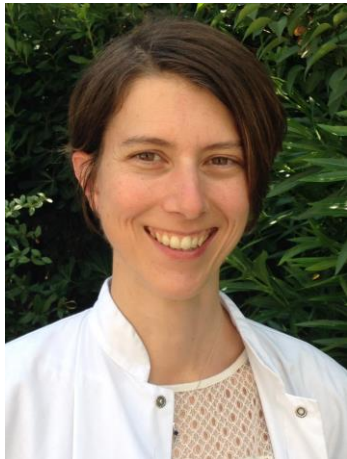


# Laryngeal reinnervation: from the accurate diagnosis to the accurate treatment



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# Introduction

- Laryngeal reinnervation
  - Evolution since the 80's
  - Pr Jean-Paul Marie, Rouen, France
  - Very interesting results
    - Unilateral et and bilateral
- The accurate diagnosis of laryngeal immobility
  - Become critical with the emergence of specific surgeries
  - Depending of the cause
- Precising the different types of vocal fold immobility
  - Mandatory in daily practice
  - High differences in the early management



# Cancer of the larynx and laryngeal immobility/hypomobility

- Pronostic value of the vocal fold fixation (TNM, 17)
  - Definition of T3 in non-glottic larynx cancers
  - More subtle analysis of the vocal fold mobility in glottic cancer.
    - Physiopathology non precised (neurogenic or mechanical motion impairment)

Out of our topic

<b>GLOTTIS</b>		
( ) T1	Tumor limited to the vocal cord (anterior or posterior commissure) with normal mobility	( ) T1
( ) T1a	Tumor limited to one vocal cord	( ) T1a
( ) T1b	Tumor involves both vocal cords	( ) T1b
( ) T2	Tumor extends to the supraglottis, and/or with impaired vocal cord mobility	( ) T2
( ) T3	Tumor limited to the glottis with vocal cord fixation and/or invasion of paraglottic space, and/or inner cortex of thyroid cartilage	( ) T3
( ) T4	Moderately advanced local disease	( ) T4
( ) T4a	<u>Moderately advanced local disease</u> . Tumor invades through the outer cortex of the thyroid cartilage and/or invades tissues beyond the larynx (e.g., trachea, soft tissues of neck including deep extrinsic muscle of the tongue, strap muscles, thyroid or esophagus)	( ) T4a
( ) T4b	<u>Very advanced local disease</u> . Tumor invades prevertebral space, encases carotid artery, or invades mediastinal structures	( ) T4b

# Laryngeal examination

```
graph TD; A([Laryngeal examination]) --> B[Laryngeal immobility/Laryngeal hypomobility];
```

Laryngeal immobility/Laryngeal hypomobility

- First step: observation
- No etiological interpretation

# How to diagnose laryngeal immobility/hypomobility?

- Laryngeal examination:
  - Voluntary tasks of adduction (phonation, cough)
  - Voluntary tasks of abduction (sniff)
  - Alternative voluntary adduction/abduction (/i/-sniff)
  - Vegetative/unvoluntary tasks: laugh, swallow, reflexive cough
  - Voluntary tasks of elongation (singing voice)
- Nasal flexible endoscopy > oral approaches
  - Awake , relaxed patient,
  - Natural and comfortable position

# Laryngeal immobility

- Laryngeal immobility:
  - Absence of gross adduction/abduction motion in the full vocal fold (cartilaginous and membranous)
  - Focus on the vocal process
  - Or posterior part of membranous part when non visible (anterior tilt of the arytenoid)
- Precisions
  - Median, paramedian, lateral,
  - Foreshortened vocal fold
  - Sub-vertical drop
  - Position of the arytenoid



# Laryngeal immobility/laryngeal hypomobility

- Laryngeal hypomobility:
  - Reduced range and/or speed of adduction/abduction
  - Reduced rest tension
  - Lack of elongation, anterior commissure rotation
- Compared with the controlateral vocal fold when unilateral disturbance
  - Degree of hypomobility can be precised
  - Stroboscopic finding (debated)
- Diagnosis quite uneasy
  - Excellent inter-rater reliability for the diagnosis when definition is clear (Madden I, Rosen CA)
  - Almost 40% errors in the designation of the pathologic side in trainees, <10% in expert (Isseroff et al.)

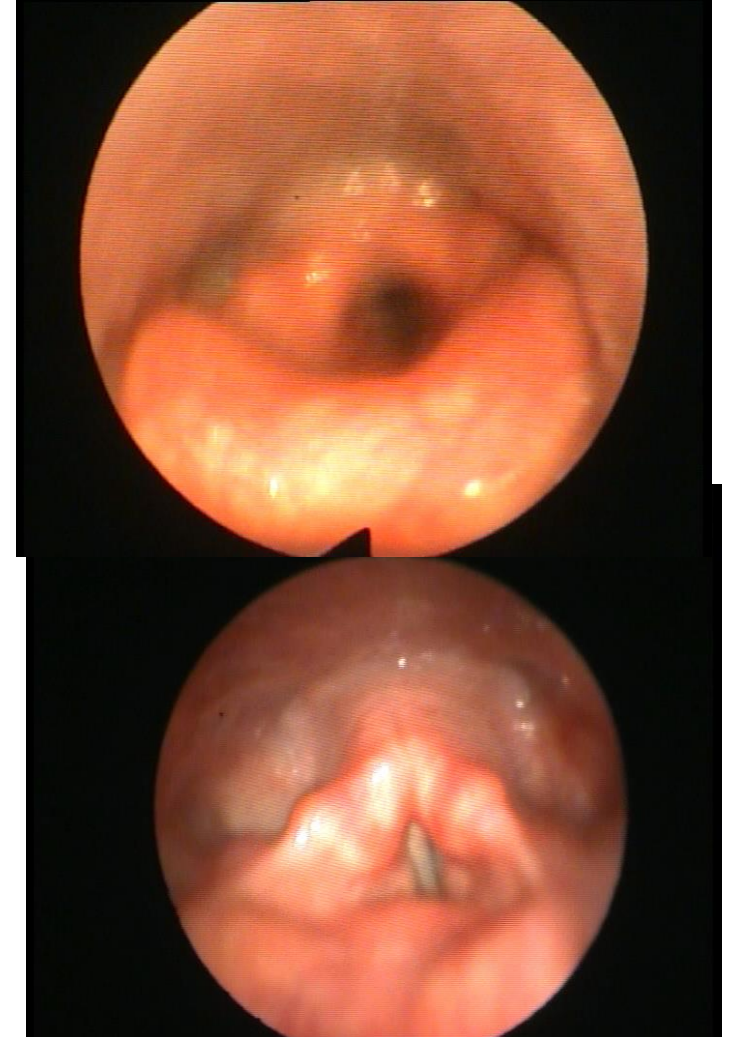


Mettre à la place Mme Noel fabienne



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Laryngeal examination

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graph TD; A([Laryngeal examination]) --> B[Laryngeal immobility/Laryngeal hypomobility]; B --> C([2nd step: interpretation  
Medical history, ad hoc investigation]); C --> D[Paralysis/paresis vs Mechanical immobility/hypomobility];
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Laryngeal immobility/Laryngeal hypomobility

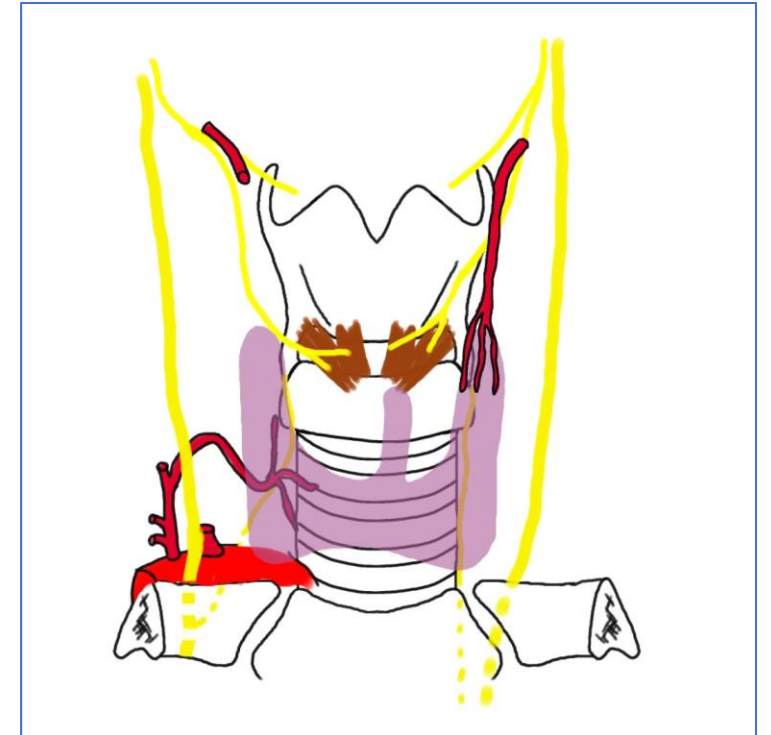
2<sup>nd</sup> step: interpretation  
Medical history, ad hoc investigation

Etiological orientation

Paralysis/paresis vs Mechanical immobility/hypomobility

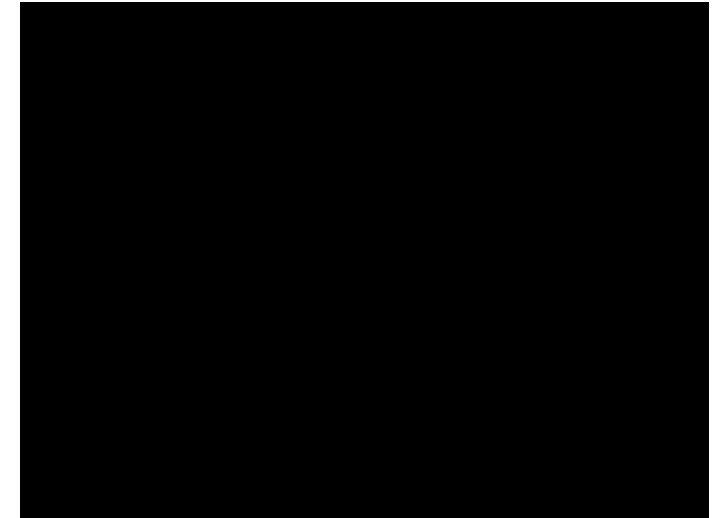
# Neurogenic laryngeal immobility/hypomobility

- Neurogenic impairment
  - Strongly suspected in the medical history
  - Confirmed with LEMG
- Laryngeal paralysis = Neurogenic laryngeal immobility
  - Absence of gross motion
  - Small degree of arytenoid movement with contraction of the IA muscle
- Laryngeal paresis = Neurogenic laryngeal hypomobility
  - Impaired range or speed of VF adduction and/or abduction and/or elongation



# Neurogenic laryngeal immobility/hypomobility

- Localization of the nervous lesion
  - Vagus nerve
    - Pharynx paresis
    - VF ab/ad-duction impairment, VF tension impairment
    - Loss of sensibility in pharynx and larynx
  - Recurrent laryngeal nerve
    - Ab/adduction impairment
  - Superior laryngeal nerve
    - VF tension impairment, ie. loss of high pitch voice (falsetto)
    - Asymetry of tension at rest or during phonation
    - Rotation of larynx axis in phonation
- Etiologic investigations mandatory
  - Imaging, neurological examination



Mettre ici Mr ruten

# Neurogenic laryngeal immobility/hypomobility

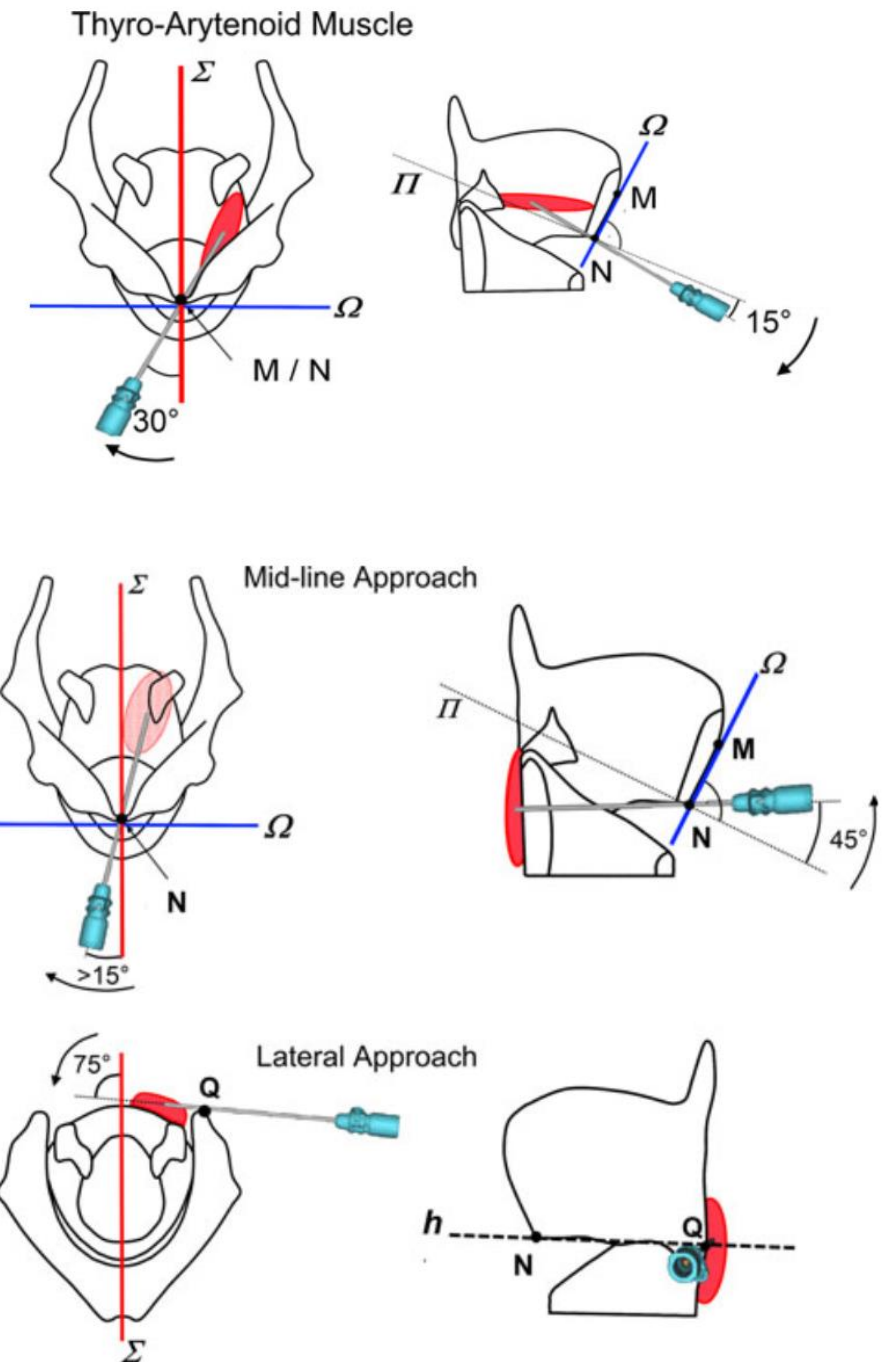
- Confirmed by LEMG
  - On both sides,
  - Of at least TA, CT and PCA
- Percutaneous approach

Eur Arch Otorhinolaryngol (2012) 269:2227–2245  
DOI 10.1007/s00405-012-2036-1

LARYNGOLOGY

## Laryngeal electromyography: a proposal for guidelines of the European Laryngological Society

Gerd Fabian Volk · Rudolf Hagen · Claus Pototschnig · Gerhard Friedrich · Tadeus Nawka · Christoph Arens · Andreas Mueller · Gerhard Foerster · Mira Finkensieper · Ruth Lang-Roth · Christian Sittel · Claudio Storeck · Maria Grosheva · M. Nasser Kotby · Carsten M. Klingner · Orlando Guntinas-Lichius



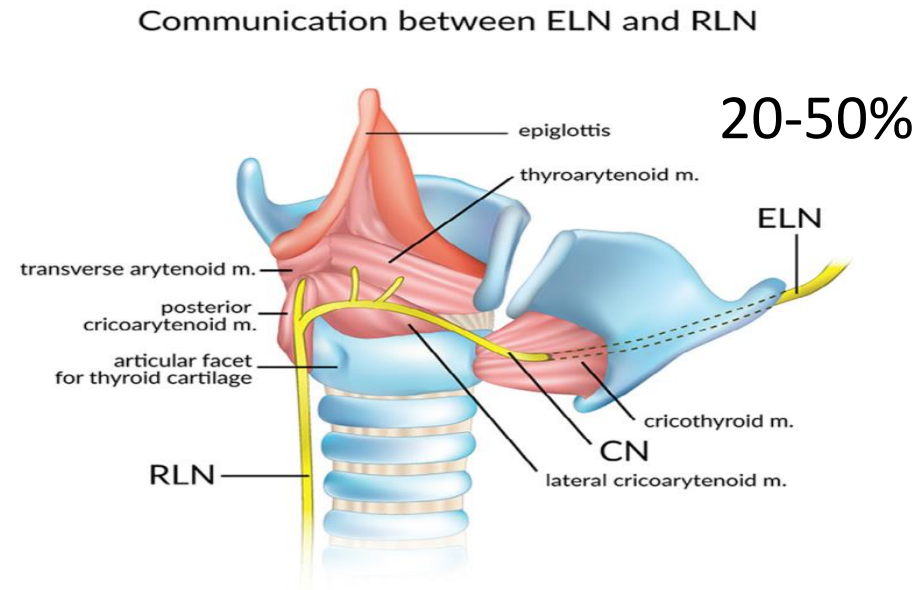
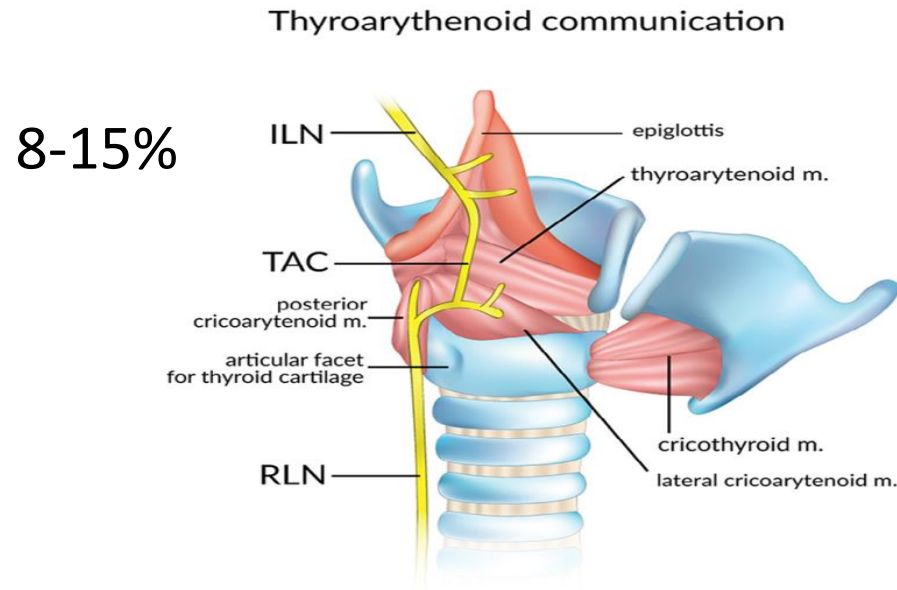
# Paralysis/paresis: LEMG interest

- **Diagnostic interest** (AANEM Practice topic, 2016)
  - In clinically suspected RLP, 48% of other diagnosis with LEMG
    - Another or additional diagnosis
      - Superior laryngeal neuropathy (anormal EMG in CT muscle)
      - Crico-arytenoid joint fixation (normal EMG in RLN and SLN territories)
      - Myopathy (myogenic pattern)
      - Stroke
  - Importance of multi-muscle LEMG (Foerster G & Mueller AH, 2017; Volk et al., 2012)



# Paralysis/paresis: LEMG interest

- Diagnostic interest (Henry M et al. 2017)
  - Limitation of EMG lesional localization due to anatomical variations in the RLN and SLN motor territories



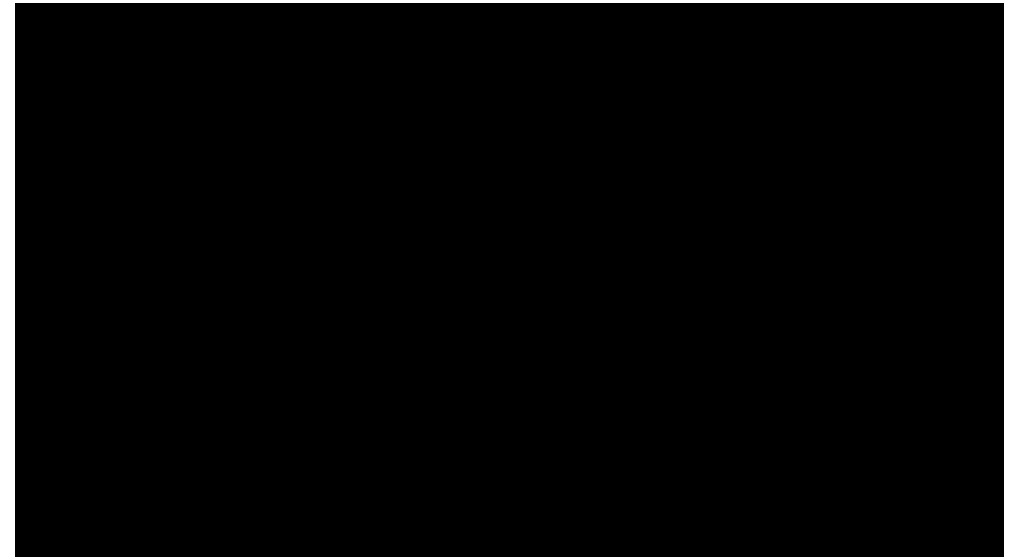
# Paralysis/paresis: LEMG interest

- **Pronostic interest** (AANEM Practice topic, 2016)
  - After 4 weeks
  - Before 4 months
    - Spontaneous recovery after 6 months is quite rare
    - Synkinetic reinnervation can lead to normal Motor Unit Potential recruitment without any VF motion
  - **Pronostic for recovery**
    - Presence of MUP, presence of polyphasic MUPs
    - Insufficient evidence for fibrillation potentials and/or positive sharp waves for predicting the recovery
- **Electrical synkinesis** (Foerster G et al. 2021)
  - Very frequent
  - may decrease the likelihood of recovery
  - May be favorable or not



# Mechanical immobility/hypomobility

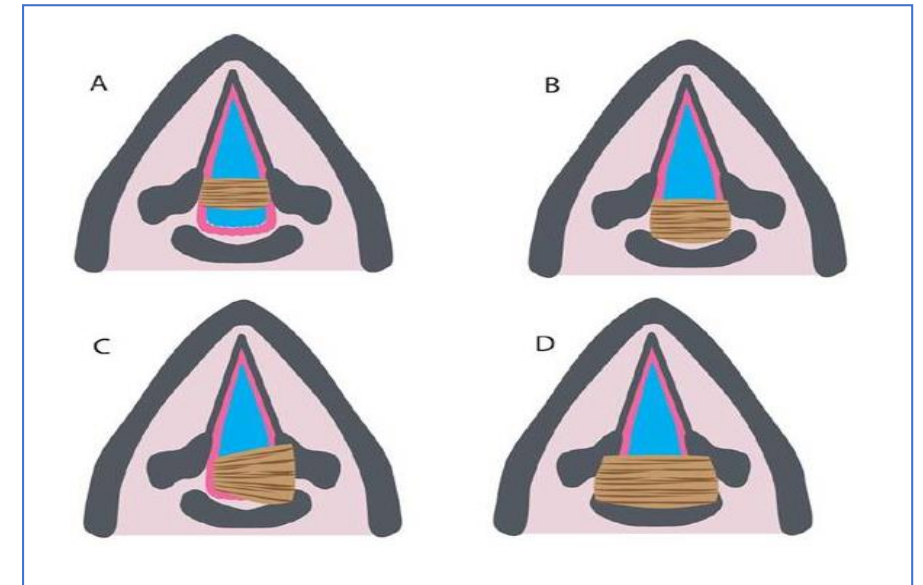
- Diagnosis:
  - Medical history
    - Long-duration in ICU with tracheal tube
    - Burns
  - Cautious laryngoscopy
    - Focused on the posterior glottic commissure
  - LEMG: normal (if isolated)
  - Direct laryngoscopy with palpation of the passive mobility of vocal folds
    - Under general anaesthesia + curare
    - Without oro-tracheal tube



Mettre ici Mr Desmedt ou Mr Paccini

# Mechanical immobility/hypomobility

- Posterior glottic stenosis
- Pathology of the crico-arytenoid joint (CAJ)
  - Dislocation/subluxation (uni or bi-lateral)
    - Trauma
  - Ankylosis (uni or bi-lateral)
    - Trauma
    - Arthritis/synovitis (Rheumatoid polyarthritis, psoriasis...)



Bogdasarian & Olson, 1980  
Refined by Attalah et al. , 2021.

# Laryngeal examination

Laryngeal immobility/Laryngeal hypomobility

2<sup>nd</sup> step: interpretation  
Medical history, LEMG, CAJ palpation

Etiological orientation

Paralysis/paresis

- Muscles involved/  
-Uni- or bilateral  
-Causal lesion

Mechanical immobility/hypomobility

- Pathology of CAJ  
-Uni- or bilateral  
-Local or general pathology

- Posterior glottis stenosis  
+/- CAJ involvement  
-Always bilateral

# Laryngeal examination

Laryngeal immobility/Laryngeal hypomobility

Etiological orientation

Paralysis/paresis

Mechanical immobility/hypomobility

- Muscles involved/
- Uni- or bilateral
- Localization of the Causal lesion

- Pathology of CAJ
- Uni- or bilateral
- Local or general pathology

- Posterior glottis stenosis
- +/- CAJ involvement
- Always bilateral

Spontaneous recovery potential

Cause, time between onset and management

Treatment

# Laryngeal examination

Laryngeal immobility/Laryngeal hypomobility

Etiological orientation

Paralysis/paresis

- Muscles involved/
- Uni- or bilateral
- Localization of the Causal lesion

~~Spontaneous recovery potential~~

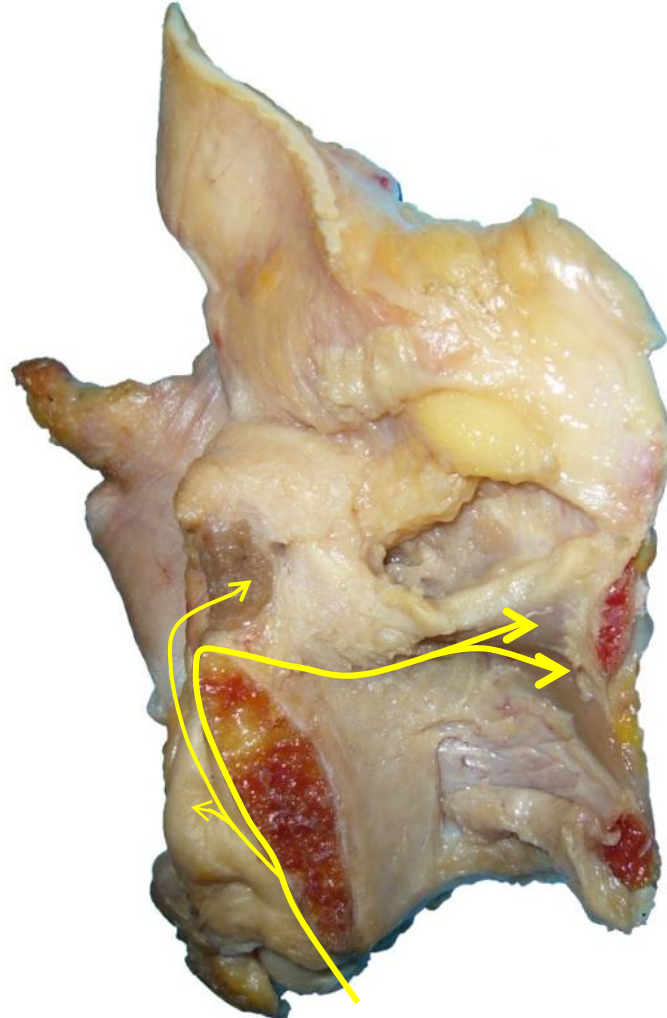
~~Cause, time between onset and management~~

Consider laryngeal reinnervation

# Principles of Laryngeal reinnervations

## Unilateral non-selective reinnervation

- Reinnervation the whole hemilarynx
- Restoration of the VF trophicity
- Stabilization of the aryténoïd
- Avoid defavourable synkinesis
  
- No movement recovery expected



## Bilateral selective reinnervation

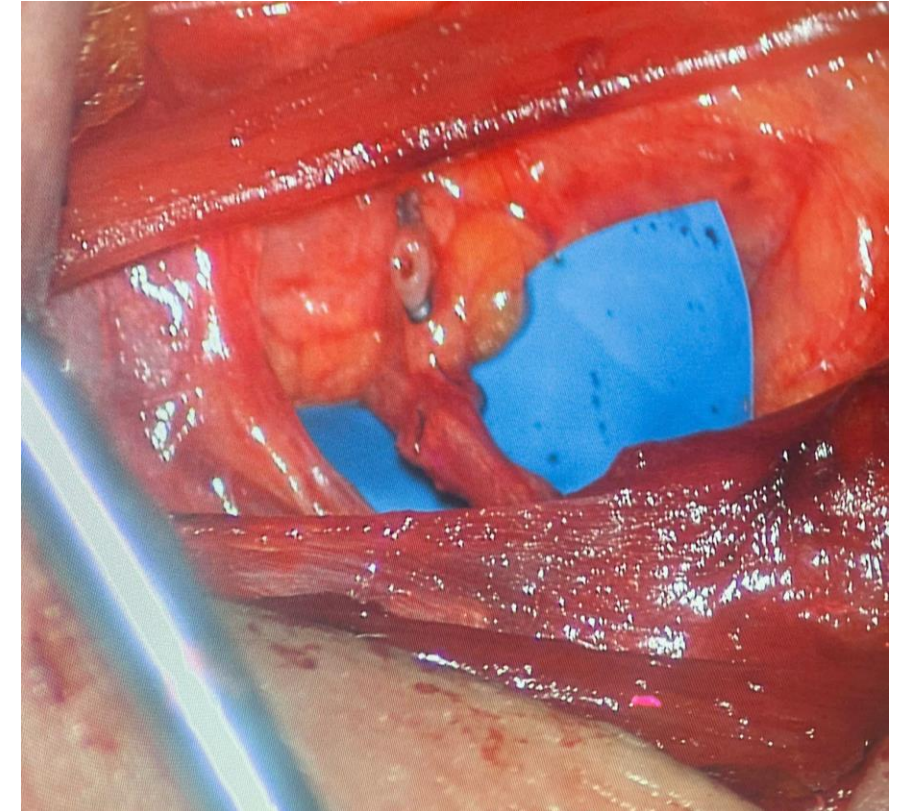
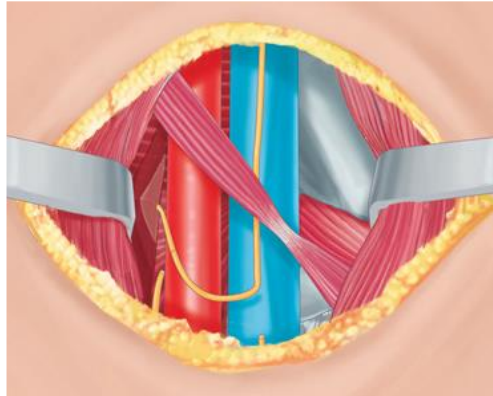
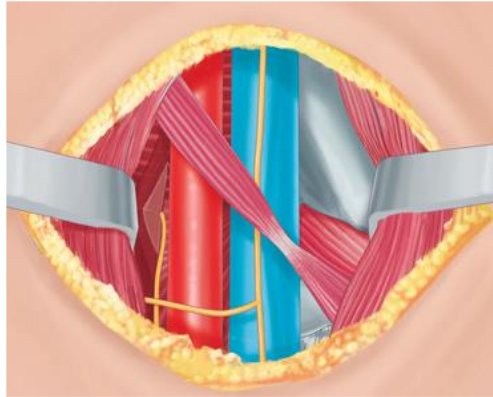
- Aims at recovering the differential innervation
  - of the abductor muscles
  - and of the adductor muscles
- Aims at movement recovery
  
- No choice between voice and breathing
  - Difference with all the glottic enlargement procedures
  - No scar on the vocal folds

# Unilateral non selective reinnervation: When and who?

- Immediately in case of per-op section of the recurrent (voluntary or not)
  - Especially during thyroidectomy
  - Suture RLN-RLN or ansa cervicalis –RLN, +/- interposition nerve graft
- Secondarily:
  - Neurogenic etiology of the immobility is certain
  - Pronostic of recovery if absent
    - Wait for about 1 year after the onset if the nerve has not been identified as sectioned
    - Use temporary mini-invasive treatments for symptoms release
  - Still possible when high delays
  - Possible salvage after other techniques failure
  - Patient has >2 years of life expectancy

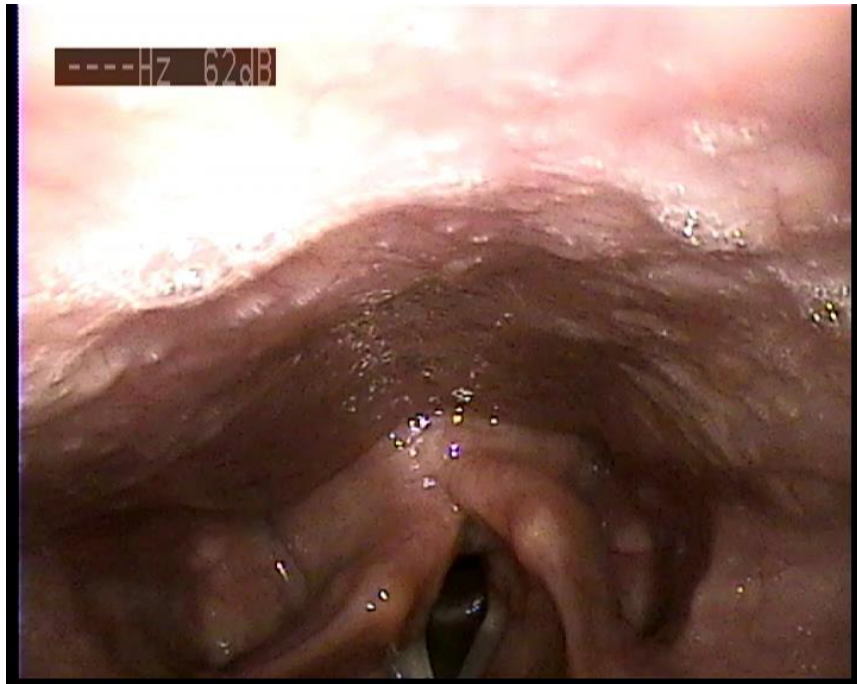


# Principles of unilateral reinnervation

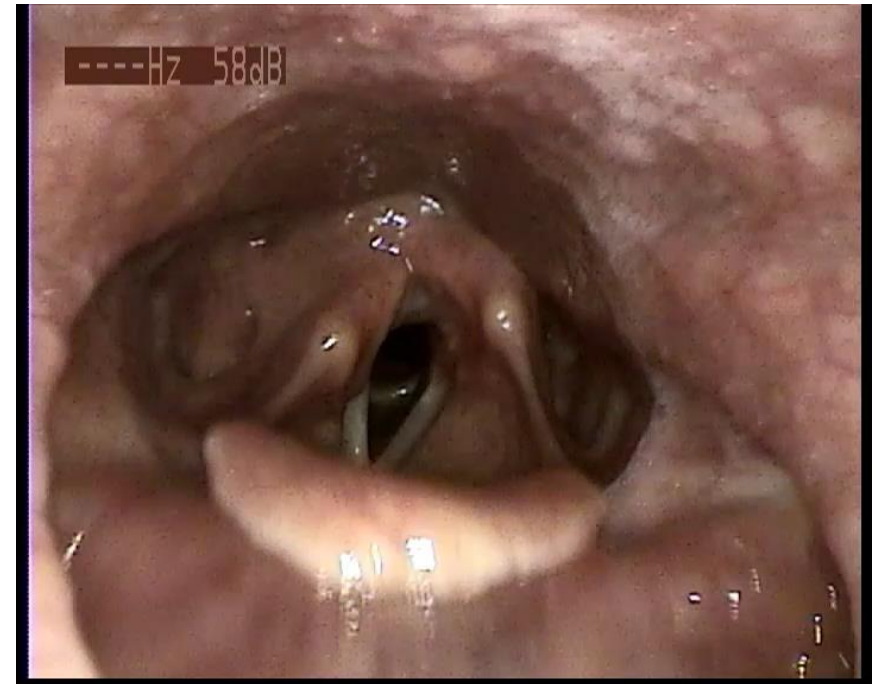


# Clinical case

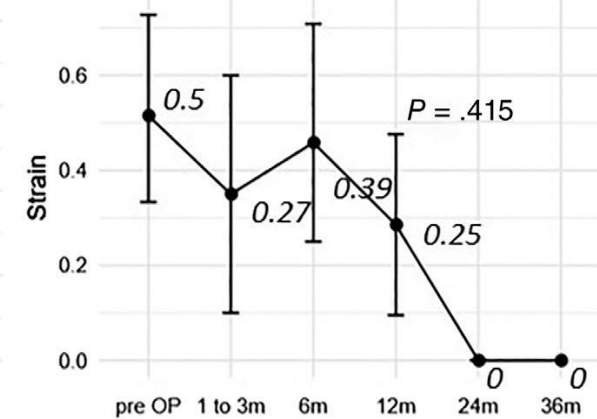
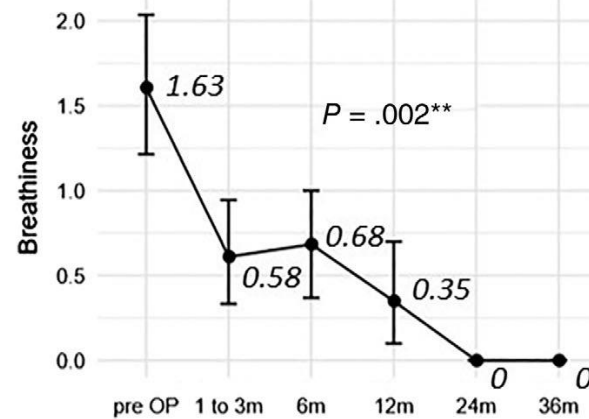
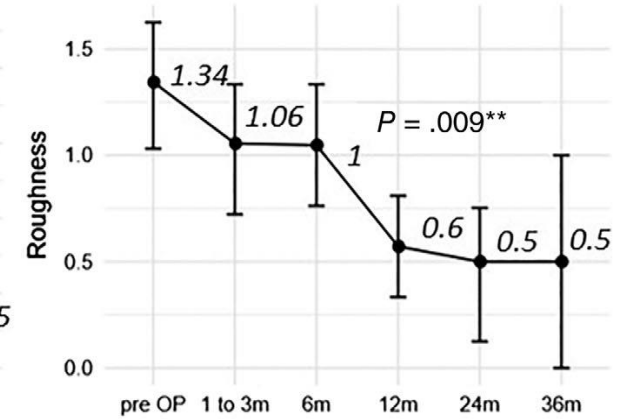
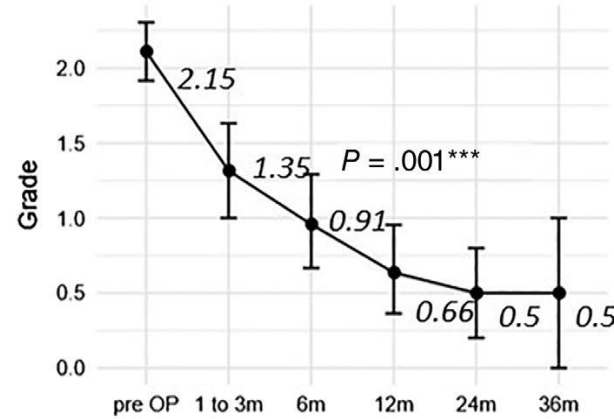
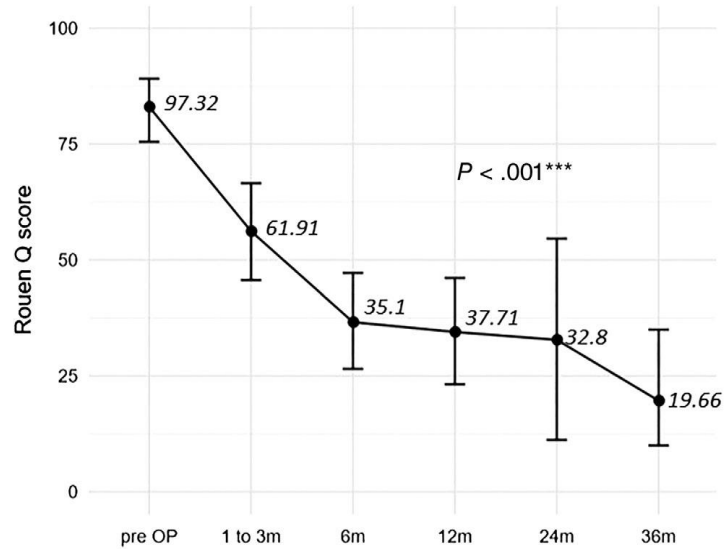
- Lady, 39 y-o, physiotherapist
- Thyroidectomy le 17/08/2018
- 1st assessment: 21/09/2018
  - MPT:8,01s ; VHI:60/120



- 19/07/2019: laryngeal reinnervation
- 10/07/2020:
  - TMP:12 s ; VHI:14

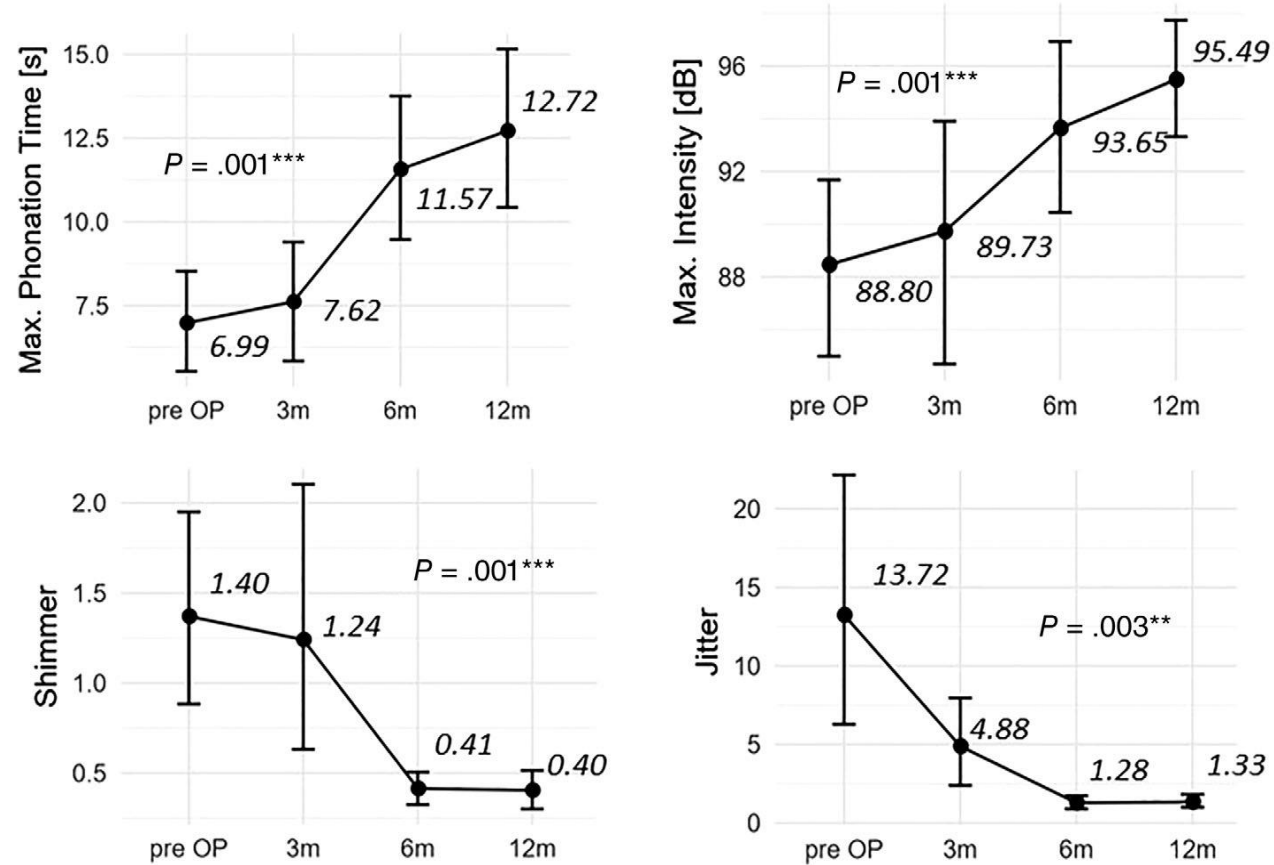


# Unilateral reinnervation outcomes



Nonselective Reinnervation as a Primary or Salvage Treatment of Unilateral Vocal Fold Palsy.

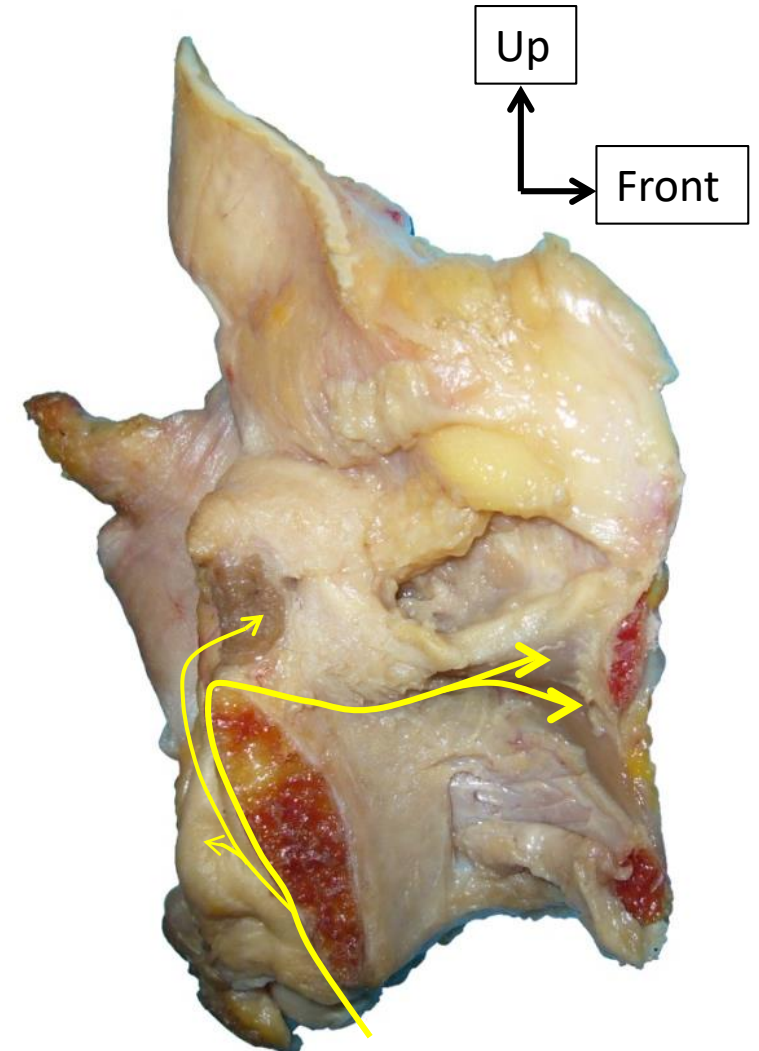
# Unilateral reinnervation outcomes

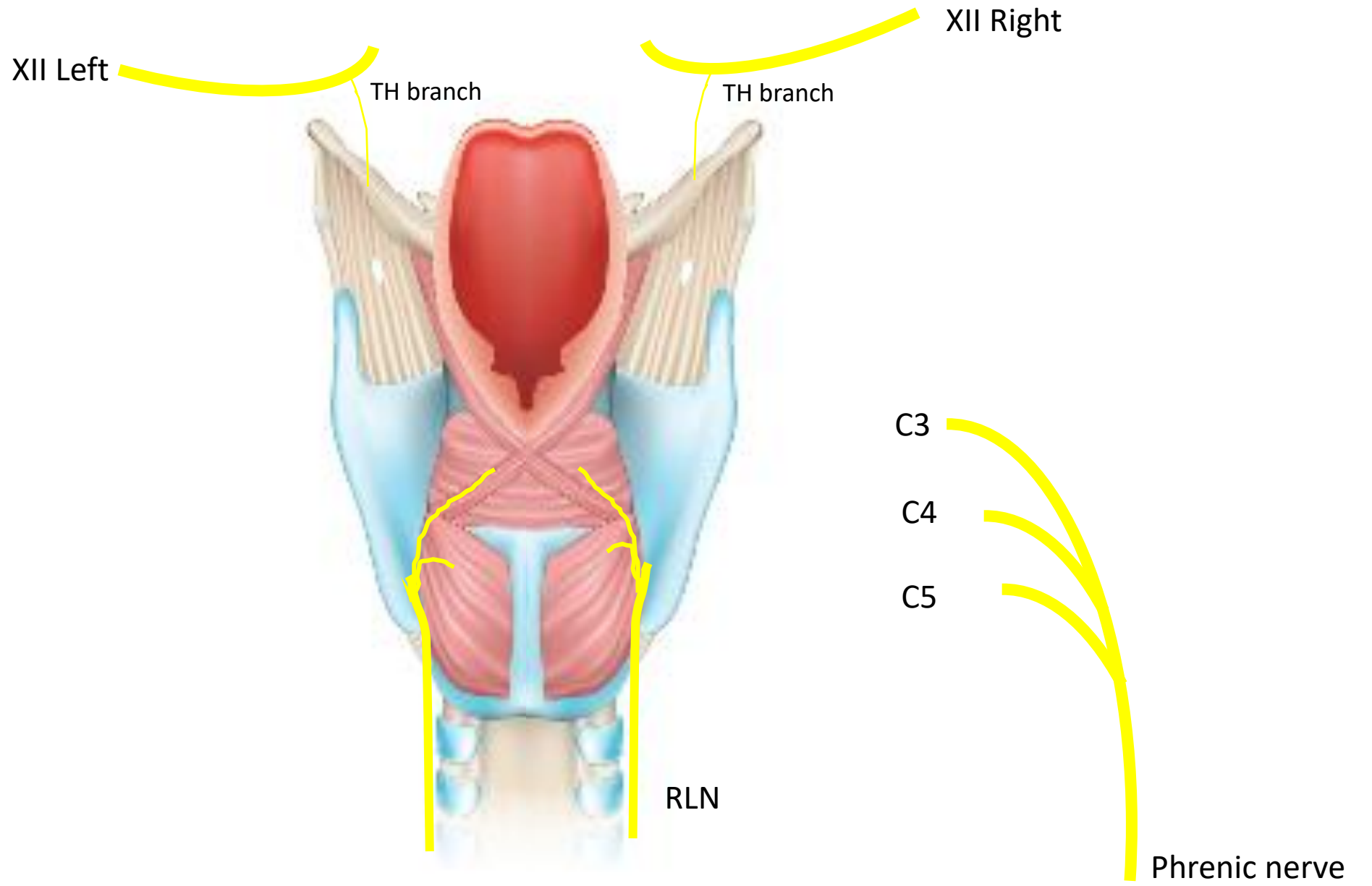


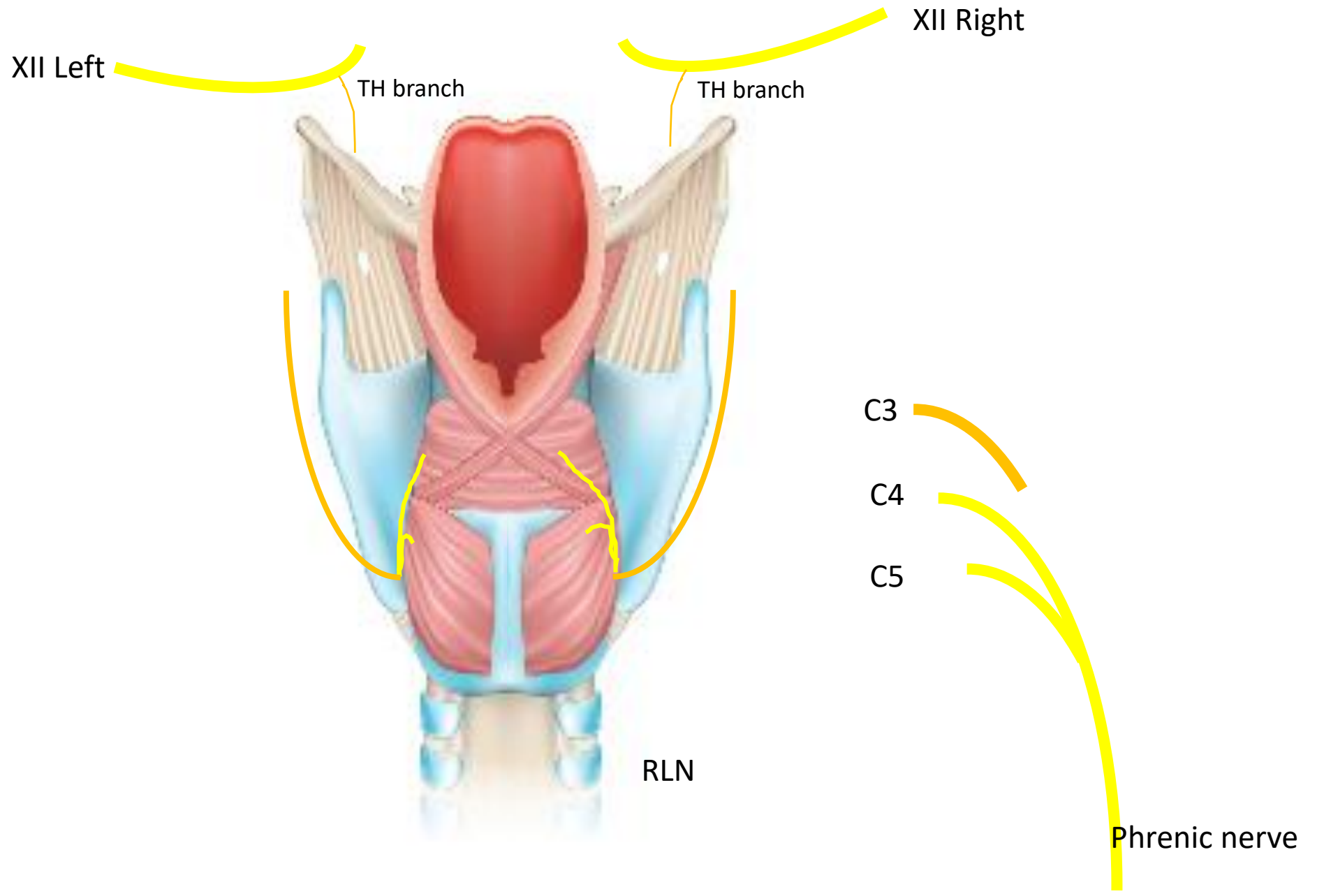


# Principles of bilateral selective laryngeal reinnervation

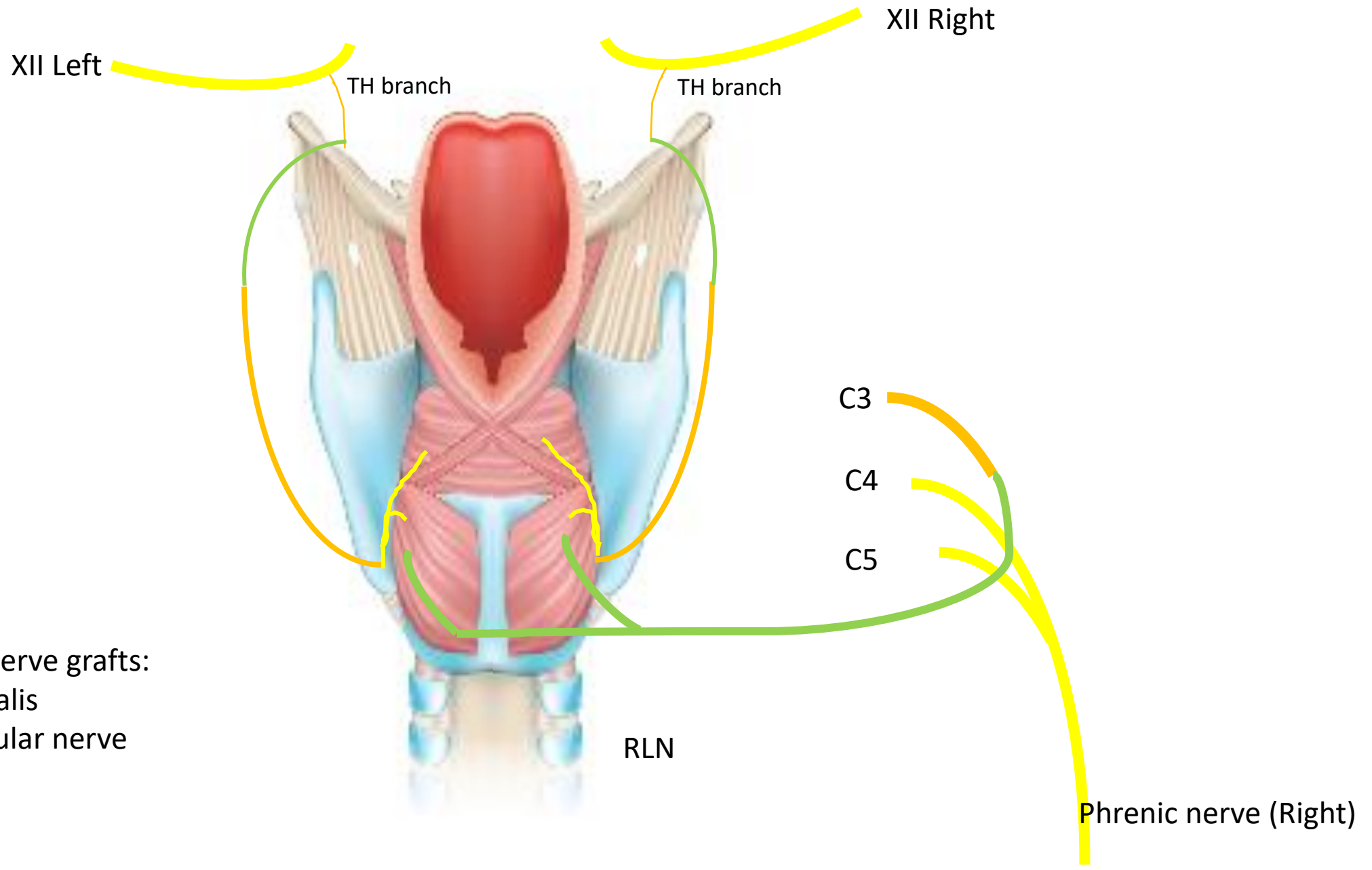
- Section of the recurrent nerves and selective reinnervation of ab/adductors
  - Separating the nervous pathway
  - To avoid unfavorable synkinesis
- Using regional nervous grafts
  - With activation during inspiration
    - Abduction
    - Strong innervation
  - With activation during phonation
    - Adduction
    - Slight innervation











Interposition nerve grafts:

- Ansa cervicalis
- Great auricular nerve

# Bilateral selective reinnervation: Post-operative period

- 10-12 hours of surgery
- Transitory tracheostomy
- Special care of swallowing in the early post-operative
  - +/- naso-gastric tube
  - Thicken diet
- Hospital stay about 7-10 days
  
- Immédiate laryngeal relaxation
- Reinnervation course during > 12 months

# Bilateral selective reinnervation: Outcomes

- Prospective study, 40 cases
  - Evaluation >1 year after surgery
    - 35/40 improved ventilatory parameters
      - 3 required arytenoidectomy or other glottic enlargement
    - 27 VF remobilization of at least one side
    - 16 VF remobilization on 2 sides
      - 14/30 without any scar)
    - Recovery of diaphragm function in most cases

# Bilateral selective reinnervation: When and who?

- Bilateral laryngeal paralysis
  - No spontaneous recovery possible
  - **Waiting time after the onset of the paralysis around 2 years**
- Confirmed by a very reliable LEMG
  - On both sides,
  - Of at least TA AND PCA
  - Possibly with endoscopic approach
    - Under sedation + local anesthesia of the larynx
    - Very important collaboration with the anesthesiologist
- Certainty of exclusion of mechanical immobility
  - Mechanical testing under GA and curare
- Avoid any previous scars into the larynx
  - Previous Laser glottic enlargement is associated to worse outcomes

# Bilateral selective reinnervation: When and who?

- Exclusion of neurogenic impairments from degenerative diseases
  - Classically: history of thyroidectomy
  - Or metachronous surgeries on both recurrent nerves
- **Avoid unknown etiology**
  - Possible Multi-Systemic Atrophy
  - Possible Amyotrophic Lateral Sclerosis



# Conclusion

- Unilateral non selective reinnervation
  - Now a routine surgery in our two centers
  - Very interesting results for young people
- Bilateral selective reinnervation
  - For now, 2 patients have undergone BSR in Belgium
    - One in Leuven (10/2022) and one in Liège (02/2023)
    - Performed together
    - For now:
      - both patients are decanulated and experience high improvement for breathing,
      - Slight mobility is observed on one side in each patient
      - 1 patient has a good voice, but not the other one.

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