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ORIGINAL ARTICLE

Utility of 64 multislice CT-virtual laryngoscopy in presurgical planning of laryngeal and hypopharyngeal carcinomas

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KEYWORDS

Larynx; Virtual laryngoscopy; Multislice CT; Conventional laryngoscopy; Tumor staging **Abstract** *Objective:* To evaluate the utility of 64-multislice CT with virtual laryngoscopy in diagnosis and pre-therapeutic planning of laryngeal and hypopharyngeal carcinomas in comparison with conventional laryngoscopy.

Patients and methods: Forty patients with laryngeal and hypopharyngeal carcinomas were subjected to 64-multislice CT examinations with multiplanar reformation and CT-virtual laryngoscopy. The results were compared with those of direct and indirect laryngoscopy. Multiple variables like primary subsite of the mass, invasion of anterior commissure, posterior commissure and subglottic extension of mass were analyzed and the Chi-square test was used to study the association between each 2 variables.

Results: Excellent correlation was found between direct laryngoscopy and CTVL in detection and localization of primary subsite of laryngeal carcinomas. A statistically significant difference existed between both modalities in favor of CTVL in identifying subglottic extension, anterior and posterior commissures invasion ($P \le 0.001$) as well as in evaluating the hidden areas of the hypopharynx. Direct endoscopy was more valuable, however in identifying mucosal surface irregularities and vocal cord involvement diagnosed as cord fixation ($P \le 0.001$).

Abbreviations: NCI, National cancer institute; AJCC, American joint committee on cancer; kV(p), kilovolt (peak); Ma, milliampere; TMN staging, tumor-node-metastases staging; DL, direct laryngoscopy; CTVL, computed-tomography-virtual-laryngoscopy

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Conclusion: Virtual laryngoscopy is a noninvasive and reliable technique that in combination with axial and MPR CT images is valuable in staging and pretherapeutic planning of laryngeal/hypopharyngeal carcinomas. It is not an alternative to conventional laryngoscopy but may assist direct endoscopy without causing additional radiation exposure or discomfort to the patient.

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1. Introduction

The National Cancer Institute (NCI) has reported 12.250 new cases of laryngeal cancer and 3670 deaths from it in 2008 (1). More than 95% of laryngeal and hypopharyngeal tumors are squamous cell carcinomas arising from the mucosal surface of the aerodigestive tract. The treatment plan for an individual patient with laryngeal cancer depends on a number of factors, including location of the tumor, stage of the tumor, histology, and the patient's age and other medical co morbidities (2).

Computed tomographic virtual endoscopy is a non-invasive diagnostic modality allowing visualization of intra-luminal surfaces by three-dimensional representation of two dimensional reconstruction of air/soft tissue interfaces (3,4). Patients benefit from the virtual laryngoscopy without the intolerance associated with the direct endoscopy, or the presence of luminal obstruction due to an infection, neoplasm or congenital defects (5).

Multislice CT is crucial to the assessment of laryngeal pathologies including subglottic larynx, anterior and posterior commissures, paraglottic and pre-epiglottic spaces, cartilage and extralaryngeal structures as invasive laryngoscopy is limited in its ability to evaluate these regions (6,7). Multislice CT can simultaneously acquire accessory data sets such as sagittal and coronal multiplanar views, CT angiography, CT laryngoscopy and even high quality cervical spine studies (8). Upon correlation of the findings in CT virtual laryngoscopy becomes more widely utilized with routine conventional laryngoscopic evaluation of the neck especially for preoperative surgical planning (8).

The present study was designed to evaluate the utility of MSCT with virtual laryngoscopy in the detection, staging and pretherapeutic planning of laryngeal and hypopharyngeal carcinomas and to compare these findings with those of conventional laryngoscopic techniques.

2. Materials and methods

This retrospective study included 40 patients with laryngeal and hypopharyngeal tumors who were evaluated and treated at the Otolaryngology department of Ain Shams University Hospitals during the period from October 2009 to October 2011. The study was carried out after the permission of the Ethics Committee of Scientific Research, Faculty of Medicine, Ain Shams University with informed consent of the subjects.

The most common initial complaints for all patients were hoarseness of voice (22), followed by dysphagia (7), neck nodule (5), sore throat (3) and deeply seated neck pain (3). Following detailed history regarding the onset and duration of illness, previous operations and other medical problems and questioning the family history and habits (e.g., Tobacco smoking, alcohol consumption) all patients were examined blindly by more than one ENT physician, in office by indirect laryngoscopy to assess the laryngeal/hypopharyngeal mucosa, lumen and mass pathology and the clinical findings were recorded. Disagreement between the physicians was resolved by consensus.

Multislice CT-virtual laryngoscopy studies were performed for all patients within the same week before direct laryngoscopic guided biopsy.

Direct laryngoscopy under general anesthesia and biopsies were subsequently obtained. Retrospective medical chart review was performed to incorporate clinical & direct endoscopic examination, including the visible and palpable extent of the lesion, involvement of the vocal cords, mobility of the vocal cords, the state of the laryngeal mucosa and lumen and mass pathology.

2.1. CT image acquisition

CT examination was performed using a 64 channel-multidetector CT scanner (volume CT, light speed; GE Healthcare Milwaukee, Wisconsin) after intravenous injection of 50 ml nonionic, low osmolar contrast agent manually. Patients were asked to breathe quietly and not to swallow for the duration of the scan and the scans were performed in a cranio-caudal direction, from the base of the skull to the aortic arch. The scanning parameters included 120-140 kVp, tube current of 150-280 mA, and a 512 × 512 pixel matrix. The FOV was 16-18 cm. The data were reconstructed into 1.25 mm slice images, resulting in a total of 120-180 axial slices. The scanning time ranged from 8 to 12 s, depending on a single breath-holding time of the subjects. Coronal and sagittal reformatted images of the entire neck were also obtained. Images were reviewed with soft tissue and bone window settings. The images were then transferred to advantage windows workstation (GE-Sun-Microsystems) with manufacturer-provided software that allows generation of 2D multiplanar reconstruction, 3D shaded surface display, and virtual endoscopy. Virtual laryngoscopy images were evaluated simultaneously with axial CT and coronal and sagittal multi-planar (MPR) reformatted images via Shaded Surface Display (SSD) software package. This program works on a segmentation principle that allows voxel elimination on the basis of a determined threshold density value that is fixed at -500 HU for the larynx thus the mucous/air interface is visualized and the surface is smooth and in perspective due to shading in various tonalities of gray.

2.2. Data analysis

Two radiologists with experience in head and neck radiology reviewed the scans of the study subjects independently. They classified the tumors into two groups: group I (the laryngeal tumors) and group II (the hypopharyngeal tumors). A solitary case of stomal recurrence was included in group I. The readers were blinded to the subjects' clinical and endoscopic results. Laryngeal and hypopharyngeal mucosa, lumen and mass pathology initially evaluated by direct endoscopy were reevaluated by virtual laryngoscopy. The readers recorded, on a standardized data abstraction form, the mass size, its primary subsite, exact extension to other sub sites, and possible invasion of specific structures as well as lymph node involvement. Local staging was based on the criteria for head & neck cancer staging according to the TNM scale of The American Joint Committee on Cancer (AJCC) (2002) (9).

2.3. Comparing Virtual and direct laryngoscopy

Data from virtual laryngoscopy were compared with those obtained from the conventional laryngoscope. The submucous lesion spread to nearby structures was calculated from the virtual images corresponding to the axial scans. Finally the cases in which visual examination could provide extra-information useful for patients' management were high lightened.

2.4. Statistical analysis

Weighted k statistics was calculated to assess the level of agreement between both radiologists for lesion characterization and pretherapeutic staging. The level of agreement was defined as follows; k values of 0.00-0.40 indicated poor agreement, k values of 0.41-0.75 indicated good agreement, k values of 0.76-1.00 indicated excellent agreement.

3. Results

Among the 40 patients enrolled in the study final results show that 30 patients had laryngeal neoplasms and 10 patients had hypopharyngeal neoplasms. Patients with laryngeal tumors were 26 males (86.7%) and 4 females (13.3%) with ages ranging from 43 to 85 years (mean age 60.2 years) whereas those with primary hypopharyngeal neoplasms were all females with ages ranging from 30 to 70 (a mean age of 49.8). Squamous cell carcinoma was the histologic result in all cases.

Three patients have been excluded from the results because of poor diagnostic quality of the examination owing to noncooperation artifacts of swallowing during image acquisition.

The distribution of laryngeal lesions was 13 transglottic, 5 glottic–subglottic, 8 supraglottic (including 3 epiglottic masses), 3 glottic, and one stomal recurrence. Among the 10 tumors originating from the hypopharynx, 5 were originating in the piriform sinuses and 5 from the postcricoid region. When included in our study 7 lesions were in stage II, 24 were in stage III and 9 were in stage IV a. Lymph node staging was

TMN stage	Group I (laryngeal	l = 30)	Group II (hypopharyngeal $= 10$)		
	Number	Percentage	Number	Percentage	
T II	7	23.3%	0	0%	
T III	16	53.3%	8	80%	
T IVa	7	23.3%	2	20%	
N 0	2	6.7%	0	0%	
N 1	4	13.3%	0	0%	
N 2b	11	36.7%	3	30%	
N 2c	13	43.3%	7	70%	

Table 2	Distribution	of	lesions	as	regards	deep	tumoral	extension.
					<u> </u>			

	Laryngeal neoplasms (30)		Hypopharyngeal neoplasms (10)	
	No.	(%)	No.	(%)
Preepiglottic fat space	20	66.7	2	20
Paraglottic/parapharyngeal fat space	22	73.3	5	50
Cartilage	12	40	2	20
Extra-laryngeal/extrapharyngeal spread	8	26.7	2	20
Lower limit	22 Subglottis		8 Upper esophagus. 2 Postericoid	80
	C C			20



Figure 1 (A) Axial post contrast CT images showing a right vocal cord mass (block arrow). (B) & (C) Coronal and sagittal images showing transglottic extension across the laryngeal ventricle with infiltration of the paraglottic space on the same side (thin black arrow) however with sparing of the preepiglottic space & anterior commissure (thin white arrow). (D) Coronal image clearly delineates the multiple bilateral enlarged deep cervical lymph nodes (star). (E) & (F) Virtual laryngoscopy images show surface mucosal irregularity by the mass at the right false vocal fold (E) and true vocal fold (F) with luminal narrowing. (G) Virtual laryngoscopy image in caudocranial direction confirms subglottic extension. Diagnosis; transglottic carcinoma TMN; T3N2c Mx. Stage IV.

Table 3 Comparison between endoscope and CT as regardsmucosal surface irregularity and destruction in laryngeal &hypopharyngeal neoplasms.

Endoscope	CT		Р	Significance
	Irregular	Cannot	_	
Irregular (30)	12 (30%)	28 (70%)	< 0.05	S
Cannot	0	0		

This table shows statistically significant difference using Fisher exact test especially in large lesions.

primarily based on size criteria in all cases, whereas globular appearance, central necrosis and matting were noted in 3 cases. TNM staging of all lesions is listed in Table 1.

In patients with laryngeal neoplasms (group I) MSCT detected infiltration of the pre-epiglottic fat space in 20 patients (66.7%); of the paraglottic space in 22 patients (73.3%); cartilage invasion in 12 patients (40%); extralaryngeal spread in 8 patients (26.7%) and subglotttic extension of masses in 22 cases. While in group II; infiltration of the pre-epiglottic space was noted in 2 patients (20%); infiltration of the paraglottic space was noted in 5 patients (50%); cartilage invasion was noted in 2 patients (20%); extrahypopharyngeal spread was noted in 2 patients (20%); lower limit of the tumor was noted at the esophagus in 4 patients (40%) and at post cricoid region in 3 cases (30%) (Table 2).

Satisfactory MPR images were obtained in all cases. Compared with axial images, coronal MPR could better display and distinguish the true and false vocal cords, transitional area, laryngeal ventricle, piriform sinus, paraglottic space and subglottic region. They were also superior in the assessment of lymph node metastases. Whereas sagittal MPR could directly show the epiglottis, preepiglottic space, anterior commissure, retropharyngeal wall and upper segment of esophagus. One supraglottic carcinoma involving the true cords and anterior commissure was clearly delineated on coronal MPR and difficult to establish on axial images. Two supraglottic carcinomas had a suspected involvement of the anterior commissure on axial images but the margin between the lower portion of the tumor and the anterior commissure was shown to be normal on MPR (Fig. 1.). There was an excellent agreement between both radiologists in assigning the primary subsites of the tumors, in detecting neoplastic infiltration of the para laryngeal fat spaces. However, early cartilage invasion was

0

0

0

Supra

Glottis

Stomal recur.

0

0

0

missed by one of the readers in one case, subglottic extension was not reported in another case and there was a disagreement regarding anterior commissure in a third case.

3.1. Comparison between virtual and conventional laryngoscopy

The concordance between VL and conventional endoscopy for primary detection of the neoplasms was 96% (29 of 30). Virtual laryngoscopy allowed correct identification of all exophytic lesions, but was unable to depict a flat neoplasm on the right vocal cord in one case that was, however, diagnosed using axial scans due to enhancement of pathological tissues. VL failed identification of mucosal surface irregularity and destruction in 12 cases which were clearly reported as positive by direct endoscopy (30%) (Table 3). Regarding the localization of the primary subsite of laryngeal tumors, a significantly high association existed between direct endoscope and CTVL using chi-square test, with the only difference occurring in one case (5.3%) reported to be epiglottic in direct laryngoscopy and transglottic by CTVL (Table 4). On the other hand a statistically significant difference was reported between endoscope and CTVL in localization of hypopharyngeal masses using chi-square test, as 2 of the cases (50%) diagnosed by CT as primary subsite in the left pyriform was diagnosed by endoscope as post cricoid in origin, while one of the cases (20%) diagnosed by CT as post cricoid in origin was diagnosed by endoscope as left pyriform in origin (Fig. 4, Table 5).

VL allowed suitable evaluation of the anterior and posterior commissures, Morgagni's ventricle as well as of the subglottic region and of inferior margin of the vocal cords in all cases with laryngeal neoplasms (group I) (Table 6). Regarding identification of anterior and posterior commissures invasion statistically significant difference existed between direct and virtual laryngoscopy. CTVL depicted infiltration of the anterior commissure in 22 out of the 30 cases; 5 of these cases (22.7%) were reported by direct laryngoscopy as having clear anterior commissure, while in one of them (4.3%) the anterior commissure could not be evaluated by direct laryngoscopy. Among the 8 cases that were negative at CT, direct laryngoscopy detected positive anterior commissure infiltration in 2 of them (25%). Posterior commissure invasion was detected by both modalities in 5 cases and was missed by direct laryngoscope in two cases of which one was reported as negative and the other could not be evaluated by CTVL. Regarding subglottic extension of the laryngeal tumors, CTVL reported subglottic extension in 22 laryngeal neoplasms, among whom

Table 4 Direc	Direct endoscope and C1 vL as regards detection of the primary subsite of laryngear tumors.								
Endoscope	CT						X^2	Р	
	Trans.	Gl-sub	Epig.	Supra.	Recur.	Glot			
Transglottic	13 (94.7%)	0	0	0	0	0	108	< 0.001 HS	
Glottis-subg	0	5 (100%)	0	0	0	0			
Epiglo.	1 (5.3%)	0	2 (100%)	0	0	0			

 Table 4
 Direct endoscope and CTVL as regards detection of the primary subsite of larvngeal tumors.

0

0

0

Chi-square test shows statistically significant association between direct laryngoscopy and CTVL in localization of 1ry subsite of laryngeal neoplasms, with the only difference occurring in one case reported to be epiglottic in direct laryngoscopy and transglottic by CTVL.

0

0

5 (100%)

0

1 (100%)

0

0

3 (100%)



VR 90,0 Ex; Ded 1

Figure 2 (A) Axial post contrast CT images show a left sided transglottic mass producing thickening of the left true vocal fold. (B) & (C) Coronal and sagittal reformatted images showing infiltration of the left paraglottic space (thin black arrow) and preepiglottic space (thin white arrow). (D) Virtual laryngoscopic images show mucosal surface irregularity of the left true vocal fold (block arrows). (E) Virtual laryngoscopic image in caudocranial direction confirms subglottic extension T3N1Mx.

3 cases were negative by direct endoscopy (13.6%) and one case could not be evaluated by the endoscope (4.5%) (Figs. 1–3).

Direct endoscopy was more valuable in identifying vocal cord involvement in patients with laryngeal neoplasms, diagnosed as cord fixation, with statistically significant differences between both modalities (Table 7). The 8 cases that were negative in CTVL were also negative by direct laryngoscopy. Among the 21 cases that were positive by CTVL, 3 cases (14%) were negative, 16 cases (76%) were positive and 2 cases (10%) could not be evaluated by direct laryngoscopy. A solitary case could not be evaluated by both modalities.

Excellent correlation was found between direct laryngoscopy and CTVL in identifying tumor extension to the posterior pharyngeal wall and postcricoid region (Table 8) in hypopharyngeal tumors. The only case reported with posterior pharyngeal wall extension by DL was also positive by CTVL whereas 2 of the 9 cases that were free by laryngoscopy were positive by CTVL.

4. Discussion

Laryngeal and hypopharyngeal SCC represent more than 90% of the malignant tumors in these regions (10). SCC usually



Figure 3 (A) Post contrast axial CT images reveal soft tissue mass lesion glottic in origin involving both true vocal cords and the anterior commissure (thin white arrows). (B) & (C) Sagittal and coronal reformatted images ascertain infiltration of the anterior commissure (thin white arrow) and left paraglottic space, with caudal extension to the subglottis (thin black arrow). (D) & (E) Virtual laryngoscopy in craniocaudal direction shows the mucosal surface irregularity of the false vocal fold (D), and left vocal cord mass with anterior commissure infiltration (E). (F) Virtual laryngoscopic image in caudocranial direction confirms subglottic extension (block arrows). T3N2cMx.

progresses slowly and more frequently affects men, particularly in their 6th and 7th decades of life. It has been shown to present its highest incidence among smokers and individuals with high alcohol consumption (11). In our study six times more men were affected with laryngeal carcinoma than women, nine times more in smokers than non smokers and the peak incidence of the disease occurred within the age range from 30 to 85. The mean age of patients with hypopharyngeal carcinoma was 49.8 years and all patients were females. Patients often present with voice changes, sore throat, swallowing difficulty, or a lump in the neck. Clinical mirror examination and direct endoscopy are used to evaluate the larynx and hypopharynx (2). SCC typically begins in the inner laryngeal and hypopharyngeal surfaces and presents in three different types; infiltrative, bulky or mixed. A local dissemination pattern can be found on mucosa surfaces or when there is deep invasion of structures in these organs, found with consequent submucosal extension. It is a potentially curable tumor. The survival rates depend on early diagnosis, and adequate treatment for each situation (11). The extent of the tumor has substantial impact on treatment decisions for laryngeal cancer. For example, early T1 and T2 tumors of the glottis and supraglottis can be treated with laser excision. In more advanced tumors, a total or partial laryngectomy may be indicated (12,13). The aim of therapy is to conserve the laryngeal function while achieving the best life

Figure 4 (A) Post contrast axial CT images revealed a large soft tissue mass centered over the post cricoid region with positive infiltration of both pyriform fossae and posterior pharyngeal wall (white stars). (B) Midline sagittal reformatted image shows preservation of the low density preepiglottic fat plane. (C) Coronal reformatted images depicted infiltration of the paraglottic spaces on both sides (white block arrows) and multiple bilateral enlarged lymph nodes (star). (D) & (E) Virtual laryngoscopy revealed obliteration of both pyriform fossae with encroachment on the posterior wall of the larynx yet mucosal surface irregularity could not be evaluated.

expectancy and quality of life for patients. Because of the variety of therapeutic options for laryngeal tumors and their associated indications and contraindications based on tumor extension, imaging plays a key role in the staging of laryngeal cancer (2).

Direct laryngoscopy is the most important examination for pre-therapeutic management of laryngohypopharyngeal disease (14). Direct visualization of the mucosa and biopsy availability in conventional laryngoscopy counteracts the disadvantages such as being invasive and requiring sedation, and the dependence of the assessment to operator's experience (15). Failure to observe lesions beyond stenosis or obstruction and limited viewing restricted to the lumen are among important disadvantages of the conventional method (4).

The utility of CT in diagnosis and preoperative staging of laryngeal/hypopharyngeal carcinoma is widely accepted (16),

Table 5 Direct endoscope and CTVL as regards detection ofthe primary subsite of hypopharyngeal tumors.

Endoscope		CT			Р
	Post cr.	Lt. pyrif.	Rt.pyrif.		
Post cr.	4 (80%)	2 (50%)	0	11	< 0.001HS
Lt pyrif.	1 (20%)	2 (50%)	0		
Rt. Pyrif.	0	0	1 (100%)		

but the quality of conventional CT is influenced by motion artifacts especially from breathing or swallowing during scanning. Small lesions, subtle cartilage invasion and lymph nodes with normal size may be missed. MSCT with volume acquisition and rapid scan time can overcome these drawbacks and visualize cervical vessels with sufficient enhancement to increase the contrast between lymph nodes and vessels to facilitate detection of cervical lymphadenopathies (17).

Current 64-channel multidetector CT scanning technology with isovoxel sagittal and coronal reformatted images, the standard neck CT with 1- to 2-mm reformatted images, appears to suffice for staging of laryngeal cancer (2). Multiplanar reformatted images display the anatomic landmarks of laryngeal structures, the tumor and the extent of involvement from multiple views and are far superior to axial images. Moreover, curved MPR may exhibit structures that could not be displayed on one plane either by standard coronal or sagittal MPR (17).

In our study MPR provided more information about tumor involvement than obtained from axial images in 5 cases. With axial images the laryngeal ventricle could not be directly visualized, so it was difficult to demonstrate a supraglottic carcinoma extending toward a true vocal cord whereas the relationship between the lower margin of the tumor and the upper margin of the true vocal cord could be directly visualized on coronal MPR. Coronal MPR clearly depicted infiltration through the paraglottic space and was also useful in detecting subglottic extent of the tumor. Sagittal MPR could directly investigate the involvement of the preepiglottic space and anterior commissure. Tumors involving cervical vessels and lymphadenopathies could be better displayed on curved MPR along **Table 7**Comparison between direct endoscope and CTVL asregards involvement of the vocal cords in laryngeal tumors.

СТ				Р
Negative	Positive	Cannot		
8 (100%)	3 (14%)	0	23	< 0.001 HS
0	14 (76%)	0		
0	2 (10%)	1 (100%)		
	CT Negative 8 (100%) 0 0	CT Negative Positive 8 (100%) 3 (14%) 0 14 (76%) 0 2 (10%)	CT Cannot Negative Positive Cannot 8 (100%) 3 (14%) 0 0 14 (76%) 0 0 2 (10%) 1 (100%)	CT X ² Negative Positive Cannot 8 (100%) 3 (14%) 0 23 0 14 (76%) 0 0 0 2 (10%) 1 (100%) 1

the carotid sheath than by axial images and the degree of compression, narrowing or obstruction of airways could be better delineated.

Evolution in imaging techniques and particularly the development of programs specific to CT data reprocessing has brought endoscopic 3D visualization in hollow organs (18,19). This type of examination has been thoroughly validated in large intestine studies (18,20,21) and has been proved to be suitable for examination of the airways and in particular of the laryngeal and hypopharyngeal areas to provide endoscopic representation of the various anatomic structures in these sites (18,19,22). Furthermore post processing time is short especially if compared to colon studies due to the rectilinear path of the central axis of the organ and short length of the organ (23–27).

Virtual endoscopy does not allow visualization of the morphology, vascularization and color of the mucous membrane. According to the literature this is why surface flat lesions without space occupying effect go unidentified. This finding was confirmed in our study in which virtual endoscopy failed to identify mucosal surface irregularity and destruction in 8 cases which were clearly depicted by direct endoscopy (26.7%). However all masses detected by direct endoscopy were clearly identified by virtual laryngoscopy. A solitary flat neoplasm on the right vocal cord went unnoticed, it could however be identified using axial scans due to enhancement of pathological tissues.

Walshe et al. (24) were able to detect all the lesions correctly on virtual laryngoscopy before direct laryngoscopy. In 2005, Magnano evaluated patients with laryngeal cancer with virtual endoscopy. In their manuscript it was noted that this technique

Endoscope	CT		X^2	Р	Significance
	Negative	Positive			
Anterior commissure					
Negative	6 (75%)	5 (22.7%)	6.9	< 0.05	S
Positive	2 (25%)	16 (72.7%)			
Cannot evaluate	0	1 (4.5%)			
Posterior commissure					
Negative	23 (100%)	1 (14.3%)	24	< 0.001	HS
Positive	0	5 (71.4%)			
Cannot evaluate	0	1 (14.3%)			
Subglottic extension					
Negative	8 (100%)	3 (13.6%)	18	< 0.001	HS
Positive	0	18 (81.8%)			
Can not evaluate	0	1 (4.5%)			

 Table 6
 Comparison between direct endoscope and CTVL as regards invasion of the anterior & the posterior commissures and subglottic extension in laryngeal tumors.

Endoscope	СТ		Р	Significance
	Negative	Positive		
Posterior pharyngeal	wall			
Negative	7(77.8%	2 (22,2%)	> 0.05	NS
Positive	0	1 (100%)		
Postcricoid region				
Negative	0	0	> 0.05	NS
	0	10 (100)		

 Table 8
 Comparison between direct endoscope and CTVL as regards extension to the posterior pharyngeal wall & postcricoid region in hypopharyngeal tumors.

could be performed in the presence of severe stenosis and did not require sedation and additional scanning. On the other hand, it showed limits in the identification of all lesions and did not allow biopsies and functional imaging to be performed (23-25). In fact, all of the masses detected in conventional endoscopy were also diagnosed by virtual endoscopic evaluation. According to his findings, virtual laryngoscopy, with only 50% specificity, fails to differentiate between mucus, and tumor as confirmed by the false positive diagnosis considering viscous-dense mucus secretion in 4 patients. Virtual laryngoscopy failed to detect only three mucosal infiltrations indicating its high sensitivity (88%). Beser et al. (28) in a study including 38 patients with hoarseness of voice also reported a sensitivity of 88% of the virtual laryngoscopy while its specificity was only 50%. Positive and negative predictive values were 79% and 66% respectively. Accuracy of the virtual laryngoscopy was 76%. Retrospective evaluation of 6 lesions detected in virtual but not in conventional laryngoscopy resulted with the finding of viscous-dense mucous secretion. On the contrary, three lesions detected by conventional laryngoscopy could not be detected by virtual evaluation. A total of six patients were evaluated and considered as normal both by conventional and virtual laryngoscopic examinations.

Virtual laryngoscopy compared to axial scans allows better evaluation of Morgagni's ventricles and of the inferior margin of the vocal cords. VE together with axial scans allows calculation of the intra and extraluminal extension of the neoplasm (parameter T) and eventual lymph nodes (parameter N). This examination also permits ascertaining normality of the inferior vocal cord plane surface and subglottic region. This is a very important information to plan therapeutic strategy and is not always obtainable with flexible endoscopy (2,3,5,6). Subglottic extension is a determining factor contraindicating conservative surgery.

These statements agreed well with our findings. The primary subsite, size and extent of the laryngeal tumor correlated well with direct laryngoscopy reports. However, we found a statistically significant difference between direct endoscopy and CTVL in favor of the latter in detection of subglottic extension. By the caudocranial approach CTVL could investigate the distal portion of the tumor better than DL and it reported a subglottic extension in 22 cases, of which, direct endoscope missed 3 cases (13.6%) and could not evaluate one (4.5%) due to large size of the lesion that hindered the passage of the endoscope below glottis level. We also found a statistically significant difference between direct endoscopy and CTVL in detection of anterior and posterior commissures invasion, with 27.2% of cases reported as having anterior commissure invasion by CTVL that could not be detected by direct endoscopy and 28.6% of cases showing posterior commissure invasion by CTVL that could not be detected by direct endoscopy.

In our study adequate concordance was found between CTVL and direct laryngoscopy in evaluation of the hidden areas in the hypopharynx namely, pyriform sinuses bilaterally and posterior pharyngeal wall, despite some disagreements between both modalities in primary localization of four hypopharyngeal masses.

CTVL was not able to investigate the motion of laryngeal structures such as the vocal cords or the epiglottis, nevertheless, it showed a higher ability in visualizing the extension of the tumor to the vocal cords with no hindrance by large supraglottic obstructing masses in both groups of patients. In contrast to direct endoscopy which could not evaluate the lower extend of the tumor in most cases.

Virtual endoscopy shows some limitations, the quality of the examination depends on patient collaboration and functional tests. Mucosal staining and biopsies cannot be obtained, however the images obtained are much related to what the ENT specialist is used to and may direct the endoscopists to the site to be examined and eventually biopsied. Successful imaging depends on some patency of the lumen, on the precise data obtained by CT scan, on the presence of massive pooling of secretions and on the collapse of soft tissues against the opposite mucosal wall that decrease the examination quality. Naturally swallowing, phonation and breathing during the examination impair CT and VL examination (26,27).

In conclusion, MSCT with virtual laryngoscopy has susbstantially improved the diagnostic accuracy of staging of laryngohypopharyngeal carcinomas. It provides better anatomic resolution within shorter time and wider anatomic range however it still showed some limitations in deciding whether there is thyroid cartilage penetration or extralaryngeal spread. While retrograde visualization and flythrough possibilities with virtual laryngoscopy enable superior determination of tumor extension, conventional laryngoscopy is still the gold standard for laryngeal pathologies.

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