Radiological Evaluation of Laryngotracheal Stenosis

Doaa Ibrahim Hasan, Marwa Elsayed Abd Elhamed, Arig Akram Awad, Khaled Mohamed Altaher, Ahmed Mohamed El-Maghraby

Radiodiagnosis Department, Faculty of Medicine- Zagazig University, Egypt.

Email: Arigakram91@gmail.com

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Abstract

Background: The Incidence of laryngotracheal stenosis is increasing nowadays due to increasing incidence of prolonged endotracheal intubations with increasing incidence of polytrauma, neurovascular accidents, and complex surgical procedures with subsequent intensive care unit's admission and intubation. Several surgical procedures have been used to treat laryngotracheal stenosis. Choice of procedure depends upon age of patient, site of stenosis, nature of stenosis, etiology and general condition of patient. Recent state-of-the-art computed tomography and improved three-dimensional (3-D) postprocessing techniques have revolutionized the capability of visualizing airway pathology, offering physicians an advanced view of pathology and allowing for appropriate management planning. Imaging of the trachea-bronchial tree has improved recently, in large part due to the advancements of computed tomography (CT), allowing for volumetric isotropic voxel imaging, and its associated improvements in post-processing software that allows for advanced 3-Dvisualization. Thus, airway imaging has become a tool that physicians can use to help plan interventional procedures, such as bronchoscopy, stent placement, surgery and subsequent follow-up. It is clear that airway imaging competes with invasive bronchoscopy as a choice in establishing a diagnosis. CT neck examinations are performed with a single breath hold from the base of the skull to the lung apices, an area that measures approximately 24 cm in craniocaudal dimension, and 80 axial sections 3 mm thick are obtained in 8–12 seconds. The raw data are subsequently reconstructed using a soft-tissue kernel (B31f, Somatom Definition Flash, Siemens Healthineers, Boston, Mass), field of view of 180 mm, and section thickness of 0.75 mm at increments of 0.5 mm.

Keywords: Radiological Evaluation, Laryngotracheal Stenosis

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Introduction

Historically, infection and external trauma to the airway have been the primary causes of LTS. However, sequelae of intubation have become the primary etiology. Other common etiologies resulting in LTS include post-tracheostomy airway stenosis, congenital lesions, radiation, benign and malignant neoplasms, collagen-vascular diseases and idiopathic. **(1)**

Endotracheal intubation:

The most common cause of acquired stenosis is endotracheal intubation, accounting for approximately 90% of mature laryngotracheal stenosis. Traumatic intubation and the pressure induced by the endotracheal tube (ETT) are the principal factors that contribute to post-intubation stenosis. When the pressure from the ETT exceeds the pressure of capillary perfusion, it causes ischemia, followed by edema, necrosis and ulcers. Later on, in the repair process, the granulation tissue can lead to a decrease in the airway lumen and to obstruction. **(2)**

The Incidence of laryngotracheal stenosis is increasing nowadays due to increasing incidence of prolonged endotracheal intubations with increasing incidence of polytrauma, neurovascular accidents, and complex surgical procedures with subsequent intensive care unit's admission and intubation. **(3)**

Several surgical procedures have been used to treat laryngotracheal stenosis. Choice of procedure depends upon age of patient, site of stenosis, nature of stenosis, etiology and general condition of patient. **(4)**

Chapter 5: Assessment of laryngotracheal stenosis

Radiological evaluation:

Recent state-of-the-art computed tomography and improved three-dimensional (3-D) postprocessing techniques have revolutionized the capability of visualizing airway pathology, offering physicians an advanced view of pathology and allowing for appropriate management planning. **(5)**

Imaging of the trachea-bronchial tree has improved recently, in large part due to the advancements of computed tomography (CT), allowing for volumetric isotropic voxel imaging, and its associated improvements in post-processing software that allows for advanced 3-Dvisualization. Thus, airway imaging has become a tool that physicians can use to help plan interventional procedures, such as bronchoscopy, stent placement, surgery and subsequent follow-up. It is clear that airway imaging competes with invasive bronchoscopy as a choice in establishing a diagnosis. **(5)**

Suffice it to say that fast acquisitions of isotropic volumetric data with advanced reconstruction techniques are now capable of generating high quality images with functional information. This has made a significant impact in the direct planning and management of patients. **(6)**

The unique inherent natural contrast of the airways and lung parenchyma permits imaging with a relatively lower radiation dose without significant loss of information (100-120 kV, 60-160 mAs). Imaging is obtained in suspended inspiration. Expiratory imaging is obtained to evaluate for tracheomalacia and to evaluate the mosaic perfusion pattern in the lungs to look for small airway disease. **(5)**

Proper assessment of the site, degree and length of laryngotracheal stenosis is essential for proper selection of the procedure and helps in anticipating future prognosis. Imaging can provide a simple, noninvasive and readily available tool for such assessment. **(7)**

At initial assessment, all patients with suspected airway compromise should undergo a plain radiography with anteroposterior and lateral views that include both upper and lower airway evaluation. Careful examination of plain films can identify subglottic stenosis, inflammatory processes, or widening of the mediastinum that help to distinguish upper from lower airway obstructive pathologies.44**(8)**

CT neck examinations are performed with a single breath hold from the base of the skull to the lung apices, an area that measures approximately 24 cm in craniocaudal dimension, and 80 axial sections 3 mm thick are obtained in 8–12 seconds. The raw data are subsequently reconstructed using a soft-tissue kernel (B31f, Somatom Definition Flash, Siemens Healthineers, Boston, Mass), field of view of 180 mm, and section thickness of 0.75 mm at increments of 0.5 mm. **(9)**

A thin slice CT scan of the larynx and trachea can be useful to distinguish a purely intrinsic stenosis with intact laryngotracheal framework from a stenosis with laryngotracheal framework deformity or collapse. 46

Recent advances in computed tomography technology offered 3D multiplanner reconstruction with the introduction of virtual bronchoscopy as an imaging software with much data. Virtual bronchoscopy (VB) is a novel CT-based imaging technique that allows a three-dimensional (3D) evaluation of the interior and peripheral wall of the airway down to the seventh division of the laryngotracheal tree. Such technique can provide generous information regarding cases of laryngotracheal stenosis. **(10)**

3-D reconstructions include external and internal renderings of the airways. External 3-D rendering of the airways is equivalent to CT bronchography. 3-D segmentation of the trachea-bronchial tree provides a rapid anatomic overview of the airways. 3-D reconstructions allow the recognition of mild and focal airway stenoses, providing accurate anatomically more relevant information on the shape, length, and severity of airway stenoses. 3-D images demonstrate the changes of tracheomalacia on inspiration and expiration well. **(11)**

Internal 3-D rendering of the airways gives images equivalent to bronchoscopy and is aptly referred to as virtual bronchoscopy. It enables the viewer to navigate through the lumen of the airway to the sixth-order and seventh-order subdivisions. Virtual bronchoscopy is a uniquely useful noninvasive method of assessment of tight airway stenosis, which cannot be negotiated on conventional bronchoscopy. It allows for preplanning transbronchial biopsies, evaluation of aspirated foreign bodies and tracheomalacia. **(12)**

Virtual bronchoscopy may obviate the need for invasive conventional bronchoscopy in certain circumstances. It is a great noninvasive alternative to conventional bronchoscopy in special subgroups of patients such as young children, very sick patients or elderly patients who may not be able to tolerate bronchoscopy. Virtual bronchoscopy does not permit tissue sampling, which can be done with endoscopic bronchoscopy. **(13)**

3D reconstructions (Virtual endoscopy) of the laryngotracheal airway offer useful information as to the location, extent and severity of the obstruction. In cases of total obstruction of the airway, virtual endoscopy is helpful in visualizing the length of the stenosis and the distal portion of the airway**(14)**

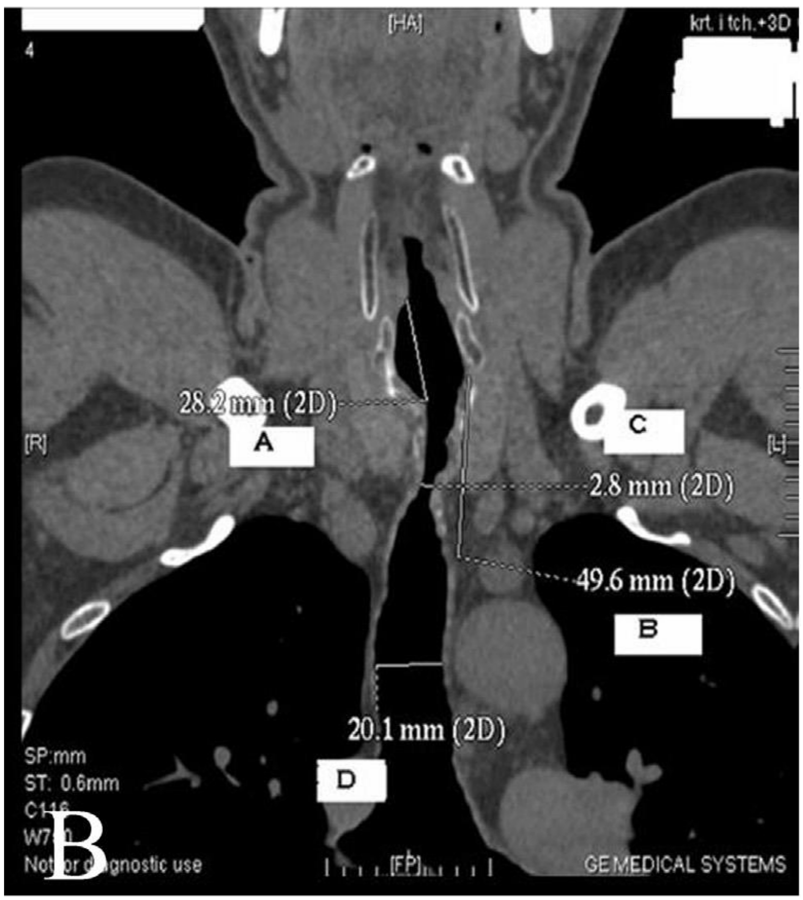

Figure 1: CT Coronal image with measurements of tracheal stenosis (A) length from the vocal cord, (B) length of planned segmental resection of trachea, (C) diameter of tracheal stenosis, (D) diameter of normal trachea. **(14)**

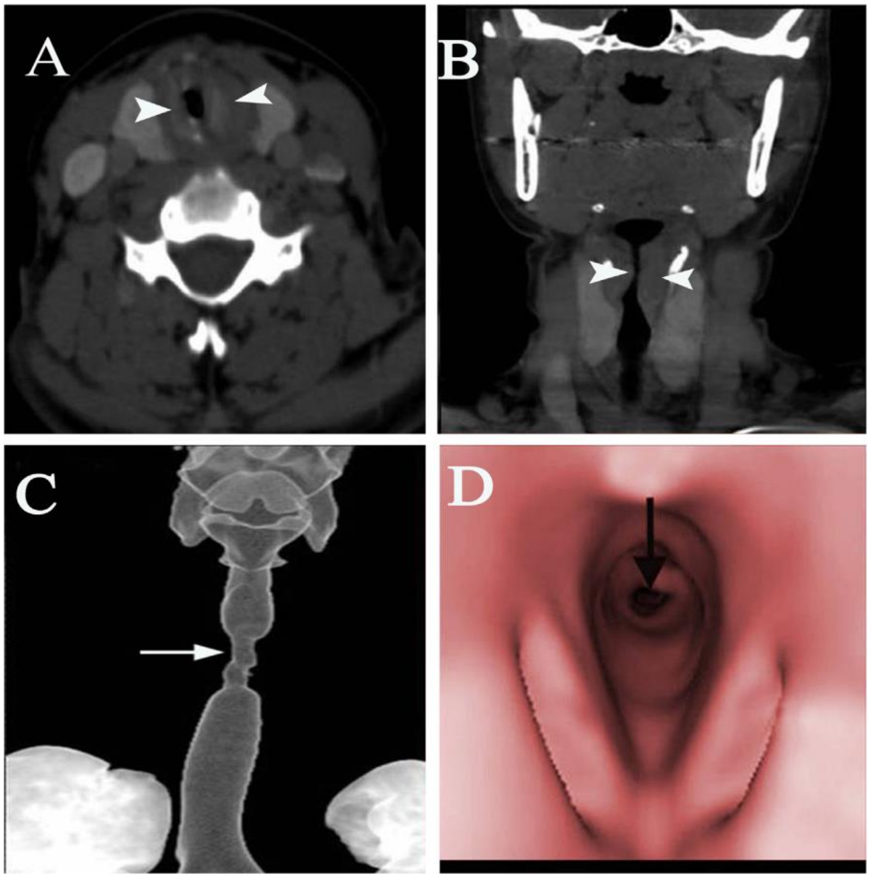

Figure 2: Multidetector CT with multiplanar reformatted imaging of subglottic and upper tracheal stenosis. (A) axial, (B) coronal, (C) 3D external volume rendering and (D) virtual bronchoscopy. **(15)**

An MRI (magnetic resonance imaging) may be indicated for assessment of vascular compression of the airway secondary to congenital cardiovascular anomalies or the mediastinal extent of a tumor mass. The contrast resolution is finer than the CT-scan. **(16)**

Henes et al. studied the accuracy of MRI for grading of subglottic stenosis (SGS) in patients with Wegener's granulomatosis. They concluded that MRI is an attractive noninvasive and radiation-free alternative for monitoring the severity of SGS in patients with Wegener's granulomatosis **(17)**

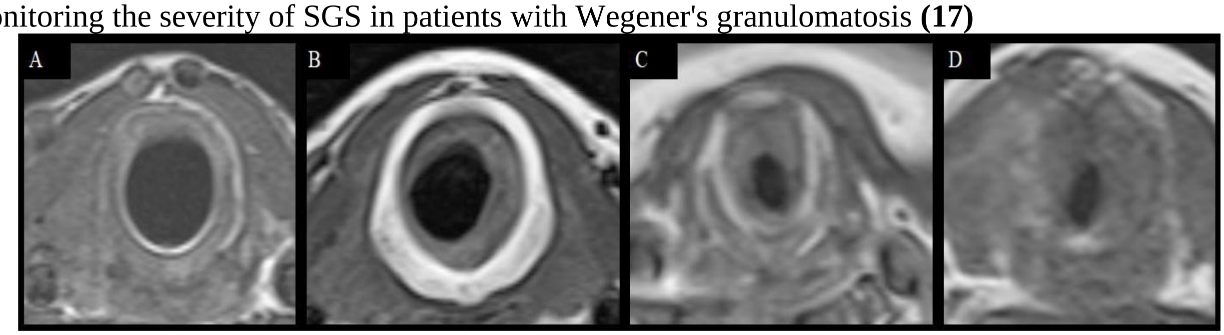

Figure 3: Axial T1-weighted MRI of patients with confirmed Wegener's granulomatosis and increasing grades of subglottic stenosis. (A) a man without evidence of subglottic stenosis, (B) a man with a stenosis of 25%, (C) a woman with a stenosis of 58% and (D) a woman with a stenosis of 77% . **(17)**

Endoscopic workup

Awake transnasal fiberoptic laryngoscopy (TNFL):

In adult patients, this can provide precise information on (a) normal vocal fold (VF) mobility, (b) unilateral or bilateral restricted VF abduction often linked to posterior glottis stenosis (PGS), and (c) unilateral or bilateral VF immobility that can result from neurogenic VF paralysis or PGS with or without cricoarytenoid joint fixation. In infants and children, it is not always well-accepted by some children, especially in the toddler age group. **(16)**

Asleep TNFL:

This exam is carried out under general anesthesia in spontaneous respiration. It should be part of all airway assessments for four main purposes:

(a) Assessment of VF mobility in patients for whom awake TNFL failed.

(b) Detection of obstructive sleep apnea (OSA) related narrowing (e.g., tonsillar hyperplasia and base of tongue prolapse) that may represent a contraindication to a single stage laryngotracheal resection or reconstruction.

(c) Dynamic visualization of localized or diffuse tracheomalacia, especially in pediatric. **(16)**

Dynamic examination of the trachea and bronchi during inspiration, expiration and coughing is essential for the diagnosis of localized or diffuse tracheomalacia. In tracheostomized patients, the fiberoptic can be introduced through the tracheostomy tube to examine the distal airway. **(16)**

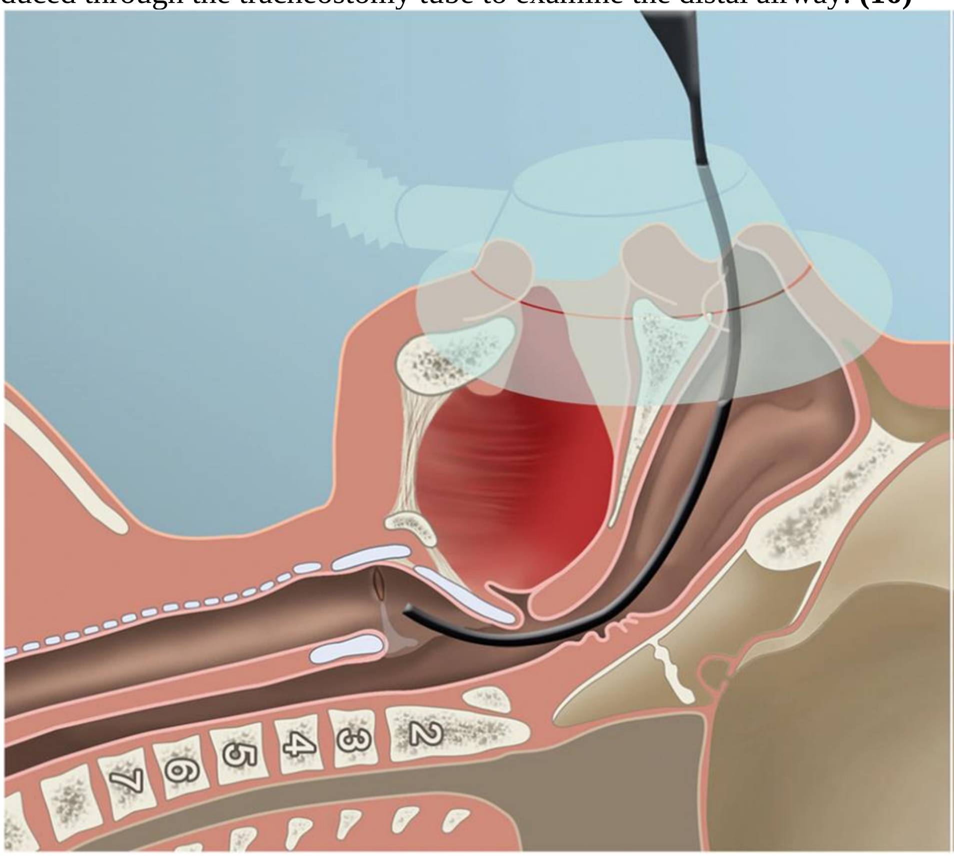

Figure 4: Diagram of transnasal fiberoptic laryngoscopy through a facemask in the anesthetized, spontaneously breathing patient. **(16)**

Direct transoral laryngotracheoscopy with a bare zero degree rod-lens telescope:

The larynx is exposed using the anesthetic laryngoscope while the telescope is used to assess the exact location of the stenosis with respect to the vocal cords and the tracheostoma. So as to plan the surgery accurately, especially in the case of a resection anastomosis, precise measurements of the grade, site and cranio-caudal extent of the stenosis are essential. The degree of stenosis is measured by passing telescopes, bougies or endotracheal tubes of different given sizes through the stricture. **(18)**

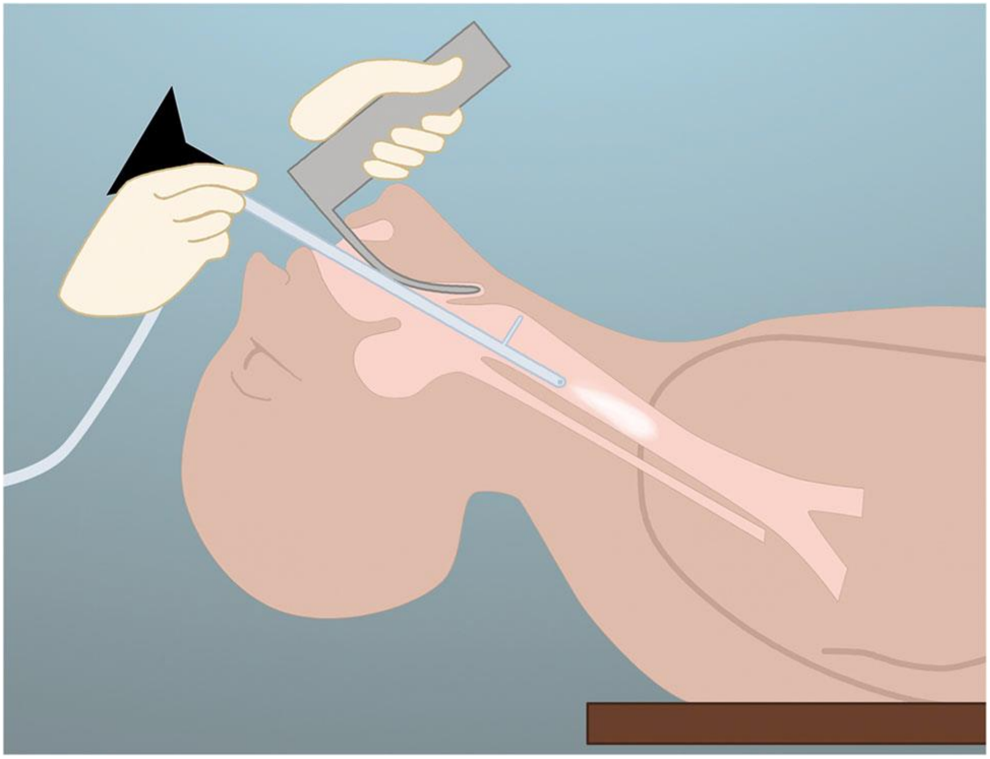

Figure 5: Diagram of direct transoral laryngoscopy using a bare rigid 0 telescope under general anaesthesia. **(16)**

Suspension microlaryngoscopy:

Benjamin-Lindholm or Parsons laryngoscopes are usually preferred for obtaining a panoramic view of the pharyngolarynx and subglottis. Telescopes are used to measure the exact length and site of the stenosis in the cranio-caudal direction. The telescope is inserted through the laryngoscope and further advanced to the level of the vocal cords. The recorded distance is marked on the shaft of the telescope **(16)**

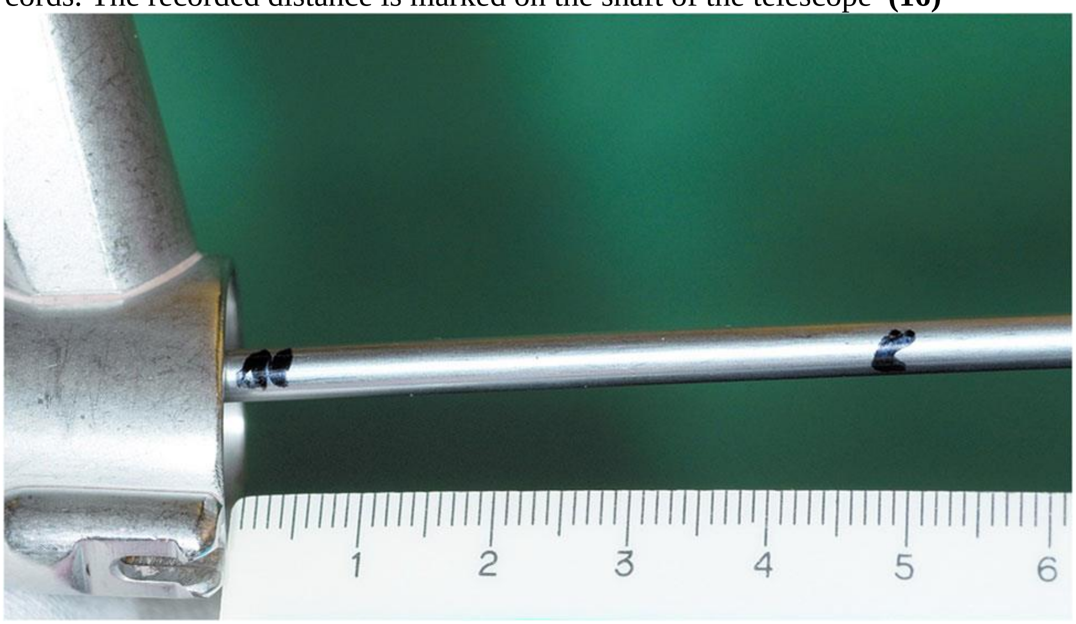

Figure 6: Assessment of the precise location of the LTS cranio-caudal extent with respect to the vocal folds and tracheostoma: the rod lens telescope is used for precise measurements that are marked on the shaft of the instrument with an ineradicable pen. **(16)**

Repeated measures are similarly taken at the upper and lower margins of the stenosis and tracheostoma, and lastly at the level of the carina. A diagram with all of the measurements should be added to the endoscopy report. Such measurements are crucial when a resection and anastomosis is considered. **(16)**

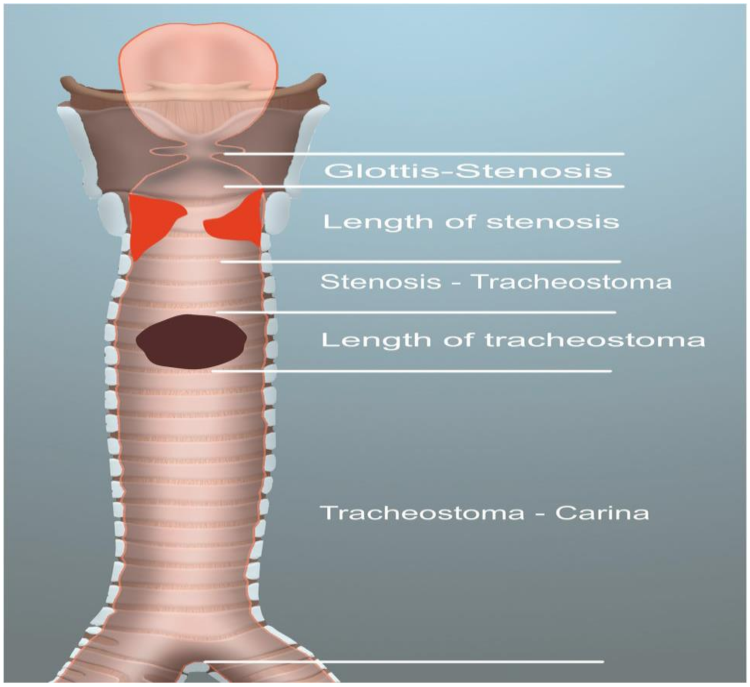

Figure 7: Diagram of endoscopy report. The length and precise location of the stenosis with respect to the vocal folds and tracheostoma, as well as the length of the tracheostoma and residual normal trachea (in centimeters and number of normal tracheal rings) must be recorded. **(16)**

Bronchoesophagoscopy:

The preoperative assessment of the patient with LTS is incomplete if the lower airways and esophagus are not examined. **(19)**

The inspection of the lower airway through the tracheostoma is done either with a rigid instrument (open tube bronchoscope, bare rod lens telescope) or a flexible bronchofiberscope. The distance from the lower edge of the tracheostoma to the carina is measured, and the number of residual normal tracheal rings is precisely counted. Acquired lesions may originate from local trauma induced by the tracheostomy cannula. **(20)**

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