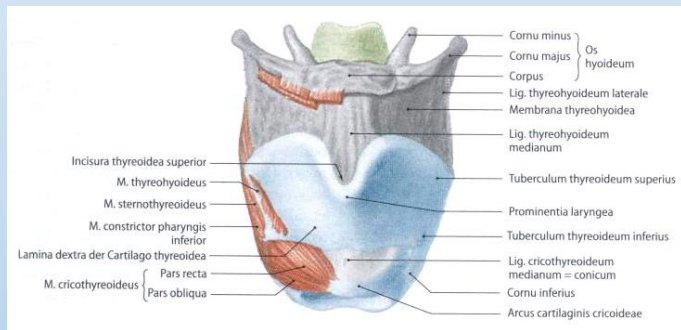
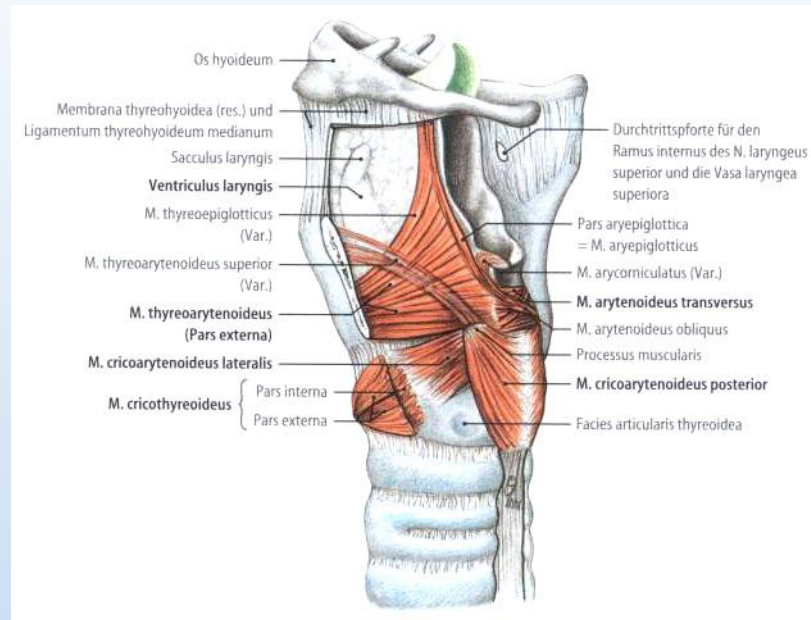
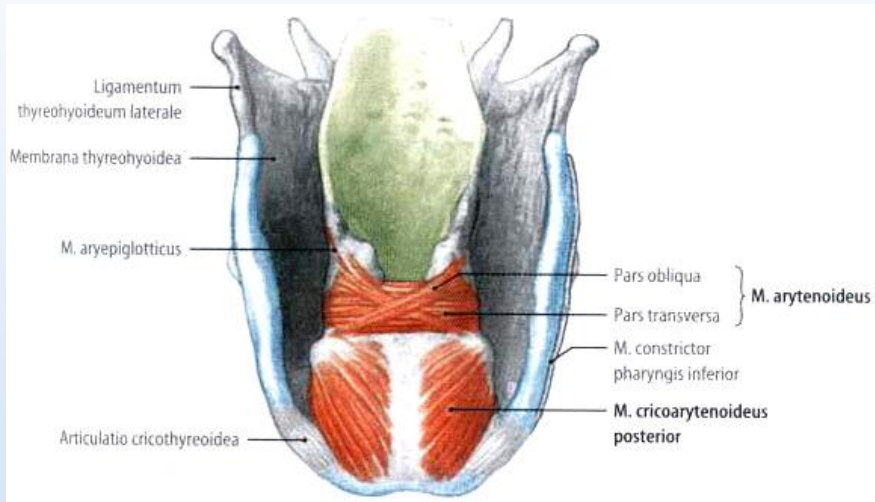


The thyroid cartilage is tilted around a common axis, also extending (stretching) the vocal ligaments

Course adjustment of vocal ligaments

Muscle: Cricothyroid m. (oblique and straight parts)

(Cerato-cricoid ligaments in the capsule)



INNERVATION

Superior laryngeal n. (X.)

- cricothyroid m.
- the mucosa above the glottis

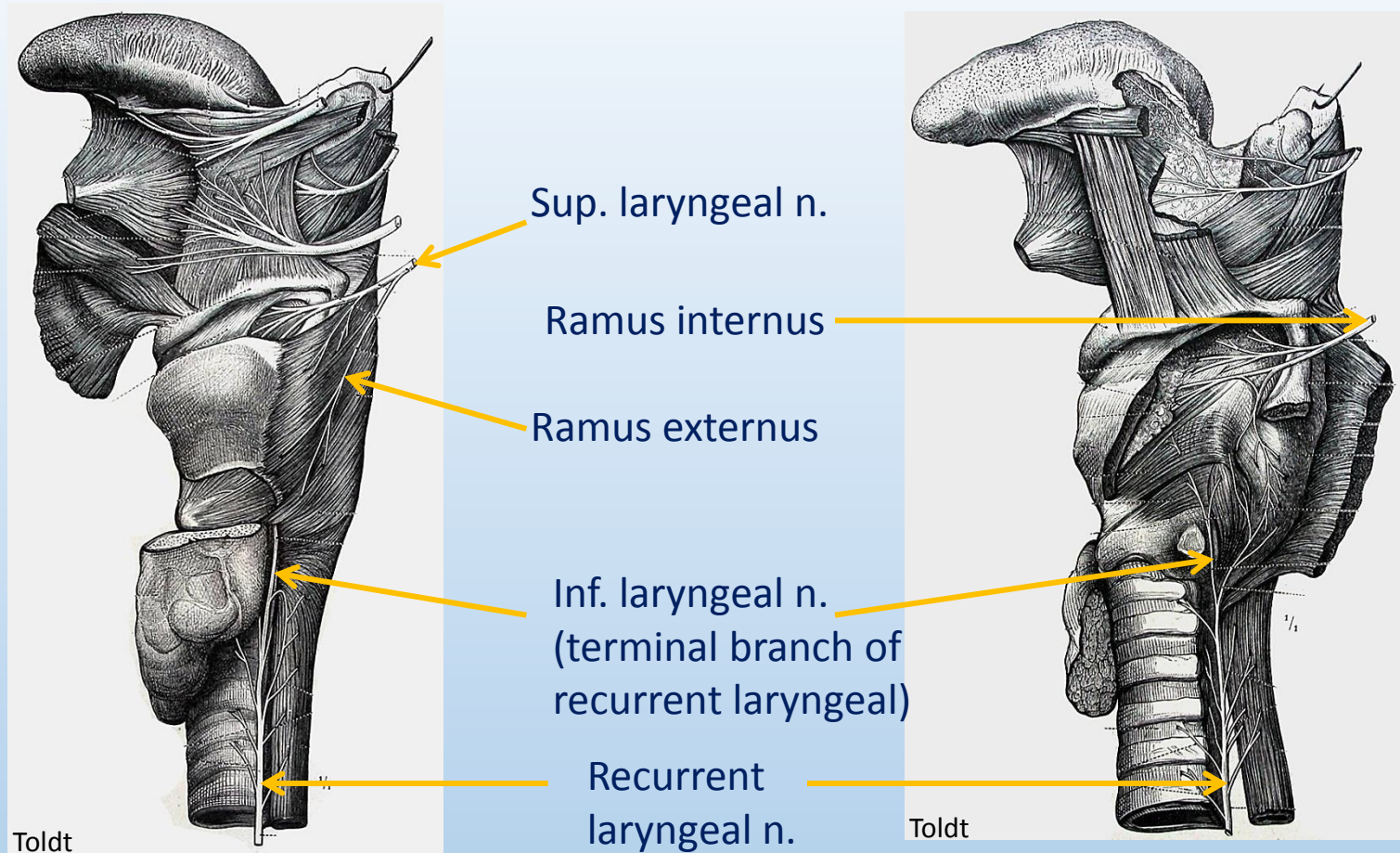
Superior laryngeal a.

(from sup. thyroid a.)

Inferior laryngeal (recurrent laryngeal) n. (X.)

- all internal muscles
- the mucosa under the glottis

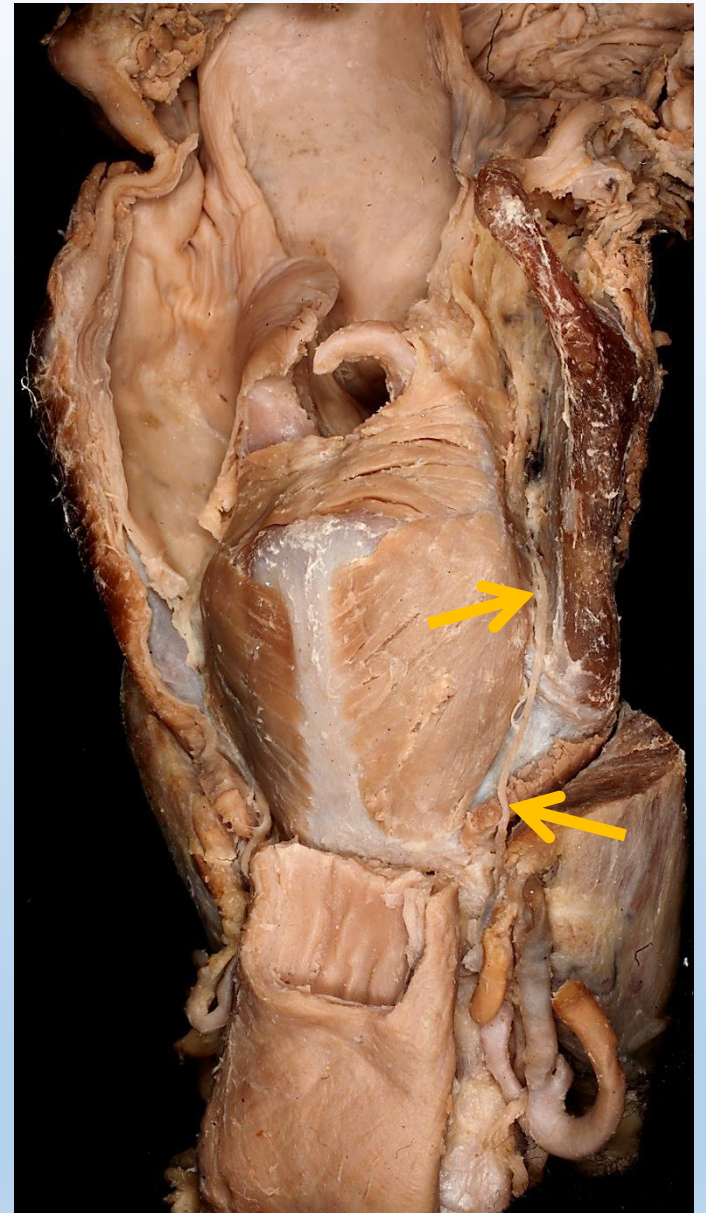
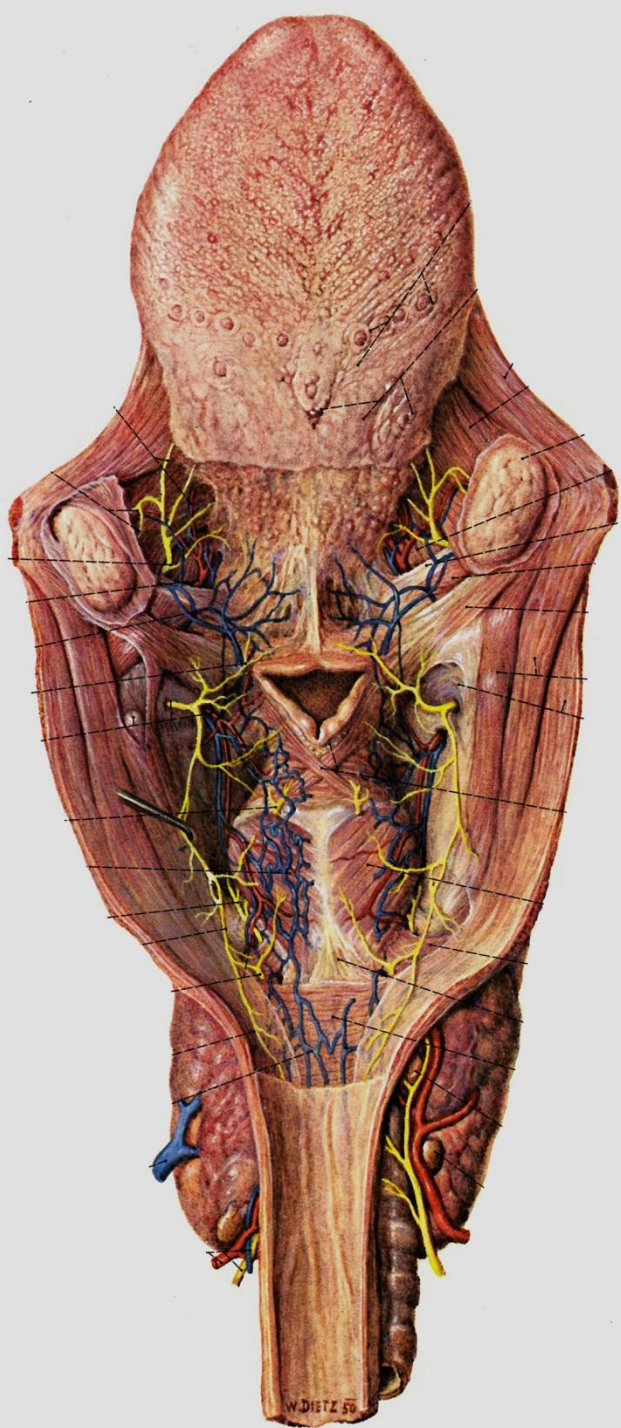
Innervation of laryngeal muscles



Sup. laryngeal n. and recurrent laryngeal n. from vagus n. (X.)

Inferior laryngeal n. Innervation of laryngeal muscles excepting cricothyroid m.

Cricothyroid m: Superior laryngeal n., ramus externus



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Variations of the innervation pattern of laryngeal musculature

Chapter 11

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Understanding the anatomy of the larynx from the era of Gimbernat to the present day moving towards laryngeal transplantation

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SUMMARY

Knowledge of the gross anatomy of the larynx in Spain throughout the period when Gimbernat was working as a surgeon and anatomist was considerable; very much comparable to our present understanding. However, the lack of aseptic surgical technique, anaesthesia, and antibiotics limited the ability to undertake complex surgery. Nevertheless, it was during that period when for first time it became possible to diagnose some laryngeal pathologies, thanks to the invention, by a Spanish singer, Manuel Garcia (1805-1906), of a primitive laryngoscope that made it possible to see the laryngeal interior. Only in 1873 was the first major surgery of the larynx reported when Billroth undertook the first laryngectomy to treat surgically laryngeal carcinoma. It was more than a hundred years later, before the first laryngeal transplantation was attempted by Strome and his team (1998), and though initially meeting with some success, that transplanted larynx had to be removed 14 years later. Based on our current understanding of laryngeal anatomy and surgical technique,

we argue that there are four factors that must be addressed if satisfactory transplantation of the larynx to be achieved: 1) psycho-social and ethical aspects; 2) tissue viability vs. rejection; 3) restoration of a vascular, and 4) selective reinnervation of the larynx has to be achieved. The three first factors are being addressed, however, the selective reinnervation remains challenging because the nerve supply of the larynx is now known to be much more complex than many accounts imply. This is because: 1) each laryngeal muscle may receive a variable number of nerve branches; 2) there are multiple connections between the different laryngeal nerves; 3) many laryngeal nerves and connections are mixed conveying both motor and sensory fibres; and 4) the laryngeal muscles may receive a dual nerve supply, from both the recurrent laryngeal and superior laryngeal nerves.

Key words: Recurrent laryngeal nerve – Internal laryngeal nerve – External laryngeal nerves – Laryngeal vessels – Bonellis – Lacaba

INTRODUCTION

The Spanish anatomist-surgeon Antonio Gimbernat i Arbós was born in 1734 in Cambrils (Tarragona), living until 1816 (Salcedo y Ginstal, 1926, 1927). He worked for most of his professional life in the Royal Colleges of Cadiz, Barcelona and Madrid (Salcedo y Ginstal, 1926, 1927). These Colleges were established with the aim of

whilst others report the development of synkine (Crumley, 2000) and/or the loss of muscular power because the number of motor units has been reduced (Ohya et al., 1972).

DOGMAS OF THE NEUROANATOMY OF THE LARYNX

All the above-mentioned problems with the laryngeal reinnervation arise as the consequence of four dogmas about innervation of the larynx that persist, despite the fact that evidence from modern studies have shown that these dogmas are misconceptions based upon weak or insubstantial evidence.

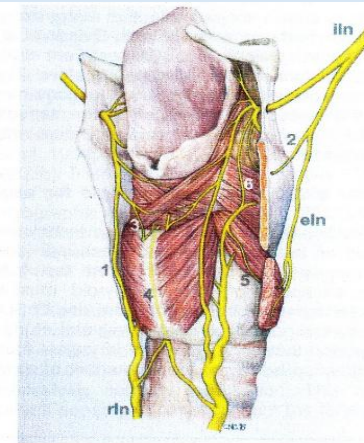


Fig. 1. Drawing of a posterolateral view of the larynx showing the laryngeal neural connections (published by Sañudo et al., 1999). Abbreviations: **eln**, external branch of superior laryngeal nerve; **iln**, internal branch of superior laryngeal nerve; **rln**, inferior laryngeal or recurrent nerve; **1**, Ramus communicans (Galen' connection); **2**, Foramen thyroideum connection; **3**, Superficial arytenoid plexus; **4**, Cricoid connection; **5**, Cricoid connection; **6**, Thyroarytenoid connection.

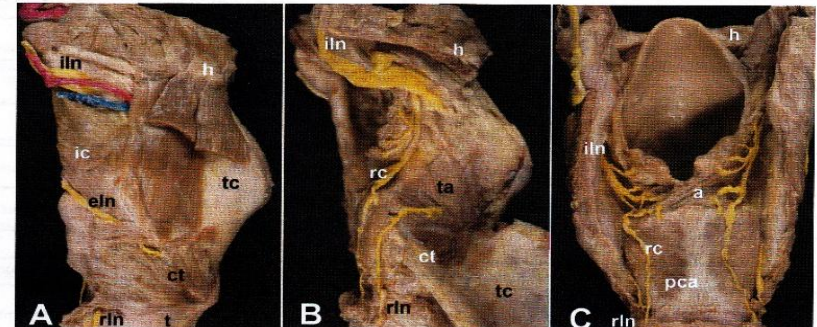


Fig. 2. Muscles and nerves of the larynx. **A**, External right lateral view of the larynx; **B**, the lamina of thyroid cartilage has been reflected back down to show the laryngeal muscles; **C**, Posterior view of the larynx. Abbreviations: **a**, arytenoid muscle; **ct**, cricothyroid muscle; **eln**, external branch of superior laryngeal nerve; **h**, hyoid bone; **ic**, inferior constrictor muscle of the pharynx; **iln**, internal branch of superior laryngeal nerve; **pca**, posterior cricoarytenoid muscle; **rca**, Ramus communicans (Galen' connection); **rln**, inferior laryngeal or recurrent nerve; **t**, trachea; **ta**, thyroarytenoid muscle; **tc**, thyroid cartilage;

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Variations of the innervation pattern of laryngeal musculature

Table 3. Dual motor nerve supply of the laryngeal muscles reported in humans. Based on the studies published by Wustrow et al. (1988), Wu et al. (1994), Martín-Oviedo et al. (2011), Masuoka et al. (2016) and Pascual-Font et al. (2016).

MUSCLE	MAIN NERVE SUPPLY	SECONDARY NERVE SUPPLY
Thyroarytenoid	Anterior branch of RLN	IbSLN EbSLN
Posterior cricoarytenoid	Anterior branch of RLN	IbSLN EbSLN
Lateral cricoarytenoid	Anterior branch of RLN	IbSLN
Interarytenoid (Oblique and transverse)	Anterior branch of RLN	IbSLN
Cricothyroid	External branch of SLN	IbSLN Anterior branch of RLN

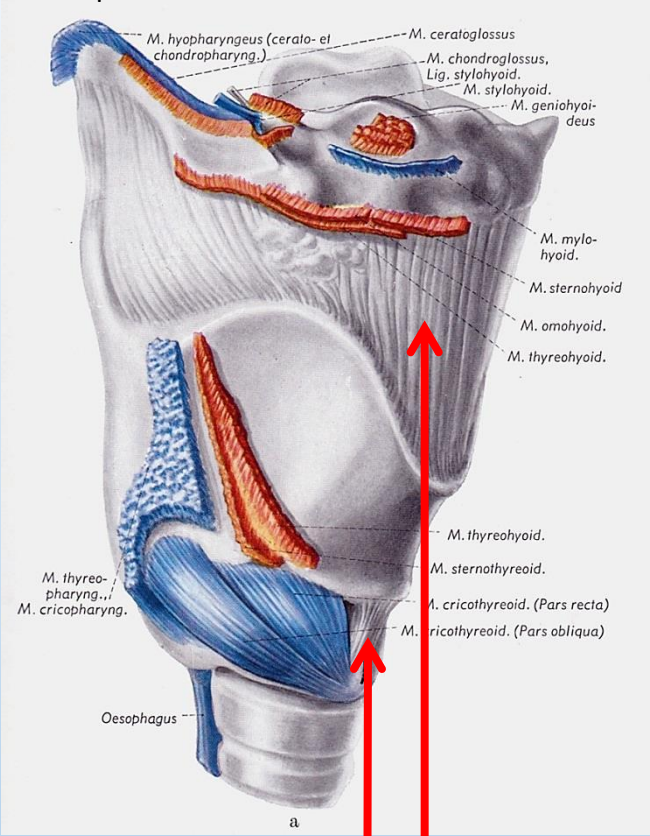
EbSLN, external branch of the superior laryngeal nerve; **IbSLN**, internal branch of superior laryngeal nerve; **RLN**, recurrent laryngeal nerve.



Fig. 2. Muscles and nerves of the larynx. **A**, External right lateral view of the larynx; **B**, the lamina of thyroid cartilage has been reflected back down to show the laryngeal muscles; **C**, Posterior view of the larynx. Abbreviations: **a**, arytenoid muscle; **ct**, cricothyroid muscle; **eln**, external branch of superior laryngeal nerve; **h**, hyoid bone; **ic**, inferior constrictor muscle of the pharynx; **iln**, internal branch of superior laryngeal nerve; **pca**, posterior cricoarytenoid muscle; **Ramus communicans** (Galen' connection); **rln**, inferior laryngeal or recurrent nerve; **t**, trachea; **ta**, thyroarytenoid muscle; **tc**, thyroid cartilage;

Ligaments

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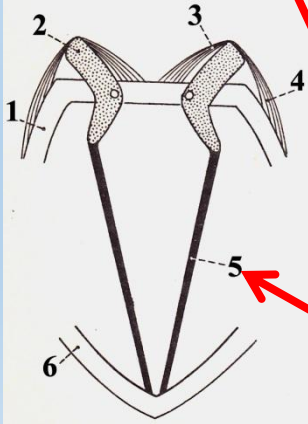
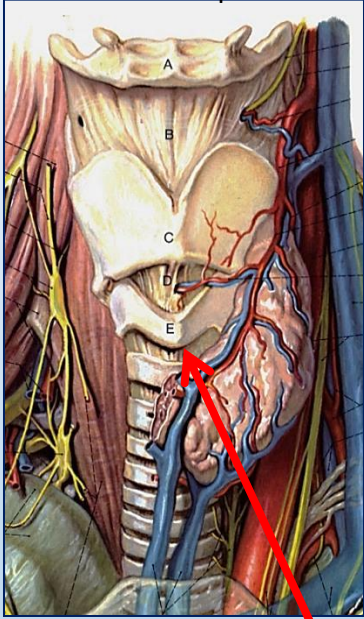


Thyrohyoid membrane comprising the medial and lateral thyrohyoid lig.

Conus elasticus comprising the medial cricothyroid (conical) lig.

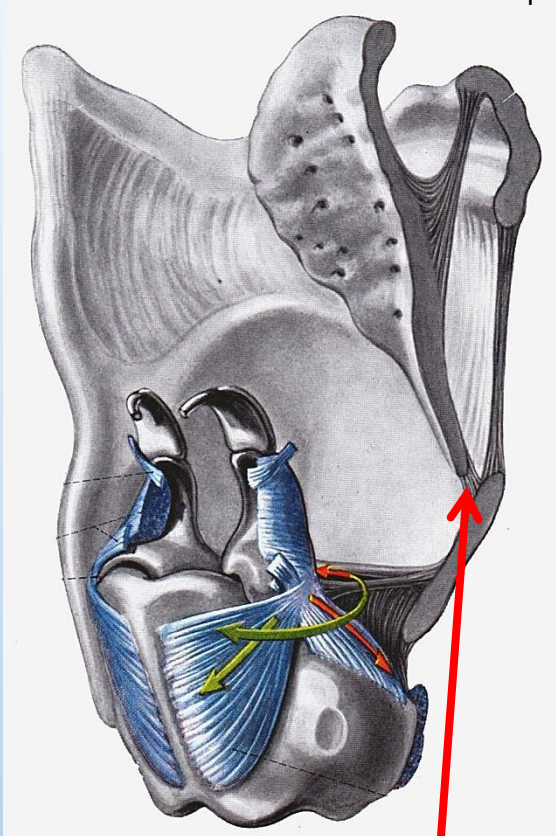
CONIOTOMY

Pernkopf

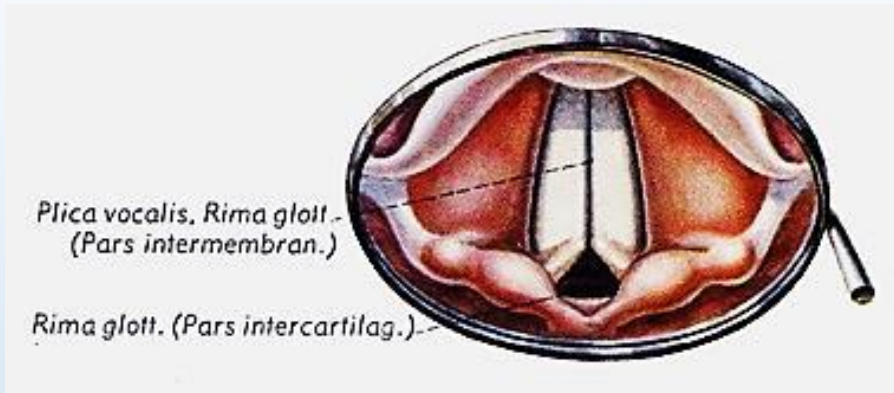


Kiss

Pernkopf



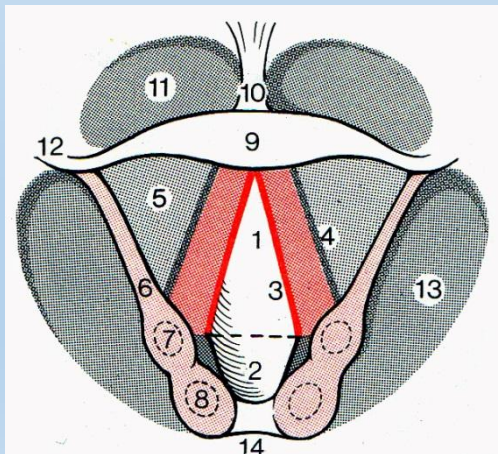
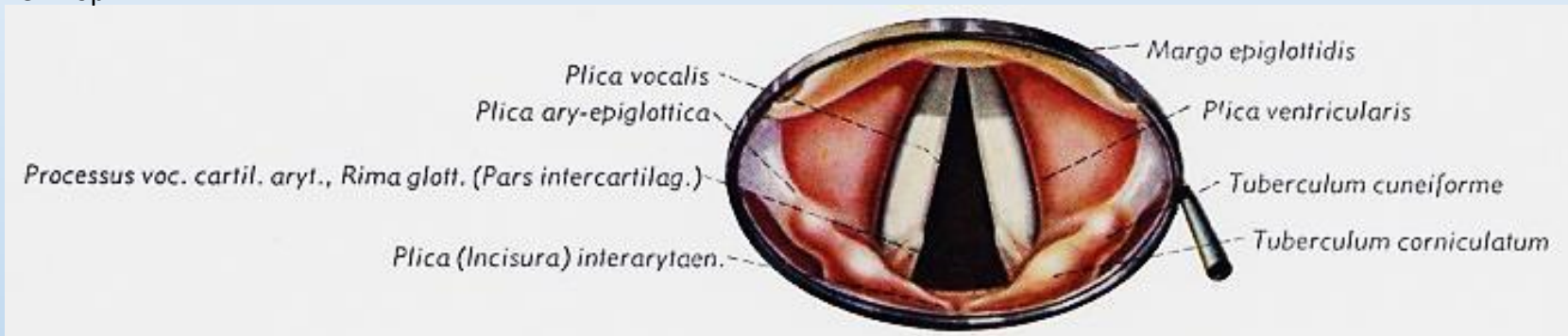
Thyroepiglottic lig.
 Corniculopharyngeal lig.
 Cricotracheal lig.
 Vocal lig.



Rima glottidis = **Glottis**

1. Pars intermembranacea = Glottis Phonatoria
2. Pars intercartilaginea = Glottis Respiratoria

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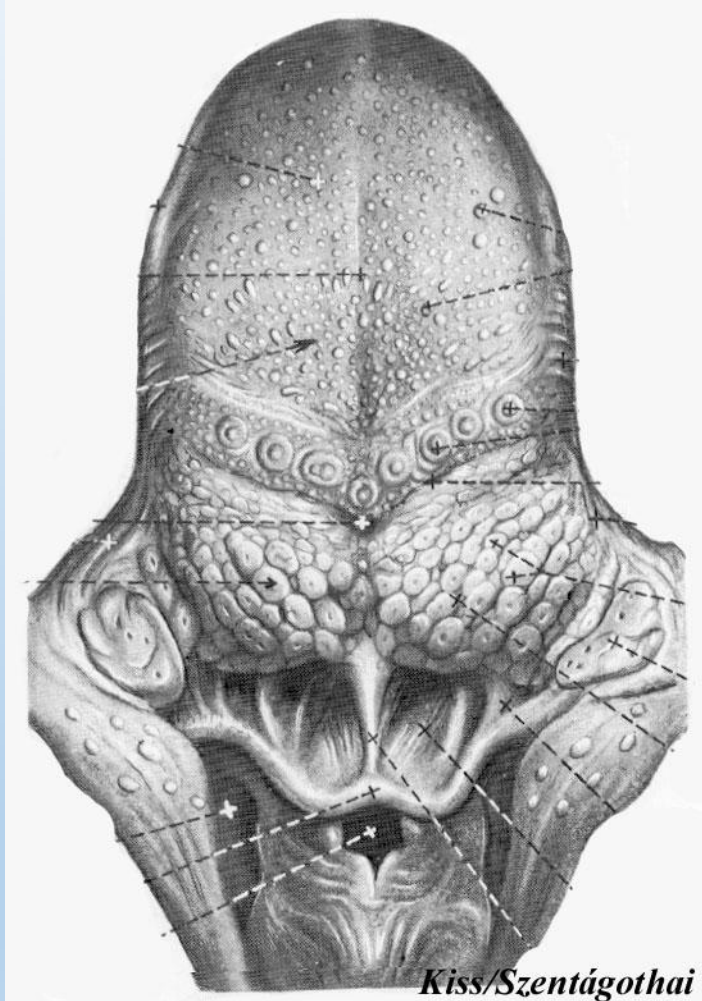


- 7. Cuneiform cartilage (*Wrisberg*) → Cuneiform tubercle
- 8. Corniculate cartilage (*Santorini*) → Corniculate tubercle
- 9. Epiglottis
- 10. Median glossoepiglottic fold

Faller

ISTHMUS OF THE FAUCES

EPIGLOTTIS



EPIGLOTTIS

Glossoepiglottic folds

Vallecula epiglottica

PIRIFORM RECESS

Plica nervi laryngei

ADITUS LARYNGIS

Aryepiglottic folds

Cuneiform tubercle (Wrisberg)

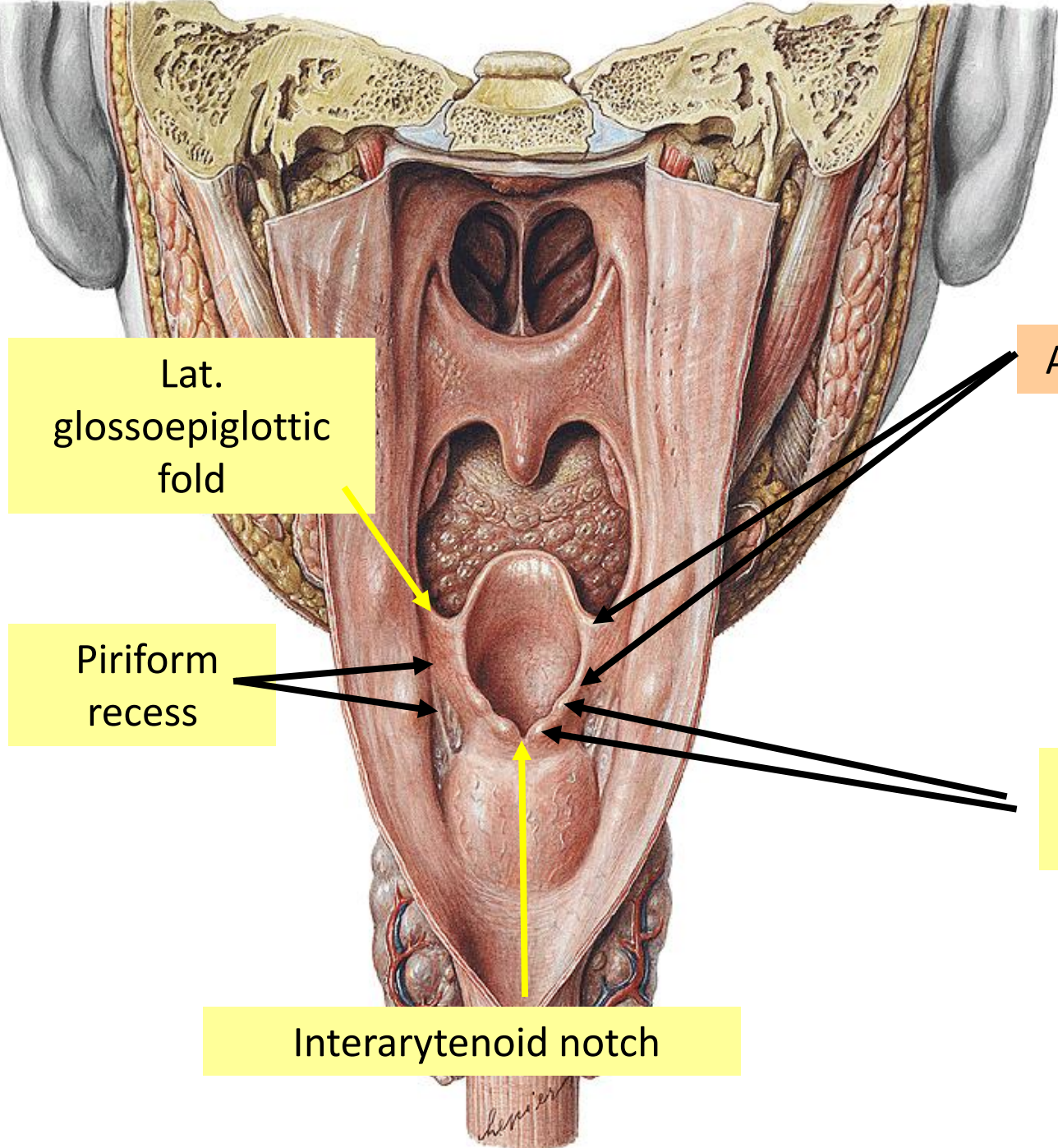
Corniculate tubercle (Santorinus)

Interarytenoid notch

Stratified squamous non-keratinizing vs. pseudostratified ciliated epith.

ADITUS LARYNGIS

(Laryngeal inlet)



Lat.
glossoepiglottic
fold

Piriform
recess

Interarytenoid notch

Aryepiglottic fold

Corniculate
and cuneiform tubercles

FIBRO-ELASTIC MEMBRANES OF LARYNX

Epiglottis

Quadrangular membrane

Plica vestibularis

Plica vocalis

Triangular membrane

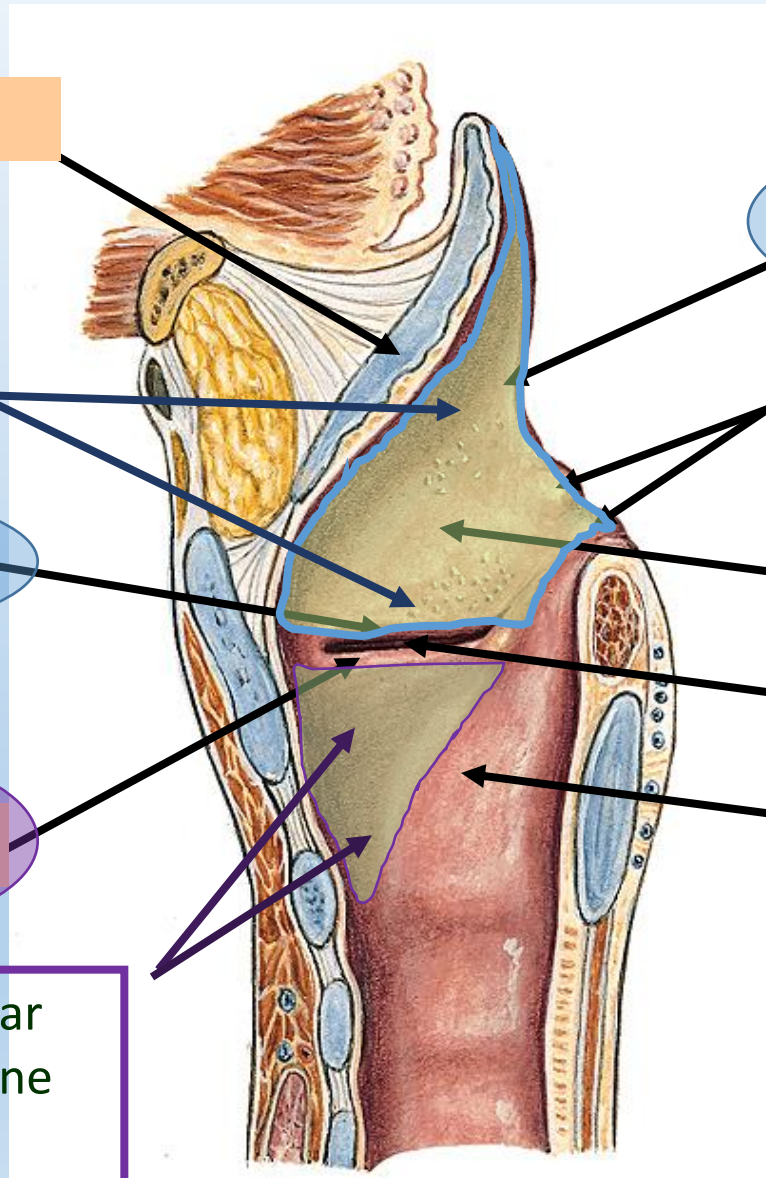
Plica aryepiglottica

Tuberculum corniculatum et cuneiforme

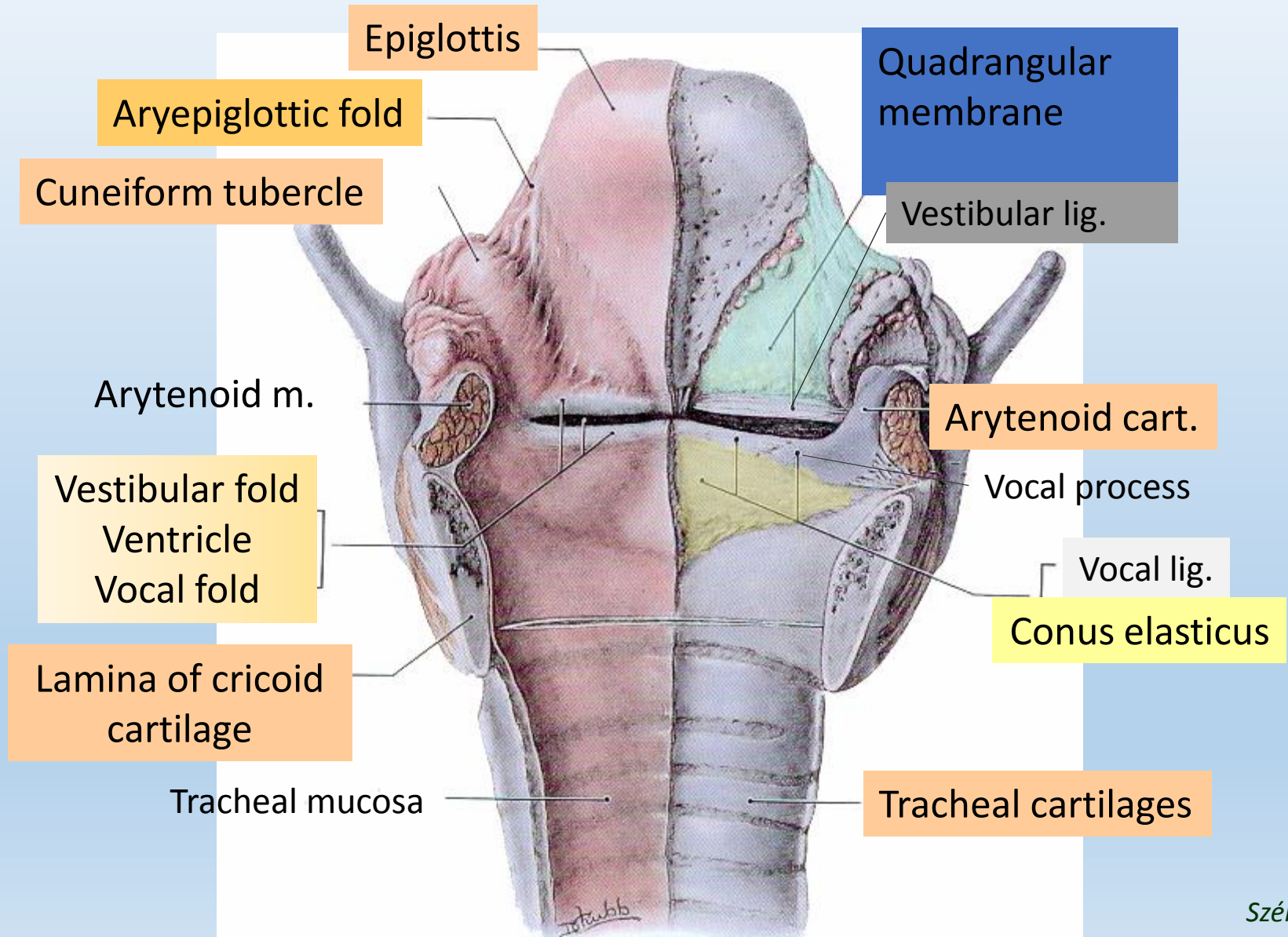
Laryngeal vestibule

Ventricle (laryngeal sinus)

Subglottal (infraglottal) space

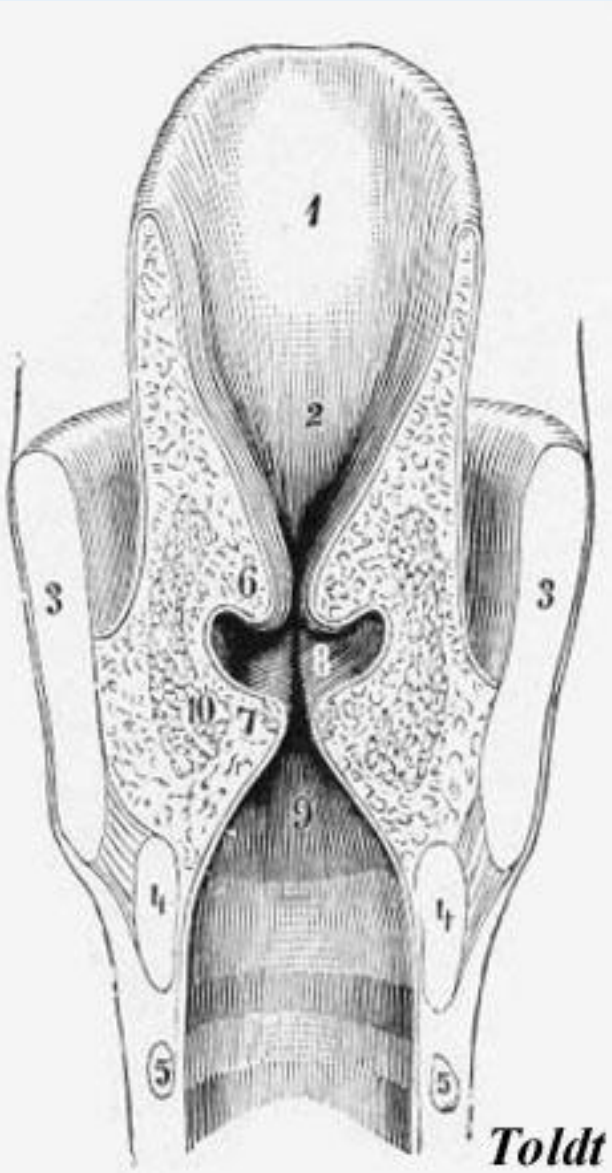


MEMBRANA FIBRO-ELASTICA LARYNGIS



GLOTTIS

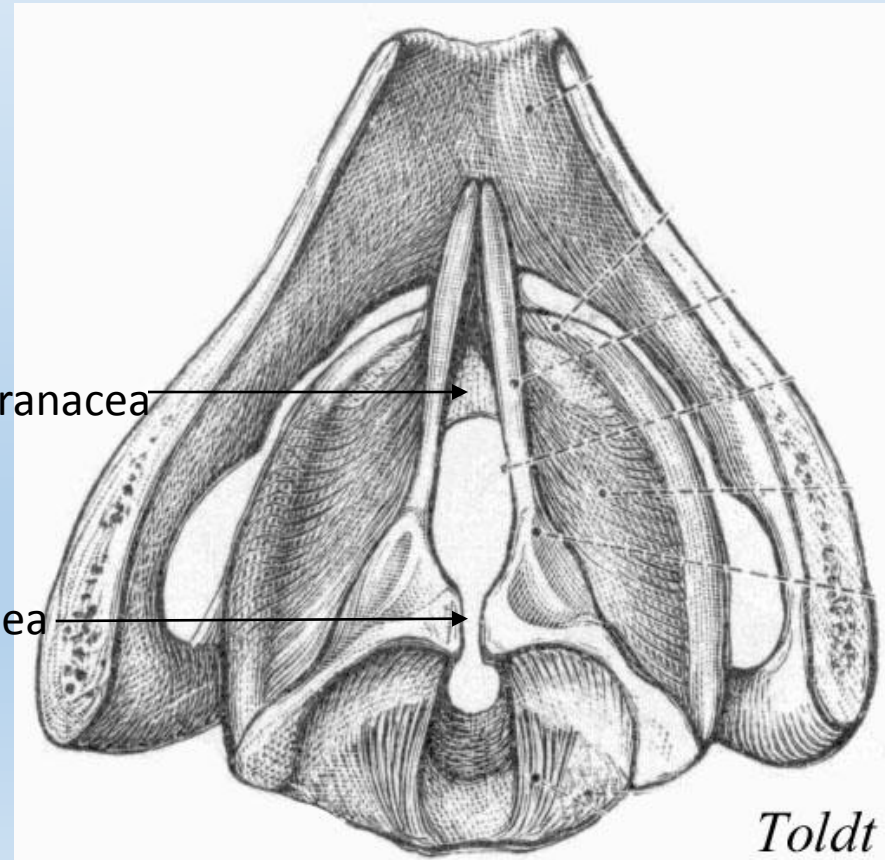
Laryngeal structures forming the boundaries of glottis



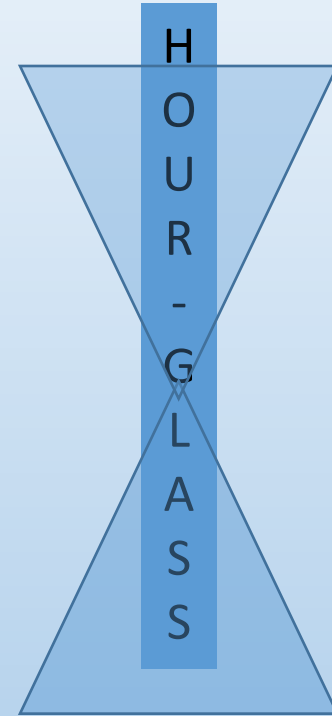
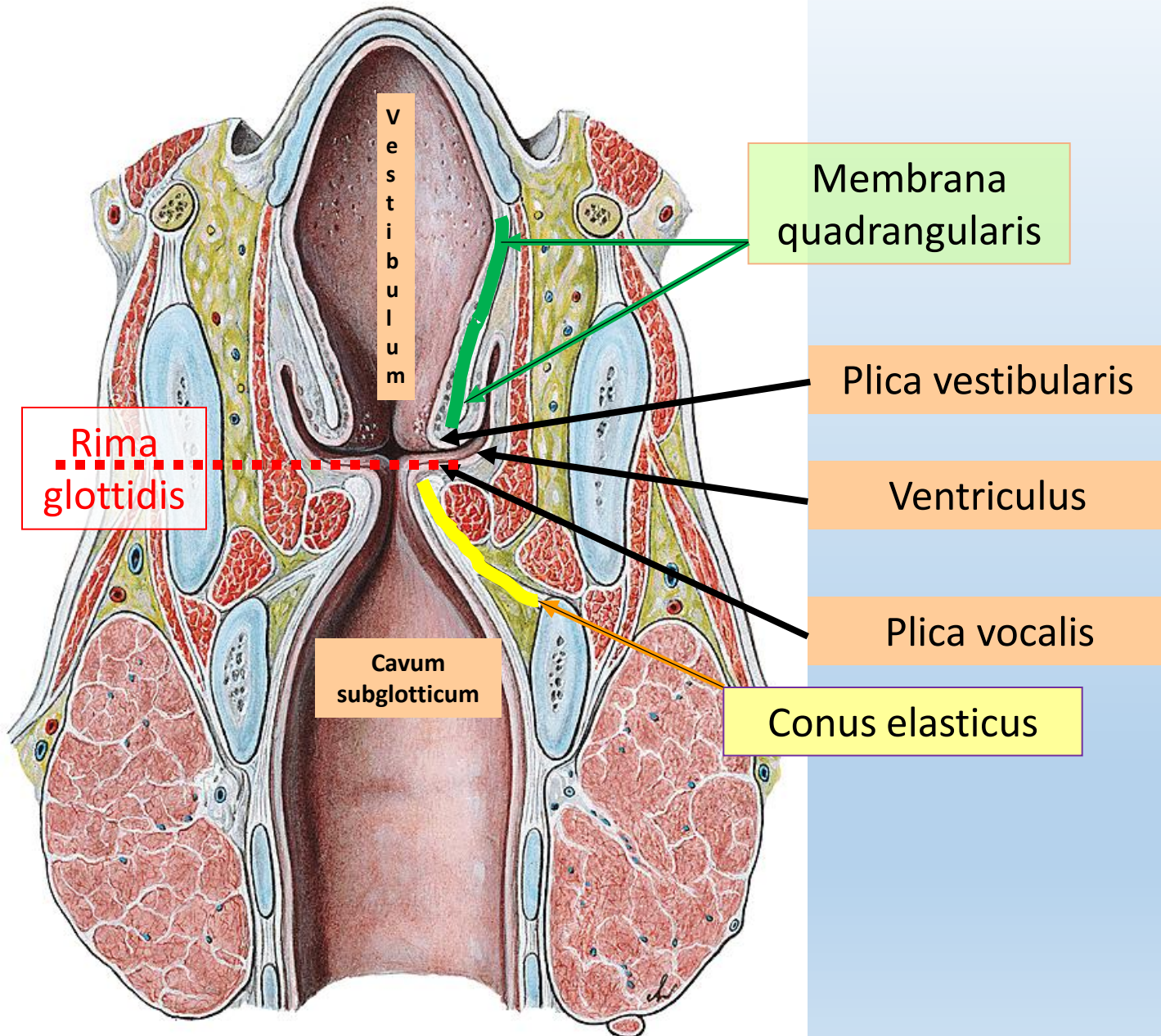
Rima glottidis
2-2,5 cm long
0,5-1,5 cm wide

Pars intermembranacea

Pars intercartilaginea



MUCOSA OF LARYNX



MICROSCOPY OF LARYNX

Laryngeal vestibule

Respiratory' epithelium
Loose connective tiss. (Oedema!)
Seromucous glands
Quadrangular membrane

Level of vocal folds

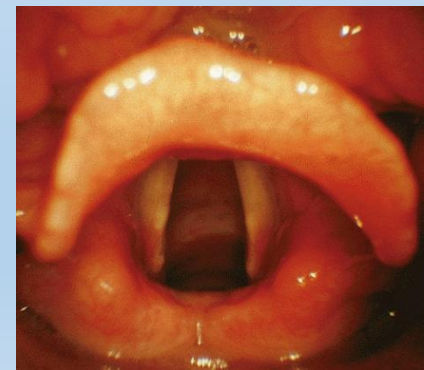
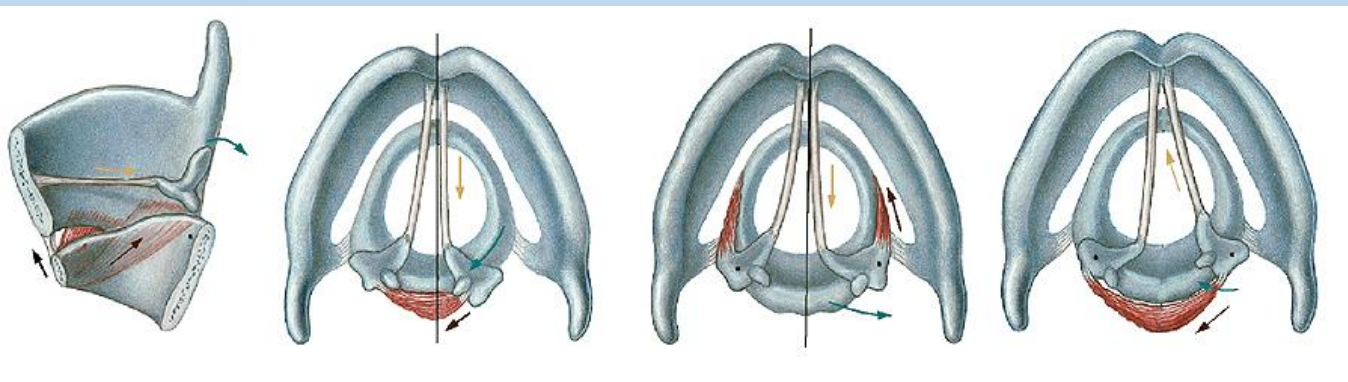
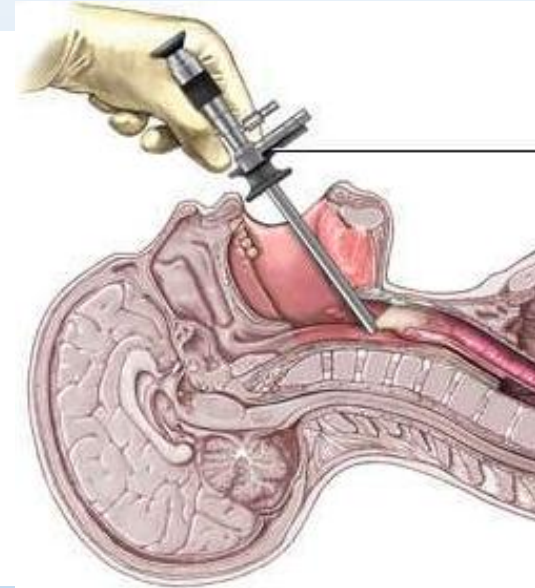
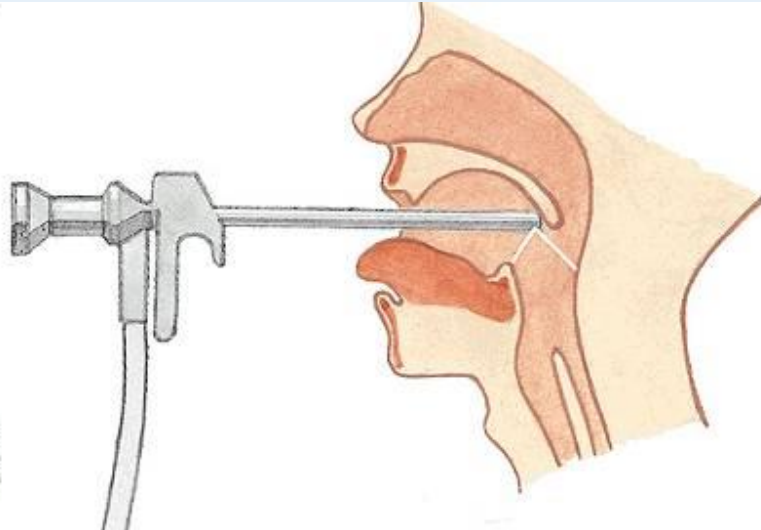
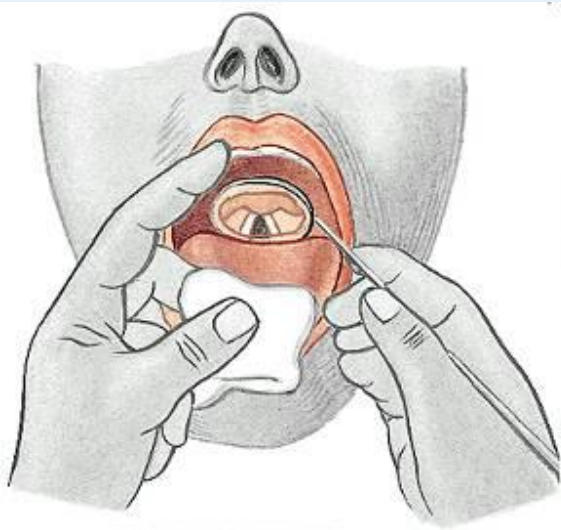
Stratified non-keratinizing squamous epithelium
Connective tissue tightly adherent to vocal folds
No glands
Robust muscle (M. vocalis)
Triangular membrane



Sacculus laryngis
(Sound amplifier)

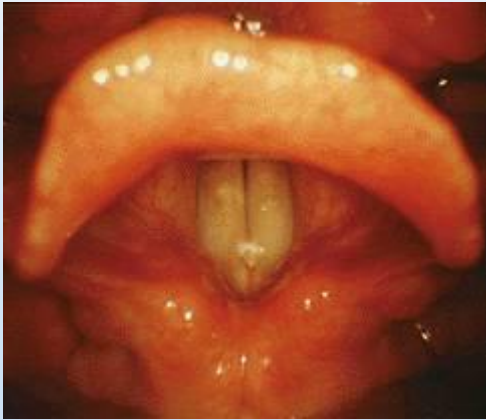
Toldt

LARYNGOSCOPY

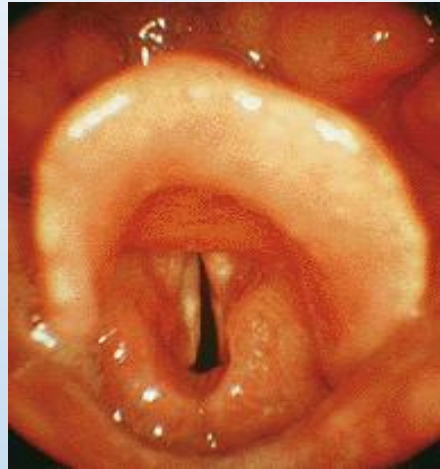


LARYNGOSCOPY

View of normal glottis



Normal speech



Whispering



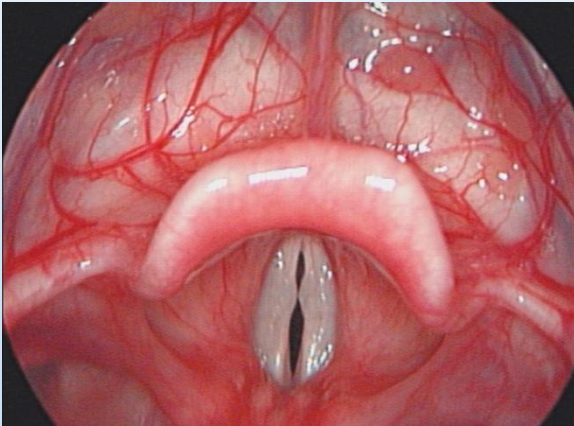
Forced inspiration
(glottis wide open)



Phonation

LARYNGOSCOPY

View of pathological glottis



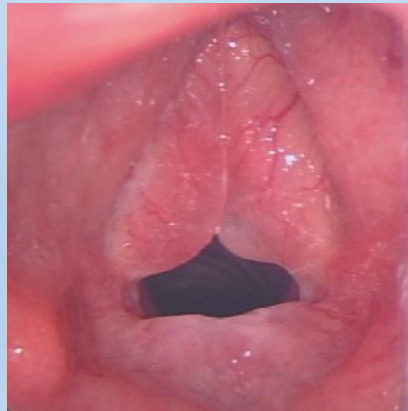
Vocal cord nodule = Fibroma



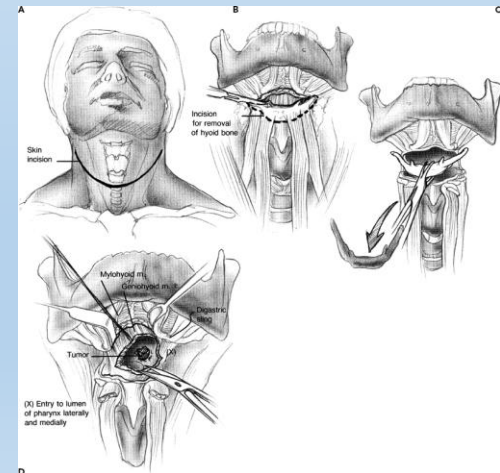
Laryngeal cancer



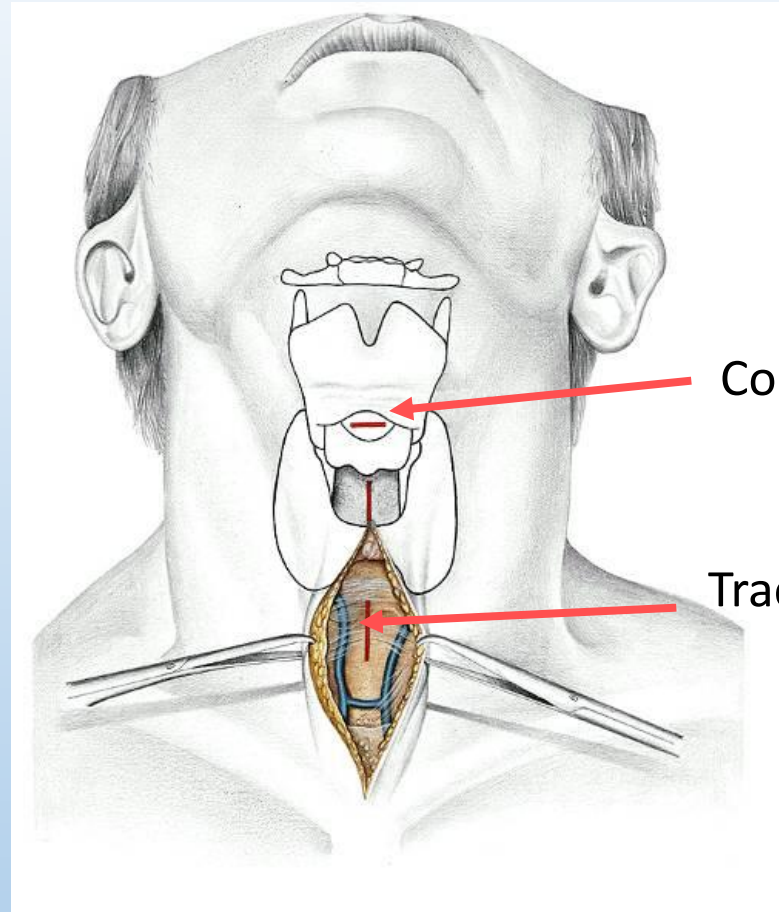
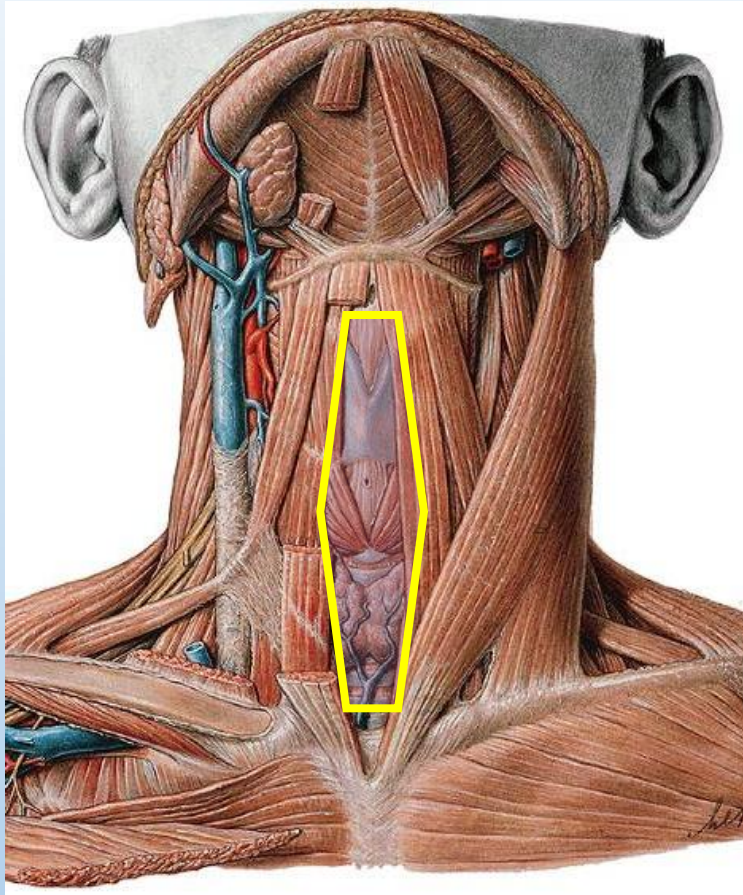
Polypus



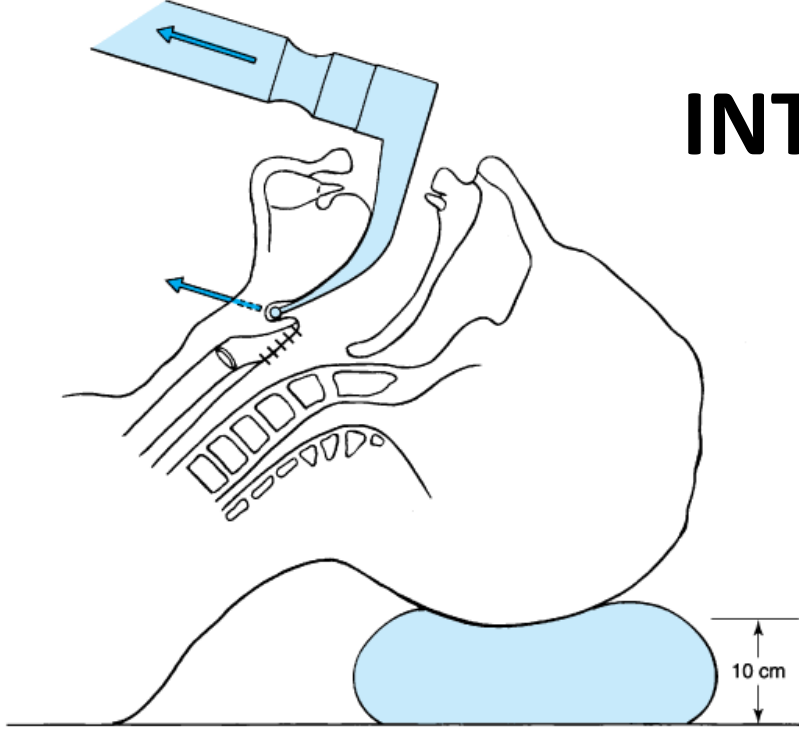
Reinke's
Oedema



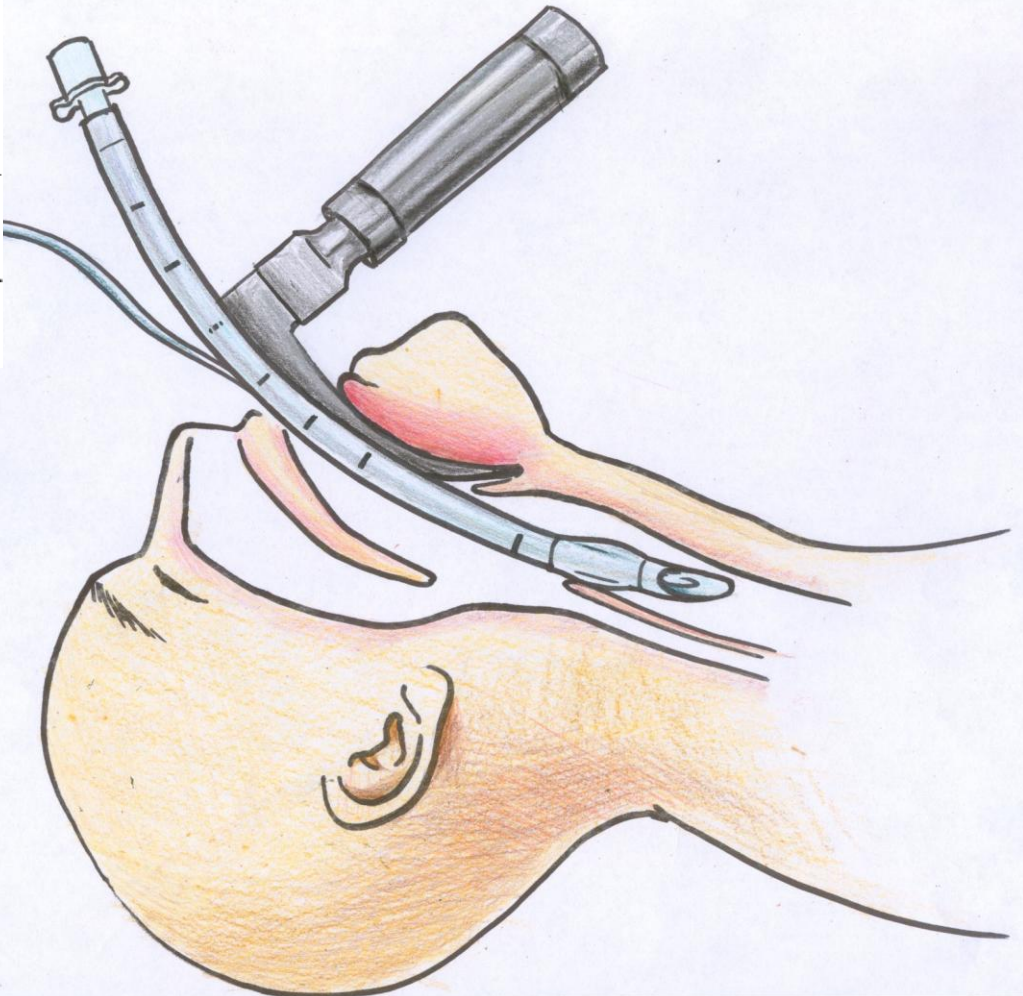
MIDDLE CERVICAL REGION



INTUBATION



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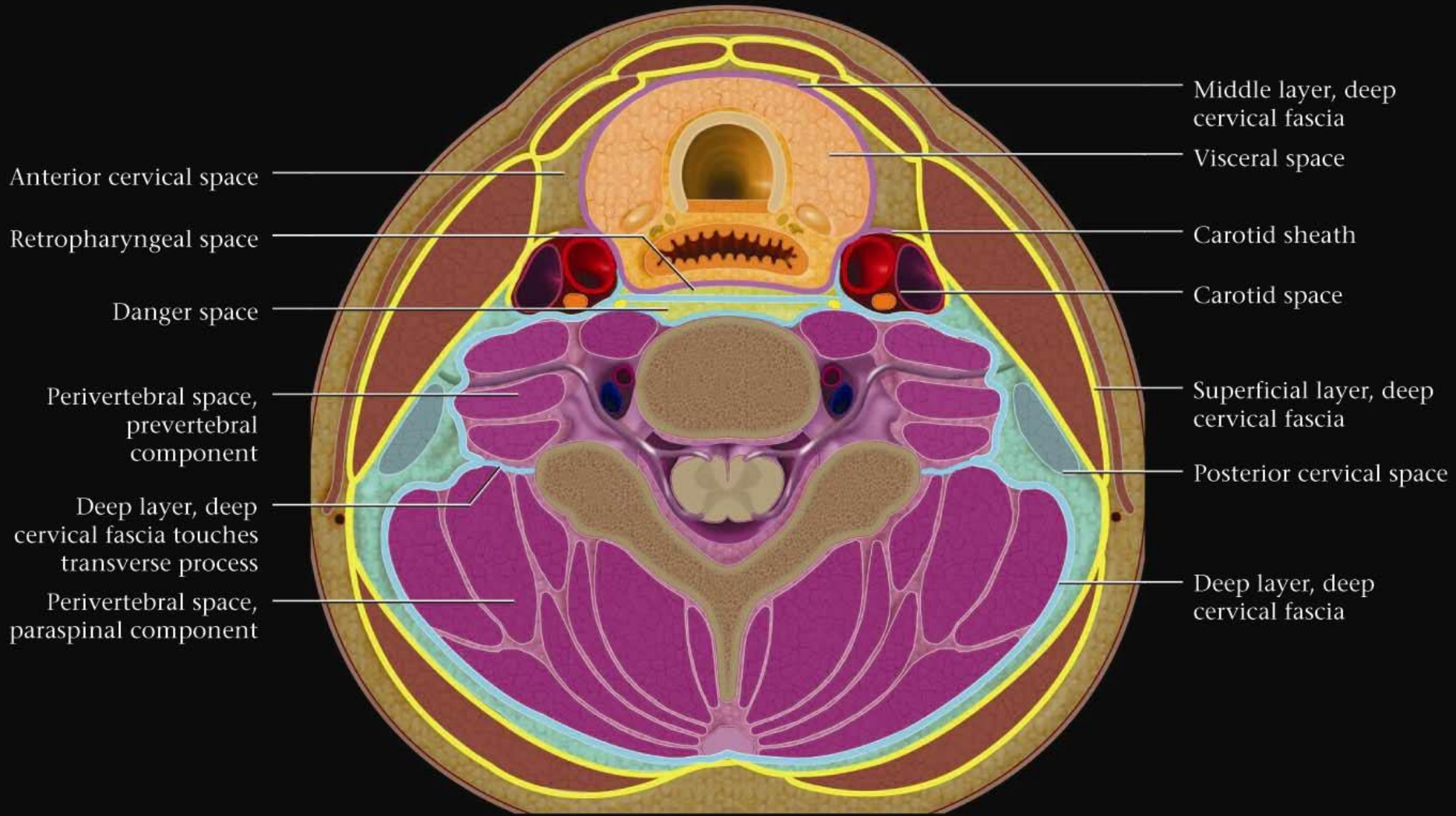


Courtesy of Dr Peter Magyar

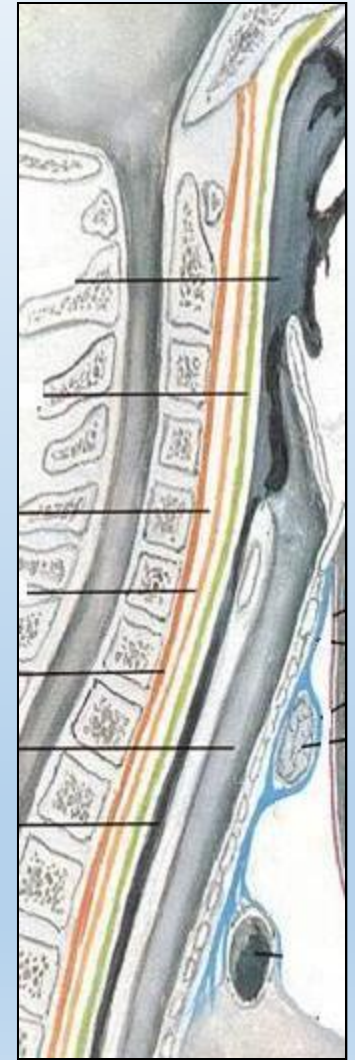
Anterior visceral space

Anterior cervical space

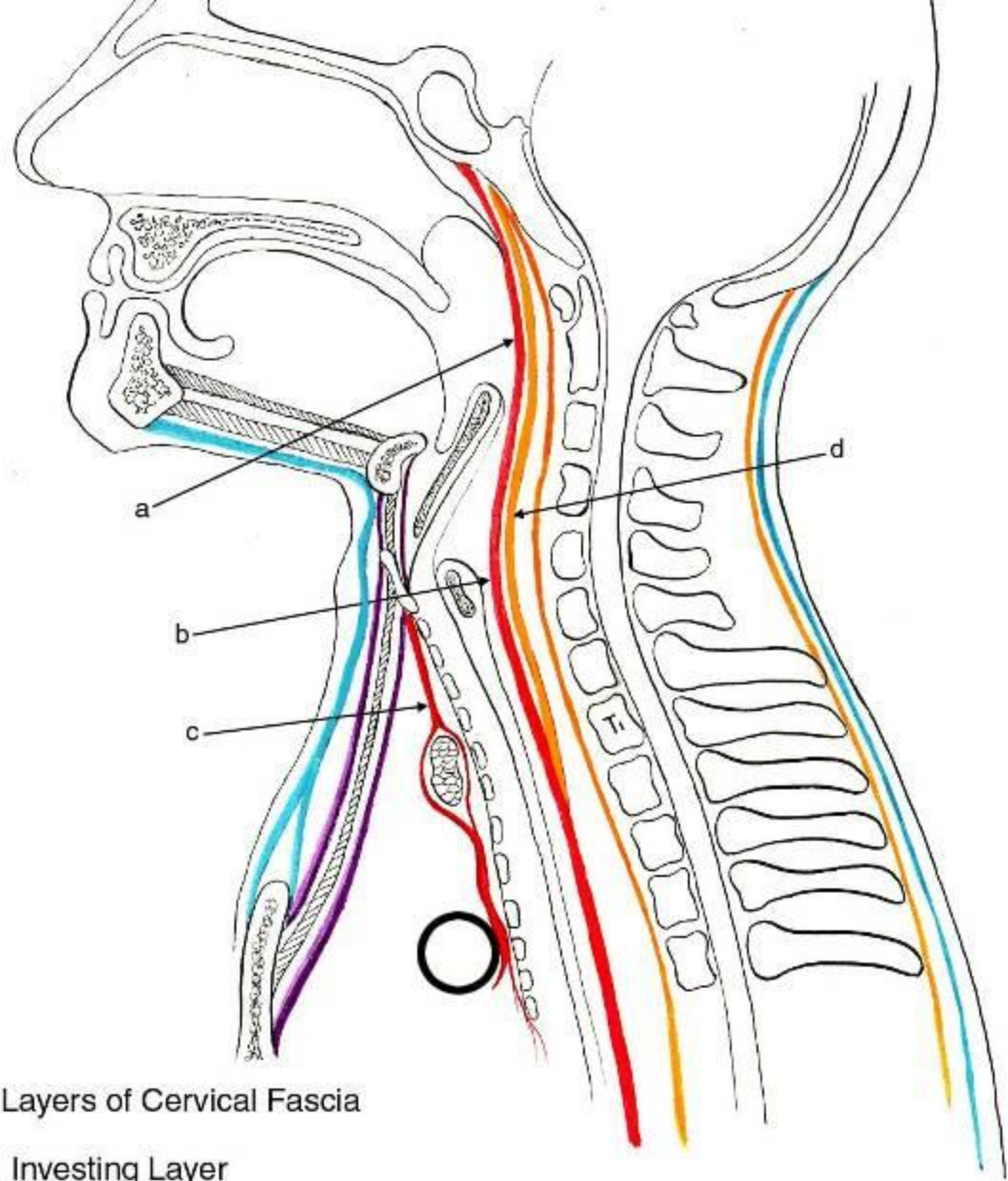
Posterior cervical space



- Anterior border: alar fascia
Posterior border: prevertebral fascia
- From skull base to diaphragm



Sagittal plane



Deep Layers of Cervical Fascia

- Investing Layer
- Middle Layer
- Visceral Layer
- Vertebral Layer
- d- Alar fascia
- a- Pharyngeal fascia
- b- Retrovisceral (esophageal) fascia
- c- Pretracheal fascia