An Overview of the Larynx

The larynx or voice box is a cylindrical space which lies at the upper end of the trachea opposite to the 3rd-6th cervical cartilages. It is a cartilaginous structure made up of 6 different types of cartilages. Major cartilages forming the framework of the larynx are thyroid, cricoid and epiglottis. The unpaired cartilages are three in number, namely arytenoids, corniculate and cuneiform. Cricoid cartilage is in the form of a complete ring which lies below the thyroid cartilage. Vocal cords are attached to the thyroid and arytenoid cartilages. Various muscles wrap the cartilages which produce movements at the cricoarytenoid and cricothyroid joints.

Structure and Function of the Muscles of the
Larynx

The Innermost layer of the larynx is the mucous membrane which consists of **pseudostratified columnar ciliated epithelium**, except at the vocal cords which have stratified squamous epithelium. (See Anatomy of the Lower Airways – Larynx and Trachea).

In the adult, the larynx is located at the level of C6 and lifts to C4 with swallowing. In infants, the larynx is a conical space with soft and compressible cartilages situated a bit higher against the C3 or C4 vertebrae and reaches C1 or C2 while swallowing.

**Normal Functions of the Larynx:**

- Protects the lower airways (prevents large foreign bodies from reaching the lungs)
- Produces voice with assistance from the lips, tongue, palate and pharynx
- Assists in Respiration/Breathing (controls the air column and the amount of air that passes through it)
- Plays a role in the **Valsalva maneuver**, the production of a **cough** and in increasing intraabdominal pressure during delivery or defecation

**A Clinical Approach to the Larynx**

The larynx creates an inlet to the airways and is exposed to bacteria and viruses leading to a number of infections. Even trauma can lead to the disturbance of laryngotracheal anatomy and physiology.

**Laryngotracheal Trauma**

Road traffic accidents, a direct blow to the neck, strangulation, penetrating injuries, and gunshot wounds can cause injury to the larynx.

**Laryngotracheal trauma should be suspected if the following signs and symptoms are present after a traumatic episode:**

1. Hoarseness of the voice
2. Pain or difficulty in swallowing as well as aspiration of food particles
3. **Dyspnea** with or without stridor
4. Hemoptysis
5. Bruises on the neck’s skin with or without tenderness on palpation
6. Displacement of cartilages due to fracture with or without bony crepitus

Laryngeal edema, hematoma or mucosal tear with asymmetry of the glottis (defined as the part of the larynx consisting of the vocal cords and the slitlike opening between
them) or the laryngeal inlet (the opening that connects the pharynx and the larynx) revealed after a **laryngoscopy** confirms the presence of the injury.

**Management:** A patient in an emergency suffering from respiratory distress should be evaluated and managed depending on the severity of the disturbance. Humidification and nebulization with steroids and bronchodilators relieve edema and swelling along with the respiratory distress.

If respiratory distress does not improve, the airway is secured, but not by **endotracheal intubation**, as it may be difficult and hazardous, instead, **tracheostomy or, as an emergency, cricothyroidotomy** is done. Three to four days later, when the patient becomes stable, open reduction of the fractures is done and mucosal tears are repaired using an absorbable material such as catgut. Normal anatomy is restored by repositioning of the structures using various techniques by the ENT surgeon.

Broad spectrum antibiotics with good upper respiratory tract cover, like clarithromycin, amoxicillin or cephalosporin, are given to prevent chondritis and cartilage necrosis.

**Inflammatory Processes of the Larynx**

**Laryngitis**

![Image: “Endoscopic documentation of larynx with LPR” by Phoni. License: CC BY-SA 3.0](image)

Acute inflammation of the larynx can be infectious or non-infectious. Infection is usually viral initially, but a superimposed bacterial invasion may occur. Inflammation results in fever, hoarseness, pain, or an irritating cough, which worsens at night along with a dry throat and malaise. Common bacteria are *S. pneumoniae, H. influenza, S. aureus* and *streptococci*.

At laryngoscopy, initially the vocal cords and the **epiglottis** show **erythema** and edema. Later, the swelling worsens and the redness increases, increasing the severity of the symptoms. Laryngitis secondary to **diphtheria** or tonsillitis is called **acute membranous laryngitis**.

**Management:** Nebulizers with steam and steroids improve the edema. Voice rest and avoiding irritants like smoke along with cough suppressants and pain-killers relieve the discomfort. If a productive cough starts along with a fever, an antibiotic medication is given.
Chronic Laryngitis

After recurrent infections of the larynx, vocal cords and the surrounding structures become constantly inflamed. Repeated infections of the pharynx, exposure to dust, fumes, smoke, or vocal abuse can predispose humans to chronic inflammation. Usually, patients complain of hoarseness, dry cough, constant aching and pain in the throat. Local examination shows dull red, rounded vocal cords with viscous mucus around them.

**Management:** Avoiding irritants, voice rest, speech therapy, steam inhalation and expectorants are given to relieve the symptoms. Antibiotic treatment is given for 7—10 days to protect against infections.

Reinke’s Edema

**Reinke’s Space (Superficial Lamina Propria)** is a layer just underneath the surface lining of the vocal fold. Composed of cells, special fibers, and other substances (extracellular matrix), Reinke’s Space has a key role in vocal fold vibration. Reinke’s edema is characterized by the “sac-like” appearance of the fluid-filled vocal cords. The swelling of the vocal folds causes the voice to become deep and hoarse. It’s common in smokers, usually in response to smoke exposure. It can lead to laryngitis.

Epiglottitis

[Image: “Reinke Edema” by Welleschick. License: CC BY-SA 3.0]

[Image: “Epiglottitis endoscopy”. License: CC BY-SA 3.0]
Acute inflammation of the epiglottis and surrounding structures in the supraglottic space is more life-threatening and sudden on onset than laryngitis, mostly affecting children who are aged 2—7 years. \textit{H. influenza} is the culprit in children. Patients present with dysphagia and sore throat along with dyspnea, with or without stridor. \textit{Vaccination} is available and should be pursued. It has drastically decreased the number of cases with epiglottitis in the United States. Two or three doses should be given before six months of age. In the United States, a fourth dose is recommended between 12 and 15 months of age.

Examination of the oral cavity and laryngoscopy reveal edema and congestion of the supraglottic structures. Physical examination in the Emergency Room is usually avoided as it may precipitate obstruction of the airway. It can be done in an ICU setting. A \textbf{thumb sign} on an x-ray of the soft tissues of the neck (lateral view) confirms the diagnosis. A throat swab and blood cultures can also be helpful.

\textit{Image: “Left column: Normal epiglottis. Right column: Epiglottitis” by Mad Chaos. License: CC BY-SA 3.0}

**Management:** Hospitalization should be considered depending on the severity of the disease. Antibiotics like ampicillin or third generation cephalosporin are effective against \textit{H. influenza}. Dexamethasone or hydrocortisone is given to relieve edema and inflammation. Oxygen inhalation and nebulization along with increased hydration are recommended.

\textbf{CROUP: Acute Laryngotracheobronchitis}
Inflammation of the larynx, trachea, and bronchi is mostly viral (Parainfluenza virus), affecting children aged up to 3 years. Patients complain of flu-like symptoms and a characteristic barking cough accompanied by stridor.

The presence of the steeple sign on x-ray (also called wine bottle sign, it refers to the tapering of the upper trachea on a frontal chest radiograph reminiscent of a church steeple) indicates a possible diagnosis of croup.

**Management:** Patients come to the emergency room presenting with a barking cough. Nebulization with adrenaline, normal saline and bronchodilators are all actions taken to relieve the distress. After hospitalization, steroids like hydrocortisone are given along with antibiotics. Tracheostomy is considered if the respiratory distress worsens. Many cases of croup have been prevented by immunization for influenza and diphtheria.

**Laryngeal Diphtheria**
Formation of pseudomembranes over the larynx, pharynx, and tonsils is caused by infection of the *C. diphtheriae*. Its exotoxins can also cause myocardiitis. A Patient presents with a sore throat, malaise, a low-grade fever, croupy cough, dyspnea, and stridor. On examination, whitish membranes are observed over the throat and larynx. Lymphadenopathy leading to a bull’s neck appearance is a characteristic of this disease.

**Management:** Complete bed rest, antibiotic prescription, and antitoxins treat the disease in 2—4 weeks. Benzylpenicillin is the antibiotic of choice. Diphtheria antitoxin 20,000 to 100,000 units I.V in a normal saline drip for 5 days is recommended.

**Other infections of the larynx secondary to diseases:**

The larynx is infected by other disease states like tuberculosis, lupus erythematosus, syphilis, leprosy and scleroderma.

**Congenital Lesions of the Larynx**

**Laryngomalacia**

Excessive flaccidity of the supraglottic larynx leads it to be sucked out of position during inspiration thus producing stridor. This condition manifests at birth and disappears after 2 years of age. A laryngoscopy confirms the diagnosis.
Laryngeal Web

Incomplete recanalization of the larynx produces a congenital weak cry and airway obstruction. Thin webs can be cut using a scalpel or CO₂ laser. Thick webs need excision and placement of dilators.

Laryngocele

This is the dilatation of the laryngeal saccule, the space between the true and false vocal cords. It may be internal, external or combined. Treatment is excision through endoscopy.

Local Changes in the Larynx

![Local changes in the Larynx](localchangesinlarynx)
Non-Neoplastic Lesions

Vocal Nodules

![Image: “Histopathologic image of vocal fold nodule or polyp” by Unknown. License: CC BY-SA 3.0]

Trauma to the vocal cords after vocal abuse or misuse leads to the formation of pin head to half pea sized nodules symmetrically located on both cords. Edema and hemorrhage in the sub mucosal space become nodular after fibrosis.

These singer’s/screamer’s nodules can be managed conservatively through voice rest, speech therapy as well as by educating the patients on the cause. Otherwise, excision can be done under an operating microscope. Professional singers and people who have a lot of vocal demands are often affected by nodules.

Vocal Polyp

![Image: “vocal polyp” by Wellenschik. License: CC BY-SA 3.0]

Finger-like projections called polyps are often formed after vocal abuse or misuse mostly in adulthood and old age. It can also occur after some allergic response or smoking.

The patient presents with hoarseness; if the polyp is large, it can even lead to stridor or intermittent choking. It is managed by surgical excision followed by speech therapy.
Contact Ulcer
Vocal misuse in which laryngeal cartilages rub against each other leads to ulceration and granuloma formation. Patients usually complain of hoarseness and discomfort in the throat. An ulcer is visible on examination.

Intubation Granuloma
Granulomas result after prolonged endotracheal intubation or after injury to the vocal processes during intubation. The mucosal ulceration which is initially produced is followed by granuloma formation and produces hoarseness and even dyspnea. Voice rest and endoscopic removal are recommended.

Neoplastic Lesions

Squamous Papillomas
Juvenile papillomas mostly occur in infants and children. These are usually viral in origin and multiple in number, producing hoarseness and stridor. Local examination shows glistening white irregular growths, which may be pedunculated or sessile and usually bleed easily.

Management: Complete excision, cryotherapy, micro-electrocautery, or CO₂ laser are the various treatment options.

Chondroma: Tumor of the Cartilages
The most commonly cartilage affected by chondromas is the cricoid. It causes dyspnea or even dysphagia.

Hemangioma
Capillary type hemangiomas occur in infants, while cavernous types are common in adults.

Granular Cell Tumor
Mostly, it is submucosal and arises from the Schwann cells. It can differentiate into a malignant tumor.

Laryngeal Carcinoma
Laryngeal cancer is more common in males. Its incidence is increasing due to various risk factors. This malignant disease is seen in adult males after age 40.

The various risk factors include:
- Smoking
- Alcohol use
- Air pollution
- Carcinogens exposure
- Radiation exposure
Supraglottic Cancer

Usually, a silent invasion occurs in the surrounding structures. Early metastasis occurs into the lymph nodes, more often into the upper and middle jugular lymph nodes.

The patient presents with throat pain, dysphagia, tender enlarged lymph nodes, and weight loss. Hoarseness is a late symptom.
Glottic Cancer
Vocal cords become fixed due to tumor formation and hoarseness results, hence diagnosing the disease can be done earlier relative to other laryngeal cancers. Stridor may result after development of edema.

Subglottic Cancer
This condition is usually rare, but it involves the structures below the glottis, even the trachea. Hoarseness is a late symptom. Metastasis occurs on the prelaryngeal, pretracheal and paratracheal lymph nodes.

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<tr>
<th>Classification of laryngeal carcinoma according to the site by the American joint committee of cancer</th>
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<td><strong>Sites</strong></td>
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Grade of Cancer
The grade of cancer tells you to what extent the cancer cells look like normal cells under a microscope. **There are 3 grades of laryngeal cancer:**

- **Grade 1** (low grade) – well differentiated
- **Grade 2** (intermediate grade) – moderately differentiated
- **Grade 3** (high grade) – poorly differentiated

TNM Stages of Cancer of the Larynx

**TNM stands for Tumor, Node, and Metastasis. The system describes:**

- The size of a primary tumor (T)
- Whether the lymph nodes have cancer cells in them (N)
- Whether the cancer has spread to a different part of the body (M)

American Joint Committee on Cancer gave the TNM Classification of Laryngeal Carcinoma:

**T in TNM classification**

- **Tx** – Primary tumor which cannot be assessed
- **To** – No evidence of primary tumor
- **Tis** – Carcinoma in situ
- **T1** – Tumor less than or equal to 2 cm in greatest dimension
- **T2** – Tumor greater than 2 cm in greatest dimension but < 4 cm
- **T3** – Tumor greater than 4 cm in greatest dimension
- **T4a** – Moderately advanced local disease
- **T4b** – Very advanced local disease
N stages of laryngeal cancer

There are 4 main lymph node stages in cancer of the larynx. N2 is divided into N2a, N2b and N2c. The important point here is presence or absence of cancer in any of the nodes, and in case of the former, the size and site of the involved lymph node.

- **N0** - no lymph nodes containing cancer cells
- **N1** - one lymph node involved on the same side of the neck which is less than 3 cm in size
- **N2a** - one lymph node on the same side of the neck, 3 cm—6 cm in size
- **N2b** - more than one lymph node, but none are more than 6 cm in greatest dimension; all the nodes must be on the same side of the neck as the cancer
- **N2c** - lymph nodes on the other side of the neck from the tumor or in nodes on both sides of the neck, but none is more than 6 cm in size
- **N3** - at least one lymph node containing cancer larger than 6 cm in size

M stages of laryngeal cancer

**There are two stages to describe whether cancer of the larynx has spread:**

- **M0** - there is no cancer spread
- **M1** - the cancer has spread to other parts of the body, such as the lungs

Diagnosing the Cancer

Hoarseness of 3 weeks that does not improve is an important point in the history of the disease. Examination of the neck is important to find palpable lymph nodes. **The following investigations need to be done:**

Laryngoscopy

Appearance of the lesion can be ulcerative (infrahyoid epiglottic involvement), exophytic (suprahyoid epiglottic involvement), or nodular (glottis).

Vocal cords may be fixed showing invasion or involvement of the recurrent laryngeal nerve. **After laryngoscopy, the following radiological tests should be performed:**
1. **Chest x-ray** to investigate any associated lung disease and mediastinal lymph nodes
2. Contrast-enhanced CT scan or MRI for soft tissue lateral view of the neck
3. Positron emission tomography-computerized tomography scan (PET-CT). This is a radiologic tool that detects metabolic signals from cells with high metabolic activity like cancer cells.
4. Fine needle aspiration (FNA) of a neck mass may be useful to diagnose malignant lymphadenopathy from a laryngeal tumor, and may be an alternative means of establishing a diagnosis rather than direct biopsy via direct laryngoscopy.

## Treatment Options for Laryngeal Carcinoma

### 1. Radiotherapy

Radiotherapy is effective with a 70—90 % cure rate if...

- ...cords are not fixed.
- ...no subglottic extension.
- ...cartilage is not involved.
- ...no lymph node is involved.
- ...no signs of invasion.

### 2. Surgery

1. **Conservative surgery includes**
   1. Cordectomy through a laryngofissure
   2. Partial fronto-lateral laryngectomy
   3. Partial horizontal laryngectomy (excision of supraglottis)

2. **Total laryngectomy:** Block dissection is done along with laryngectomy. It is an option if:
   1. Fixed cords with a T3 stage tumor
   2. All T4 lesions
   3. Cartilages are involved
   4. Failure to cure the disease by radiotherapy or conservative surgery
   5. Tranglottic cancers which involve supraglottic and glottis

### 3. Combined Therapy

Combining surgery with radiotherapy is also very effective. Radiation treatment before and after surgery can decrease incidences of recurrence.

## Vocal Rehabilitation after Treatment

### Esophageal Speech

Patients are taught to swallow air and keep it in the upper esophagus and slowly eject it. A rough voice is produced but the patient can speak 6—10 words.

### Artificial Larynx

An **Electrolarynx** is a device used to produce voice. Another device is called transoral
**pneumatic** device which uses expired air from the tacheostome to vibrate the diaphragm and produce sound.

**Vocal Cord Paresis**

Paralysis of the vocal cords can be unilateral or bilateral due to the involvement of the nerves supplying the larynx, i.e. recurrent laryngeal nerve, superficial laryngeal nerve.

**Causes:**

1. Lesions in the nuclei of the nerves: Nucleus Ambiguus in the medulla. Vascular disturbance or tumor compressing the medulla may also be a cause. Polio and syringomyelia can also affect the larynx.
2. Higher lesions of the vagus nerve: in the skull or parapharyngeal space. For example, tubercular meningitis, nasopharyngeal cancer, glomus tumor, metastatic lymph nodes, lymphoma.
3. Low vagal injury, i.e. recurrent laryngeal nerve injury
4. Systemic causes, like syphilis, diabetes, diphtheria, viral infections
5. Idiopathic (30% of the cases)

**Causes of recurrent laryngeal nerve paralysis:**

1. Trauma to the neck
2. Thyroid surgery
3. Thyroid disease
4. **Thyroid cancer**
5. Cervical and mediastinal lymphadenopathy
6. **Esophageal cancer**
7. Enlarged left auricle
8. **Aortic aneurysm**

*Semon’s law* states that in a progressive lesion of the recurrent laryngeal nerve, the **abductors are paralysed before the adductors.**

**Wagner and Grossman theory**

It states that: in complete paralysis of recurrent laryngeal nerve, the vocal cord lies in the **paramedian position** because the intact cricothyroid muscle adducts the cord (due to an intact superior laryngeal nerve). If the superior laryngeal nerve is also paralysed, the cord will assume an intermediate position because of the loss of adductive force.

**Clinical Features:**

Unilateral paralysis is usually asymptomatic; some patients may have voice problems, but issues regarding aspiration or airway obstruction are rare.

In bilateral paralysis, cords are in median or paramedian position. The Airway is inadequate and dyspnea with or without stridor develops. Condition becomes worse on exertion.

**Treatment:**
Unilateral paralysis needs no treatment.

Patients with bilateral paralysis present in emergency and often need a tracheostomy. Later, either a permanent tracheostomy is done with a speaking valve, or alternatively, surgery is done.

**Surgical treatment: lateralization of the cord**

- Arytenoidectomy
- Thyroplasty type II
- Cordectomy with CO₂ laser via endoscopy
- Nerve muscle implant

**Complete (combined) paralysis of the larynx:**

If both the nerves supplying the cords are involved, complete paralysis of the cords occurs. Thyroid surgery is the most common cause. Patients present with hoarseness of the voice and aspiration of liquids.

Treatment includes speech therapy and surgically medialization of the cords through injection of Teflon paste or thyroplasty type I or arthrodesis of the cricoarytenoid joint.

**Review Questions**

Solutions can be found below the references.

1. **A child, 4 years old, presented to the emergency with an acute attack of a severe cough and respiratory distress. While he was in hospital, he also developed stridor. He has had a history of sore throat for the last 2 days. On examination, supraglottic structures were edematous and congested. Which of the following most common causative agents in this disease is the child suffering from?**
   
   A. Coli
   B. Pneumonae
   C. Influenza
   D. Diphtherae

2. **A child came to the family physician with hoarseness and respiratory difficulty along with flu-like symptoms. He was referred to an ENT surgeon who investigated the disease and did laryngeal endoscopy. The figure shows the larynx of the child. In addition, the child has a history of a chronic cough and noisy breathing.**

   A. Chronic bronchitis
   B. Croup
   C. Vocal cyst
   D. Squamous papilloma of larynx
   E. Asthma
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Post-Laryngectomy Voice Rehabilitation via University of Missouri

Correct Answers: 1C, 2D

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