Imaging of the Larynx

With Contributions by

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Foreword by

A. L. Baert

With 145 Figures in 371 Separate Illustrations, 8 in Color
To my wife, Isabelle

And our children,
Simon, Lies, Thomas and Tim

Robert Hermans
Foreword

Notwithstanding the important role of direct clinical and endoscopic examination in the modern management of pathological conditions of the larynx, radiological study and, more specifically, cross-sectional imaging by CT and MRI make definite diagnostic contributions by virtue of their potential to display superbly the deeper extent of laryngeal lesions. Indeed, remarkable progress has been achieved during recent years in CT and MRI techniques as applied to the neck region.

This book sets out to provide a sorely needed update of our knowledge of the diagnostic potential of these cross-sectional methods and constitutes a very welcome addition to our series “Medical Radiology”, which aims to cover all important clinical imaging fields of modern diagnostic radiology. It will be of great interest to general and head and neck radiologists as well as to ENT surgeons and radiotherapists.

Professor R. Hermans and the other distinguished contributors to this work are internationally renowned experts in the field and they have accumulated vast experience and a wealth of radio-pathological knowledge of the larynx over the years. I would like to congratulate them most sincerely for this outstanding volume, its comprehensive contents and its superb illustrations.

I hope that this book will meet with the same great success as previously published volumes in the series. I would appreciate any constructive criticism that might be offered.

Leuven

Albert L. Baert
Preface

The larynx is an organ of considerable anatomical and functional complexity. Clinical evaluation allows appreciation of the presence of pathology, but it has been known for several decades that cross-sectional radiological techniques allow more comprehensive evaluation of the submucosal extent of pathological processes in the larynx. The introduction of CT and MRI has revolutionised laryngeal radiology. Current radiological modalities provide reliable and fast cross-sectional visualisation of laryngeal structures to a unprecedented level of detail.

During the past decade, numerous studies have clarified the significance of imaging abnormalities in the larynx. Mainly in the management of patients with laryngeal cancer, the most frequent cancer in the head and neck region (apart from skin cancer), this enhanced knowledge has strengthened the impact of imaging in patient care. For example, significant progress was achieved by obtaining more sophisticated radiopathological correlations, and the added value of imaging to monitor tumour response after therapy has been scientifically established.

The purpose of this book is to provide a comprehensive review of state-of-the-art laryngeal imaging. Several distinguished head-and-neck radiologists have contributed to this book, allowing full coverage of advanced laryngeal imaging. The technological evolution continues, and new possibilities in the evaluation of pathological processes, including laryngeal diseases, are still emerging; at the end of the book, a number of chapters demonstrate these newer developments and their potential impact on patient care.

Progress has not only been made in diagnostic imaging of the larynx; clinical diagnostic techniques, as well as therapeutic strategies, have undergone significant changes over the past years. Care has been taken to portray the role of imaging within these developments.

The ultimate goal of all medical actions is to provide our patients with the best possible therapy for their health problems; it is hoped that this book contributes to this purpose.

Leuven

Robert Hermans
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KATHELIJNE G. DELSUPEHE and PIERRE R. DELAERE

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1.1 Functional Anatomy

The larynx is a complex and delicate structure consisting of a cartilage backbone and fine muscular structures. Together they act to serve the three main functions of the larynx:

- Protection of the airway during deglutition
- Provision of an overpressure of air in the lungs (the so-called “subglottal pressure”).
- Production of voice

1.1.1 Laryngeal Framework

The laryngeal framework consists of the thyroid cartilage, suspended by the thyrohyoid membrane to the hyoid bone, the cricoid cartilage and the epiglottis. Posteriorly the arytenoid cartilages complete the framework (Figs. 1.1 and 1.2).

Eight intrinsic laryngeal muscles connect the different cartilages and enable fine coordinated movements required for its functions. All these muscles have an adductor (“closing”) function except the posterior cricoarytenoid muscle. The latter is an important muscle since it is the only one which can open the glottis (abductor) (SUNDBERG 1987).

The lining of the vocal folds consists of stratified squamous epithelium. The other parts of the larynx are covered by a ciliated pseudocolumnar epithelium (GRAY 2000; HIRANO 1991).

1.1.2 Supraglottis and Glottis

In order to protect the airway during deglutition, constriction of the glottis can be done at three different levels. These three levels form functional sphincters capable of closing off the trachea completely from the...
epiglottis thereby preventing food and liquid penetrating during swallowing (Logemann 1983).

- **Epiglottis and aryepiglottic folds**: These contain the aryepiglottic muscles, the quadrangular membrane and the cuneiform cartilages. They are attached to the lateral margins of the epiglottis and run laterally, posteriorly and inferiorly to surround the arytenoid cartilages (Fig. 1.3)

- **False vocal folds**: These consist of two shelves of muscle and connective tissue running anteriorly to posteriorly immediately above the level of the true vocal folds (Fig. 1.3)

- **True vocal folds**: These are composed of the vocalis and thyroarytenoid muscles. They are attached to the vocal process of the arytenoids posteriorly, to the inside surface of the thyroid lamina laterally and to the thyroid notch anteriorly (Figs. 1.3 and 1.4) (Hirano 1991).

The same three functional sphincters can generate, together with the diaphragm muscle and abdominal wall muscles, an increased air pressure, the so-called "subglottal pressure". This is required for coughing, and to provide the Valsalva's maneuver and the gag reflex (Jiang et al. 2000; Scherer 1991; Sundberg 1987).

1.1.3 **Voice Dynamics**

The most delicate and complex function of the larynx is of course phonation or voice production. This requires fine neuromuscular control and coordination. During phonation pulmonary air power supplied to adducted vocal folds is transduced into acoustic power as the vocal fold vibrates passively (Scherer 1991). This vibration is enabled through an ingenious three-layer structure of the true vocal fold. The "body of the vocal fold" consists of the vocal muscle, the epithelium and the superficial layer of the lamina propria acting as a "cover", and the intermediate and deep layers of the lamina propria (consisting of collagenous and elastic tissue) forming a "transitional zone" (Fig. 1.5). Because of the different stiffness characteristics of these layers, they are somewhat decoupled mechanically from each other during phonation, enabling the mucosa to oscillate with a certain freedom from the ligament and the muscle (Hirano 1991; Hirano and Bless 1993). Finally, glandular structures produce a mucociliary blanket which lubricates the vocal fold,
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assisting in its vibration, and protects it (Gray 2000).

The vibration of the vocal fold runs in cycles. A simple overview of a vibratory cycle is depicted in Fig. 1.6.

![Fig. 1.5: Histopathology of the vocal fold](image)

**Fig. 1.5.** The histopathology of the vocal fold results in three functionally dynamic layers (frontal section).

![Fig. 1.6: Schematic depiction of a simple vocal vibratory cycle](image)

**Fig. 1.6.** Schematic depiction of a simple vocal vibratory cycle. Frontal section through the glottis and subglottis at different time frames.

### 1.2 Clinical Evaluation of the Patient

#### 1.2.1 History and Risk Factors

There is no substitute for a thorough medical and vocal history when evaluating dysphonia.

Most adults and older children with laryngeal disease present with a voice abnormality and most infants with stridor. However many other symptoms may relate to abnormalities of the larynx (see Table 1.1) (Simpson and Fleming 2000).

A printed questionnaire may be helpful to assist in history taking. Specifically, besides the usual items in the complete medical history, the voice history should reveal the onset and duration of vocal symptoms, known causes or exacerbating influences, nature and severity of symptoms, personality, and vocal commitments and activities. Special attention should be given to several known risk factors for benign and malignant laryngeal conditions as shown in Table 1.2. Finally the patient should be asked what his/her vocal aspirations are, thus establishing the consequent motivation for rehabilitation, in order to tailor therapy to his/her individual needs (Bastian 1998).

#### Table 1.1. Main symptoms relating to the larynx

<table>
<thead>
<tr>
<th>Symptom</th>
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<tbody>
<tr>
<td>Hoarseness, vocal fatigue</td>
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<tr>
<td>Breathiness, shortness of breath</td>
</tr>
<tr>
<td>Odynophonia</td>
</tr>
<tr>
<td>Persistent cough</td>
</tr>
<tr>
<td>Globus sensation</td>
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<tr>
<td>Laryngospasm</td>
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<tr>
<td>Painful or difficult swallowing</td>
</tr>
<tr>
<td>Aspiration causing coughing or choking</td>
</tr>
<tr>
<td>Hemoptysis</td>
</tr>
<tr>
<td>Lump in neck</td>
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</tbody>
</table>

#### Table 1.2. Important risk factors for laryngeal conditions

<table>
<thead>
<tr>
<th>Risk Factor</th>
</tr>
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<tbody>
<tr>
<td>Smoking</td>
</tr>
<tr>
<td>Alcohol consumption</td>
</tr>
<tr>
<td>Gastro(esophageal)laryngopharyngeal reflux</td>
</tr>
<tr>
<td>Overuse (increased talkativeness)</td>
</tr>
<tr>
<td>Vocal commitments/vocal activities</td>
</tr>
<tr>
<td>Environmental irritants (air conditioning, smog, chemical or volatile agents)</td>
</tr>
<tr>
<td>Recent upper respiratory tract infection</td>
</tr>
<tr>
<td>History of laryngeal trauma including intubation</td>
</tr>
</tbody>
</table>
1.2.2 Clinical Examination of the Neck

Inspection and palpation of the head and neck region should be included in the clinical evaluation of the larynx. The palpation is mainly intended to detect lymph nodes. Cervical lymph nodes can be detected in five different areas; each of these areas should be examined carefully. In case of malignancy, the location of the lymph nodes will help to locate a primary tumor (Fig. 1.7). Carcinomas of the supraglottic larynx metastasize bilaterally to the deep cervical lymph nodes of regions II, III and IV. Small primary glottal tumors rarely give lymph node metastasis. Larger glottal tumors can metastasize to regions II, III and IV (see also Chap. 6).

1.2.3 Auditory Perceptual Assessment of the Vocal Capabilities

The vocal capability battery plays a crucial role, along with a sophisticated patient history and laryngeal examination, in making the diagnosis and directing subsequent management. This often neglected part of the evaluation provides multidimensional information concerning the nature and severity of the voice disturbance. Voice clinicians must model and elicit spoken and sung vocal tasks with their own voices and then analyze these sounds for basic vocal capabilities and limitations by auditory perception (Bastian 1998).

A widely used and validated model for making perceptual judgments is the GRBAS (grade, roughness, breathiness, asthenicity and strain) scale. The rating is made on current conversational speech or by reading a passage. G stands for the severity of the hoarseness and the overall vocal quality. Two components of hoarseness are identified: breathiness (B) is the auditory impression of turbulent air leakage through an insufficient glottic closure, and roughness (R) or harshness is the impression of irregular glottic pulses of abnormal fluctuation in fundamental frequency. These three parameters have shown sufficient inter- and intra-rater reproducibility for clinical use. In addition to the vocal capability the clinician also notes the level of effort and the overall “vocal personality”. These behavioral parameters, scored as asthenicity (A) and strain (S), are less reproducible for current clinical use. Each of the parameters is graded on a four-point scale (0 = normal, 1 = slight deviance, 2 = moderate deviance, 3 = severe deviance) (Dejoneckere 2000).

1.3 Technical Evaluation

1.3.1 Office Examination of the Larynx

1.3.1.1 Mirror Examination

The mirror examination (Figs. 1.8, 1.9) method is known universally and has been used for many years. The mirror allows three-dimensional viewing and good color resolution. Due to its limited diagnostic value and limitations in patients with pronounced gag reflexes and absence of permanent documentation, it is now replaced by newer techniques (see below). It should no longer be used as the sole method of evaluation in dysphonic patients.

1.3.1.2 Rigid Laryngeal Telescope

Rigid laryngoscopy is performed using a 70° or 90° angled telescope (Fig. 1.10). It offers an extremely clear and magnified view of the larynx and the vocal
Clinical Evaluation of the Larynx

Fig. 1.8. Mirror examination. Indirect mirror laryngoscopy is performed with an external light source reflected by a small dental mirror and directed towards the larynx and pharynx. The mirror is typically positioned at the level of the soft palate while the patient is in the sniffing position and the tongue is drawn forward by the examiner.

Fig. 1.9. Indirect mirror views of the larynx: a during respiration (glottis open) and b during phonation (glottis closed) (1 true vocal cord, 2 false vocal cord, 3 aryepiglottic fold, A arytenoid cartilage, E epiglottis, P piriform sinus, black arrowhead entrance of laryngeal ventricle, white arrowhead anterior commissure)

Fig. 1.10. Rigid laryngeal telescope. This technique is also performed in a non-physiological position with the patient in the sniffing position and the examiner assisting with tongue protrusion.

Some patients require topical oropharyngeal anesthesia. In a small percentage of patients, because of anatomic limitations or a hyperreflexive gag reflex, this technique may be unsuccessful. However, a light source and rigid endoscope are less expensive than a high-quality flexible endoscope.

1.3.1.3
Fiberoptic Nasolaryngoscope

Fiberoptic nasolaryngoscopy (Fig. 1.11) is particularly helpful in patients with exceptionally strong gag reflexes and in pediatric patients. The method is limited by its poorer resolution for subtle to moderate mucosal lesions (unless the tip of the endoscope can be closely approximated to the vocal folds) (BASTIAN et al. 1989) and by the cost (including maintenance and repair) especially for high-quality equipment.

1.3.1.4
Strobe Illumination

Strobe illumination is a specialized method of illuminating the vocal folds quasi-synchronized with vocal fold vibration. The addition of strobe illumination to any of these three examining instruments allows the laryngologist to evaluate mucosal vibratory dynamics in apparent slow motion, for example to understand mucosal scarring. The method requires a stable or nearly stable vocal fold vibratory pattern during phonation and a source to synchronize the stroboscopic light source by a bell microphone applied to the neck. Video documentation can be ob-
Fig. 1.11. Fiberoptic nasolaryngoscope. Transnasal flexible endoscopy has the distinct advantage of being the only laryngeal examination method that allows the larynx to be visualized in a near-physiological position obtained when using video laryngoscopy yielding a permanent document for teaching the patient and other clinicians (voice therapists and residents) (Bastian 1998; Bastian et al. 1989; Hirano and Bless 1993).

1.3.2 Direct Laryngoscopy

Direct laryngoscopy using a rigid laryngoscope is performed with the patient under general anesthesia. When videoendoscopy is available along with the ability to biopsy suspicious lesions of the larynx and hypopharynx indirectly in the office, direct laryngoscopy will only rarely be needed for diagnostic purposes (Bastian and Delsupehe 1996; Bastian et al. 1989). It is, however, indispensable as part of the management armamentarium plan for voice restoration and is used to obtain tissue in patients in whom indirect procedures have failed.

1.3.3 Objective Measures of Vocal Output

The human voice can be analyzed by devices quantifying the vocal output aerodynamically and acoustically. A detailed description of these techniques is beyond the scope of this chapter. They are reviewed elsewhere (Bless 1991; Dejonckere 2000; Rosen and Murray 2000).

Objective voice analysis is helpful in quantifying and documenting severity and can be used in biofeedback applications, but is of little (if any) diagnostic value compared to the above-described careful history and skilful applied auditory perceptual evaluation by the voice clinician (Bastian 1998).

1.4 Role of Imaging Studies

The clinical evaluation allows the mucosal layer of the larynx to be appreciated quite well. However, the deep extent of potentially infiltrating lesions can only be judged indirectly. For example, deep spread of a squamous cell carcinoma may cause fixation of a vocal cord. However, the exact submucosal spread and volume of such a lesion can only be determined objectively by sophisticated imaging methods, such as CT or MRI. In malignant lesions, depending on their location, radiological evaluation of the neck is useful, as some adenopathies may not be palpable or are located at sites beyond clinical evaluation (e.g. retropharyngeal or paratracheal adenopathies). Also, information on extranodal tumor spread and the relation to critical structures such as the carotid arteries, is necessary for determining the optimal patient management, and can be deduced from imaging studies.

Imaging is needed in submucosal lesions covered by an intact mucosa. The origin and extent of such lesions is often difficult to determine on the basis of clinical evaluation alone. Imaging may provide important clues to the diagnosis, as representative biopsies may be difficult to obtain in deep-seated lesions.

Also in posttraumatic pathology, imaging is useful for evaluating the laryngeal framework and soft tissues. Laryngeal and tracheal stenoses are objectively documented, helping to establish the indications for and planning of reconstructive surgery.

In most cases, the function of the larynx can be appropriately evaluated in the office. The ongoing evolution of CT and MRI now allows images during phonation and other maneuvers to be obtained. There is growing evidence that in some patients such functional radiological evaluation may provide useful information.

References

Clinical Evaluation of the Larynx


2 Imaging Techniques, Radiological Anatomy, and Normal Variants

Frank A. Pameijer and Robert Hermans

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2.1 Introduction

The role of modern imaging techniques in imaging the larynx has continued to evolve over the last 10 years as a result of technological advances which have decreased scan acquisition time and otherwise improved our ability to obtain high resolution, thin section (1–3 mm) images. These technical developments permit the radiologist to visualize and assess the laryngeal anatomy free of motion artifacts.

Optimized patient care requires close cooperation between the radiologist and the physician (otolaryngologist) in charge of the patient. While the otolaryngologist uses modern laryngoscopy to evaluate the mucosal surface, it is the radiologist’s role to show the depth of penetration of a lesion. Findings of both examinations should be discussed together, preferably in an interdisciplinary setting. To be an effective consultant, the radiologist must know and describe the laryngeal anatomy from an otolaryngologist’s perspective (Chap. 1).

In the first part of this chapter the various techniques available for imaging the larynx are described together with comments concerning their currency or obsolescence. In the second part the normal radiological anatomy of the larynx is described from an “ENT perspective”, focusing on CT and MRI. In the third section the (minimal) requirements for a diagnostic CT or MRI study of the larynx are outlined. Finally, normal variants that may be encountered in laryngeal imaging are discussed.

2.2 Imaging Techniques

In the past, a variety of conventional methods have been applied to evaluate the larynx, including soft tissue views of the neck, xeroradiography, plain film tomography, laryngography and barium swallow. CT and MRI have replaced most of these studies. CT or MRI has become essential for the correct pretherapeutic staging and proper treatment of laryngeal tumors (Zbaeren et al. 1996).

Plain radiography was the first technique used to image the larynx. Soft tissue lateral views of the neck are still valuable as a survey study to assess gross airway patency. These films also show the thickness of the retropharyngeal soft-tissue and can be used to evaluate patients suspected of having a retropharyngeal abscess. However, most of these patients will undergo an additional CT or MRI study. Plain radiography can be used as a screening study to search for a foreign body. In daily practice, these films are
still done, but modern laryngoscopy is the mainstay of diagnosis and therapy in this situation. Moreover, the variability of calcification of the laryngeal cartilages creates a diagnostic problem and may be the source of “false” foreign bodies. In the past, image contrast of soft-tissue plain films was enhanced using xeroradiography. Recently, digital radiographic techniques have been introduced. Images acquired by these systems can be postprocessed. Advantages include changing of brightness and contrast interactively and magnifying regions of interest. Repeat films become unnecessary and film and film storage cost is reduced. Plain films of the larynx are still indispensable in radiotherapy planning.

Conventional tomographic techniques were used on a large scale into the 1980s. Coronal tomograms were useful for studying the area of the true vocal cords. However, only surface deformity can be visualized by this technique which, in addition, has a relatively high radiation exposure. At present, conventional tomography has become obsolete because the information derived from this examination is now routinely available from “modern” cross-sectional techniques, such as CT and MRI.

Fluoroscopic techniques employ an image intensifier with links to videotape recording or plain film technique (spot filming). With the introduction of digital fluoroscopic units, it became possible to acquire images with very high frame rates (4–8 per second). The examination is recorded on videotape and allows review without additional patient exposure. This technique has been used in various contrast examinations. Laryngography and tracheography were developed to provide a better definition of the mucosal abnormalities of the larynx and to visualize areas not well seen by endoscopy. Just as bronchography for the evaluation of pulmonary disease has been rendered obsolete, so has laryngography and tracheography by the combination of modern endoscopy and cross-sectional imaging. Nowadays, fluoroscopy in combination with oral contrast administration is most often used for the evaluation of speech and swallowing disorders.

2.2.1 Ultrasonography

Ultrasonography has no primary role in the radiological evaluation of the adult larynx. The ossification of the laryngeal cartilages in the adult prevents ultrasound imaging of the endolaryngeal soft tissues in most patients. When there is an acoustic window, some normal structures such as the thyroid cartilage may be identified. Sometimes the true vocal cords are well seen and vocal cord mobility can be assessed using phonation. However, clinical usefulness is low because the cords are (almost) always accessible to endoscopic evaluation.

Ultrasoundography in combination with fine needle aspiration cytology (FNAC) has an important role in nodal staging of the neck in head and neck cancer, including laryngeal carcinoma (Van den Brekel et al. 1991).

2.2.2 Angiography

A laryngeal paraganglioma may be confirmed if this is suspected on other studies (Konowitz et al. 1988), but otherwise the role of diagnostic angiography of the larynx is very limited. Angiography of the larynx (and pharynx) is increasingly used in chemoradiation protocols for patients with advanced head and neck cancer. In this approach, a very high dose of cisplatin is delivered to the primary laryngeal or pharyngeal tumor using a transfemoral selective intra-arterial catheter. Simultaneously, a cisplatinum-neutralizing agent (sodium thiosulfate) is administered intravenously for systemic protection (Robbins et al. 1996).

2.2.3 Cross-sectional Imaging

Pretreatment cross-sectional imaging, either CT or MRI, has become essential for the correct pretherapeutic staging and proper treatment of laryngeal tumors (Zbaeren et al. 1996). Usually, when a patient is referred for cross-sectional imaging of a laryngeal abnormality the histological diagnosis has already been established by endoscopic biopsy. Therefore, cross-sectional imaging should primarily supply additional information regarding the depth of penetration of a lesion, including its relationship to surrounding critical neurovascular structures.

In determining which imaging modality should be the first choice, various arguments can be applied (Curtin 1989; Som 1997):
- Both CT and MRI (state-of-the-art) can supply all the information needed by the otolaryngologist for adequate treatment planning.
- Soft tissue contrast of MRI is superior.
- CT is more available, lower in cost and shorter in duration (with spiral CT, the entire larynx can be examined in less than 20 s).
- Coronal (and sagittal) extension of pathology is (potentially) better depicted by MRI.
- Multidetector (spiral) CT generates high quality coronal and sagittal reconstructions.
- Shorter data acquisition time for CT results in less motion degradation caused by swallowing and respiration, or in marginally cooperative patients.
- Most radiologists prefer CT for evaluation of cervical metastatic disease.
- CT performs slightly better than MRI in staging of neck metastases (Curtin et al. 1998).

In this era of concern about cost it seems to be a good principle to do one cross-sectional study that accurately answers the clinical questions for the lowest price. Personally, the authors follow the approach advocated by Mancuso (1994). For laryngeal imaging, they prefer CT as a first choice. In less than 10% of cases, an additional MRI study is needed to resolve specific issues that would have consequences for treatment (Mancuso 1994).

### 2.2.4 Nuclear Imaging Techniques

Nuclear imaging techniques such as single photon emission computed tomography (SPECT) and positron emission tomography (PET) are recent additions to the range of investigations available to the head and neck surgeon (McGurk et al. 1998; Mukherji et al. 1996; Valdes Olmos et al. 1997). PET and SPECT offer information on metabolic processes, while cross-sectional techniques, such as ultrasound, CT and MRI (mainly) supply morphological information. Potentially, metabolic techniques can detect subtle mucosal and submucosal abnormalities that do not change gross morphology, and therefore are invisible on CT and MRI studies.

In a pretherapeutic setting, (Thallium) SPECT and CT/MRI show comparable results for detection of occult primary tumors of the head and neck (van Veen et al. 2001). Following treatment, anatomical changes, edema and scarring caused by surgery and radiotherapy often make it very difficult to assess whether recurrent or residual disease is present using clinical examination and conventional cross-sectional techniques. Various authors have reported promising results of post-treatment PET in this setting (Davis et al. 1998; HoH et al. 1997; McGurk et al. 1998). More detailed information on PET imaging in head and neck cancer is provided in Chapter 10.

### 2.3 Radiological Anatomy from an “ENT Perspective”

A discussion of laryngeal anatomy includes the mucosa, laryngeal cartilages, muscles, nerves, blood vessels and lymphatics. Instead of this “traditional” type of discussion, in the following section an attempt is made to highlight only those anatomical structures that the radiologist should be familiar with to be an effective consultant for the otolaryngologist.

The larynx is part of the respiratory tract and houses the human voice. The craniocaudal extension is from the base of the tongue to the trachea. The larynx consists of three elements: a cartilaginous skeleton, mucosa, and the paraglottic/paralaryngeal space.

- The larynx is supported externally by a cartilaginous skeleton consisting of the hyoid, epiglottic, thyroid, arytenoid and cricoid cartilages (Fig. 2.1).

![Fig. 2.1. Lateral diagram of the larynx showing the cartilaginous skeleton (mucosa, intrinsic laryngeal muscles, and paraglottic fat removed). The vocal ligament (single arrowhead) stretches from the vocal process of the arytenoid (A) to the anterior thyroid cartilage. The ventricular ligament (double arrowhead) runs from the upper arytenoid to the anterior thyroid cartilage (T thyroid lamina, SC superior cornu of thyroid). The superior cornua are attached to the hyoid by the thyrohyoid ligament (unlabeled thick arrow) which forms the posterior margin of the thyrohyoid membrane (C cricoid cartilage, E epiglottis, H hyoid bone). Note: The small structure at the upper tip of the arytenoid is the corniculate cartilage. It has no clinical significance, but is occasionally seen on CT. The small hole (unlabeled thin arrow) in the thyrohyoid membrane transmits the internal branch of the superior laryngeal nerve that provides sensation to the laryngeal mucosa](image-url)
These cartilages are connected by membranes, ligaments and joints.
- Internally the laryngeal **mucosa** (squamous epithelium) is draped over the cartilaginous framework (Fig. 2.2).
- The **paraglottic/paralaryngeal space** lies between the cartilaginous skeleton and the mucosa (Fig. 2.3). This compartment consists of (varying amounts of) fat, lymphatics and intrinsic laryngeal muscles.

The sound-making ability of the larynx is created through various mucosal folds (false and true vocal cords) that contract or relax in response to the joint action of the arytenoid cartilages and several intrinsic laryngeal muscles that are innervated by the recurrent laryngeal nerve (branch from the vagus nerve).

The following discussion includes the normal anatomy of the **hypopharynx**. The hypopharynx is part of the gastrointestinal tract and is situated below the oropharynx and cranial to the cervical esophagus. The hypopharynx and larynx are anatomically and functionally intimately related. This close association is important both from a clinical and from an imaging standpoint. Imaging studies of the hypopharynx must always include the larynx (PAMEIJER et al. 1998).

### 2.3.1 Nomenclature

The original Latin nomenclature is very helpful in understanding the laryngeal anatomy. The first part of the name identifies the nature of a structure; the second part its origin and insertion. "**Membrana thyrohyoidea**" is a membrane running from the thyroid to the hyoid cartilage (thyrohyoid membrane). "**Plica aryepiglottica**" is a mucosal fold running from the arytenoid cartilage to the epiglottis (aryepiglottic fold). "**Musculus thyroarytenoideus**" is a muscle running from the thyroid to the arytenoid cartilage (thyroarytenoid muscle, i.e., part of the true vocal cords; Fig. 2.4).
2.3.2
“ENT Landmarks” Seen on Endoscopy and/or CT and MRI (Fig. 2.5)

2.3.2.1
Cartilaginous Skeleton

2.3.2.1.1
Hyoid Bone
U-shaped bone that acts as a “rafter” from which the larynx is suspended. Muscles acting on the hyoid elevate the larynx, which is an essential part of swallowing.

2.3.2.1.2
Epiglottis
Leaf-shaped cartilage that serves as a lid to the laryngeal “voice-box”. The “stem” of the leaf, which attaches in the midline to the inner aspect of the thyroid cartilage, is called the petiole. The epiglottis can be divided into a cranial part above the level of the hyoid (suprahyoid portion or free margin) and a caudal part (infrahyoid portion or fixed portion).

2.3.2.1.3
Thyroid Cartilage
Double-winged cartilage, with prominent superior and inferior cornua (cornu = horn) projecting from the posterior margin of each side of the thyroid wings (lamina). Cranially, the superior cornua are attached to the hyoid by the thyrohyoid ligament. Caudally, the inferior cornua articulate with the cricoid, forming the cricothyroid joint. The remaining spaces between the thyroid and hyoid and the cricoid and thyroid are filled by membranes, cranially the thyrohyoid membrane, caudally the cricothyroid membrane. The anterior thyroid cartilage has a deep notch in its upper surface (i.e., superior thyroid notch). On axial imaging, this may simulate a local defect (Fig. 2.5c). In general, the angle made by the two thyroid alae is wider in women than men.

2.3.2.1.4
Cricoid Cartilage
Signet ring-shaped cartilage, with the larger “signet” part (lamina) facing posteriorly and the narrower arch anteriorly. The cricoid forms the foundation of the laryngeal skeleton and is the only complete cartilaginous ring in the respiratory tract. The inferior surface of the cricoid cartilage is the border between the larynx and the trachea.

2.3.2.1.5
Arytenoid Cartilages
Pyramid-shaped, paired cartilage. The base of the pyramid articulates with the upper margin of the cricoid lamina. This cricoarytenoid joint demarcates the level of the true vocal cords. The base of the arytenoids has two processes. The muscular process, pointing posterolaterally, is the attachment for several intrinsic laryngeal muscles. The vocal process, projecting anteromedially, forms the attachment of the vocal ligament.

2.3.2.2
Mucosa

2.3.2.2.1
Aryepiglottic Fold
Mucosal fold running from the arytenoid to the lateral margin of the epiglottis. The aryepiglottic fold “plays on two teams” (Fig. 2.5d). Its anterior surface is endolaryngeal and defines the lateral boundaries of the supraglottic larynx (respiratory tract). At the same time, its posterior surface forms part of the piriform sinus and is part of the hypopharynx (digestive tract). Because of its relationship to both the larynx and the (hypo)pharynx, tumors centered on the free edge of the aryepiglottic fold are referred to with the terms junctional or marginal.

A modified Valsalva’s maneuver (blowing air against closed lips, puffing out the cheeks) produces a substantial dilatation of the hypopharynx (Robert et al. 1993). In selected cases, obtaining images during such a maneuver may be useful to delineate the aryepiglottic folds better.

2.3.2.2.2
Vocal and Ventricular Ligaments
Two paired ligaments extending anteriorly from the arytenoids to the inner thyroid lamina. The more inferior vocal ligament forms the medial support of the true vocal cords. The more superior ventricular ligament forms the medial support of the false vocal cords. The true vocal cord is separated from the false vocal cord by a slit-like lateral out-pouching, the laryngeal ventricle. The laryngeal ventricle is the anatomically defined border between the glottic and the supraglottic larynx (Fig. 2.2). Otolaryngologists use the term “sinus of Morgagni” for this slit-like opening. Not visible to the endoscopist, the laryngeal ventricle extends superolaterally under the surface of the false vocal cord as the sacculus laryngis or appendix. Dilatation of the sacculus laryngis causing a submucosal supraglottic mass is called laryngocele.