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# Functional imaging of larynx via 256-Slice Multi-Detector Computed Tomography in patients with laryngeal tumors: A faster, better and more reliable pre-therapeutic evaluation

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ABSTRACT

*Objective:* To determine the clinical utility of using dynamic maneuvers during imaging of larynx via 256-Slice Multi-Detector Computed Tomography in the pre-therapeutic evaluation of laryngeal tumors.
*Materials and methods:* A total of 27 patients (7 women, 20 men; aged 53–76 years) diagnosed with laryngeal squamous cell carcinoma were evaluated pre-therapeutically via contrast enhanced axial CT scans during consecutive phases of phonation (PP), inspiration (IP) and Valsalva maneuver (VP).
*Results:* In 2 of 5 patients diagnosed with T1a glottic tumor, scans obtained during VP and PP were normal while the CT scans obtained during IP clearly showed a mass. In all patients (27/27) PP provided visualization of the ventricle, on coronal plane images and the pyriform sinus apices, on axial plane images. Involvement of the anterior commissure was best assessable on axial plane IP images (sensitivity 93%, specificity 92%). In cases of stage T1–T3 tumors use of dynamic maneuvers during laryngeal CT imaging showed the location and extension of the tumor better than the single phase CT scans did. We did not find a significant improvement in the pre-therapeutic evaluation in stage T4 tumors.
*Conclusion:* Providing markedly clearer and more detailed evaluation of mucosal surfaces and deep structures of the larynx and mobility of the cords than do conventional scans, use of dynamic laryngeal maneuvers during laryngeal CT imaging seems to be an useful alternative in the pre-therapeutic assessment of laryngeal tumors.



## 1. Introduction

The main rationale behind the diagnostic radiology is to make or support the diagnosis but in certain clinically diagnosed disease, radiology may provide additional data about extension of the disease as well as concomitant pathologies. One of the typical examples of these disorders are laryngeal tumors. The larynx is the second most common site of head and neck cancer and laryngeal tumors are the eleventh-most common form of cancer among men worldwide [1].

Nearly all laryngeal malignancies (>90%) are squamous cell carcinomas [2]. Unlike the supraglottic region, tumors of the true cords usually present at a fairly early stage because they interfere with normal vocalization [3]. Endoscopic evaluation does not provide information about tumor's depth of penetration or its relationship to deep structures. Although mucosal spread of cord carcinomas is better detected on laryngoscopy, the radiologic findings may provide additional information regarding the extension of tumor to deep submucosal structures and spaces [4].

Since only mucosal surfaces are able to be visualized by indirect and direct laryngoscopy, the depth of tumor, extension into the submucosal, pre-epiglottic and paraglottic tissues, skip lesions or occult submucosal disease, subclinical tumor or non-squamous pathology must be inferred from increased bulk or altered physiology. The extent of the neoplasm beneath the intact mucosa makes endoscopy directed diagnosis difficult and sampling errors may occur if only traditional superficial biopsies are performed. For this reason, experts of endoscopy may benefit from additional data from radiological investigation concerning submucosal extension of the lesion and the detection of possible sites for biopsy before laryngoscopy [2,3].

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Despite recent developments in multi-detector row CT (MDCT) that provided better anatomic resolution within a shorter acquisition time and wider anatomic coverage, lesions still remain ambiguous in many cases. In such cases, performance of dynamic examination could provide useful information about the local extent of a tumor [2].

Images obtained during respiration improve demonstration of small superficial lesions of the vocal cords while images obtained during phonation allow more precise anatomic localization of tumor borders by displaying the laryngeal ventricle and the pyriform sinuses. The Valsalva maneuver enables clearer demonstration of the paraglottic tissue.

The present study was designed to determine the clinical utility of using dynamic maneuvers during imaging of the larynx via MDCT in the pre-therapeutic evaluation of laryngeal tumors based on consecutive steps of phonation, inspiration and Valsalva maneuver.

## 2. Materials and methods

A total of 27 patients (7 women, 20 men; aged 53–76 years) diagnosed with laryngeal squamous cell carcinoma were included in this study conducted between May 2009 and September 2010. Pre-therapeutic CT imaging of the larynx was performed via contrast enhanced axial CT scans (Philips Brilliance ICT 256, Medical Systems, Best, Netherlands) during consecutive phases of phonation, inspiration and Valsalva maneuver by a single expert radiologist (I. Celebi), with informed consent of patients. Tube current 100 mAs, voltage 100 kV, detector collimation 128 × 0.625, rotation time 0.4 s, table speed of 1 mm/rotation (pitch 0.92), slice thickness 1 mm, scan time 1.26 s, FOV 250 and matrix 512 × 512 were the parameters of the CT acquisition. Except for a single patient having allergy to contrast media, 50 ml of nonionic contrast material (Ultravist 370, Schering, Berlin) was injected with a power injector at a rate of 2.5 ml/s which was followed by a 40 ml saline flush in each patient.

During initial examination, patients were asked to phonate “E” loudly 30 s after contrast material administration, while screened through the larynx from the level of the hyoid bone to the base of the cricoid cartilage (PP, phonation phase). Each patient then was asked to inhale a deep and long breath through the nose during which additional axial images were obtained from the same location through the larynx (IP, inspiratory phase). Screening of the same laryngeal regions was also performed during Valsalva maneuver (VP, valsaveur phase). Additional intravenous contrast material was not administered. During one phase CT examination each patient received an average of 30 mGy dose-length product (CT dose index, 3.9 mGy) absorbed radiation dose.

All 27 laryngeal tumors [classified to be at stage T4 ($n = 12$), T3 ($n = 6$), T2 ($n = 4$) and T1 ($n = 5$)] were evaluated retrospectively by 3 radiologists unaware of the clinical data from mirror examination under workstation (EBW). Preceding the consensus on findings, each phase of the examination was independently assessed by an expert radiologist (HY: phonation, MB: inspiration and AU: valseuver). Data concerning intra-operative findings, as well as detailed histopathologic examination of the surgical specimens were obtained to compare the accuracy of the radiologic findings. In patients without surgical operation, the clinical or pre-therapeutic classification of the primary tumor was also included in the evaluation.

Besides tumor mapping, in each patient visibility of the tumor, clarity of the pyriform sinuses and of the laryngeal ventricle, the anterior and posterior commissures, the paralaryngeal spaces (pre-epiglottic/paraglottic spaces) and vocal cord mobility were also evaluated by each radiologist. Radiologic evaluation was compared with pathological and/or clinical findings. Patients in whom radiologic evaluation was possible in all assessed points with positive correlation of pathological findings were accepted as (+). Patients in whom radiologic evaluation was not possible in all assessed points with the available images or in whom radiologic findings did not correlate with pathologic findings were accepted as (−) (Table 1).

## 3. Results

In two of 5 patients diagnosed with T1a glottic tumor, scans obtained during VP and PP were normal, but the CT scan obtained during IP clearly showed a mass. However, the laryngeal ventricle, which is the key structure for the radiologist, was not clearly visible in CT scans obtained during IP. PP provided visualization of the ventricle, on coronal plane images and the pyriform sinus apices, on axial plane images, in all patients (27/27). It was always possible to define consistently the transition zone from the false to the true vocal cords and the highest accuracy for involvement of the ventricle was achieved on PP coronal reformatted CT images (sensitivity 94%, specificity 82%) (Fig. 1).

In one patient (T3 glottic tumor), VP and PP CT showed a mass in the glottic lumen that was inseparable from both mucosal surfaces. The IP images clearly specified the surface involved by the tumor. In two patients, anterior commissure involvement was not decisive using VP and PP laryngeal CT, while IP, clearly revealed the absence of tumor in one patient and the involvement in the other (Figs. 2 and 3). Anterior commissure involvement was best assessable on IP axial plane images (sensitivity 93%, specificity 92%).

In one patient (T3 supraglottic tumor) a pre-epiglottic tumor was inseparable from the hyoid bone by evaluation of IP and VP images while it was obviously separable on the scan obtained on PP (Fig. 4). During VP, the cords (both false and true cords) were adducted leading to an obviously clearer visualization of the paraglottic fat along the outer margin of the cords. In 3 patients, the space maintained between the inner perichondrium of the thyroid cartilage and the glottic tumor was not visible under IP (considered as T3 by MB), while clear visualization of the intermediate fat plane during VP in one and during both of VP and PP in the other, when evaluated together with the cord mobility resulted in confirmation of T1 by consensus (Fig. 5). Clinical diagnosis was stage T1 tumor in these cases. In another patient (T3 supraglottic tumor), involvement of the pyriform sinus by the extensive supraglottic tumor was not clear on the scans obtained during VP and IP, whereas “e” phonation made the sinus enlarged and displayed tumor absence on the lateral and posterior wall. Air filling into the pyriform sinuses during phonation forms a negative contrast that enables separation and individual evaluation of the pharyngeal mucosa of the aryepiglottic fold from the lateral and posterior pharyngeal mucosa.

These maneuvers together are effective to display vocal cord mobility disorders as well. In cases of T1–T3 tumor, use of dynamic laryngeal maneuvers during laryngeal CT imaging identified the location and extension of the tumor better than the single phase CT scans did. We did not find a significant improvement in the pre-therapeutic evaluation in stage T4 tumors.

## 4. Discussion

An accurate pre-therapeutic staging of laryngeal cancer is necessary in order to have precise indications for treatment planning and to evaluate and compare the results of different treatment modalities [5]. Accordingly, in the pre-therapeutic work up, clinicians need to identify the various aspects of the laryngeal tumor including features of mucosal surface (pathological side, antero-