# CHAPTER 5

# SPEECH GENERATION AND CHANGES CAUSED BY LARYNGECTOMY

## 5.1 ROLE OF LARYNX IN SPEECH GENERATION

The larynx, often known as the voice box, is a structure in the neck that serves several vital purposes, such as breathing, voice production and swallowing. The anatomy of the larynx is shown in Figure 5.1. The air that flows through the vocal cords causes them to vibrate, which in turn causes sound waves in the pharynx, nose, and mouth. Human speech production begins with the larynx, made of cartilage muscle lined with mucus membranes that generate speech. It consists of two pairs of vocal folds called the voice box. It facilitates breathing, prevents food from entering the trachea, and is essential for phonation (producing sound) Honda, (2008). During speech, human vocal folds vibrate, and changes influence the pitch of the speech in terms of vibration speed and tension.

The larynx has three main parts, as shown in Figure 5.1, such as supraglottis, glottis and subglottis. The supraglottis consists of cartilage that is located above the vocal cords. The glottis has two vocal cords and a narrow opening between them in the larynx. The subglottis is the lowest part of the larynx and the area just below the vocal cords, down to the top of the trachea.

## 5.2 LARYNGEAL CANCER

Laryngeal cancer is characterized by the growth of abnormal cells on the larynx structures. There are several types of laryngeal cancer, but the most common is laryngeal cancer, with malignant cells forming in the larynx tissues. A sore throat and pain in the ear are two of the signs and symptoms of laryngeal cancer. People over 55 are more likely to develop laryngeal cancer. Due to smoking and heavy alcohol consumption, men are more likely to develop this cancer. About one in four (25%) people with head and neck cancer are more prone to laryngeal cancer.

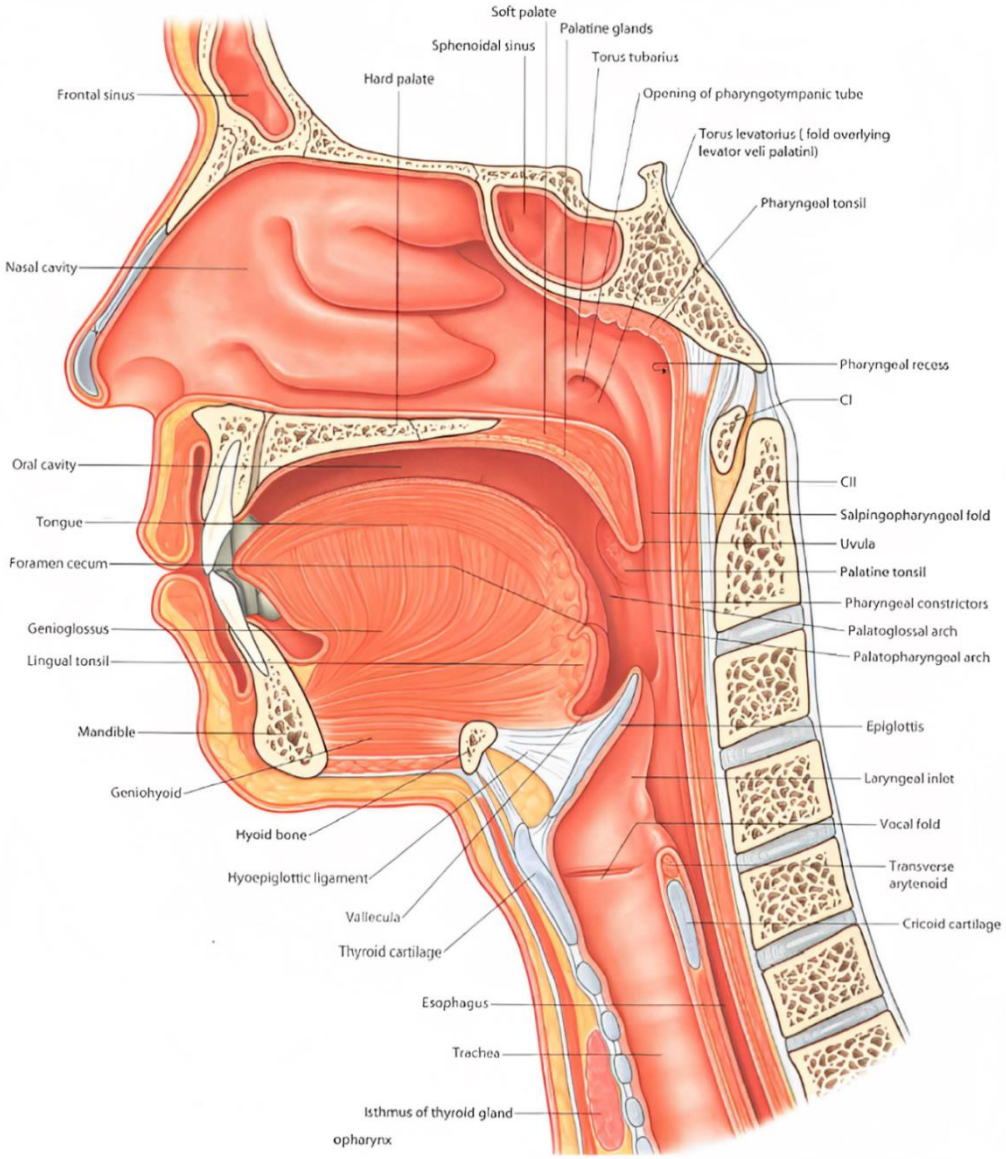


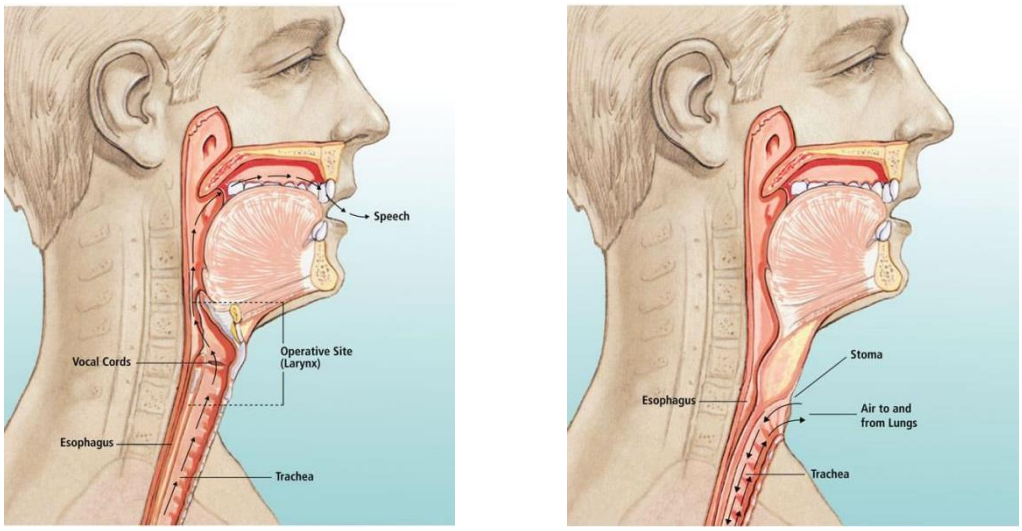

**Figure 5.1 Anatomy of Larynx / Pharynx**

**(Image Courtesy: Gray's Atlas of Anatomy)**

The treatment options for laryngeal cancer include radiation, chemotherapy and total Laryngectomy. Radiation is a medical procedure that damages or eliminates cancer cells by exposing them to high-energy particles or waves, such as protons, electron beams, gamma rays, or X-rays. Chemotherapy is a form of cancer therapy that involves using drugs to enhance radiation therapy's effects and control or stop the spread of cancer cells. It is also referred to as "chemo." Total Laryngectomy removes the larynx entirely during surgery (Dietz, 2004).

## 5.3 LARNYNGECTOMY

The surgical removal of the larynx or voice cords is known as Laryngectomy. Under general anesthesia, Laryngectomy might take five to twelve hours to be completed. The surgery starts with a neck incision to remove the afflicted laryngeal region. Pharyngotomy is the process of removing the pharynx alongside the larynx in cases of cancerous pharynxes, and the surgeon also removes the lymph nodes during the surgery. The surgeon stitches the anterior portion of the trachea to the neck to create a stoma. The stoma enables breathing through the neck and into the lungs. The neck is sewn back together, and drainage tubes are inserted into the surgical site to complete the procedure. Fluids and blood are drained from the surgical site using these tubes (Hoffmann, 2021).




**(a)** **(b)**

**Figure 5.2 Before/After Laryngectomy procedure**
**(Image Courtesy – inhealth Technologies)**

The larynxes are the areas of the throat that house vocal cords to produce sounds. The larynx connects the nose and mouth to the lungs, protecting the breathing system. If the person has undergone Laryngectomy, it will affect speaking, swallowing, and breathing. So, the person needs to learn new ways to perform all these tasks after the Laryngectomy. Additionally, people get support from speech therapists and swallowing specialists who will help them get ready for life after Laryngectomy.

In Figure 5.3(a), a regular breathing process is depicted where the air is inhaled through the nose and filtered by mucous membranes and cilia. After that, the air is moistened before entering the lungs. The exit points for exhaled air are the upper airway, nose, and mouth.

The anatomy after a complete laryngectomy is shown in Figure 5.3(b). Because the upper airway is not used, the air is not filtered, heated, or humidified. The lungs get ambient air immediately during inspiration through the trachea.

Special care must be taken to humidify the airway because the mouth and nose are bypassed. Humidification will be provided in the hospitals using a cool or warm aerosol.

The patient may eventually prefer a Heat Moisture Exchange (HME) device. A foam filter called HME assists in filtering, warming, and humidifying the air since, following a complete laryngectomy, those functionalities are lost. Coughing, mucous production, and chest infections are reduced with the HME device.

Laryngectomy may involve partial or total removal of the larynx.

### 5.3.1 Partial Laryngectomy

Treatment for minor laryngeal injuries or malignancies involves partial Laryngectomy. In partial Laryngectomy, most healthy vocal cords are left intact, and only the cancerous portion of the vocal cords are removed.

After the Laryngectomy, the patient may retain full or partial speech abilities. The technique does not impair the ability to swallow. A temporary tracheostomy is implanted in the neck to help the patient breathe. This tube is later removed and the person can breathe on their own.

Various partial laryngectomies can be done based on the location of the malignant tissue. Cancers of the supraglottis are removed with a supraglottic laryngectomy. As long as the vocal cords are free of malignancy, the patient will recover fully from surgery and be able to speak normally.

During a hemilaryngectomy, the right or left side of the voice box is surgically removed. One vocal cord will be present after surgery, and it still has some speaking functions. Transoral Robotic surgery (TORS) and transoral laser microsurgery are the least intrusive techniques most frequently employed in partial Laryngectomy. These procedures remove the cancerous areas via the oral mouth. The malignant region of the larynx can also be reached during the procedure by making a neck incision.

### 5.3.2 Total Laryngectomy

In total Laryngectomy, the larynx is completely removed, and the procedure includes the removal of the vocal cords, epiglottis, hyoid bone, thyroid, cricoid cartilage, and some of the tracheal cartilage rings.

The stoma implanted in the patient's neck during surgery becomes their sole source of breathing. After the surgery, the patient will lose the ability to speak and will require speech rehabilitation to learn alternative speaking methods.

## 5.4 SPEECH GENERATION AFTER LARYNGECTOMY

Communicating after Laryngectomy can be very challenging. Without a larynx, the person cannot make sounds or speak normally. Individuals who have undergone this surgery learn to communicate by adopting different methodologies. A total laryngectomy that removes the larynx and vocal cords makes the person's voice sound different because it no longer comes from the vocal cords. Airflow from the lungs no longer passes through the upper airway because the trachea is cut off. The most distressing side effect of Laryngectomy is stated to be speech loss, which significantly lowers the quality of life of a person.

It is crucial to value typical speech to comprehend the alterations after a Laryngectomy. The three significant processes for a normal airway to create natural voicings are air generation, vibrating mechanism, and articulation. In air generation, the larynx and upper airway must get enough airflow from the lungs. The vibrating mechanism creates a little pressure in the airflow from the lungs, causing the vocal folds located in the larynx to open (abduct) and close (adduct) faster. This results in vibration to create speech

sounds. In the articulation tract, the pharynx modulates sound, and the tongue, palate, lips, and teeth convert sound into words.

Significant strides have been achieved in voice restoration methods for laryngectomy patients during the past 50 years. An electrolarynx or tracheal oesophageal speech via a tracheoesophageal prosthesis is an additional speech choice after a laryngectomy (TEP). Each technique has its benefits and drawbacks. Depending on the person's need, a speech-language pathologist can offer advice on learning methods and communication possibilities.

Low-tech communication techniques are frequently used in the early post-operative phases, such as writing, posting messages on message boards, gesturing, mouthing words, and text-to-speech conversion (Tyburek, 2022).

### 5.4.1 Nonverbal Communication

Gestures, eye contact, facial expressions, picture boards, and silently mouthing words are all examples of nonverbal communication. Nonverbal communication also includes handwriting and computer typing. Every laryngectomy sufferer will eventually need to communicate non-verbally while they heal physically.

### 5.4.2 Oesophageal Speech

The most common method used by people after Laryngectomy is oesophageal speech. The speech and language therapist starts teaching this method shortly after the person recovers from the surgery. In this method of speaking, the food pipe (oesophagus) gets filled with air and then vibrations are caused by the air passing through the muscles in the throat. It is learned that people usually use these vibrations to convert them into speech by moving their mouths and lips.

Some people can complete the process quickly, while others take longer. Sometimes, people find it challenging to learn this method, but with some practice and guidance from the speech and language therapist, it is possible to adapt to oesophageal speech. Continuous speech is most challenging in oesophageal speech because it requires moving down enough air. In most cases, people speak in short sentences. The advantages of oesophageal speech include the fact that it does not require equipment or additional

surgery after a laryngectomy. People find it easier to use a voice prosthesis than oesophageal speech (Širić et al., 2018).

### 5.4.3 Electrolarynx

An electrolarynx is a device positioned on the lateral neck, cheek, or mouth using an intraoral adapter. It generates a vibration that serves as a sound source, as shown in Figure 5.4. A tone is created when an external vibration replaces the vocal fold vibration. The oropharynx receives the tone, and the articulators (lips, tongue, teeth, and jaw) form the sound into speech. There is no need to exhale when using an electrolarynx to make a speech because the lungs are not used as a sound source.

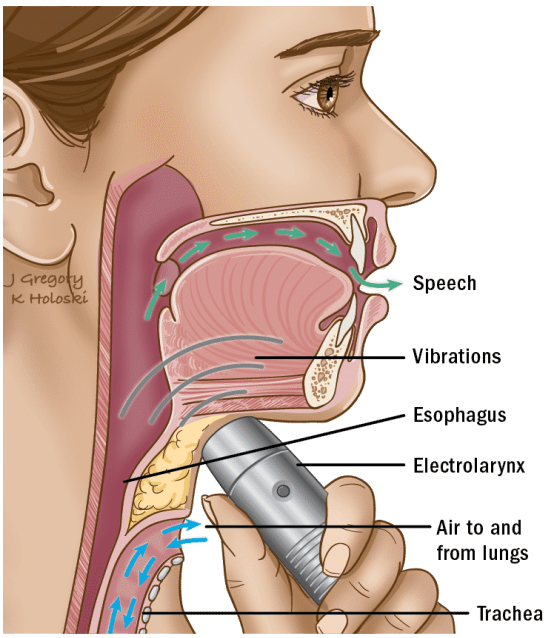



**Figure 5.3 Electrolarynx Device**

**(Image Courtesy: THANC Guide, THANC Foundation, New York)**

As soon as three to five days after surgery, speech can be generated using an electrolarynx. The gadget is held against the patient's neck, or they can utilize a mouth adapter. If the patient talks, the device will enhance and deliver the speech. However, the created voice will sound robotic, mechanical, and straightforward. It might be both a long-term and a suitable short-term treatment for some individuals Kaye et al., (2017).

### 5.4.4 Tracheoesophageal Prosthesis (TEP) Speech

After a laryngectomy, speaking with a TEP is the most natural and understandable speech. The posterior wall of the trachea connects to the oesophageal wall to provide a

tiny surgical passageway known as a tracheoesophageal puncture, as shown in Figure 5.5. The surgeon might perform the puncture while performing the Laryngectomy or later, during a different procedure.

A small voice prosthesis is inserted into the opening to permit speaking. The TEP uses a one-way valve to allow tracheal air forced upward from the lungs to flow through and enter the oesophagus, causing the walls to vibrate as a new voice Brook & Goodman, (2020). After that, the airflow passes into the oropharynx, where the articulators shape sounds (mouth, lips, tongue). The stoma must be covered for speech and airflow to be diverted through the TEP. A finger or the pressure of an HME can be used to cover the stoma. Food and liquids cannot enter the trachea from the oesophagus because a well-functioning TEP keeps its closure. Enlargement of the TE puncture, which causes aspiration of saliva, fluids and food around the prosthesis into the trachea, is one of the most challenging post-TEP problems to address. The reported rate of saliva or food ingestion surrounding the prosthesis is 7% to 42%.

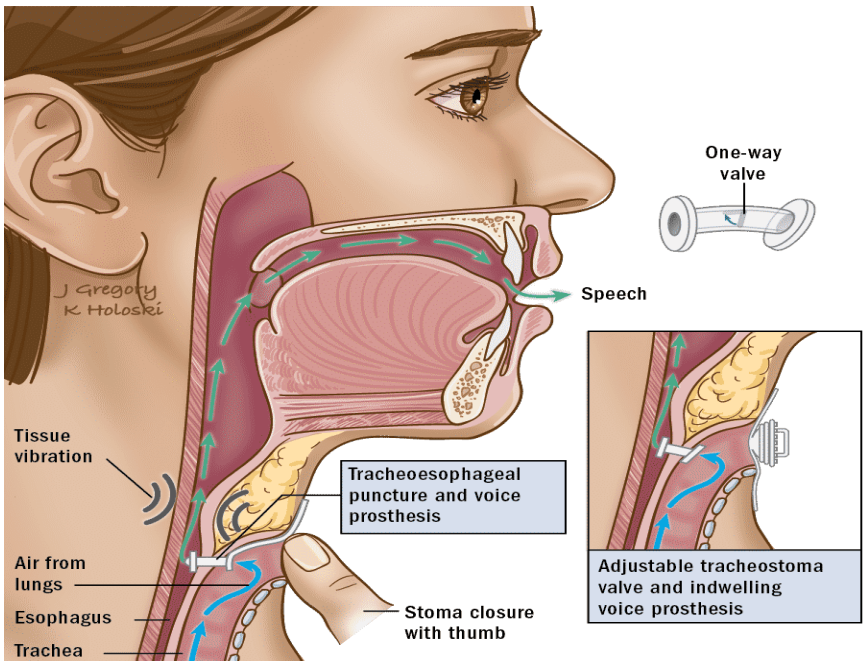



**Figure 5.4 Tracheoesophageal Prosthesis**

**(Image Courtesy: THANC Guide, THANC Foundation, New York)**

Even though there have been many improvements over the years, these devices still need to be periodically replaced by a qualified physician, usually an ENT or Speech-Language Pathologist (SLP).

## 5.5 VOICE PROSTHESIS AND THE TYPES OF VALVES

A voice prosthesis is an artificial, silicone-made device combined with voice therapy to aid laryngectomy patients in speaking. A total laryngectomy involves completely removing the larynx and the separation of the trachea and oesophagus from one another. During this operation, it is possible to create a primary puncture between the food pipe and the windpipe. It is also possible to create this opening later (secondary puncture), also called a tracheoesophageal puncture (TE puncture). The voice prosthesis is placed in this opening. In the early stages of tracheoesophageal speech, the stoma is occluded, and the air from the lungs is forced through the voice prosthesis and up the throat to create a voice sound. During Laryngectomy, a voice prosthesis sits over the stoma and performs speech. Air can be moved from the lungs into the oesophagus with practice. The resulting vibrations will create speech. The speech generated is hoarse and gurgly, giving a lower level of intelligibility.

The types of valves used in the voice prosthesis are the Groningen, Provox, and Blom Singer valves.

### 5.5.1 Groningen Valve

The Groningen are internal valves that cannot be maintained independently, as shown in Figure 5.5. They need to be changed by a professional therapist, physician, or nurse. The person can change the valve according to their needs. Sometimes, difficulty in speaking may occur due to the valve, typically resulting from spasming pharyngeal muscles. The speech and language therapist can help to try and overcome this spasm. The surgeon might also suggest treatment by injecting some botulinum toxin (Botox) into the muscle to relax it.

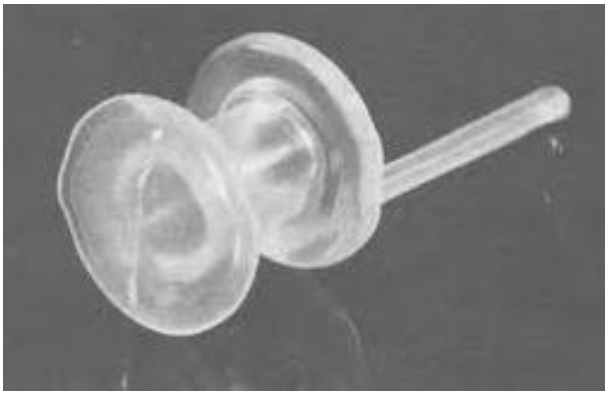


**Figure 5.5 Groningen Valve (Image Courtesy – inhealth Technologies)**

### 5.5.2 Provox Valve

Patients with early leakage through their vocal prosthesis are the target audience for the Provox valve. Frequent cleaning of the valve is required for its better utilization. If the valve is obstructed with dirt, it will be difficult for air to travel through, preventing the person from speaking. A speech therapist's guidance helps the person maintain the valve properly. The Provox valve is shown in Figure 5.6(a).

(a) (b)

**Figure 5.6 Provox Valve and Blom-Singer Valve (Image Courtesy – inhealth Technologies)**

### 5.5.3 Blom-Singer valve

More people prefer Blom singer as it acts as an external valve and can be maintained independently. The Blom-singer valve (Kramp & Dommerich, 2009) is shown in Figure 5.6(b). In this method, voice is created by momentarily closing the stoma so that air exhaled from the lungs may pass through the prosthesis in the trachea, into the oesophagus, and then let out through the mouth. Speech can be achieved by inserting a voice prosthesis inside the surgical passage from the back wall of the trachea into the oesophageal wall. Blom Singer valve is made up of an anti-fungal additive (silver oxide)

as a material preservative so that the patient can be free of fungal infection. Also, there will be valve resistance to prevent air ingestion into the stomach.

## 5.6 SUMMARY

This chapter introduces the pathological condition that arises due to the total removal of the larynx, which leads to a speech called alaryngeal speech due to the implant of the prosthesis. The speech produced by laryngectomy patients is not clear and feeble; therefore, it is essential to enhance their speech. Speech enhancement techniques are implemented for the speech signals acquired from the laryngectomy patients under different noise conditions to understand their speech better.