Original Research Article

Utility of dynamic MDCT using “EE” phonation in the evaluation of laryngeal masses

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Abstract

Background: To evaluate the utility of dynamic MDCT with “ee phonation” in the assessment of laryngeal masses. **Methods:** This was an observational study conducted on 50 patients of laryngeal masses who presented with complaints of dysphonia, dypnoea or dysphagia. These patients underwent a noncontrast CT followed by prephonation and phonation postcontrast MDCT of the neck. All scans were assessed for morphology, extent and staging of the laryngeal masses. **Results:** The most common laryngeal mass in our study was laryngeal carcinoma (80%). The remaining 20% included 1 case of chondrosarcoma, 3 cases of laryngeal tuberculosis, 5 cases of vocal nodules and 1 case of an epiglottic cyst. We found that Dynamic CT with “EE” phonation is better than conventional non-phonation CT for evaluating laryngeal masses. The involvement of the following laryngeal subsites: pyriform sinus, false vocal cords, laryngeal ventricles and true vocal cords is better appreciated on phonation MDCT than with quiet breathing CT. Phonation CT also helps to reduce false positive cases of pyriform fossa involvement. **Conclusion:** Thus in conclusion, we advocate the use of phonation MDCT for a comprehensive evaluation of laryngeal masses.

Keywords: *dynamic maneuver, larynx, Multi detector computed tomography, phonation*

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INTRODUCTION

The larynx is the inferior continuation of the oropharynx and is a unique organ with functions of phonation, respiration and swallowing. It occupies a central position in the neck. Imaging of the larynx is a challenging endeavour as the organ moves with every swallow and respiration. Patients with laryngeal masses, present with symptoms like hoarseness or change in voice, dysphagia, mass in the neck and dyspnea, if there is significant airway compromise. Laryngeal pathologies are diverse and range from infectious (laryngitis, papillomas) to laryngocoeles to benign tumours (juvenile papillomas, hemangiomas, fibromas, chondromas, myxomas, and neurofibromas) to vocal cord nodules and polyps to laryngeal carcinomas. Of the laryngeal masses, laryngeal carcinomas are the most common. They are the commonest head and neck malignancies. Smoking is implicated as the major risk factor for the same. Since the most common mass is a neoplasm, these symptoms in a patient in the appropriate age group, must prompt further investigation for laryngeal cancer. Assessment of laryngeal pathologies is primarily done using clinical examination, indirect and direct laryngoscopy[1,2,3]. Stroboscopy can be used to assess the vocal cords. However, laryngeal masses need supplementary evaluation with imaging for complete assessment to determine deeper extent, lymph nodal disease and metastatic spread. Also, certain masses are submucosal and thus may not be seen on endoscopy while others may be too large obscuring endoscopic visualization. Thus a patient presenting with symptoms of dyspnoea, dysphonia, dysphagia or mass in the neck which could be attributable to the larynx requires detailed history and clinical examination. Further, indirect and direct

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laryngoscopic examinations should be performed to evaluate the cause of symptoms, delineate extent and perform biopsy under anaesthesia. Most laryngeal tumours are mucosal lesions. Cross sectional imaging is complementary by demonstrating submucosal tumor growth, extralaryngeal spread and lymph nodal status. This can be done using either MDCT or magnetic resonance imaging (MRI). MDCT is a widely available technique as compared to MRI and avoids motion artefacts due to fast image acquisition and therefore is the modality of choice in imaging of such patients. CT has a higher specificity, for identifying thyroid cartilage invasion compared with MRI, however with a lower sensitivity. CT is more commonly used compared with MRI for initial staging of laryngeal cancer because of its cost, speed and widespread availability. Dynamic maneouvres like "ee" phonation can be undertaken using CT to better delineate the anatomical extent of the tumour as well as assess vocal cord mobility.

MATERIALS AND METHODS

THIS WAS A PROSPECTIVE STUDY CONDUCTED ON 50 PATIENTS REFERRED TO THE DEPARTMENT OF RADIOLOGY IN A TERTIARY CARE HOSPITAL FOR MDCT EVALUATION OF LARYNGEAL MASSES.

This study was done over a period of 24 months. Detailed clinical history was noted for all patients included in the study. Indirect laryngoscopic findings for each patient were also recorded according to the evaluation by the referring physician.

Images of the neck were obtained using a multidectector computed tomography (MDCT) before and following the injection of an iodinated contrast agent. Routine IV contrast consisting of 50 ml iodinated contrast agent (350 mg iodine/ml) is used in all cases. An automated power injector was used. The patient in supine position, breathing quietly is asked to refrain from coughing or swallowing. Axial scanning was performed from the skull base to the aortic arch with the acquisition plane parallel to the plane of the hyoid bone, to obtain scans parallel to the true vocal cords. Another scan is obtained with the patient performing the "ee" phonation. The raw axial image dataset is reconstructed with a section thickness of as little as 0.75 mm to obtain high quality sagittal and coronal reformatted images. A 512 × 512 matrix is used with a small field of view (FOV) between 16 and 20 cm. All images are reviewed in soft tissue and bone windows. Comparison of the extent of involvement on non-phonation and phonation MDCT as well as indirect laryngoscopy was done. Inferences were drawn from the various observations.

OBSERVATIONS AND RESULTS

Data of 50 patients was analyzed in this study. Age and sex distribution of patients was studied. There were 45 males and 5 females in this study. Males comprised 90% and females 10% of the study group. The age group ranged from 19 to 81 years. Of the possible laryngeal masses, the pathologies encountered in the current study include laryngeal carcinoma, epiglottic cyst, laryngeal chondrosarcoma, laryngeal tuberculosis and vocal nodules. The overwhelming majority of cases are those of laryngeal carcinoma (40) accounting for 80% of patients studied. The rest were seen in the following frequency

Table 1: Distribution of laryngeal pathologies

	Pathology	Number of patients	Frequency
1.	Laryngeal carcinoma	40	80%
2	Vocal nodule	5	10%
3	Laryngeal tuberculosis	3	6%
4	Chondrosarcoma	1	2%
5	Epiglottic cyst	1	2%

LARYNGEAL CARCINOMA

A. Age distribution

A total of 40 patients of laryngeal carcinoma were evaluated in this study. Their ages ranged from 42 to 81 years with a mean age of 61.5 years. Maximum patients (35%) were aged between 60-70 years.

B. Gender distribution

Out of the total of 40 patients of laryngeal carcinoma, only 3 were female while the rest of 37 patients were all males.

C. Symtomatology

The most common symptoms were dysphonea, dyspnoea and dysphagia. Less commonly patients presented with a palapable mass in the neck. All three- dysphonia, dysphagia and dyspnoea were present in 5 patients. 3 patients presented with complaints of a neck mass in addition to dysphonia. Of these 1 patient had only complaints of neck mass which was later found to be a nodal metastasis from a laryngeal primary. Of all symptoms, hoarseness of voice was the commonest (31 out of 40). 8 patients presented with stridor and severe airway compromise requiring urgent tracheostomy.

D. Distribution of laryngeal carcinoma

Table 8: Distribution of laryngeal carcinoma

	Subsites	CT	pCT
1.	Supraglottic	13 (32.5%)	13 (32.5%)
2	Glottic	8 (20%)	8 (20%)
3	Subglottic	1 (2.5%)	1 (2.5%)
4	Transglottic	18 (45%)	18 (45%)

The majority of cancers in our study (45%) were transglottic. Next most common subsite was supraglottic with 32.5% patients. The least common subsite was subglottic with only 1 patient having subglottic involvement. There was perfect concordance in subsite evaluation between both phonation and quiet breathing CT.

E. Distribution of supraglottic subsites of laryngeal carcinoma

Table 9: Distribution of subsites of laryngeal carcinoma

	Subsites	CT	pCT
1.	Aryepiglottic folds	23(57.5%)	25 (62.5%)
2.	Epiglottis	21(52.5%)	21 (52.5%)
3.	Pre-epiglottic space	23(57.5%)	23 (57.5%)
4.	Paraglottic space	30(75%)	30 (75%)
5.	False vocal cords	26(65%)	28 (70%)
6.	Vestibule	18(45%)	20 (50%)

25 cases of aryepiglottic fold involvement were picked up on phonation CT out of which 23 were also seen on non-phonation CT. Thus phonation CT is superior for detection of involvement of aryepiglottic folds. Both phonation as well as non phonation CT performed equally well in detecting epiglottic involvement. There is no difference between phonation and non phonation CT in assessing involvement of pre epiglottic and paraglottic spaces. The pre-epiglottic and paraglottic spaces were considered to be involved if there was loss of the fat attenuation of these spaces with replacement by soft-tissue attenuation or stranding of the fat in these regions. Accurate assessment of preepiglottic and paraglottic spaces is mandatory for a correct staging of supraglottic tumors' progress into T3 tumors. 28 cases of false vocal cord involvement were picked up on phonation CT out of which 26 were also seen on non-phonation CT. Thus use of phonation CT increases the detection rate of false vocal cord involvement. On phonation, there is distension of the laryngeal ventricle with air which allows better visualization of lesions. This is evidenced by greater detection of vestibular/ laryngeal ventricle involvement by phonation CT (50% cases) as opposed to non phonation CT (45%). Overall, among all the supraglottic subsites, majority of cases (30%) showed paraglottic space invasion. Involvement of the false vocal cords was seen in 28%, aryepiglottic folds in 25%, pre-epiglottic space in 23%, epiglottis in 21% and vestibule in 20 % patients. Pre-epiglottic and paraglottic spaces cannot be assessed by IDL and have similar detection rates on both phonation and non phonation CT. Due to better distension, phonation CT is superior-most in evaluating laryngeal ventricular and false vocal cord involvement. These findings are all consistent with the studies by Shimaa al Farghaly[12] and Irfan Celebi[14]

F. Distribution of glottic and subglottic subsites of laryngeal carcinoma

Table 10: Distribution of glottic and subglottic subsites of laryngeal carcinoma

	Subsites	CT	pCT
1.	One vocal cord	16 (40%)	20 (50%)
2.	Bilateral vocal cords	7 (17.5)	9 (22.5%)
3.	Anterior commissure	10 (25%)	13 (32.5%)
4.	Posterior commissure	7 (17.5%)	7 (17.5%)
5.	Subglottis	11 (27.5%)	11 (27.5%)
6.	Immobile vocal cords		18 (45%)

CT is the best modality for diagnosing **subglottic** tumours as well as subglottic extension of laryngeal masses. There is no difference between phonation and non phonation CT scans in assessing for subglottic extension. There is no role for conservative laryngeal surgeries in patients with subglottic invasion and thus it is extremely crucial to study the involvement of this region. Bulky tumor and even normal cords could hide the subglottic area. This can explain the failure of IDL to detect tumour involvement of this region. CT assessment for the subglottic involvement is more accurate than IDL which is similar to the results of multiple researches Phonation CT is superior in showing anterior commissure involvement (32.5%) as compared to 25% in non phonation CT. Involvement of one **vocal cord** was seen in 50% of all patients while 9% showed bilateral cord involvement in phonation CT. 4 cases with unilateral and 2 cases with bilateral vocal cord involvement could not be diagnosed on non phonation CT.

A total of 45% cases showed vocal cord immobility on phonation CT.

G. Involvement of hypopharyngeal subsites

Table 11: Involvement of hypopharyngeal subsites

	Subsites	CT	pCT
1.	Pyriform sinus- lateral wall	18	24 (60%)
2.	Pyriform sinus- apex	12	18 (45%)
3.	Post cricoid region	3	4 (10%)

Hypopharyngeal subsites were involved as follows: Lateral wall of the pyriform sinus- 60%, pyriform sinus apex in 45% and post cricoids region in 10%. The pyriform sinuses are collapsed during quiet breathing and distended with phonation. Pyriform sinus involvement was classified on the bases of lateral wall and involvement of apex. In this series of patients, nonphonation CT detected 18 and phonation CT detected 24 cases of lateral wall involvement. The reason for higher detection of pyiform sinus involvement on phonation CT could be due to greater distension of the pyriform sinus with air creating better contrast. On similar lines, 12 cases of apical pyriform sinus involvement were detected on non-phonation and 18 cases on phonation CT. Thus the use of phonation CT greatly increased the rate of detection of pyriform sinus involvement on our study.

H. Involvement of laryngeal cartilages

Table 12: Involvement of laryngeal cartilages

	Subsite	Involved	Percent (%)
1.	Thyroid	15	37.5
2.	Cricoid	6	15
3.	Arytenoid	11	27.5

I. Involvement of hyoid bone

Involvement of the hyoid bone was seen in only 2 patients out of a total of 40 in our study. On CT, one case showed erosion and irregularity of the bony cortices of the greater cornu and body of the hyoid bone while the other was a frank case of hyoid bone involvement showing complete destruction of one half of the bone. There is no benefit of phonation CT over non phonation CT in evaluation of hyoid involvement.

J. Involvement of prevertebral space

In our study, 2 out of the 40 patients showed prevertebral space invasion upstaging the disease to IVB. Involvement of prevertebral space was assessed on the basis of loss of the prevertebral fat plane and presence of enhancing soft tissue tumour in the region or erosion of vertebrae.

K. Involvement of viscera and carotid bundle

Tracheal and thyroid gland involvement was seen in 10% cases each while carotid bundle encasement was seen in 2 cases (5%).

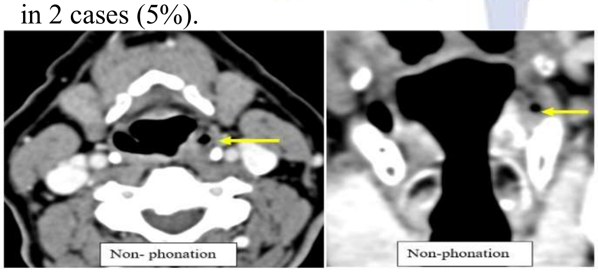

Figure 1:

Figure 2: Non phonation CT shows apparent thickening of the left pyriform sinus but with adequate distension on "EE" phonation, involvement was ruled out

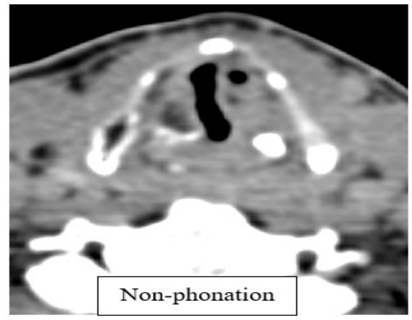

Figure 3:

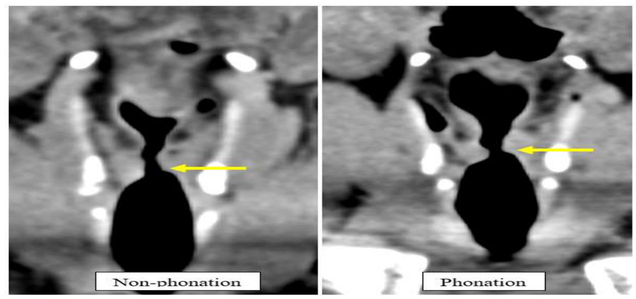

Figure 2: Left glottic carcinoma. It does not show medialization of the cords on phonation scans s/o cord fixation

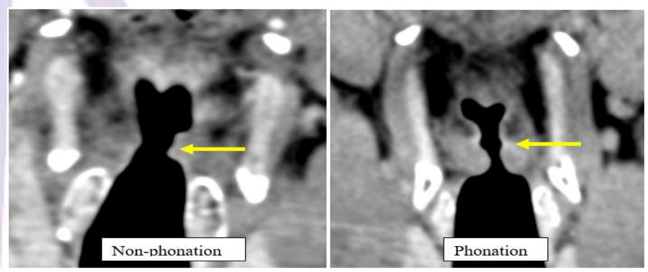

Figure 3: Prephonation and phonation scans showing better delineation of the laryngeal ventricle

DISCUSSION

MDCT of the neck with dynamic maneuvers is of considerable importance as improves the visualization of particular subsites of the larynx. Prolonged phonation of [eee], causes distention of the pyriform sinuses allows better delineation and detection of early invasion of pyriform sinuses. It also allows a better visualization of the laryngeal ventricles. With the use of MDCT scanners images of the larynx can be acquired as a single volume data during phonation which it makes it possible for direct evaluation of vocal cord mobility and paralysis. Problems due to patient co-operation and motion artifacts are largely overcome by MDCT, as the patient has to perform the maneuver only once during one rapid acquisition, and it can be performed without increased patient motion. This is because of the speed of a 128-detector MDCT that allows an entire scan to be acquired in less than 8 seconds.

Pyriform sinuses

The pyriform sinuses are collapsed during quiet breathing and distend during phonation. In our study involvement of the pyriform sinus was seen in 18 cases on nonphonation CT and 24 cases of phonation CT. The reason for higher detection of pyiform sinus involvement on phonation CT is due to greater distension of the pyriform sinus with air creating better contrast. On similar lines, 12 cases of apical pyriform sinus involvement were diagnosed on non-phonation and 18 cases on phonation CT. Thus the use of phonation CT greatly increased the rate of detection of pyriform sinus involvement in our study. In few cases of our study, pyriform fossa involvement was suspected on non-phonation CT. However review of phonation CT images, showed that the apparent thickening was due to the collapsed lumen of the pyriform sinus.

In this way due to better distension of the pyriform sinuses, phonation CT decreased the false positive cases of non phonation CT. The findings in our study corroborate with those by Farghaly *et al.*[12] and Stadler *et al.*[15].

Laryngeal ventricle

Phonation MDCT is also useful in the delineation of the laryngeal ventricle. On phonation, there is distension of the laryngeal ventricle with air which allows better visualization of lesions. This is evidenced by greater detection of vestibular/ laryngeal ventricle involvement by phonation CT (50% cases) as opposed to non phonation CT (45%). This closely agrees with the results of Latif *et al.*[21], who reported that accuracy of CT to evaluate the laryngeal ventricle is 100%. This information is very important as the laryngeal ventricle is the transition zone between supraglottic and glottic regions. Its infiltration can affect preoperative staging and therapeutic strategy. This also agrees with the results of Lell *et al.* [16], who reported that functional MDCT is more accurate than nonfunctional MDCT in the evaluation of the laryngeal ventricle.

Vocal cords

Vocal cord mobility is one of the most important TNM staging criteria by the AJCC classification; hence its assessment is very important to avoid understaging or overstaging. On CT, non phonation and phonation scans are compared to evaluate if the cords abduct and medialise post phonation. If there is no significant change in the position of the vocal cords between the two scans, it implies cord fixation and immobility. Conventional non phonation MDCT cannot evaluate vocal cord mobility. Our findings are similar to those by Shimaa al Farghaly[12], Gordon Gamsu *et al.*[13], Irfan Celebi[14] and Kim *et al.* [18]

Rest of the laryngeal subsites:

No significant difference was observed between phonation and non phonation CT in the evaluation of the subglottis, pre epiglottic and paraglottic space invasion. Similarly laryngeal cartilage involvement , prevertebral space, carotid bundle and lymph node involvement could be ascertained equally well on both phonation and non phonation CT.

CONCLUSION

Thus we conclude that dynamic MDCT of the larynx is superior to non phonation scans due to better delineation of laryngeal subsites like the false vocal cords, pyriform sinuses and laryngeal ventricles and also to assess for vocal cord mobility. Thus we advocate dynamic CT neck with EE phonation studies for a comprehensive assessment of laryngeal masses and accurate pre operative staging.

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