Laryngeal ultrasound as effective as CT scans for the diagnosis of various laryngeal lesions

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Background
Different methods have been used in the past for the diagnosis of many laryngeal diseases. Ultrasound has become a very important, widely used diagnostic tool for head and neck diseases.

Objectives
The aim of this study was to evaluate laryngeal ultrasound as an alternative to computed tomography (CT) scans in the diagnosis of different laryngeal diseases.

Study design and methods
This was a comparative cross-sectional study that was carried out between April 2010 and December 2011 in the Department of Otorhinolaryngology, Zagazig University Hospitals, Egypt. The study comprised two groups of patients: the control group (12 patients) and the study group (54 patients). Individuals of the control group who were undergoing neck ultrasound for thyroid swelling were subjected to laryngeal ultrasound only, whereas patients of the study group were subjected to both laryngeal ultrasound and CT scans of the neck.

Results
Laryngeal ultrasound was found to be effective in detecting vocal cord nodules in 27.3% of patients, polyps and cysts in all patients, Reinke's oedema in 60% of patients and laryngeal masses in 78.6% of patients. These results were comparable with those of the CT scans.

Conclusion
Laryngeal ultrasound is considered of great value in diagnosing different laryngeal lesions and can be used as an alternative to or complementary to CT scans.

Level of evidence
The level of evidence is 3a.

Keywords:
computed tomography, high resolution ultrasound, laryngeal lesions, laryngeal ultrasound

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Introduction

Different methods have been used successfully for the diagnosis and treatment of many laryngeal diseases [1]. Rigid and flexible endoscopy have been used in the otolaryngology outpatient departments for laryngeal evaluation, with the advantage that the image is larger, brighter and clearer, which allows earlier diagnosis [2].

Unfortunately, not all patients can tolerate diagnostic endoscopy, especially those with a sensitive gag reflex, limited jaw or neck mobility or those suffering from stridor. It is also difficult to perform in most infants and children [3,4].

Even during laryngoscopy, the exact extension of the laryngeal tumour, its infiltration and invasion of the laryngeal skeleton can sometimes be difficult to assess. Thus, laryngoscopy alone may not be sufficient in some cases to judge the extent of infiltrative processes or to measure the exact infiltration of a tumour. For this reason, computed tomography (CT) and MRI are often used to supplement laryngoscopy as additional imaging tools in the estimation of tumour extension and size [5].

Ultrasound was a very important, widely used diagnostic tool for head and neck diseases; however, it was rarely used in the diagnosis of laryngeal diseases. This was because of the problem in visualization of laryngeal structures and thus in performing a complete laryngeal sonographic examination due to the acoustic extinction of the ultrasound by the ossified laryngeal cartilages [6].

Ultrasonography is generally considered a safe noninvasive imaging modality for diagnosis during pregnancy and is reliable for infants and children [7,8].

The aim of this studying was to evaluate laryngeal ultrasound as an alternative to CT scans in the diagnosis of different laryngeal diseases.

Patients and methods

This study was carried out in the Departments of Otorhinolaryngology and Radiology, Zagazig University Hospitals, from April 2010 to December 2011.

Patients included in this comparative cross-sectional study were divided into control and study groups. Individuals of the control group included 12 patients who were undergoing neck ultrasound for thyroid swelling; they were subjected to laryngeal ultrasound only to identify the normal sonographic appearance of the different laryngeal structures.

The study group included 54 patients with different laryngeal lesions; these patients were previously diagnosed by indirect rigid laryngoscopy using a Hopkins rod rigid laryngoscope (70°; Carl Storz, Germany), with photo documentation and video recording using a camera (Carl Storz). Patients diagnosed with a laryngeal mass using rigid indirect laryngoscopy underwent direct laryngoscopy under general anaesthesia and biopsies were obtained for histopathological diagnosis.

Each patient included in the study group was subjected to both CT scans of the neck and laryngeal ultrasonography.

High-resolution ultrasound was done using General Electric (China) with small linear probe of 7.5 MHz frequency and Laser page printer to conduct the laryngeal ultrasound. The patient was made to lie supine with the neck slightly extended. The gel was applied on the linear examination probe. External identification of the thyroid cartilage was performed and the examination started by putting the probe transversely on the mid part of the thyroid cartilage. The probe was moved upwards and downwards until the images of the different laryngeal structures and laryngeal lesions were obtained. Laryngeal ultrasonography was performed in two phases: (a) during quiet breathing, which allowed better assessment of the vocal cords and their lesions, and (b) during phonation, by instructing the patient to make the long E sound to allow the best sonographic assessment of vocal cord mobility. Thereafter, every patient in the study group underwent a CT scan of the neck to assess the laryngeal lesion. The findings of both radiological modalities were then compared for every patient.

A dual CT scanner (High speed Dual system; General Electric) was used for the procedure. The patient was made to lie on the table in the supine position with the neck slightly extended. The examination was performed with the patient breathing quietly. Contiguous or overlapping sections were obtained from the neck. The display slice thickness was 3 mm. The gantry angle was parallel to the hyoid bone. All studies were reconstructed using the soft tissue algorithm. Further reconstruction using a suitable edge enhancement algorithm or technique to improve the bone and cartilage depiction was obtained for patients with a history of tumour. An intravenous noniodinated contrast (50 ml) was administered through an automatic injector at a rate of 3 ml/s. The neck was evaluated with scans from the skull base to the top of aortic arch. Very thin sections (1.0–1.5 mm) with multiplanar reconstructions limited to the larynx were obtained. Scans obtained during phonation or the Valsalva manoeuvre were used for assessing laryngeal function.

Results

The control group included 12 individuals who were normal, with normal laryngoscopic appearance. High-resolution neck ultrasonography was performed for every individual included in the control group, with the aim to identify the normal sonographic appearance of the laryngeal structures. Both vocal cords were easily identified and appeared echogenic. The thyroid lamina, anterior commissure, vocal process of the arytenoid cartilage and glottic space were also identified during phonation and normal breathing. The free margins and the posterior part of the vocal cords were not clearly identified (Fig. 1).

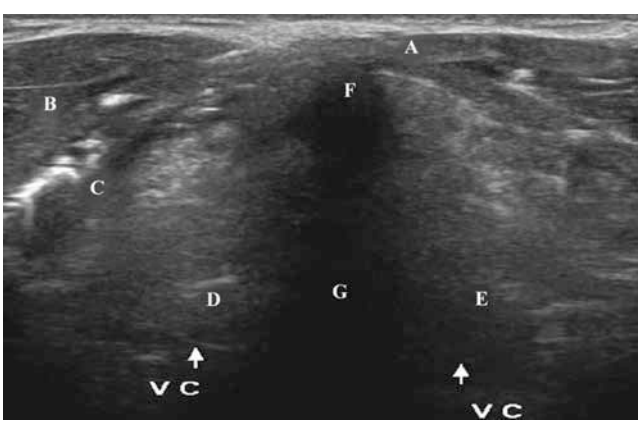
As regards the vocal cords mobility, the range of mobility was clearly visible in most of the individuals, but they were not clearly identified in three of them (25%) as the thyroid cartilage was calcified.

A total of 54 patients were included in the study group; 38 men (70.4%) and 16 women (29.6%), their ages ranged from 21 to 68 years (mean 44.5 years).

Variable symptoms were seen in the patients included in the study group, hoarseness of voice was the most common presenting symptom as it was seen in 100% of the patients, chronic cough was observed in 27.8%, followed by dysphagia in 22.2%, chocking attacks in 18.5% and, finally, stridor in 16.7% (Table 1).

The indirect laryngoscopic examination of the patients included in this study revealed laryngeal masses (whether benign or malignant) in 14 patients, vocal cord nodules in

Figure 1



Normal sonographic appearance of the larynx at the level of the vocal cord. A, skin and subcutaneous tissues; B, strap muscles; C, lamina of the thyroid cartilage; D, right vocal fold; E, left vocal fold; F, anterior commissure; G, glottic chink; VC, vocal cord.

11 (unilateral in three and bilateral in eight patients), vocal cord polyps in 14 (sessile in five and pedunculated in nine patients), vocal cord cyst in six, Reinke's oedema in five and chronic laryngitis in the form of vocal cord thickening and interarytenoid oedema in four (Table 2).

Each patient included in the study group was subjected to both CT scans of the neck and neck ultrasonography; the results of the radiological findings have been presented in (Table 3).

By reviewing these results, it has been found that:

(1) In the subgroup of patients diagnosed with vocal cord nodules ($n = 11$), the vocal cord nodule was not detected through ultrasonography in eight patients, but surprisingly, it was detected in three patients (27.3%); however, when the same patients underwent CT scans of the neck, the vocal cord nodule was detected in only one patient (9.1%) (Table 3 and Fig. 2).
(2) In the subgroup of patients diagnosed with vocal cord polyps ($n = 14$), the polyps were seen in all patients (100%) by ultrasonography, but were seen in 12 patients (85.7%) when the neck CT scan was performed (Table 3). In the two patients in whom vocal cord polyps were not detected through CT scans, the polyp was small and sessile (Fig. 3).
(3) Six patients were diagnosed with vocal cord cysts. The cyst was seen in all the patients (100%) when they were subjected to laryngeal ultrasound, but when the same patients were subjected to CT scans of the neck, the vocal cord cyst was seen in five (83.3%) and was not detected in one patient in whom the cyst was small in size (Table 3).
(4) Reinke's oedema was diagnosed in five patients; when laryngeal ultrasound was performed for these patients, it was detected in three (60%), whereas after performing CT scans of the neck, it was detected in only two patients (40%) in the form of thickened vocal cord (Table 3 and Fig. 4).
(5) Four patients were diagnosed with chronic laryngitis in the form of an interarytenoid oedema and vocal cord thickening. Signs of chronic laryngitis were not detected in any of these patients after performing laryngeal ultrasounds (0%), but a thickened cord was detected in two (50%) in the CT scan sections (Table 3).
(6) Fourteen patients with laryngeal masses were included in this study. There were three patients with

Table 1 Distribution of the presenting symptoms in patients included in the study group

Symptoms	*N* (%)
Hoarseness of voice	54 (100)
Chronic cough	15 (27.8)
Dysphagia	12 (22.2)
Chocking	10 (18.5)
Stridor	9 (16.7)

Table 2 Results of the indirect laryngoscopic examination

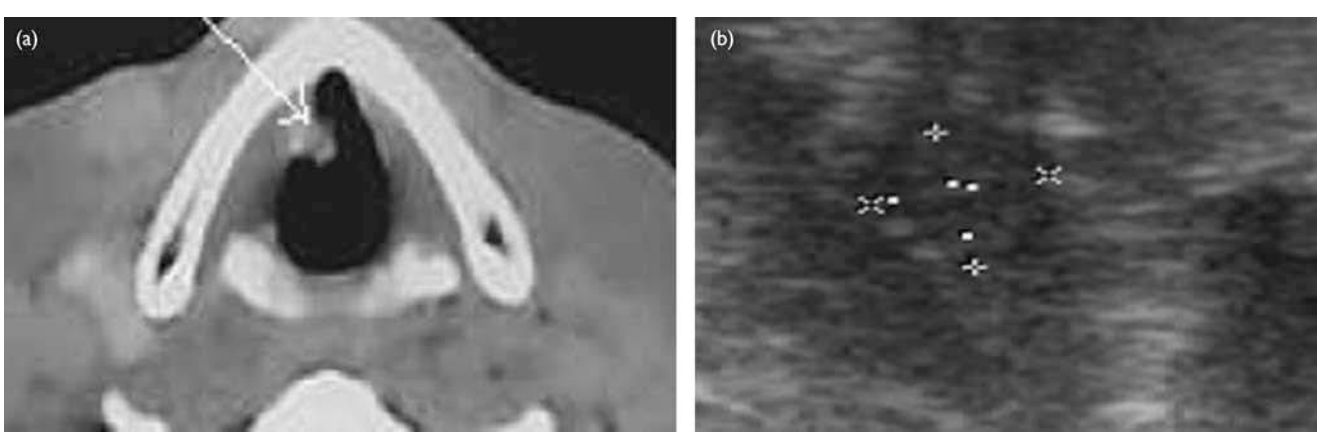
Laryngeal lesion	*N* (%)
Nodules	11 (20.4)
Polyps	14 (25.9)
Cysts	6 (11.1)
Masses	14 (25.9)
Reinke's oedema	5 (9.3)
Chronic laryngitis	4 (7.4)

Table 3 Results of the laryngeal ultrasonography and computed tomography scan of the neck for patients of the study group

	N (%)	
Laryngeal lesions	Result of laryngeal US	Result of CT scan neck
Vocal cord nodule ($n=11$)	3 (27.3)	1 (9.1)
Vocal cord polyp ($n=14$)	14 (100)	12 (85.7)
Vocal cord cyst ($n=6$)	6 (100)	5 (83.3)
Reinke's oedema ($n=5$)	3 (60)	2 (40)
Chronic laryngitis ($n=4$)	0 (0)	2 (50)
Laryngeal mass ($n=14$)	11 (78.6)	12 (85.7)

CT, computed tomography; US, ultrasonography.

Figure 2



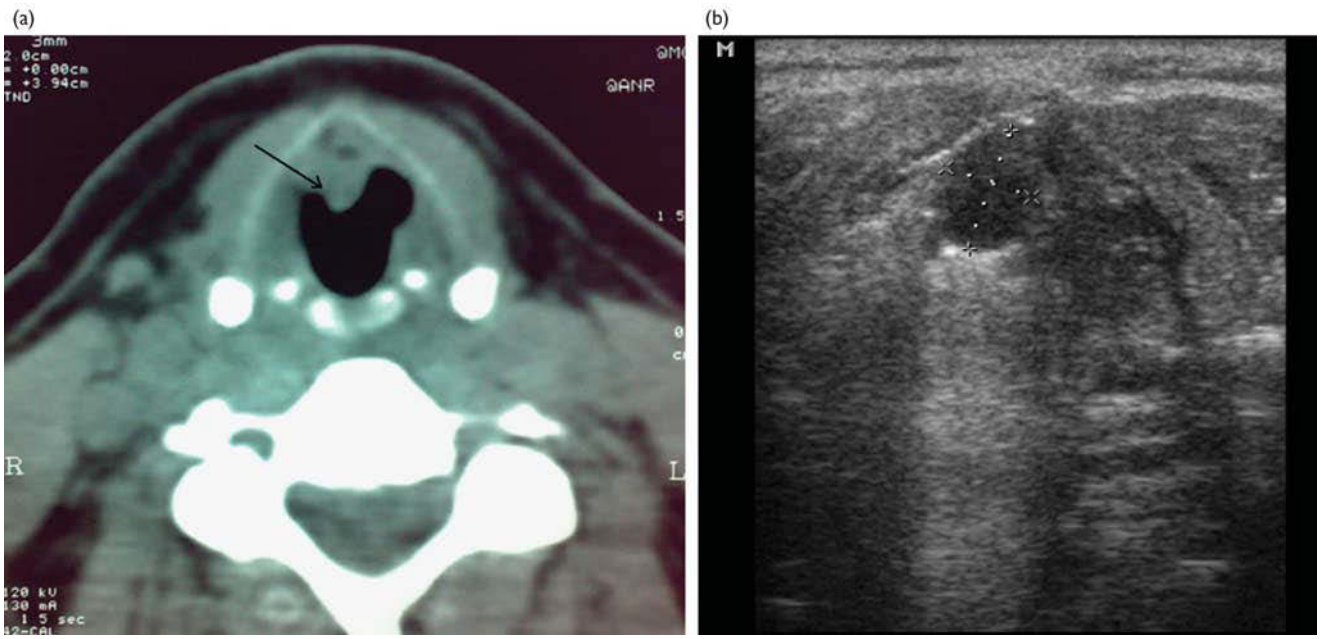
(a) Axial computed tomography image showing a right cord nodule (white arrow) and (b) the nodule seen on an ultrasonogram.

a supraglottic mass, five with a glottic mass and six with a transglottic mass. The visibility of the laryngeal mass on an ultrasonogram depends on the size of the mass, which ranged from about 4–24 mm, with a mean of 14 mm; the laryngeal mass was visible in 11 out of 14 patients (78.6%) on performing laryngeal ultrasound and was detected in 12 out of 14 patients (85.7%) on performing CT scans of the neck (Fig. 5).

Discussion

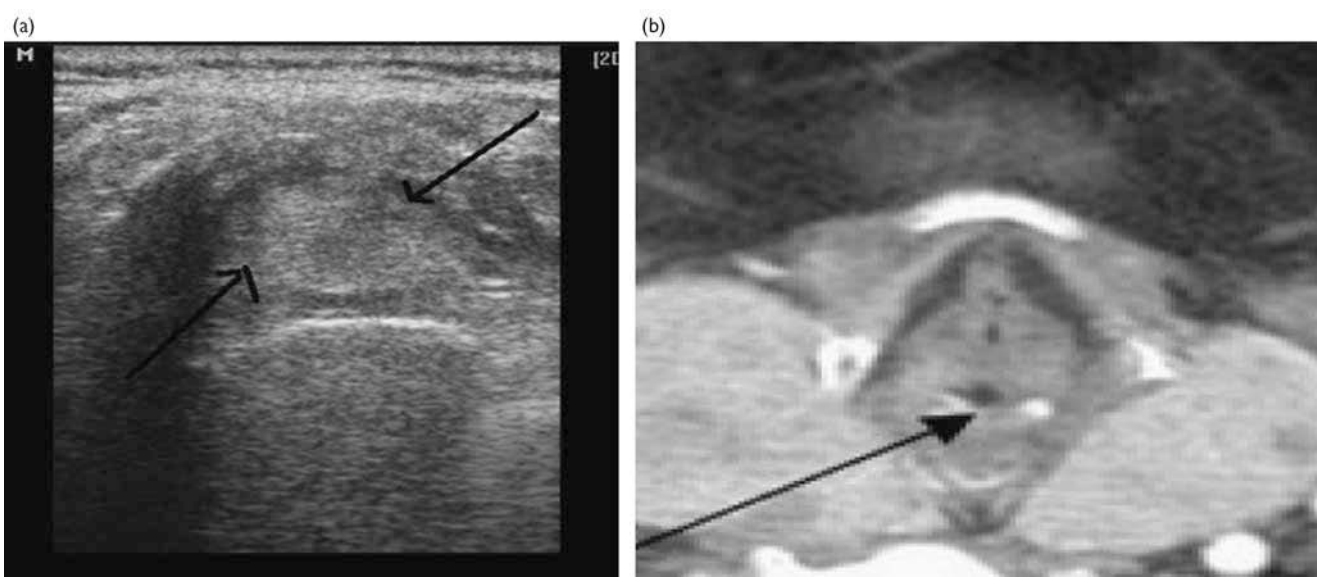
Ultrasonography has been posited as a possible mode for investigation of the larynx since the 1960s [9]. By 1973, echoes from the free margins of the true vocal folds could be unequivocally identified [10]. By the late 1980s, ultrasound was found to be useful for real-time evaluation, not only of the true vocal folds, but also of the false vocal folds and the vocal fold movement [11].

Figure 3



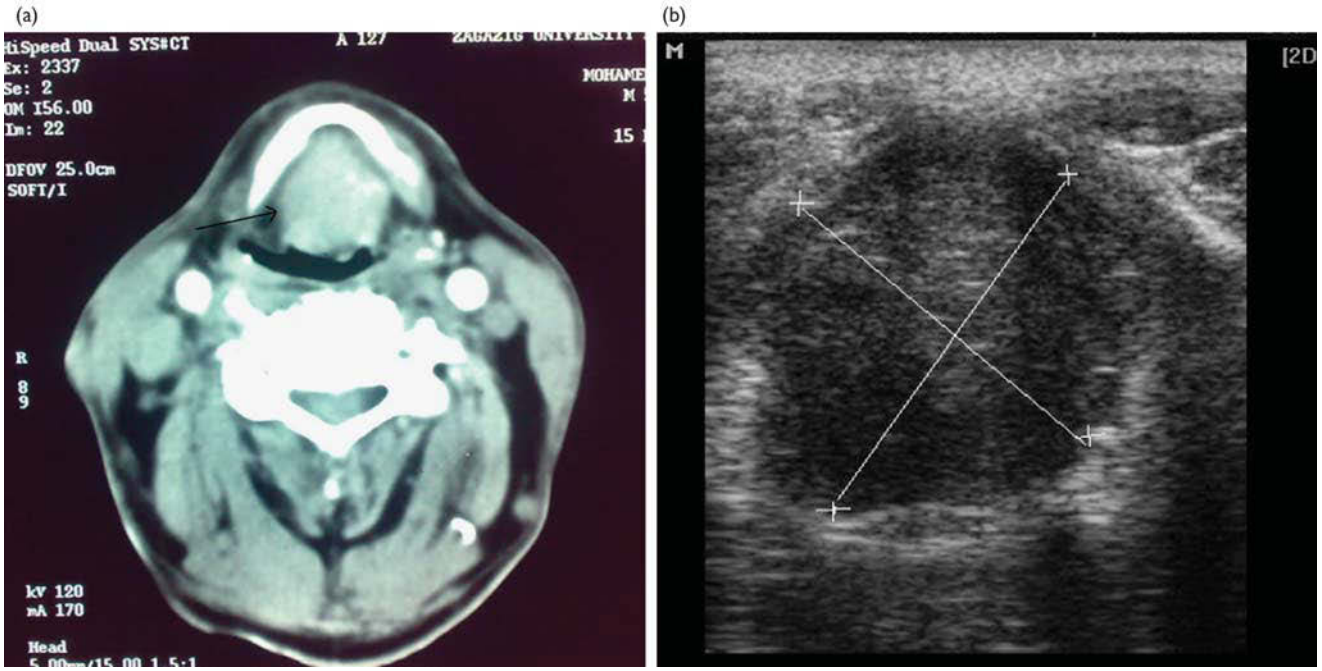
(a) Axial computed tomography image showing an anterior laryngeal polyp (black arrow) and (b) the lesion seen on an ultrasonogram.

Figure 4



(a) Diffuse laryngeal oedema seen on an ultrasonogram (black arrows) and by (b) computed tomography (black arrow).

Figure 5



(a) Axial computed tomography image showing a supraglottic mass (black arrow) and (b) the mass seen on an ultrasonogram.

Huang *et al.* [12] showed that laryngeal ultrasonography at frequencies ranging from 10 to 30 MHz is useful in the diagnosis of diseases of the vocal cords.

Anaesthesia is not necessary during laryngeal ultrasonographic examination. In addition, ultrasonography is noninvasive, painless and much less expensive than other techniques [13].

It is not surprising that laryngeal ultrasonography has been applied for normal and pathological examination in infants and children, in whom, for example, it allows for 'easy subglottic examination' of cricoid hypertrophy, subglottic haemangiomas, laryngeal stenosis and laryngeal paralysis [14].

Garel *et al.* [15] postulated that the infrequent use of ultrasound in the diagnosis of true vocal fold pathologies may be due to the general interest in other more sophisticated imaging modalities, including three dimensional CT scanning and MRI, and perhaps because of the often stated conception that 'the anterior laryngeal calcification' makes analysing of the larynx impossible.

In this study, while studying the normal sonographic anatomy of the vocal folds, the free margins of the vocal cord could be well demarcated, whereas the free margins of its posterior part were not clearly identified because of the air–soft tissue interface between the glottic air and the tissues of the margins of the vocal cords, and this is consistent with the study of Garel *et al.* [16]. Moreover, the thyroid lamina, anterior commissure, vocal process and arytenoid cartilage were also identified during phonation and normal breathing while studying the normal sonographic anatomy of the larynx during this study.

As regards the vocal cord mobility, it was clearly visible in most participants, except in three of them (25%) as their thyroid cartilage was calcified; our finding was consistent with that of Youssefzadeh *et al.* [17], who reported that the laryngeal spaces can be well-observed if the thyroid cartilage was not calcified.

In this study, it has also been found that vocal cord nodules were surprisingly detected in three patients (27.3%), whereas on performing CT scans of neck, they were detected in only one patient (9.1%). In contrast, vocal cord polyps were detected in 100% of patients on performing neck ultrasound and in 85.7% of patients on performing CT scans of the neck (Table 3). On analysis, the results of laryngeal ultrasonography revealed that it is comparable with some extent with the findings of Khalil *et al.* [18], who detected vocal cord polyps in all patients included in their study; however, in contrast to this study, they could not detect vocal cord nodules in any of the patients.

By comparing the results of ultrasonography and CT scan examination in this study, it has been found that the results of both radiologic modalities are comparable with a great extent; moreover, the laryngeal ultrasound was more valuable than CT scan in detecting vocal cord polyps, nodules, cysts and Reinke's oedema, but the CT scan results were better in detecting signs of chronic laryngitis, as vocal cord thickening was detected in two patients (50%) in the CT scan sections but could not be detected by using laryngeal ultrasound (Table 3).

Among patients with laryngeal masses included in this study, the lesion was detected in 85.7% on performing CT scans of the neck and in 78.6% on performing laryngeal

ultrasonography; therefore, we can conclude that CT scan is superior to laryngeal ultrasound in detecting laryngeal masses, but laryngeal ultrasound is of value in detecting these types of laryngeal lesions.

The results of this study are also in agreement with those of Hu *et al.* [19], who stated that laryngeal ultrasonography can be a noninvasive complementary technique for pretherapeutic staging of laryngeal carcinoma.

Ultrasonography is a noninvasive modality; it is available at almost all institutions, is not expensive, is an easily reproducible method for examining the larynx in infants and children, can be used safely during pregnancy in contrast to CT scan, is portable and can be easily transported to patients with difficulty in mobilization.

Conclusion

Laryngeal ultrasonography is considered of great value in diagnosing different laryngeal lesions and can be used as an alternative or as complementary to CT scans, especially when the facility for CT scanning is not available or its use is difficult or carries a risk to the patient.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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