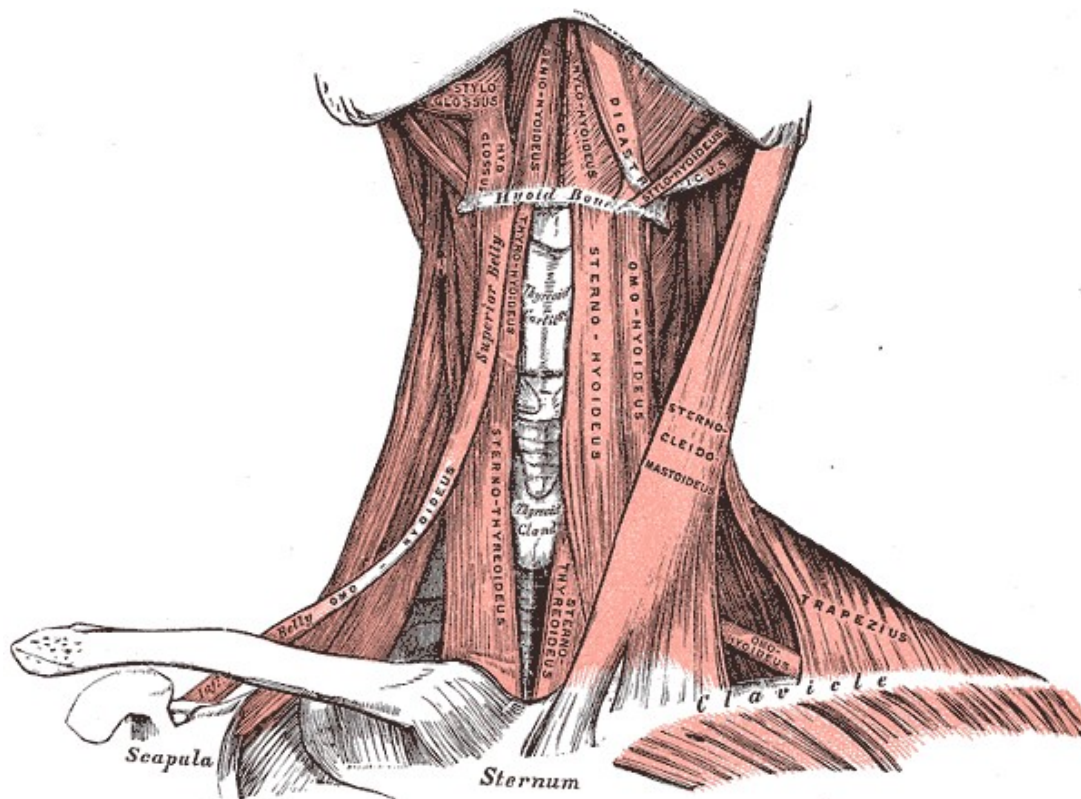


## An Overview of the Larynx

[See online here](#)

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 structures forming the framework of the larynx are the thyroid cartilage, cricoid cartilage, and epiglottis. The unpaired cartilages are three in number, namely arytenoids, corniculate and cuneiform. Cricoid cartilage forms 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.



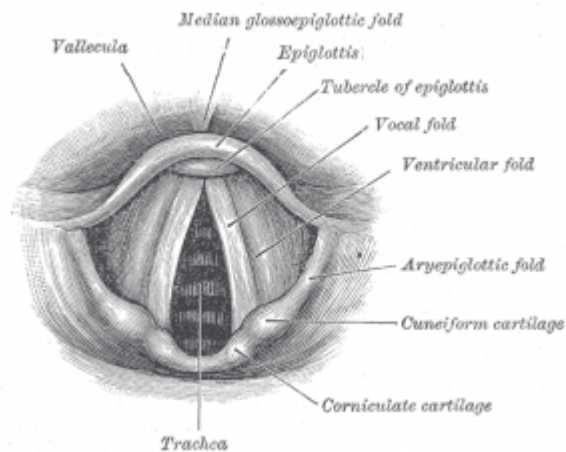
### Definition

The larynx is the organ tasked with phonation, coughing, and, more importantly, protection of the lower airway by preventing the entry of foreign objects into the airway via mechanical stimulation, upon which it closes abruptly.

### Structure and Function of the Muscles of the

# Larynx

The innermost layer of the larynx is the mucous membrane, which consists of the **pseudostratified columnar ciliated epithelium**, except at the vocal cords, which are lined by stratified squamous epithelium.

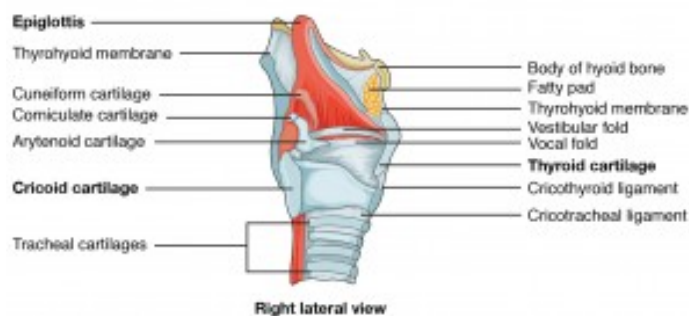
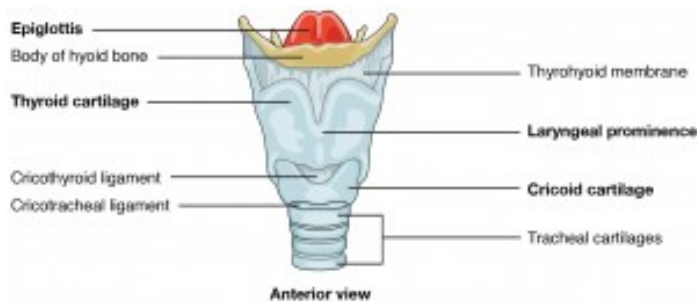


## Anatomy

The larynx is located superior to the trachea and anterior to the pharynx on the latter's inferior portion. It comprises 3 small, paired cartilages — the arytenoid, corniculate, and cuneiform cartilages; and 3 large, unpaired cartilages — the epiglottis, cricoid, and thyroid cartilages. It also contains other structures, such as ligaments, muscles, nerves, and vessels.

The muscles of the larynx are classified into 2 types. **Extrinsic muscles** attach inside the larynx to the hyoid bone. They are further subdivided into 2 groups:

- Suprahyoid: digastric, geniohyoid, mylohyoid, and stylohyoid muscles that work together to lift the larynx
- Infrahyoid: omohyoid, thyrohyoid, sternohyoid, and sternothyroid muscles that lower the larynx and hyoid bone



[Image](#): "The larynx" by OpenStax College - Anatomy & Physiology. License: [CC BY 3.0](#)

**Intrinsic muscles** are located inside the larynx. They help control stress over the glottis and vocal cords. This group includes the thyroarytenoid, cricothyroid, posterior cricoarytenoid, transverse arytenoid, and lateral cricoarytenoid muscles.

In adults, 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, reaching C1 or C2 while swallowing.

## Functions

- Protects the lower airways (prevents large foreign bodies from reaching the lungs)
- Produces vocal sounds 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 intra-abdominal pressure during labor or defecation
- Plays a significant role in the direction of food into the esophagus through the epiglottis, thereby protecting the trachea from choking

## Clinical Approach

The larynx creates an inlet to the airways and is exposed to bacteria and viruses, which can lead 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 event:**

1. Hoarseness of the voice
2. Pain or difficulty in swallowing, or 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
7. Swelling in the neck
8. Difficulty in speaking or generating sound
9. Laryngeal edema, hematoma, or mucosal tear with an asymmetry of the glottis (defined as the part of the larynx comprising the vocal cords and the slit-like opening between them) or the laryngeal inlet (the opening that connects the pharynx and the larynx), revealed after a **laryngoscopy** confirming the presence of the injury

### Management

Every patient in the emergency department who is suffering from respiratory distress should be evaluated and managed depending on the severity of the presentation.

Humidification and nebulization with steroids and bronchodilators can relieve edema and swelling, along with respiratory distress.

If respiratory distress does not improve, the airway should be secured, but not by **endotracheal intubation**, as it may be difficult and hazardous. Instead, **tracheostomy or, in an emergency, a cricothyroidotomy**, should be performed.

Three to 4 days later, when the patient becomes stable, open reduction of the fractures should be performed and mucosal tears repaired using an absorbable material such as catgut. Normal anatomy is restored by repositioning the structures using various techniques by the ear, nose, and throat surgeon.

Broad-spectrum antibiotics with appropriate upper respiratory tract coverage, such as clarithromycin, amoxicillin, or cephalosporin, are administered to prevent chondritis and cartilage necrosis.

## Inflammation

### Laryngitis



Image: "Endoscopic documentation of larynx with LPR" by Phoni.  
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Acute inflammation of the larynx can be infectious or noninfectious. Infection is usually viral; however, a superimposed bacterial infection is common. Inflammation results in fever, hoarseness, pain, or an irritating cough, which worsens at night, along with a dry throat and malaise. Runny nose and headache may be associated symptoms. Symptoms may last for 2–3 weeks even if the voice is kept at rest.

Common bacterial agents include ***Streptococcus pneumoniae***, ***Haemophilus influenzae***, and ***Moraxella catarrhalis***.

Laryngoscope would show **erythema** and edema of the epiglottis. Later, swelling worsens and 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. Resting the voice and avoiding irritants such as smoke, along with taking cough suppressants and painkillers, can help relieve discomfort. If a productive cough accompanies a fever, antibiotics should be

prescribed.

## Chronic laryngitis

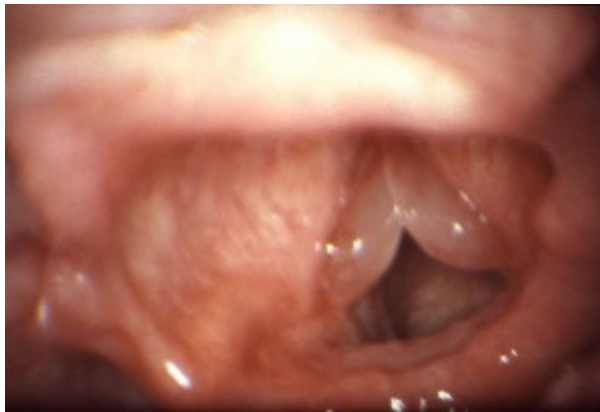
After recurrent infections of the larynx, vocal cords and the surrounding structures become constantly inflamed. Repeated infections of the larynx, exposure to dust, cigarette smoking, alcohol consumption, fumes, smoke, or vocal abuse can predispose patients to chronic inflammation. Usually, patients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

### Management

Avoiding irritants, resting the voice, speech therapy, steam inhalation, and expectorants help relieve symptoms. [Antibiotic treatment](#) is given for 7-10 days to protect against infection.

## Reinke's edema

**Reinke's space (superficial lamina propria)** is a layer lying just beneath 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 is common in smokers and can lead to laryngitis.



[Image](#): "Reinke edema" by Welleschick. License: [CC BY-SA 3.0](#)

## Epiglottitis



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 in onset than laryngitis, and mostly affects children aged 2–7 years. [H. influenza](#) is the culprit in children. Patients present with dysphagia and sore throat along with dyspnea, with or without stridor. [Vaccination](#) is available and should be pursued, as it has drastically decreased the number of cases of epiglottitis in the United States. Two or 3 doses should be given before 6 months of age. In the United States, a 4th dose is recommended between 12 and 15 months of age.

Examination of the oral cavity and laryngoscopy reveals edema and congestion of the **supraglottic structures**. Physical examination in the emergency department is usually avoided as it may precipitate obstruction of the airway, but it can be done in an [ICU setting](#). A **thumb sign** on an X-ray of the soft tissues of the neck (lateral view) can confirm the diagnosis. X-ray is avoided until the airway is secure, as agitation in children may cause sudden obstruction. A throat swab and blood cultures can also be helpful.

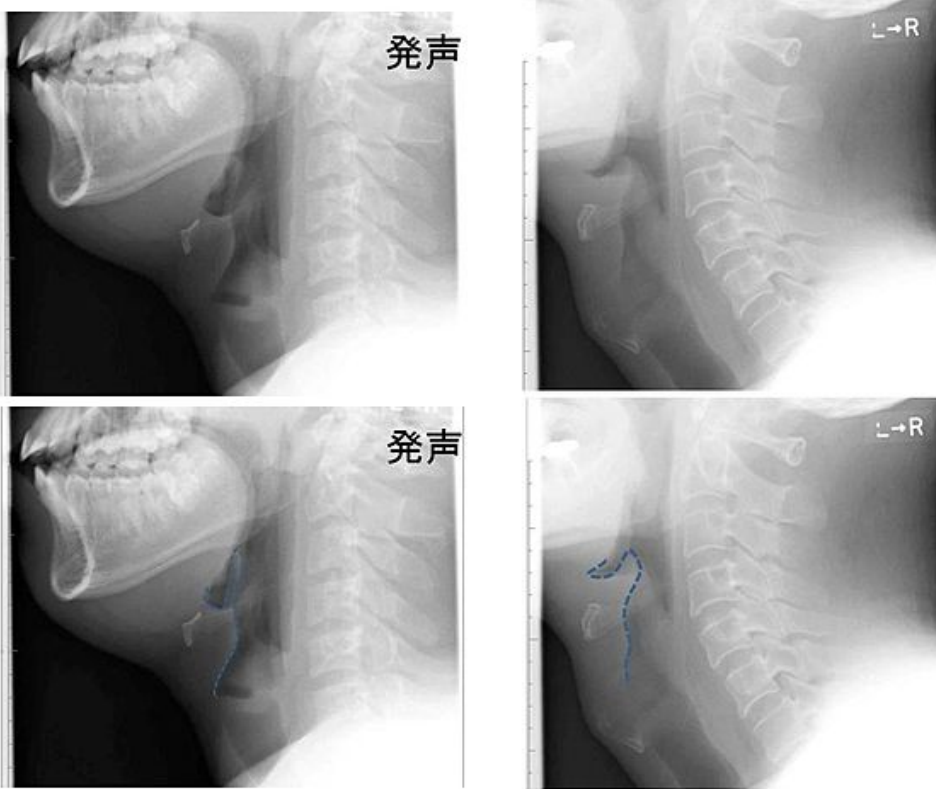


Image: "Left column: Normal epiglottis. Right column: Epiglottitis" by Mad Chaos. License: [CC BY-SA 3.0](https://creativecommons.org/licenses/by-sa/3.0/)

## Management

Hospitalization should be considered depending on the severity of the disease. Antibiotics such as ampicillin or 3rd-generation cephalosporin are effective against *H. influenzae*. Analgesics such as aspirin and ibuprofen can be prescribed to control fever and pain. Dexamethasone or hydrocortisone is given to relieve edema and inflammation. Oxygen inhalation and nebulization along with increased hydration are recommended.

## Croup: Acute laryngotracheobronchitis



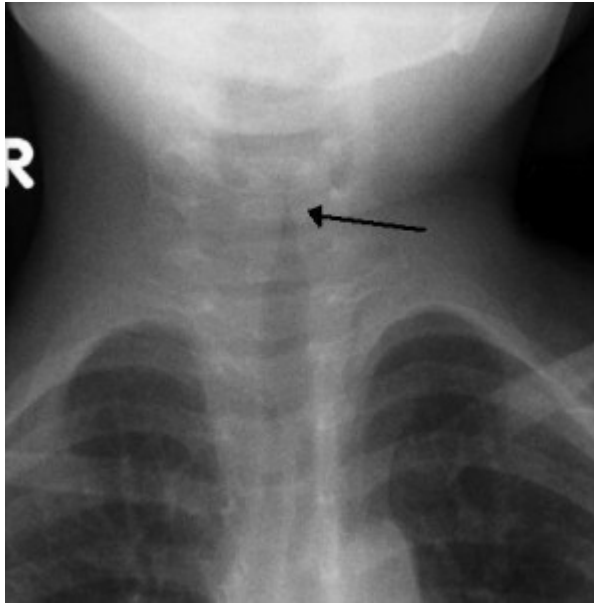


Image: "Croup steeple sign" by Frank Gaillard. License: [CC BY-SA 3.0](https://creativecommons.org/licenses/by-sa/3.0/)

Inflammation of the larynx, trachea, and bronchi is usually viral (parainfluenza virus), affecting children up to the age of 3 years. It is the most common life-threatening pediatric illness. Patients complain of **flu-like symptoms** and a characteristic seal-like barking cough accompanied by inspiratory stridor.

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

## Management

Patients present to the emergency room with a barking cough. Nebulization with adrenaline, normal saline, and bronchodilators is indicated to relieve distress. After hospitalization, steroids such as hydrocortisone should be given along with antibiotics. Tracheostomy is considered if respiratory distress worsens. Many cases of croup have been prevented by immunization for influenza and diphtheria.

## Laryngeal diphtheria





Image: "Dirty white pseudomembrane classically seen in diphtheria" by Dileepunnikri. License: [CC BY-SA 3.0](https://creativecommons.org/licenses/by-sa/3.0/)

The formation of a pseudomembrane over the larynx, pharynx, and tonsils is caused by infection by *C. diphtheriae*. Its exotoxins can also cause **myocarditis**. Patients present with a sore throat, malaise, a low-grade fever, croupy cough, dyspnea, and stridor. On examination, a whitish membrane is observed over the throat and larynx. Lymphadenopathy leading to a "bull neck" appearance is characteristic of this disease.

## Management

Complete bed rest, antibiotic prescription, and antitoxins can be lifesaving.

**Benzylpenicillin** is the antibiotic of choice. Diphtheria antitoxin 20,000–100,000 units IV in a normal saline drip for 5 days is recommended.

## Other infections of the larynx secondary to diseases

The larynx can be affected by other diseases, including [tuberculosis](#), [lupus erythematosus](#), [syphilis](#), leprosy, and [scleroderma](#).

## Congenital lesions

### Laryngomalacia

Excessive flaccidity of the **supraglottic larynx** leads it to be sucked out of position during inspiration, which can produce stridor. This condition manifests at birth and disappears after 2 years of age. A laryngoscopy confirms the diagnosis.



## Vocal cord paralysis

Vocal cord paralysis is the 2nd most common congenital anomaly of the larynx caused secondary to central neuromuscular immaturity. Paralysis may occur due to lesions in the central nervous system from hydrocephalus, spina bifida, etc. An inspiratory stridor at rest is the key symptom; in children, it worsens on agitation. The condition requires urgent airway intervention by intubation.

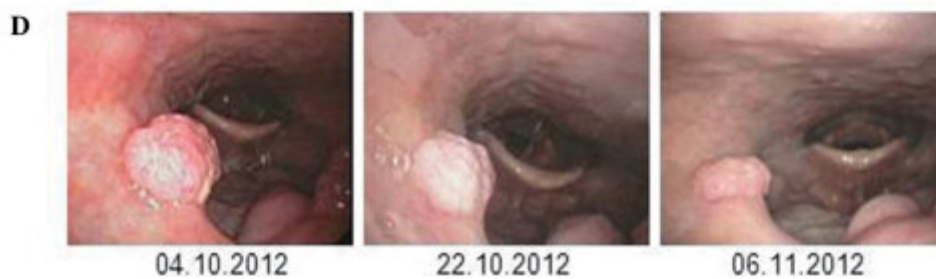
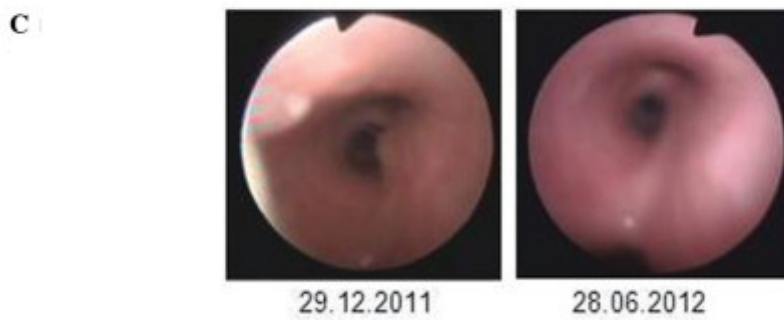
## Laryngeal web

Incomplete recanalization of the larynx produces a congenital weak cry and airway obstruction. Thin webs can be cut using a scalpel or CO<sub>2</sub> laser. Thick webs need excision and placement of dilators.

## Laryngocele

Laryngocele is the dilatation of the laryngeal sacculle, the space between the true and false vocal cords. It may be internal, external, or both. Treatment involves excision through endoscopy.

## Local changes



[Image](#): "Local changes in the larynx" by Unknown. License: [CC BY 3.0](#)

## Non-Neoplastic Lesions

Vocal nodules

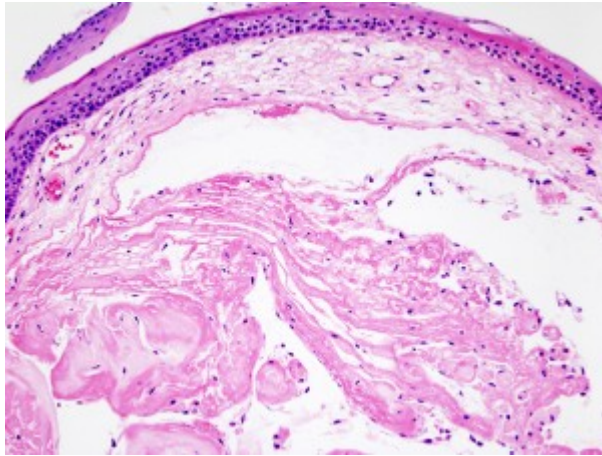


Image: "Histopathologic image of vocal fold nodule or polyp" by Unknown. License: [CC BY-SA 3.0](https://creativecommons.org/licenses/by-sa/3.0/)

Trauma to the vocal cords after vocal abuse or misuse leads to the formation of a pinhead- to half-pea-sized nodules symmetrically located on both cords, or singer's nodules. Edema and hemorrhage in the submucosal space become nodular after fibrosis. Hoarseness, vocal fatigue, and pain in the neck after prolonged use of the voice are symptoms of laryngeal nodules.

These singer's/screamer's nodules can be managed conservatively through resting the voice and speech therapy, as well as by educating patients on the cause. Otherwise, excision can be done under an operating microscope. Professional singers and individuals with significant vocal demands are often affected by nodules.

## Vocal polyp

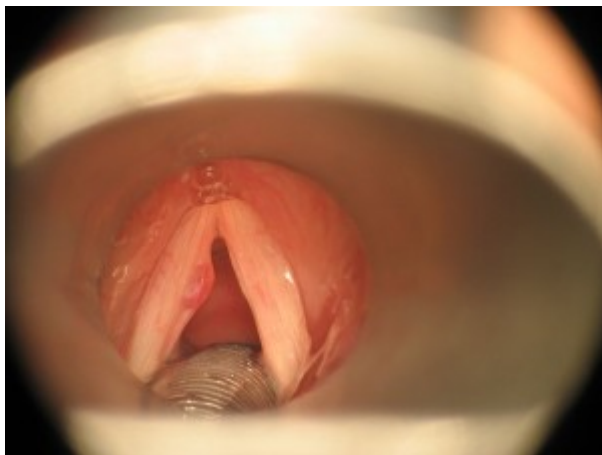


Image: "vocal polyp" by Wellenschik. License: [CC BY-SA 3.0](https://creativecommons.org/licenses/by-sa/3.0/)

Finger-like projections called polyps are often formed after vocal abuse or misuse, mostly in adulthood and old age. They can also occur after certain allergic responses or as a result of smoking.

Patients usually present with hoarseness. If the polyp is large, it can lead to stridor or intermittent choking. Vocal polyps are 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 can result after prolonged endotracheal intubation or after an injury to the vocal processes during intubation. The mucosal ulceration that is initially produced is followed by granuloma formation and produces hoarseness and even dyspnea. Resting the voice 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 CO<sub>2</sub> laser are the various treatment options.

### Chondroma: Tumor of the cartilages

The cartilage most commonly affected by chondromas is the cricoid cartilage. Chondromas cause dyspnea or even dysphagia.

### Hemangioma

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

### Granular cell tumor

These tumors are mostly submucosal and arise from the **Schwann cells**. They can differentiate into malignant tumors.

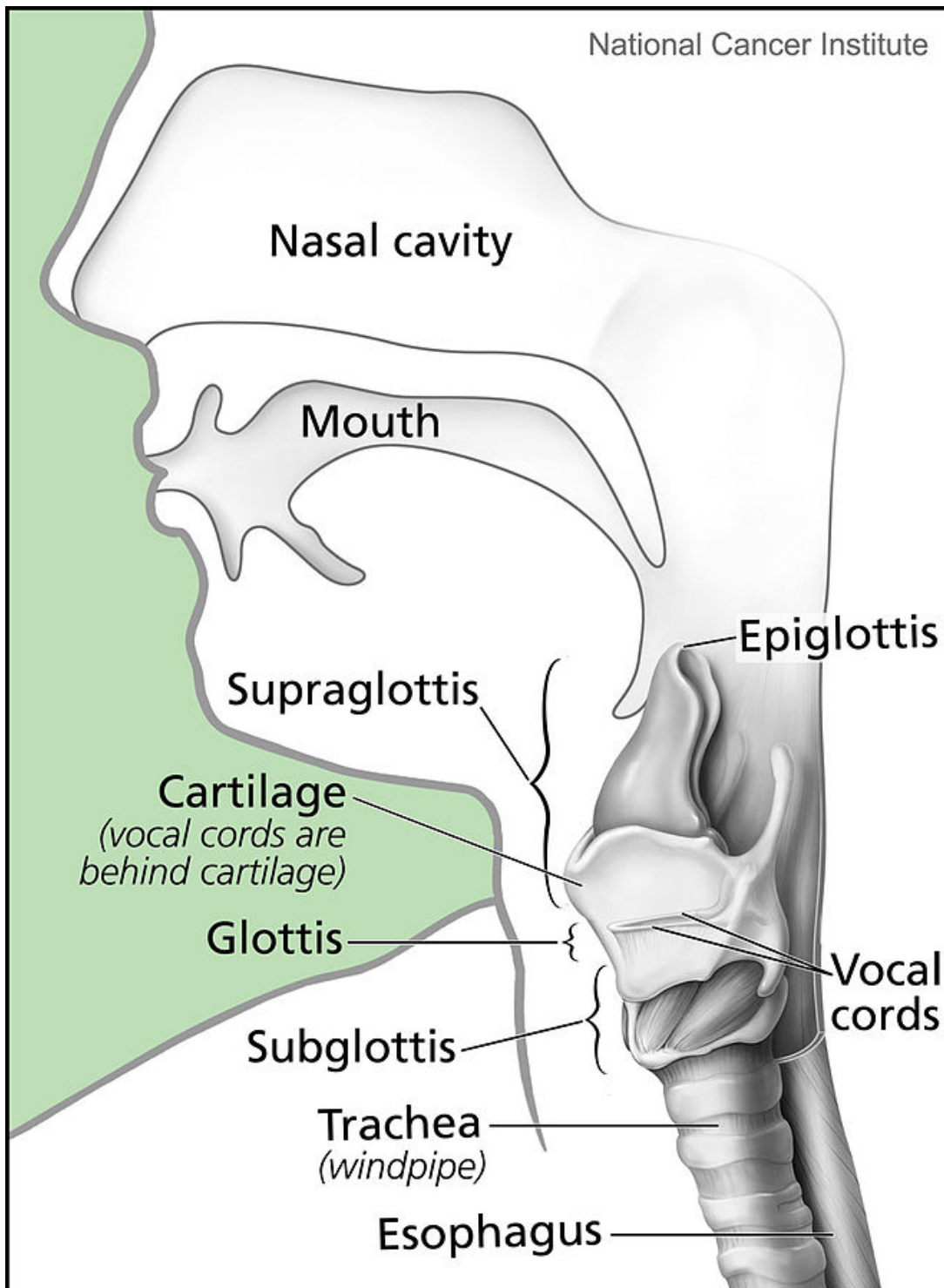
## Laryngeal Carcinoma

Larynx cancer (better known as laryngeal cancer) is a disease in which cancer cells form in the tissues of the larynx. Laryngeal cancer is more common in men than in women. The incidence is increasing due to various risk factors. This malignant disease is seen in adult males after the age of 40.

#### The various risk factors include:

- Smoking
- [Alcohol use](#)

- Air pollution
- Carcinogens exposure
- Radiation exposure
- Exposure to asbestos, mustard gas, petroleum products



Larynx and nearby structures.

## Supraglottic cancer

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

lymph nodes. Patients present 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, as a result, hoarseness develops. Diagnosis can be done earlier relative to other laryngeal cancers. Stridor may result after the development of edema.

## Subglottic cancer

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

**Laryngeal carcinoma is classified according to the American Joint Committee on Cancer as follows:**

Sites	Subsites
Supraglottis	Suprahyoid and infrahyoid epiglottis Aryepiglottic folds Arytenoids False cords
Glottis	True cords with the anterior and posterior commissure
Subglottis	Up to the lower border of the cricoid cartilage

## Grades of cancer

The grade of cancer indicates 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

## Tumor, node, and metastasis (TNM) stages of cancer of the larynx

**The TNM system describes:**

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

## American Joint Committee on Cancer TNM Classification



# of laryngeal carcinoma

## T: Tumor sizes

- **Tx:** primary tumor that cannot be assessed
- **To:** no evidence of primary tumor
- **Tis:** carcinoma in situ
- **T1:** tumor  $\leq$  2 cm in greatest dimension
- **T2:** tumor  $>$  2 cm in greatest dimension but  $<$  4 cm
- **T3:** tumor  $>$  4 cm in greatest dimension
- **T4a:** moderately advanced local disease
- **T4b:** very advanced local disease

## N: Lymph nodes

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

- **N0:** no lymph nodes containing cancer cells
- **N1:** 1 movable lymph node involved on the same side of the neck,  $<$  3 cm in size
- **N2a:** 1 movable lymph node on the same side of the neck, 3-6 cm in size
- **N2b:** more than 1 lymph node, but none  $>$  6 cm in greatest dimension; all 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  $>$  6 cm in size
- **N3:** at least 1 lymph node containing cancer  $>$  6 cm in size

## M: Spread

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

## Diagnosis

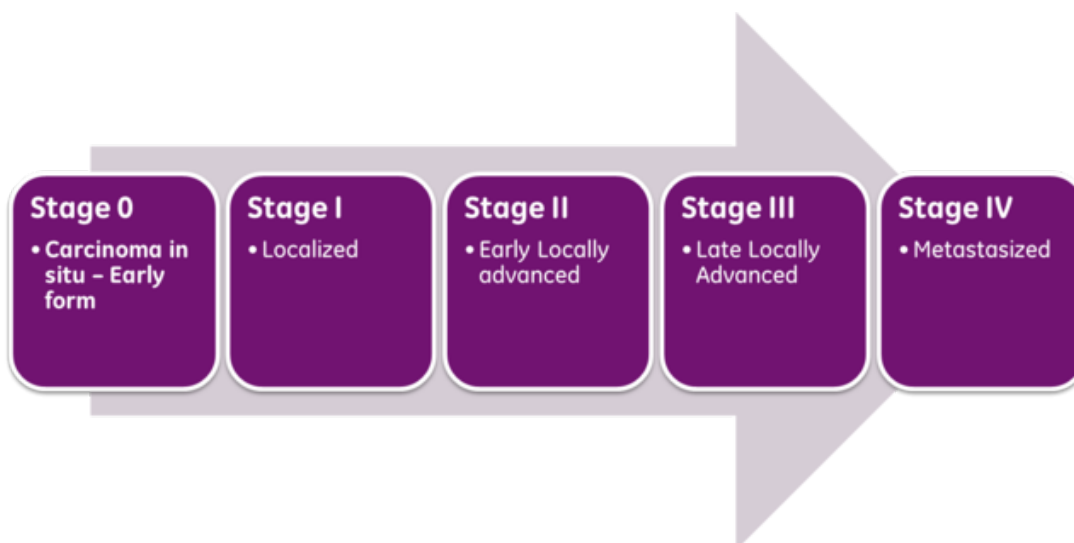


Image: "Stages of cancer" by Simplyanon. License: [CC BY-SA 3.0](https://creativecommons.org/licenses/by-sa/3.0/)

Hoarseness lasting 3 weeks or longer that does not improve is an important point in the history of the disease. Dyspnea, dysphagia, stridor, pain, and swelling with irritating cough, anorexia, and cachexia are representative symptoms of the disease. Examination of the neck is important to find palpable lymph nodes. **The following investigations need to be carried out:**

## Laryngoscopy

The 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 computed tomography (CT) scan or magnetic resonance imaging for soft tissue lateral view of the neck
3. Positron emission tomography-CT scan. This is a radiologic tool that detects metabolic signals from cells with high metabolic activity such as cancer cells.
4. Fine needle aspiration of a neck mass may be useful to diagnose malignant lymphadenopathy from a laryngeal tumor and may be an alternative way of establishing a diagnosis rather than direct biopsy via direct laryngoscopy.

## Treatment

### Radiotherapy

Radiotherapy is effective (70%–90% cure rate) if:

- Cords are not fixed
- There is no subglottic extension
- Cartilage is not involved
- No lymph node is involved
- There are no signs of an invasion

Radiotherapy shows good results in early diagnosis and preserves the voice, with side effects such as dryness, skin excoriation, dysphagia, and hair loss.

### Surgery

1. **Conservative surgery includes:**
  1. Cordectomy through a laryngofissure
  2. Partial frontolateral laryngectomy
  3. Partial horizontal laryngectomy (excision of supraglottis)
2. **Total laryngectomy involves block dissection, which is performed along with laryngectomy. It is an option:**
  1. For fixed cords with a T3 stage tumor
  2. For all T4 lesions
  3. If cartilages are involved
  4. If the disease has not been cured by radiotherapy or conservative surgery
  5. If there are transglottic cancers involving the supraglottic and glottis

## Combined therapy

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

## Vocal Rehabilitation after Treatment

### Esophageal speech

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

### Artificial larynx

An **electrolarynx** is a device used to produce voice. Another device is called a **transoral pneumatic** device; it uses expired air from the tracheostomy 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, e.g., the recurrent laryngeal nerve or the superficial laryngeal nerve.

### Causes

- Lesions in the nuclei of the nerves: nucleus ambiguus in the medulla. Vascular disturbance or tumor compressing the medulla may also be a cause. Poliomyelitis and syringomyelia can also affect the larynx.
- Higher lesions of the vagus nerve in the skull or parapharyngeal space, e.g., tubercular meningitis, nasopharyngeal cancer, glomus tumor, metastatic lymph nodes, lymphoma
- Low vagal injury, e.g., recurrent laryngeal nerve injury
- Systemic causes such as syphilis, diabetes, diphtheria, or viral infections
- Idiopathic (30% of cases)

#### Causes of recurrent laryngeal nerve paralysis:

- Trauma to the neck
- Thyroid surgery
- Thyroid disease
- [Thyroid cancer](#)
- Cervical and mediastinal lymphadenopathy
- [Esophageal cancer](#)
- Enlarged left auricle
- [Aortic aneurysm](#)

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

# Wagner and Grossman theory

This theory 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 paralyzed, the cord will assume an intermediate position because of the loss of adductive force.

## Clinical features

Unilateral paralysis is usually asymptomatic; although some patients may have voice problems, issues regarding aspiration or airway obstruction are rare. It may present as a sudden onset of breathy, weak, low-pitched dysphonia. Patients experience shortness of breath.

In bilateral paralysis, cords are in a median or paramedian position. The airway is inadequate and dyspnea with or without stridor can develop. The condition becomes worse on exertion.

## Treatment

Unilateral paralysis needs no treatment.

Patients with bilateral paralysis often need a **tracheostomy**. Later, either a permanent tracheostomy with a speaking valve is done or, alternatively, surgery is performed.

## Surgical treatment: lateralization of the cord

- Arytenoidectomy
- Thyroplasty type II
- Cordectomy with CO<sub>2</sub> laser via endoscopy
- Nerve-muscle implant

## Complete (combined) paralysis of the larynx

If both 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 surgical medialization of the cords through injection of Teflon paste, thyroplasty type I, or arthrodesis of the cricoarytenoid joint.

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Notes