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Anatomy and Physiology of Respiration and Swallowing

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Disclosures

FINANCIAL
Nancy B. Swigert received an honorarium for giving this presentation
Receives royalties on The Source for Dysphagia (ProEd)

NON-FINANCIAL
Has presented and published previously on this topic
Serve on Medical Advisory Board for National Foundation on Swallowing Disorders
Goals for the presentation:

- 1.) Discuss relationship between respiration and swallowing
- 2.) Describe neurophysiology of swallowing and breathing
- 3.) State oral and pharyngeal structures involved in swallowing and breathing
- 4.) Match cranial nerves to motor and sensory functions in swallowing and breathing
- 5.) Perform a basic cranial nerve exam as part of clinical swallow evaluation

Why learn about the structures?

- The structures are the architecture on which breathing and swallowing are built
- Provide the framework for the highly coordinated movements of respiration and swallowing
Why learn about cranial nerves?

- The cranial nerves are responsible for the sensory input to the structures and movements of the muscles of the:
  - Oral cavity
  - Hypopharynx
  - Pharynx
  - Larynx
  - Respiratory System
- Understand the reason for the impaired swallow

Why learn about respiration-swallowing coordination?

- Shared muscles and structures
- A significant impact of pharyngeal dysphagia is aspiration and possible aspiration pneumonia
- Understanding the interrelated mechanism of breathing and swallowing helps understand how aspiration can occur
Why is understanding neurophysiology important?

- You might select the wrong treatment techniques for the problem
  - A sign/symptom may have more than one possible physiologic cause
- You might select a treatment technique or method which doesn’t even make sense for the problem (e.g. treating a delay when the problem is reduced laryngeal elevation)
- You might select a treatment technique that could do more harm than good

One “symptom” can have more than one cause

<table>
<thead>
<tr>
<th>Sign/symptom</th>
<th>Different physiologic causes</th>
<th>Functional short term goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient has residue in the pyriforms after the swallow</td>
<td>Reduced laryngeal elevation</td>
<td>Patient will increase laryngeal elevation to reduce the amount of food remaining in the pyriforms which could fall into the airway</td>
</tr>
<tr>
<td></td>
<td>Reduced anterior movement of hyolaryngeal complex</td>
<td>Patient will increase anterior movement of hyolaryngeal complex to reduce the amount of food remaining in the pyriforms which could fall into the airway</td>
</tr>
</tbody>
</table>
Why assess cranial nerves?

- To enhance your understanding of what is causing the swallowing disorder in this client
- To give you insights into the areas of swallowing you might want to assess in more depth

CNS control of the swallow

- Before the bolus enters the mouth, the individual recognizes the bolus (through sight and smell), this is registered by the cortical structures, which prepare the swallowing system for that particular bolus.
CNS control of the swallow

- The bolus enters the oral cavity, and is sensed by the peripheral nerves, which send sensory (afferent) information to the brainstem (nucleus tractus solitarius).
- The brainstem 'communicates' with the cortical structures to ultimately determine the precise physiological nature of the swallow.

CNS control of the swallow

- The reflexive part of the swallow is triggered by sensory stimulation i.e. bolus contact on the faucial arches, tonsils, soft palate, posterior pharyngeal wall and deep muscle receptors in the base of tongue.
CNS control of the swallow

The Nucleus Tractus Solitarius (where all the sensory information accumulates) in the brainstem then instructs the Nucleus Ambiguus (also in the brainstem) to execute the motoric swallowing response.

The nucleus ambiguus sends efferent (motor) excitation to the oral, pharyngeal and esophageal muscles.

- **SWALLOW!**

Nucleus tractus solitarii

- The nucleus of the solitary tract, or NTS (Latin: *nucleus tractus solitarii*), is located along the length of the medulla (with a small portion in the lower pons).
- The solitary tract runs in the middle of the nucleus, creating a speck of white matter (axons of the tract), surrounded by grey matter (the nucleus).
- This stands out on a stained section, which is where the name solitary comes from.
Central control of breathing and swallowing

- Swallowing thought to be under control of Central Pattern Generator (Meltzer 1899, 1907; Doty, 1967, 1968)
  - Input arm – peripheral afferents
  - Organizing arm – commanding interneurons
  - Output arm – motor neurons
- Center must have a filtering arrangement
  - Swallow only when stimuli match the code
  - Because other reflexive activities (cough, gag) recruit the same muscles but are filtered out by center
- Afferent pathways (CN IX and X) also carry info from sensory end organs for control of respiratory rhythm

Central control of breathing and swallowing

- Afferent pathways from peripheral swallowing and respiratory regions ascend to nucleus tractus solitarius (NTS) in medulla
- Different animal models have shown different locations in the medulla
  - Dorsal region: NTS
  - Ventral region: around the Nucleus Ambiguous (NA)
Central control of breathing and swallowing

- **Efferent portal**
- Swallow-related motor output to muscles of mouth, pharynx, and larynx is transmitted by axons with cell bodies in brainstem
  - Trigeminal motor nucleus
  - Facial motor nucleus
  - Nucleus Ambiguous
    - Has interneurons but also large motor neurons
  - Hypoglossal Motor Nucleus
Central control of breathing and swallowing

- Production of basic respiratory rhythmicity also occurs in medulla
- Dorsal respiratory group (sensory neurons)
- Ventral respiratory group (motor neurons)

Cortical control

- Increasing evidence that cortical structures play a role in coordination of swallowing and breathing.
- Compensatory movements for swallowing (e.g. supraglottic) involve recruitment of pre-motor and motor cortex
Is shared control a good thing?

- If there is injury to swallowing CPG, and there are other neurons common to both respiration and swallowing, it may reduce overall impact of injury on swallowing function or vice versa.
- OR, If one CPG contains neurons common to both functions, may place the individual at functional disadvantage, and at greater risk, for both processes to be affected in case of isolated injury.

Breathe? Swallow?

- Two physiologic functions that cannot occur at the same time.
- However, the functions complement one another and overlap.
  - Some techniques for impaired swallowing modify both swallow physiology and breathing.
  - Changes in respiration, ventilation and swallowing occur with normal development and aging.
  - And with many different disease processes.
Coordination of breathing and swallowing in humans

- Most studies investigated relationships:
  - Phase(s) of respiration associated with swallowing
  - Duration of apneic period
  - Methodologies varied
  - Difficult to draw conclusions
Coordination of breathing and swallowing in humans: phases

- Expiratory phase of respiration is favored part of the respiratory cycle for the swallow
- Apneic period occurs most frequently in at some point in expiratory phase
- EX-EX
- IN/EX
- Rarely: EX/IN or IN/IN
- In infants, spontaneous swallows equally distributed b/t EX and IN phases
  - Related to neural structures, neural development and maturation, H&N anatomy

Review of respiration
Swallowing can affect respiration

- Spontaneous and water-induced swallows during expiration increased expiratory time and total time of swallow breath.
- Tidal volume of post-swallow breath immediately after was increased.
- Increased expiratory time in pre- and post-swallow breaths when compared to basal respiration.
- Swallows produced a "true" resetting of the respiratory rhythm.

Coordination of breathing and swallowing in humans-phases

- Patients with advanced age and diseases associated with aging favor inspiration phase.
  - Neurologic disease
  - COPD
  - H&N Cancer
- Switch of EX to IN preference did not relate to occurrence of aspiration pneumonia in patients with stroke.
- Did relate to higher Pen-Asp scores.
Coordination of breathing and swallowing in humans-apnea

- Apneic period always accompanies swallow
- Triggered before or after initial bolus transit through oral cavity
- Onset of apnea highly variable
- Apnea duration increased with liquid bolus volume
  - Other studies do not support this finding
  - We need to know…because…

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Coordination of breathing and swallowing in humans-apnea

- If increasing volumes of liquid up to 25 ml (bolus size of average liquid intake in healthy adults) does result in longer apnea…then…
  - Challenge may stress the respiratory capability of patients with dysphagia + pulmonary disease
    - May interfere with extent and duration of airway closure required to prevent aspiration

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Coordination of breathing and swallowing in humans-apnea

- Average length of apnea 0.5 to 3.5 s, typically 1.0 to 1.5 s in healthy adults
- Apnea offset not always a post-swallow gesture
  - May occur during descent of larynx during exhalation

Relationship of respiration and swallowing

- Breath phase at which swallow is initiated determines volume of the swallow
  - Near end of inspiratory-expiratory phase = largest volumes
  - That is, large swallows are found when lungs remain inflated at end of tidal breath
  - Allows more oxygen reserves to be available for blood O2 saturation  (Paydarfar, et al 1995)
Swallow breathing pattern can be altered by either swallowing or breathing (Martin-Harris, 2005)
  
  E.g. Increase in ventilatory drive during hypercapnia (increased CO2) decreases swallowing frequency

  Swallow during hypercapnia associated with increased incidence of aspiration and laryngeal irritation (Nishino et al 1989; Kijimo et al 2000)

Swallowing can alter breathing
  
  E.g. During repetitive swallowing, there are greater inspiratory-expiratory times, yet tidal volume and minute ventilation are maintained

  (Issa & Porostocky 1994)

  \[ \text{minute ventilation} = \text{Tidal volume} \times \text{breaths per minute} \]
Relationship of respiration and swallowing

- Swallow breathing pattern can be volitionally modified
  - Subjects instructed to breathe out to residual volume and then swallow – overall duration of swallow was prolonged (slower swallows)
  - Swallows at total lung capacity were shorter in duration (faster swallows)
  - Gross et al. 2008

Aerodigestive Tract: note the common muscles to swallowing

- During quiet inspiration
  - Genioglossus, styloglossus, stylopharyngeus, cricopharyngeus
  - The first three counterbalance airflow resistance through upper respiratory tract by stiffening and enlarging the upper airways during breathing
    - During swallowing, essential for bolus propulsion
  - CP is tonically active during quiet breathing to keep air from entering the esophagus
    - During a swallow, CP relaxes
Aerodigestive Tract

- Sternothyroid and omohyoid muscles
  - Return the larynx to rest following hyolaryngeal excursion
  - Stabilize the larynx during quiet inspiration
  - Omohyoid prevents collapse of the lung apices and vessels during deep inspiration

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Aerodigestive Tract

- Velopharyngeal port
  - Open for respiration
  - Closed for swallowing to prevent backflow of material into nasal passages
- Posterior tongue in swallowing keeps bolus in oral cavity
- Tongue base puts pressure on bolus tail
  - Base of tongue is ventral wall of respiratory pharynx and is critical to airway maintenance

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Aerodigestive Tract

- **Larynx**
  - Opens at glottis and supraglottis for breathing
  - Abducted glottis remains during inspiration, but TVF slightly adduct to paramedian position during expiration
    - Accomplished by PCA which increases the horizontal diameter of the glottic opening and CT which increases the A-P dimension of opening
  - Closed tightly for swallowing

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The Six Cranial Nerves Involved in Speech and Swallowing

- CN V - - Trigeminal nerve
- CN VII - - Facial nerve
- CN IX - - Glossopharyngeal nerve
- CN X - - Vagus nerve
- CN XI - - Spinal accessory nerve
- CN XII - - Hypoglossal nerve

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**CONTINUED**
Mnemonic for the Cranial Nerves

<table>
<thead>
<tr>
<th></th>
<th>(olfactory)</th>
<th>Some</th>
<th>(sensory)</th>
</tr>
</thead>
<tbody>
<tr>
<td>On</td>
<td>(olfactory)</td>
<td>Some</td>
<td>(sensory)</td>
</tr>
<tr>
<td>Old</td>
<td>(optic)</td>
<td>Say</td>
<td>(sensory)</td>
</tr>
<tr>
<td>Olympus’</td>
<td>(oculomotor)</td>
<td>Marry</td>
<td>(motor)</td>
</tr>
<tr>
<td>Towering</td>
<td>(trochlear)</td>
<td>Money</td>
<td>(motor)</td>
</tr>
<tr>
<td>Top</td>
<td>(trigeminal)</td>
<td>But</td>
<td>(both)</td>
</tr>
<tr>
<td>A</td>
<td>(abducens)</td>
<td>My</td>
<td>(motor)</td>
</tr>
<tr>
<td>Finn</td>
<td>(facial)</td>
<td>Mother*</td>
<td>(motor)</td>
</tr>
<tr>
<td>And</td>
<td>(auditory)</td>
<td>Says</td>
<td>(sensory)</td>
</tr>
<tr>
<td>German</td>
<td>(glossopharyngeal)</td>
<td>Bad</td>
<td>(both)</td>
</tr>
<tr>
<td>Vended</td>
<td>(vagus)</td>
<td>Business</td>
<td>(both)</td>
</tr>
<tr>
<td>At</td>
<td>(accessory)</td>
<td>Marry</td>
<td>(motor)</td>
</tr>
<tr>
<td>Hopps</td>
<td>(hypoglossal)</td>
<td>Money</td>
<td>(motor)</td>
</tr>
</tbody>
</table>

Oral cavity

- First part of the digestive tract
- Initiates digestive process
  - Mixes saliva
  - Start propulsion of bolus
- A quick review of the structures
Lips, tongue, teeth, hard and soft palate

http://emedicine.medscape.com/article/1899122-overview#a2

Cheeks, gums, floor of mouth
Pharyngeal structures (review)

- Tongue
- Pharynx
- Larynx

Let’s look at muscles and innervations for motor and sensory for:

- Lips
- Cheeks
- Tongue (oral and pharyngeal function)
- Soft palate
- Pharynx
- Hyoid and Larynx
- Intrinsic larynx
Lips

- Close on utensils:
  - Spoon
  - Cup
  - Straw
- Keep bolus in the mouth

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Function</th>
<th>Innervation - Motor</th>
<th>Innervation - Sensory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buccinator</td>
<td>Compresses lips</td>
<td>VII Facial</td>
<td>V Trigeminal Nerve: Maxillary branch to upper lip</td>
</tr>
<tr>
<td></td>
<td>Pulls corners of lips</td>
<td></td>
<td>Mandibular branch to lower lip</td>
</tr>
<tr>
<td>Orbicularis oris</td>
<td>Closes, opens, protrudes, inverts and twists lips</td>
<td>VII Facial</td>
<td></td>
</tr>
</tbody>
</table>
Muscles of lips

- Temporalis
- Masseter
- Buccinator
- Obicularis Oris

Innervation to lips

- Temporal
- Zygomatic
- Buccal
- Marginal
Sensory innervation to lips: Trigeminal

Maxillary branch: sensation upper lip

Mandibular branch: sensation lower lip

IMPAIRED PHYSIOLOGY OF LIPS: IMPACT ON SWALLOWING

<table>
<thead>
<tr>
<th>What physiologic problem might you observe if impairments in lip muscles</th>
<th>What symptoms might it cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inability to compress lips</td>
<td>Can’t close on spoon</td>
</tr>
<tr>
<td></td>
<td>Can’t drink from straw</td>
</tr>
<tr>
<td></td>
<td>Loses liquid anteriorly when drinking from cup</td>
</tr>
<tr>
<td></td>
<td>Can’t keep bolus in mouth</td>
</tr>
<tr>
<td>Can’t invert lips</td>
<td>Can’t invert top or bottom lip to use teeth to clean lips</td>
</tr>
</tbody>
</table>
Cheeks

- Cheeks press tightly against gums/teeth to keep food out of buccal cavities
- Compress to help with sucking

---

**Cheeks**

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Function</th>
<th>Innervation-Motor</th>
<th>Innervation-Sensory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buccinator</td>
<td>Flattens and tightens cheeks</td>
<td>CNVII Facial</td>
<td>CNV Trigeminal Maxillary branch</td>
</tr>
</tbody>
</table>

---

**CONTINUED**
Muscle of cheeks

Innervation to cheeks
Sensory innervation to cheeks: Trigeminal

Maxillary branch: sensation cheeks

IMPAIRED PHYSIOLOGY OF CHEEKS: IMPACT ON SWALLOWING

<table>
<thead>
<tr>
<th>What physiologic problem might you observe if impairments in cheeks</th>
<th>What symptoms might it cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inability to tighten the cheeks</td>
<td>Reduced ability to suck from straw</td>
</tr>
<tr>
<td></td>
<td>Food and liquid pool in buccal cavities</td>
</tr>
</tbody>
</table>

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CONTINUED
Animation of oral phase

- Maintains seal with the soft palate
- Squeezes bolus posteriorly
- Helps initiate the pharyngeal phase
Animation of tongue lateral view

Tongue extrinsic muscles

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Function for swallowing</th>
<th>Function for breathing</th>
<th>Innervations Motor</th>
<th>Innervations - Sensory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genioglossus</td>
<td>Protrusion; press tongue to teeth or alveolar ridge (posterior fibers)</td>
<td>Counterbalance airflow through upper respiratory tract by stiffening and enlarging upper airways</td>
<td>CN XII Hypoglossal</td>
<td>CN V Trigeminal-anterior 2/3 general</td>
</tr>
<tr>
<td></td>
<td>Retraction (anterior fibers)</td>
<td></td>
<td></td>
<td>VII Facial -anterior 2/3 taste</td>
</tr>
<tr>
<td></td>
<td>Draw tongue downward (all fibers)</td>
<td></td>
<td></td>
<td>IX Glossopharyngeal posterior 1/3 general and taste</td>
</tr>
<tr>
<td>Styloglossus</td>
<td>Pulls tongue up and back</td>
<td></td>
<td>CN XII Hypoglossal</td>
<td>X Vagus posterior general</td>
</tr>
<tr>
<td>Palatoglossus</td>
<td>Pulls tongue back to make the groove</td>
<td></td>
<td>CN X Vagus (pharyngeal branch)</td>
<td>CN XI Accessory</td>
</tr>
<tr>
<td>Hyoglossus</td>
<td>Retracts or depresses tongue; elevates hyoid</td>
<td></td>
<td>CN XII Hypoglossal</td>
<td></td>
</tr>
</tbody>
</table>
Tongue: intrinsic muscles

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Function for swallowing</th>
<th>Innervations - Motor</th>
<th>Innervations - Sensory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superior longitudinal</td>
<td>shortens tongue or may turn tip and lateral margins upward to create concave appearance, lateralizes tongue</td>
<td>XII Hypoglossal</td>
<td></td>
</tr>
<tr>
<td>Inferior longitudinal</td>
<td>shortens tongue or pulls tip downward, lateralizes tongue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transverse</td>
<td>Narrows and elongates tongue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical</td>
<td>flattens the tongue</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Extrinsic muscles of tongue

![Extrinsic muscles of tongue diagram](image)
Intrinsic muscles of tongue

Innervation to tongue: Hypoglossal and Vagus
Sensory to the tongue

**IMPAIRED PHYSIOLOGY OF TONGUE – IMPACT ON SWALLOW**

<table>
<thead>
<tr>
<th>What physiologic problem might you observe if impairments in tongue muscles</th>
<th>What symptoms might it cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Back of tongue to soft palate does not seal to keep bolus in mouth</td>
<td>Premature loss of bolus over back of tongue. Can result in penetration or aspiration</td>
</tr>
<tr>
<td>Base of tongue fails to pull back towards pharyngeal wall adequately</td>
<td>Residue in valleculae</td>
</tr>
<tr>
<td>Increased stage transition duration (is this perhaps a sensory deficit in the back of the tongue? OR sensory deficit in the pharynx?)</td>
<td>Penetration Aspiration before the swallow</td>
</tr>
<tr>
<td>Inability to protrude and retract tongue</td>
<td>Can’t move bolus back in oral cavity</td>
</tr>
<tr>
<td>Inability to cup, flatten, lateralize the tongue</td>
<td>Reduced ability to form and manipulate bolus Can’t clear residue</td>
</tr>
</tbody>
</table>
Soft Palate

- Pulls tight against base of tongue
- Lifts to seal off nasal cavity

Soft Palate/Faucial Arches

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Function for swallowing</th>
<th>Function for breathing</th>
<th>Innervation Motor</th>
<th>Innervation Sensory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensor veli palatini</td>
<td>Tenses soft palate; may help close nasopharynx</td>
<td>Velopharyngeal port open for respiration</td>
<td>V Trigeminal</td>
<td>CN VII Facial, CN IX, CN X, Glossopharyngeal, CN X, Vagus</td>
</tr>
<tr>
<td>Palatoglossus</td>
<td>narrows the faucial opening (this muscle is in the anterior faucial arch); pulls soft palate down and forward</td>
<td></td>
<td>Vagus</td>
<td>CN Vagus</td>
</tr>
<tr>
<td>Levator veli palatine</td>
<td>Lifts soft palate</td>
<td></td>
<td>Vagus</td>
<td>XI Accessory</td>
</tr>
<tr>
<td>Salpingopharyngeus</td>
<td>Lifts soft palate</td>
<td></td>
<td>Vagus</td>
<td></td>
</tr>
</tbody>
</table>
Animation soft palate

Muscles of soft palate/faucial arches

continued
Another look at the muscles

Innervation to soft palate

Also XI Accessory
Innervation to soft palate sensory

IMPAIRED PHYSIOLOGY OF SOFT PALATE: IMPACT ON SWALLOW

<table>
<thead>
<tr>
<th>What physiologic problem might you observe</th>
<th>What symptoms might it cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can’t elevate soft palate</td>
<td>Backflow of bolus to nasal cavity</td>
</tr>
<tr>
<td>Asymmetrical elevation of soft palate</td>
<td>Partial backflow to nasopharynx</td>
</tr>
<tr>
<td>Can’t pull palate tight against back of tongue</td>
<td>Loses bolus prematurely over the back of the tongue</td>
</tr>
</tbody>
</table>
Pharynx

- Muscles of pharynx surround the:
  - Nasopharynx
  - Oropharynx
  - Laryngopharynx
- They squeeze the bolus into the esophagus
### Pharynx

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Function for Swallowing</th>
<th>Function for breathing</th>
<th>Innervation: Motor</th>
<th>Innervation: Sensory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superior and middle constrictors</td>
<td>Contract on bolus to squeeze it down</td>
<td>CN X Vagus (pharyngeal branch)</td>
<td>CN IX and CN X (pharyngeal plexus) – general sensory</td>
<td></td>
</tr>
<tr>
<td>Inferior constrictor</td>
<td>Includes thyropharyngeus (superior) and cricopharyngeus (CP) (Inferior). CP is tonic until it relaxes during swallowing to open so bolus can pass</td>
<td>CP tonic (active) during quiet breathing to keep air from entering esophagus</td>
<td>CN X (pharyngeal branch)</td>
<td>CN IX and CN X (pharyngeal plexus) – general sensory</td>
</tr>
<tr>
<td>Palatopharyngeus</td>
<td>Elevates; contracts on bolus; some laryngeal elevation</td>
<td>CN X (pharyngeal branch)</td>
<td>CN IX and CN X (pharyngeal plexus) – general sensory</td>
<td></td>
</tr>
<tr>
<td>Salpingopharyngeus</td>
<td>Elevates and laterally draws walls up</td>
<td>CN X (pharyngeal branch)</td>
<td>CN IX and CN X (pharyngeal plexus) – general sensory</td>
<td></td>
</tr>
<tr>
<td>Stylopharyngeus</td>
<td>Elevates pharynx; some laryngeal elevation</td>
<td>Counterbalance airflow through upper respiratory tract by stiffening and enlarging upper airways</td>
<td>CN IX (Glossoharyngeal)</td>
<td>CN IX and CN X (pharyngeal plexus) – general sensory</td>
</tr>
</tbody>
</table>

### Muscles of pharynx

- Cut edge of lateral pterygoid plate
- Auditory tube
- Levator veli palatini
- Stylopharyngeus
- Superior constrictor
- Stylohyoid ligament
- Middle constrictor
- Thyroid membrane
- Inferior constrictor
- Dehiscence of Killian
- Cricopharyngeus part of inferior constrictor
- Oesophagus
- Pterygo-mandibular raphe
- Buccinator
- Mylohyoid muscle
- Hyoid
- Thyroid muscle
- Thyroid cartilage
- Cricothyroid muscle
- Cricoid cartilage
- Trachea

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CONTINUED™
Motor and sensory to pharynx: IX and X

The Glossopharyngeal Nerves - IX

- Parotid gland
- Parasympathetic fibers
- Glossopharyngeal nerve (IX)
- Angular trunk
- Superior ganglion
- Inferior ganglion
- Cric ganglion
- Stylopharyngeus
- To carotid sinus and body
- Pharyngeal mucosa
- Common carotid artery

Impaired physiology of pharynx – Impact on Swallow

<table>
<thead>
<tr>
<th>What physiologic problem might you observe if impairments in tongue muscles</th>
<th>What symptoms might it cause</th>
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</table>
| Increased stage transition duration (is this perhaps a sensory deficit in the back of the tongue? OR sensory deficit in the pharynx?) | Penetration
Penetration
Aspiration before the swallow |
| Reduced laryngeal elevation/pharyngeal shortening | Can contribute to penetration during swallow
Can result in residue in pyriforms |
| Reduced constriction of pharyngeal walls | Residue in pharynx, pyriforms |
Hyolaryngeal complex

- Hyoid bone is attached to thyroid cartilage below and tongue above
- Can be pulled in many different directions
  - Supra-hyoid muscles
  - Infra-hyoid muscles
- Moves up and forward as larynx elevates
  - Protects the airway
  - Pulls open the PES

Animation lateral focus on hyoid
Hyolaryngeal complex (Hyoid and Larynx)

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Function/Location</th>
<th>Innervation</th>
<th>Sympathetic/Parasympathetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mylohyoid</td>
<td>Upward movement of hyoid</td>
<td>CN V Trigeminal (mylohyoid branch)</td>
<td>Cervical spinal, cervical plexus</td>
</tr>
<tr>
<td>Geniohyoid</td>
<td>Upward and forward of hyoid</td>
<td>Cervical plexus C1</td>
<td>Cervical spinal, cervical plexus</td>
</tr>
<tr>
<td>Anterior belly digastrics</td>
<td>Jaw opener</td>
<td>CN V</td>
<td>Cervical spinal, cervical plexus</td>
</tr>
<tr>
<td>Posterior belly digastrics</td>
<td>Posterior, upward movement hyoid</td>
<td>CN VII (Facial)</td>
<td>Cervical spinal, cervical plexus</td>
</tr>
<tr>
<td>Stylohyoid</td>
<td>Posterior, upward movement hyoid</td>
<td>CN VII</td>
<td>Cervical spinal, cervical plexus</td>
</tr>
<tr>
<td>Hyoglossus</td>
<td>Upward hyoid</td>
<td>CN XII Hypoglossal</td>
<td>Cervical spinal, cervical plexus</td>
</tr>
<tr>
<td>Thyrohyoid</td>
<td>Moves hyoid and larynx together</td>
<td>Cervical plexus C1</td>
<td>Cervical spinal, cervical plexus</td>
</tr>
<tr>
<td>Sternohyoid</td>
<td>Pulls larynx down</td>
<td>Stabilize larynx during quiet inspiration</td>
<td>Ansa cervicalis</td>
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<tr>
<td>Sternohyoid</td>
<td>Pulls hyoid down</td>
<td>Stabilize larynx during quiet inspiration; prevents collapse of lung apices during deep inspiration</td>
<td>Ansa cervicalis</td>
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<td>Omohyoid</td>
<td>Pulls hyoid down</td>
<td>Stabilize larynx during quiet inspiration; prevents collapse of lung apices during deep inspiration</td>
<td>Ansa cervicalis</td>
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Impaired physiology of hyolaryngeal complex – Impact on Swallow

<table>
<thead>
<tr>
<th>Impaired Physiology</th>
<th>What Symptoms Might It Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced anterior and superior movement of hyolaryngeal complex</td>
<td>Decreased PES opening Residue in pyriforms Epiglottis does not fully invert, allowing penetration</td>
</tr>
<tr>
<td>Reduced closure at entrance to airway</td>
<td>Allows penetration into vestibule May allow aspiration during the swallow</td>
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Larynx

- Protects airway by closing and moving up and forward
  - See previous slides on hyolaryngeal complex
- As larynx lifts, epiglottis flips down to send bolus on either side of larynx
- True and false folds adduct to close the glottis
### Larynx

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Function for swallowing</th>
<th>Function for breathing</th>
<th>CT innervations motor</th>
<th>Sensory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thyroarytenoid</td>
<td>Adductor, tensor or relaxer</td>
<td></td>
<td>CN X (left recurrent laryngeal)</td>
<td>CN X (internal laryngeal) mucous membrane at valleculae, epiglottis, aryepiglottic folds and most of larynx</td>
</tr>
<tr>
<td>Cricothyroid (pars oblique and recta)</td>
<td>Lengthen and tense Vf, alters distance b/t thyroid and arytenoids</td>
<td>Increases A-P dimension of opening during inspiration</td>
<td>CN X (external laryngeal)</td>
<td>CN X (recess laryngeal) – mucous membrane below Vf CN X special sensory to epiglottis</td>
</tr>
<tr>
<td>Posterior cricoarytenoids</td>
<td>Abduct and internally rotate arytenoids</td>
<td>Increases horizontal diameter of glottic opening during inspiration</td>
<td>CN X (left recurrent laryngeal)</td>
<td>-CN X (left recurrent laryngeal)</td>
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<tr>
<td>Lateral cricoarytenoids</td>
<td>Adduct and internally rotate arytenoids</td>
<td></td>
<td>CN X (left recurrent laryngeal)</td>
<td>-CN X (left recurrent laryngeal)</td>
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<tr>
<td>Transverse arytenoids</td>
<td>Adduct arytenoids</td>
<td></td>
<td>CN X (left recurrent laryngeal)</td>
<td>-CN X (left recurrent laryngeal)</td>
</tr>
<tr>
<td>Oblique arytenoids</td>
<td>Adducts arytenoids</td>
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Impaired physiology of larynx – Impact on Swallow

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<td></td>
<td>May allow aspiration during the swallow</td>
</tr>
<tr>
<td>Reduced closure of airway at glottis</td>
<td>Allows aspiration of material</td>
</tr>
</tbody>
</table>

Closure at level of larynx

- Rarely is it just failure of true and/or false vocal folds to close
- The coordinated movements of closure of the larynx are intricately related to the elevation and forward movement of the larynx
Cranial nerves and muscles

- Smell and see: 1, 4, 2
- And look around: 3, 4, 6
- Raptus and smell: 3
- Chink your teeth: 5
- Smile and hear: 7, 8
- Then say A-H-I: 9
- And see if you can swallow: 10
- Do you sit in death? 11, 6, 12

Incorporating cranial nerve testing into clinical swallow exam

- Closes & opens mandible: V Trigeminal
- Rotary jaw movement: V Trigeminal
- Cheeks hold food out of sulci: VII Facial
- Opens, closes, protrudes, inverts lips: VII Facial
- Raises back of tongue: X Vagus (Pharyngeal)
- Lifts soft palate: X Vagus (Pharyngeal)
- Lifts soft palate: XI Accessory
- Retracts tongue: XII Hypoglossal
- Elevates tongue up and back: XII Hypoglossal
- Pulls tongue tip downward: XII Hypoglossal
- Narrows and elongates tongue: XII Hypoglossal
- Laterizes tongue: XII Hypoglossal
Assessing CN on instrumental exam

- Closes & opens mandible  V Trigeminal
- Rotates jaw movement  V Trigeminal
- Raises hyoid  V Trigeminal
- Cheeks hold food out of sulci  VII Facial
- Opens, closes, protrudes, inverts lips  VII Facial
- Pulls soft palate down and forward  X Vagus
- Raises back of tongue  X Vagus (Pharyngeal)
- Lifts soft palate  X Vagus (Pharyngeal)
- Squeezes pharynx  X Vagus (Pharyngeal)
- Adducts vocal folds  X Vagus (Recurrent laryngeal)
- Draws hyoid up and forward  X Vagus (Recurrent laryngeal)
- Lifts soft palate  X Accessory
- Shuts off nasopharynx  X Accessory
- Narrows tongue  X Hypoglossal
- Elevates tongue up and back  X Hypoglossal
- Pulls tongue up downward  X Hypoglossal
- Narrows and elongates tongue  X Hypoglossal
- Lateralizes tongue  X Hypoglossal
- Draws hyoid up and forward  X Hypoglossal
- Pulls thyroid up to hyoid  X Hypoglossal

- Bold items can be seen only on instrumental

---

Practice case A

- Bedside evaluation reveals:
  - Pocketing in L cheek
  - Diffuse residue in oral cavity
  - Can’t clear residue in L cheek with tongue sweep

---

Nancy B. Swigert
What cranial nerves might be impaired?

- V Trigeminal (could be sensory deficit?)
- VII Facial (could be motor with decreased tone in cheek)
- XII Hypoglossal (motor- poor tongue movement)

Can we determine etiology?

- Could be:
  - Stroke
  - TBI
  - MS
  - ALS (bulbar)
Practice Case B

- Bedside evaluation reveals:
  - Jaw movement WNL
  - Tongue movement WNL
    - Protrusion/retraction
    - Lateralization
    - Back of tongue elevation
  - Palatal movement WNL
  - Can’t elevate eyebrow on R
  - Pucker is asymmetrical
  - Can’t maintain closure with cheek puff

What cranial nerves might be impaired?

- Jaw = Trigeminal OK
- Palate = IX, X and XI OK
- Tongue = Hypoglossal OK

- Unilateral decreased movement of R face indicates isolated damage to Facial CN VII
Facial nerve palsy

- Facial nerve palsy occurs when there is damage to the seventh cranial (facial) nerve. It is a type of mononeuropathy.
- This type of nerve damage may occur with local growths, such as a tumor, that put pressure on the facial nerve.
- Facial nerve palsy may also be caused by:
  - HIV infection
  - Lyme disease
  - Sarcoidosis
  - It also may have no obvious cause.

Symptoms of facial nerve palsy

- Change in the appearance of the face
  - Difficulty closing one eye
  - Difficulty making expressions, grimacing
  - Difficulty with fine movements of the face
  - Facial droop
  - Paralysis of one side of the face
- Difficulty eating (items fall out of the weak corner of the mouth)
- Face feels pulled to one side
- Face feels stiff
- Headache
- Impairment of taste
  - Increased loudness of sound in one ear
  - Pain behind the ear (for Bell’s palsy)
  - Sensitivity to sound (hyperacusis)
Practice Case C

- Bedside results indicate:
  - Jaw movement WNL
  - Movement of soft palate WNL
  - Lip movement WNL
  - No pharyngeal signs
  - Tongue
    - Fasciculations on L
    - Can’t lateralize to R
    - Residue on L

References

What cranial nerves might be involved?

- V, VII, I, X, XI all appear to be functioning
- XII Hypoglossal nerve damage
  - Muscle for protrusion (genioglossus) is contralateral only
  - Other muscles bilateral innervation
  - So the lesion must be……
    - Lower motor neuron

What might damage the XII nerve?

- Causes include a tumor or bone abnormality at the base of the skull, a stroke, infection of the brain stem, or an injury to the neck, such as that due to surgical removal of a blockage from an artery in the neck (endarterectomy).
- Amyotrophic lateral sclerosis (Lou Gehrig’s disease) can also damage the hypoglossal nerve.
- Which of these might be LMN?