1. Airway Anatomy

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Laryngeal Skeleton

- Hyoid:
  - Attachment for thyroid cartilage via thyrohyoid membrane & extrinsic mm of larynx
  - U shaped body
  - Body & paired greater & lesser horns

- Skeleton has 9 cartilages:
  - Singles:
    - Thyroid
    - Cricoid
Epiglottic  
- Paired:

Artyenoid
Corniculate
Cuneiform

Thyroid cartilage:
- Laryngeal prominence
- Superior thyroid notch
- Inf thyroid notch
- Post border of each lamina:

- Superior horn
- Inferior horn

Thyrohyoid membrane – attaches supeior horn to hyoid

Cricothyroid joints:
- Inf horn and cricoid cartilage
- Rotation and gliding of thyroid cartilage to allow chang length vocal cord

Cricoid cartilage:
- Thicker and stronger than thyroid cartilage
- Made of hyaline cartilage
- Lies at C6-7 (adults); C3-4 (children)
- Only cartilage to encircle the airway
- Attached to:
  - Thyroid – cricthyroid cartilage
  - 1st tracheal ring – cricotracheal ligament

Arytenoid cartilages:
- Paired 3 sided pyramidal cartilages
- Predominately responsible for opening & closing of larynx
- Each has:
  - Apex superiorly – attached to corniculate cartilage which attaches to ary-epiglottic fold
  - Vocal process anteriorly – attachment for vocal cords
  - Muscular process projecting laterally from base

Corniculate cartilages:
- Tiny paired fibroelastic cartilages
- Lies in aryepiglottic folds
- Articulate with arytenoids medially
- Provide stiffening for post A-E folds

Cuneiform cartilages:
- Tiny elongated elastic cartilages
- Lie in A-E folds
- Not functionally significant

Crico-arytenoid joints – bases of arytenoid and superior of cricoid

Vocal ligaments:
- From:
  - Lamina of thyroid cartilage (ant)
  - Vocal process of arytenoid (post)

Epiglottic cartilage –
- Elastic cartilage giving flexibility
- Attached to thyroid cartilage by thyroepiglottic ligament
- Aryepiglottic folds = formes from mucosal continuation from epiglottis to surface of arytenoids

Interior of Larynx
- Laryngeal cavity extends from laryngeal inlet to inf border of cricoid cartilage
- Cavity includes:
  - Laryngeal vestibule = laryngeal inlet to vestibular folds
  - Middle part of laryngeal cavity = between vestibule & folds
  - Laryngeal ventricle = recesses extend laterally between vestibular & vocal folds
  - Infraglottic cavity = continous with the trachea
- Vocal folds (cords):
  - Each fold contains:
    - Vocal ligament =

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1. Airway Anatomy

- thickened elastic tissue
- it is the medial free edge of the conus elasticus

- vocalis muscle = fine muscle immediately lateral and attaching to vocal ligaments
  - = source of tone from larynx
  - main insp sphincter when tightly closed (adducted)

- glottis = vocal apparatus of larynx
  - made up of:
    - vocal folds
    - vocal processes
    - rima glottidis = aperture between folds
Nerves of the Larynx

- Superior laryngeal nerve
  - Divides into:
    - Internal branch –
      - Sensory to:
        - Ipsilateral larynx from sup boundary to true cords
        - Pyriform sinus
        - Epiglottis
    - External branch –
      - Motor
        - Cricothyroid muscle
      - Sensory:
        - Ant infraglottic larynx cricothyroid membrane
        - Unilateral paralysis $\implies$ failure of ipsilateral cord closure event with intact RLNs

- Recurrent (inf) laryngeal nerve:
  - Motor:
    - All intrinsic mm of larynx on same side except cricothyroid mm (ext laryngeal from Vagus)
  - Sensory:
    - Ipsilateral mucosa below true cords
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- L RLN longer course, turning around aortic arch; R RLN turns around subclavian artery
- paralysis of RLN \(\Rightarrow\) paramedian vocal cord position due to adduction action of SLN

(cricothyroid)

**Muscles of Larynx**

**Intrinsic Muscles of Larynx**

**Nerves**

• Inferior laryngeal nerve (recurrent laryngeal nerve) supply all EXCEPT cricothyroid (external laryngeal from CN X)

**MMs**

• Cricothyroid:
  - Covers cricothyroid membrane laterally
  - A: adducts & tenses vocal ligament

• Thyro-Arytenoid:
  - O: at front – post part of angle of thyroid laminae
  - I: at back ant surface of arytenoid
  - R: runs alongside vocal ligaments in AP route
  - A: adducts and then thins & tenses vocal ligament

• Post crico-arytenoid:
  - O: post surface of lamina of cricoid cartilage
  - I: vocal process of arytenoid cartilage
  - A: adducts vocal ligs (ONLY)

• Lateral crico-arytenoid:
  - O: arch of cricoid cartilage in going forwards
  - I: vocal process of arytenoid cartilage
  - A: adducts vocal cords

• Transverse & oblique arytenoids:
  - O&I: one arytenoid cartilage to contralat one
  - A: adducts arytenoid cartilage \(\Rightarrow\) closing post rima glottidis

• Vocalis:
  - O: Lat surface of vocal process of arytenoid
  - I: ipsilat vocal lig
  - A: relaxes post vocal lig while maintaining ant tension
Extrinsic Muscles of Larynx

Suprahyoid Muscles

- **Mylohyoid**:
  - O: mylohyoid line mandible on internal surface
  - I: hyoid
  - N: V₃
  - A: elevates floor mouth & tongue during speaking

- **Geniohyoid**:
  - O: Inf mental spine underneath & anterior
  - I: body hyoid
  - N: XII
  - A: shortens floor of mouth, widens pharynx

- **Stylohyoid**:
  - O: Styloid process
  - I: body hyoid
  - N: CN VII
  - A: elongates floor of mouth by elevating & retracting hyoid

- **Digastric**:
  - Anterior belly:
    - O: digastric fossa of mandible (ant & internal)
Airway Anatomy

- N: V3
  - Posterior Belly:
    - Mastoid notch on temporal bone
    - N: CN VII
  - I: sling of digstric & intermediate ligament on body & greater horn of hyoid
  - A:
    - with infrahyoid mms: depresses mandible against resistance
    - elevates hyoid during swallow & speaking

**Infrahyoid Muscles**

- Nerves: all from Cervical plexus EXCEPT thyrohyoid (CN XII)
- Sternohyoid:
  - O: manubrium & med clavicle
  - I: body hyoid
  - N: C1-C3 branches
  - A: depresses hyoid after elevation during swallow
- Omohyoid:
  - O: sup border scapula near suprascapular notch
  - I: hyoid
  - N: C1-C3 branches
  - A: depress, retract steady hyoid
- Sternothyroid:
  - O: Post manubrium
  - I: oblique line of thyroid
  - N: C2-3
  - A: depress hyoid & larynx
- Thyrohyoid: (extension up of sternothyroid)
  - O: Oblique line thyroid
  - I: inf border hyoid
  - N: CN XII
  - A: depress hyoid, elevate larynx

**Mouth & Pharynx**

- structures make up floor of mouth:
  - mandible
  - tongue
  - lip
  - teeth
  - hyoid
  - muscles:
    - geniohyoid
    - stylohyoid
    - genioglossus

**Nerves to Tongue**

- Sensory nerve supply:
  - General sensation (touch/temp) ant 2/3: lingual nerve (CN V3)
  - Taste ant 2/3: chorda tympani nerve (CN VII)
  - except vallate papillae
  - Post 1/3 tongue & vallate papillae all sens: lingual branch CN IX glossopharyngeal
- Motor nerve supply:
  - All mms CN XII hypoglossal EXCEPT palatoglossus
  - receive innervation vagus CN X
Muscles of Tongue

Extrinsic

- Genioglossus:
  - O: short tendon from mental spine of mandible
  - I: fan shaped to entire dorsum (underside) of tongue & to hyoid
  - A: [middle]: longitudinal furrow along centre tongue
  - [ant] pulls apex down
  - [post] pulls tongue forward
  - [unilat] tongue side to side

- Hyoglossus:
  - O: hyoid body
  - I: inferior lat aspect tongue
  - A: depresses tongue

- Styloglossus:
  - O: Styloid process
  - I: joins hypoglossus – into sides tongue post
  - A: retrudes tongue & pulls sides up ⇒ trough in centre for swallowing

- Palatoglossus:
  - O: soft palate
  - I: posterolat tongue, blends laterally with intrinsic tranverse muscles
  - A: elevate post tongue or depress soft palate

  ![Diagram of Tongue Muscles](image)

Intrinsic Muscle of tongue

- Sup longitudinal:
  - thin layer deep to mucous membrane
  - A: curls tongue longitudinally upwards

- Inf longitudinal:
  - Narrow band close to inf surface
  - O&I: root of tongue & hyoid to apex
  - A: pulls longitudinally downwards & retrudes tongue

- Transverse:
  - Deep to superior long.
  - A: narrows & elongates tongue

- Vertical:
  - Intersects transverse
  - A: flattens and broadens tongue
Trachea
- Larynx (C6) → termination at corena (t4-5 IV disc)
- Enters superior mediastinum slightly to right of median plane
- Post surface flat against oesophagus
- Terminates above the heart and does not enter post mediastinum
- Function:
  - Conduit for air
  - Epithelium propels debris towards pharynx
- Fibrocartilaginous tube
- Supported by incomplete tracheal cartilages (rings) which deficient posteriorly
- Gaps spanned by trachealis muscle
- Adult trachea = 2.5cm diameter

Pharynx
- Superior portion of alimentary system post to oral & nasal cavities
- From cranial base → inf border of cricoid cartilage (ant) & inf border C6 vertebra (post)
- Widths:
  - Widest opposite hyoid (5cm)
  - Narrowest at oesophageal opening (1.5cm)
- Divided into 3 parts:
  - Nasopharynx
  - Oropharynx
  - Laryngopharynx

Nasopharynx
- Resp function
- Post extension of nasal cavities
- Nose opens through 2 choanae (paired openings)
- Lymphoid tissues aggregated into masses called tonsils
- Adenoids = pharyngeal tonsils
  - In sup/post wall of nasopharynx
Oropharynx
- boundaries:
  - sup: soft palate
  - inf: base of tongue
  - laterally: palatoglossal & palatopharyngeal arches
- extends from soft palate to sup border of epiglottis

Laryngopharynx
- lies post to pharynx
- from:
  - sup border of epiglottis AND pharyngo-epiglottic folds to
  - inf border cricoid cartilage ⇒ narrows into oesophagus
- post related to C4-C6
- communicates with larynx through laryngeal inlet on ant wall
- pyriform fossa (recess)
  - = small depression on either side of laryngeal inlet
  - separated from laryngeal inlet by ary-epiglottic fold
- branches of laryngeal & recurrent laryngeal nerves lie deep to mucus membrane of piriform fossa & vulnerable to injury

Pharyngeal Muscles
- action to constrict pharynx during swallowing:
  - superior, middle & inf pharyngeal constrictors (CN X) (external layer)
  - elevate, shorten & widen pharynx & larynx during swallow & speaking (internal layer):
    - palatopharyngeus (CN X)
    - salpingo-pharyngeus (CN X)
    - stylopharyngeus (CN IX)
Laryngeal Physiology

- 3 basic functions:
  - protection of airway
  - respiration
  - phonation

Protection of Airway
  - primary function is as a sphincter to protect lower airway from entrance of liquid & food

Tri-Sphincteric Mechanism
  - 3 protective tiers within the larynx:
    - Ary-epiglottic fold
      - Functional muscular closure
      - Closes during swallowing diverting things into pyriforms & oesophagus
      - High position of the folds at the laryngeal inlet also serves to divert vomit away from airway
    - False vocal cords:
      - Exit valves to prevent egress of air from trachea (expectorator function)
      - With ↑ pressure below (in sealed position) ⟹ close more tightly
        - Occurs due to down turned direction of their free margins ∴ no muscle activity
      - Passive closure of false cord alone essential to good cough production
        - ↓: bilat vocal cord paralysis doesn’t affect expectorator functions
    - True vocal cords
      - Most significant at preventing aspiration
      - Upturned margins ⟹ able to prevent ingress of air by resisting pressure from above
        - ↓ why if laryngeal spasm ↑ positive pressure only seals cords further
  - In Valsalva Maneœuvre – tight closure of both sets of fold ⟹ resist very strong exp forces

Neuromuscular Physiology

Afferent System
  - Density of sensory innervation greatest at laryngeal inlet
    - esp laryngeal surface of epiglottis
  - Post half of cords has more receptors than ant

Efferent System
  - See SLN, RLN actions previously

Glottic Closure Reflex
  - Reflex laryngeal closure produced by rapid contraction of thyroarytenoid muscle in response to SLN stimulation
    - ↓ can see in response to other stimuli eg stimuli of all major CN afferents
  - Thyroarytenoid:
    - an adductor when vocal cords prev abducted (if already adducted it relaxes true vocal cords)
    - fastest striated muscles

Laryngospasm
  - = exaggeration of glottic closure reflex
  - maintained well beyond end of stimuli
  - most likely when:
    - intubation
    - light anaesthesia
    - manipulation of upper aerodigestive tract
Airway Anatomy

1. FBs
   - Blood or mucus in glottic chink

   - Causes of inhibition in reflex:
     - ↑paCO2
     - ↓paO2
     - Positive intrathoracic pressure
     - Inspiration phase of respiration

2. Cough Reflex
   - Voluntary or involuntary (receptors in larynx or lower respiratory tract)
   - 3 phases:
     - Inspiratory:
       - Larynx opens wide → rapid deep inspiration
     - Compressive:
       - Tight closure of glottis & strong activation of exp muscles
     - Expulsive:
       - Larynx opens widely → sudden outflow of air 6-10 litres/sec

3. Apnea Reflex
   - Supraglottic larynx has chemical & thermal sensors → apnoea
   - Prevents aspiration
   - Implicated in SIDS – maturation of airway reflexes → ↑likelihood of apnoea & laryngospasm
   - Initiation:
     - Water – especially in infants (in adults likely → coughing)

4. Circulatory Reflexes
   - Stimulation of larynx eg intubation & OSA
   - Stim →
     - ↑bp
     - ↑vagal stimuli → bradycardia → ↓bp
   - Afferent limb = SLN
   - SLN afferent activity is ↓ed by hypocapnia

5. Respiratory Function
   - CNS control of respiratory function is dual:
     - Voluntary – higher cortical centres
     - Involuntary – medullary centres
   - Each can override each other eg voluntary breath holding → ↑CO2 → medulla will eventually force vocal cord abduction
   - Widening of glottis occurs by bursts of activity in RLN
   - Glottis opens just prior to diaphragmatic descent
   - Degree of abductor activity varies directly with degree of ventilatory resistance ie ↓ with tracheotomy
   - Variations in RR result from changing duration of exp phase rather than insp phase
     - Changes triggered by receptors in:
       - Lungs
       - Subglottic trachea
       - Larynx

Phonation

- Voice created by coordinated interaction between:
• Larynx, Lungs, Diaphragm, Abdo mms
• Throat, neck,
• Lips, tongue, cheek, soft palate

• Tone created by larynx then modified in upper aerodigestive tract
• Mm action on cords:
  o Cricothyroid mm - positionned near midline (isotonic)
  o thyroarytenoid – finer adjustments (isometric)
• ↑pitch:
  o cricothyroid mm: lengthens true cord & tenses it
  o thyroartenoid mm: thins and tenses