Role of Ultrasonography in the Diagnosis of Vocal Cord Lesions in Comparison to Laryngoscope

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Abstract

Background: Hoarseness of voice is a common complaint due to various laryngeal lesions. Laryngeal lesions may be benign such as cysts, nodules, or polyps, or masses (rather benign or malignant). Recently the laryngoscope is the gold standard for such lesion's diagnosis, however Ultrasound is a great promising non-invasive tool for laryngeal lesions detection.

Objectives: This study aims to evaluate the value of high-resolution Ultrasonography in the diagnosis of various laryngeal lesions by using the direct laryngoscope as a gold standard.

Patient and methods: This prospective cross-sectional study was done at Qena university hospital (ENT & radiology departments), south valley university between January 2022 till January 2023, this study conducted on 50 patients with a laryngeal complaint, by comparing the results of US with direct laryngoscope results.

Results: US could diagnose 100% of cysts, 92.3% of masses, 88.9% of polyp and 6 cases couldn't be diagnosed. (non-diagnosed lesions by US were small nodules and anterior commissure lesions). Overall sensitivity of the US was 88%.

Conclusion: Ultrasonography can be used effectively in diagnosis of many laryngeal lesions with higher sensitivity to larger ones. It can complement laryngoscope in the work-up of patients with hoarseness of voice and suspected laryngeal masses.

Keywords: High resolution ultrasonography; Direct laryngoscope; Laryngeal lesions.

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Introduction

Patients with Voice disorders seek a medical consult when pitch, quality, or loudness significantly differ from what patients and their surroundings expect from their voice. Especially when associated with other complaints, such as throat irritation, vocal fatigue, laryngeal pain, or pharyngolaryngeal reflux, **(Van Houtte et al., 2010).**

Voice disorders can have a significant influence on a person's life, as the voice is an important tool for communication. Psychological, emotional, employment-related problems, effects on family and friends, and reduced quality of life can all arise from voice disorders, **(Brinca et al., 2015).**

Surprisingly little attention has been paid to the role that laryngeal pathology plays in voice disorders. We could explain that by a propensity to only seek help in sever circumstances, such as when one feels a laryngeal foreign body or has a burnt throat, or other conditions, and changes from ''normal'' quality, loudness, or pitch are frequently, **(Brinca et al., 2015).**

It is believed that certain benign vocal fold mucosal disorders result from excessive vibratory trauma to the vocal folds caused by vocal overuse. This excessive vibratory trauma can harm the mucosal tissue, leading to tissue reactions like vocal polyps that resemble blisters and vocal nodules that resemble calluses., **(Bastian and Thomas, 2016).**

Ultrasonography is a low cost, safe, noninvasive, non-radiating imaging modality for diagnosis, **(Wang et al., 2020).**

Using the US should be considered a powerful imaging method for the diagnosis of various laryngeal pathologic processes. Malignant or benign; polyp, nodule, or cyst, **(Nasr et al., 2013).**

The aim of this study is to evaluate the value of high-resolution ultrasonography (HRUS) in the diagnosis of various laryngeal lesions comparing the findings with the results of direct laryngoscope.

Patients and methods

This was a prospective cross-sectional study conducted at ENT and Diagnostic Radiology departments in South Valley University. This study has been given approval by the Ethics Committee of Faculty of Medicine, south valley University, Qena, Egypt. (**Ethical approval code is** SVU-MED-RAD028-1-22-1-312).

This study was conducted on 50 patients with a laryngeal complaint as: chronic dysphonia, chronic throat pain, sensation of lump in the throat or dysphagia which primarily diagnosed to have laryngeal lesion by indirect laryngoscope.

Study subjects

A. Inclusion criteria:

1. Patient with chronic hoarseness of voice, proved to have laryngeal space occupying lesion with indirect laryngoscope. (Cyst, polyp, nodule or mass)
2. Patients aged 20-70 years.
3. Informed written consent was taken from all patients.

B. Exclusion criteria:

1. Post-operative.
2. Post-irradiation
3. Dissatisfaction with participating in the study.

c. Sample Size Calculation: Fifty Patients were chosen from those who attended to ENT and Diagnostic Radiology Departments, (complained of chronic dysphonia, chronic throat pain, sensation of lump in the throat or dysphagia) in the period between January 2022 and January 2023.

$$\text{Sample size} = \frac{\frac{Z^2 \, x \, P(1-P)}{e^2}}{1+(\frac{Z^2 \, x \, P(1-P)}{e^2 N}}$$

N=population size. Z= Z-score.
e= margin of error. p= standard of deviation.

Study tools

I-History taking: (name, age, sex, complaint onset and duration, operative history).

complaints as: (chronic dysphonia, throat pain, sensation of throat lump, dysphagia)

II- Examination:

1- Local examination of the neck for any palpable mass or cyst.

2- Indirect laryngoscope. (Laryngeal mirror): for any cyst, nodule, polyp, or mass.

3-Fibroptic laryngoscope (Karl Storz ,11302BD, German), if assessment by laryngeal mirror is difficult.

III- Investigations:

* **Neck ultrasound**: linear transducer, 9L (LogiQ S8, 2021, Thailand): to evaluate nodule, polyp or mass primarily diagnosed by indirect laryngoscope.

-US technique: Patients lay supine, neck slightly extended and gel was applied on the neck or linear probe (7.5-12 MHz). We started examination by identification of the thyroid cartilage and putting the probe transversely on the mid part of the thyroid cartilage. By moving the probe downwards and upward, we obtained the imaging of the laryngeal areas in anterior and lateral axial views. Laryngeal ultrasonography was done in two phases: during quiet breathing and during phonation by informing the patient to say (long E).

IV-Direct assessment:

* Direct laryngoscope (Kleinsasser operating laryngoscope for adult, and children, medium 17 cm length and small 15 cm length respectively, German) as a gold standard for all cases in this study.

Research outcome measures: To compare sensitivity, specificity, and accuracy of laryngeal ultrasound studies in the detection of vocal cord lesions.

Statistical analysis

Data were verified, coded by the researcher, and analyzed using IBM-SPSS 23.0. Descriptive statistics: Means, standard deviations, medians, ranges, and percentages were calculated. Test of significances: a chi-square test was used to compare the difference in distribution of frequencies among different groups. For continuous variables, in dependent T test analysis was carried out to compare the means of dichotomous data. A significant p-value was considered when it is equal to or less than 0.05. The sensitivity, specificity, positive likelihood ratio (PLR: sensitivity/[1-specificity]) and negative likelihood ratio (NLR: [1-sensitivity/specificity) of US were calculated.

Results

A total of 50 patients were included in this prospective cross-sectional study. Patients were primary diagnosed to have laryngeal lesions by indirect laryngoscope at ENT department, they underwent evaluation by high resolution ultrasonography at radiology department to evaluate its ability for vocal cord lesion detection, final diagnosis made by the direct laryngoscope as it is the recent gold standard for laryngeal evaluation. We compared the US and direct laryngoscope findings to evaluate the sensitivity of US for laryngeal lesion detection.

Patients age ranges from 20-70 y, all of them complain of hoarseness of voice, 80% of them were males, 60% of them were smokers.

Regarding the sex, male to female ratio were 4 to1. Regarding the occupation, 48% of the cases were teachers, 28% were farmers,16% were housewife, 8% were traders. Regarding the risk factors, 60% of the cases were smokers and 60% had voice abuse. The mean age was 49.6 years as shown in **(Table.1).**

Table 1. Base line criteria of the cases

Variables		Frequency	Percent
	Age (years)	**Mean ± std (49.6± 16.7)**	**Min-max (23-70)**
Sex	**Male**	40	74.1
	Female	10	18.5

Occupation	**Housewife**	8	16.0
	Farmer	14	28.0
	Teacher	24	48.0
	Trader	4	8.0
Smoking	**Yes**	30	60
	No	20	40
Voice abuse	**Yes**	30	60
	No	20	40

US examination done in axial anterior and lateral views, thyroid cartilage calcification was a big challenge specially in old males, as it caused posterior acoustic shadowing interfered with visualization of the VC, doing the examination through the thyrohyoid membrane could overcome this problem. Color doppler was another challenge as it depended on patient cooperation for holding breath.

Regarding US criteria of the lesions and their final diagnosis, there was a statistically significant relationship, all 4 cysts were anechoic, homogenous with smooth surface and had no vascularity or calcification **(Fig.1A).** Half of the masses had heterogenous shaped 75% of them have irregular surface, 83.8% of them were sessile and 58.3% of them have internal vascularity **(Fig.3b)** and 33.3% of them had calcifications "punctate" **(Fig.3A, Fig.4A).** 83.8% of the polyps have homogenous shape **(Fig.2A)** and 12.5% of them have irregular surface, 62.5% of them were sessile and 12.5% of them have internal non-significant vascularity and none of them had calcifications as shown in (**Table. 2).**

Table 2. The comparison of different types of laryngeal lesion's features based on the US diagnosis

Variables		**Cyst N= (4)**	**Mass N= (24)**	**Polyp N= (18)**	**No lesion N= (6)**	**P value**
Pattern	Homogenous	4(100%)	12(50.0%)	14 (87.5%)	0.0%	0.000**
	Heterogeneous	0.0%	12(50.0%)	2 (12.5%)	0.0%	
	No lesion	0.0%	0.0%	0.0%	6(100%)	
Borders	Smooth	4(100%)	6(25.0%)	14(87.5%)	0.0%	0.000**
	Irregular	0.0%	18(75.0%)	2(12.5%)	0.0%	
	No lesion	0.0%	0.0%	0.0%	6(100%)	
Mobility of the VC	free mobile VC	4(100%)	6(25%)	14(87.5%)	6(100%)	0.000**
	limited mobile	0.0%	6(25%)	0.0%	0.0%	
	Fixed	0.0%	12(50.0%)	2 (12.5%)	0.0%	
Size of the lesion in maximum diameter (mm)	less than 12	4(100%)	4(16.7%)	12(75.0%)	0.0%	0.000**
	12-22	0.0%	10(41.7%)	4(25.0%)	0.0%	
	more than 22	0.0%	10(41.7%)	0.0%	0.0%	
	No lesion	0.0%	0.0%	0.0%	6(100.0%)	
Shape	Sessile	4(100%)	20(83.3%)	10(62.5%)	0.0%	0.000**
	Pedunculated	0.0%	4(16.7%)	6(37.5%)	0.0%	
	No lesion	0.0%	0.0%	0.0%	6(100.0%)	
Internal Vascularity	Yes	0.0%	14(58.3%)	2(12.5%)	0.0%	0.000**
	No	4(100%)	10(41.7%)	14(87.5%)	0.0%	
	No lesion	0.0%	0.0%	0.0%	6(100%)	
Calcification	Yes	0.0%	8(33.3%)	0.0%	0.0%	0.000**

	No	4(100%)	16(66.7%)	16(100%)	0.0%	
	No lesion	0.0%	0.0%	0.0%	6(100%)	
Echogenicity	anechoic "cystic"	4(100%)	0.0%	0.0%	0.0%	0.000**
	Isoechoic	0.0%	16(66.7%)	16(100%)	0.0%	
	Hyperechoic	0.0%	8(33.3%)	0.0%	0.0%	
	No lesion	0.0%	6(100.0%)	0.0%	6(100%)	

Regarding the whole VC lesion without differentiation, 44 lesions detected by US were diagnosed also by laryngoscope, but 6 cases that missed to be diagnosed by the US were diagnosed by direct laryngoscope to have lesions. There was statistically significant difference in diagnosis of the lesions by both US and laryngoscope as shown in **(Table.3).**

Table 3.Paired comparison between findings of direct laryngoscope and laryngeal US

Variables			**Laryngoscope**		**PV**
			Positive N=50	**Negative N=0**	
US ability for lesion detection	**Positive**	**Count**	44	0	0.00**
		% Within laryngoscope	88%	0.0%	
	Negative	**Count**	6	0	
		% Within laryngoscope	12%	0.0%	

We could define lesions by US into 4 cysts, 24 masses, 16 polyps, and 6 cases without lesions. By referring these cases to direct laryngoscope, we found that they were 4 cysts **(Fig.1B)**, 26 masses **(Fig.3C, Fig.4B)**, 18 polyps **(Fig.2B)**, 2 nodules as shown in **(Table.4).**

Table 4. Differential diagnosis of the lesion by US and direct laryngoscope

Maneuver	**Cases**				
	Cyst	Mass	Polyp	Nodule	no lesions
US	4(8.0%)	24(48.0%)	16 (32.0%)	0	6 (12.0%)
Laryngoscope	4(8.0%)	26 (52.0%)	18 (36.0%)	2 (4.0%)	0

The missed lesions to be diagnosed by the US were nodules in two patients, mainly because of their small size. 2 polyps and 2 small masses, as they were located at the anterior commissure that was a difficult area to reach by the US probe. Regarding Ultrasound TP, TN, FP, FN, Sensitivity, specificity, NPV, PPV and accuracy they were 44,0,0,6, 88%,0%, 0%, 100%,88% respectively as shown in **(Table.5).**

Table 5.Sensitivity, specificity, NPV, PPV and accuracy of US

Variable	TP	TN	FP	FN	Sensitivity	Specificity	NPV	PPV	Accuracy
US	44	0	0	6	88%	0%	0%	100%	88%

*TP (true positive) *TN (true negative) *FP (false positive) *FN (false negative) *NPV (Negative predictive value) *PPV (Positive predictive value).

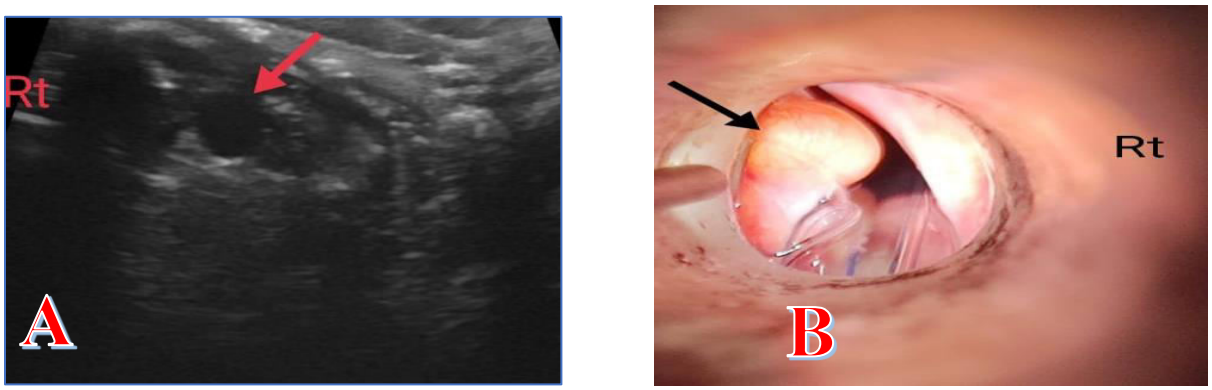

Fig.1. A male patient, 40 years, non-smoker with history of voice abuse, presented by hoarseness of voice for 3 years. A:US, axial view, shows left VC well defined anechoic lesion measures 7.5x6.5 mm, with no internal vascularity or calcifications. B: Direct laryngoscope shows left VC cyst.

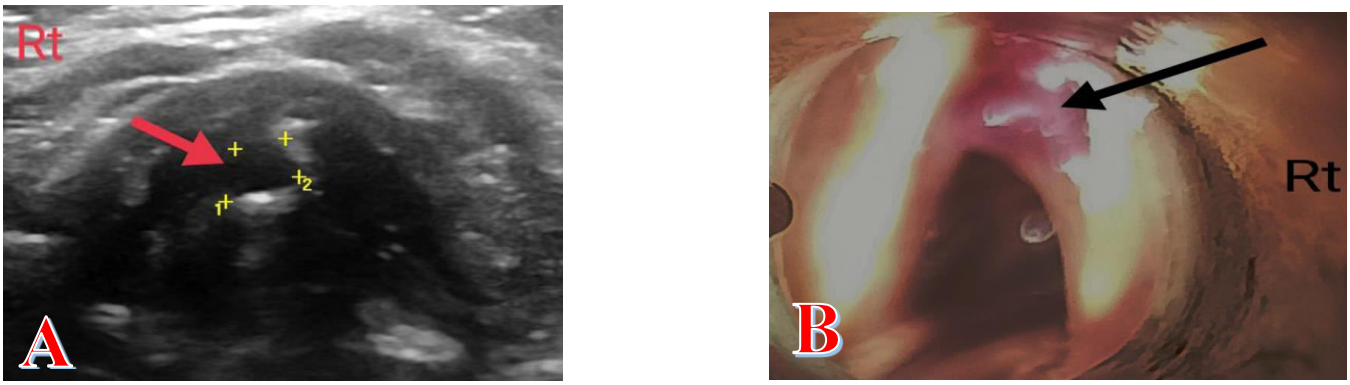

Fig. 2. A male patient, 53y, non-smoker with history of voice abuse, presented by hoarseness of voice for 1 year **A:** US, axial view, shows right VC well defined homogenous isoechoic lesion measures 6x7mm, no internal vascularity or calcifications**. B:** The lesion diagnosed by direct laryngoscope as right VC polyp.

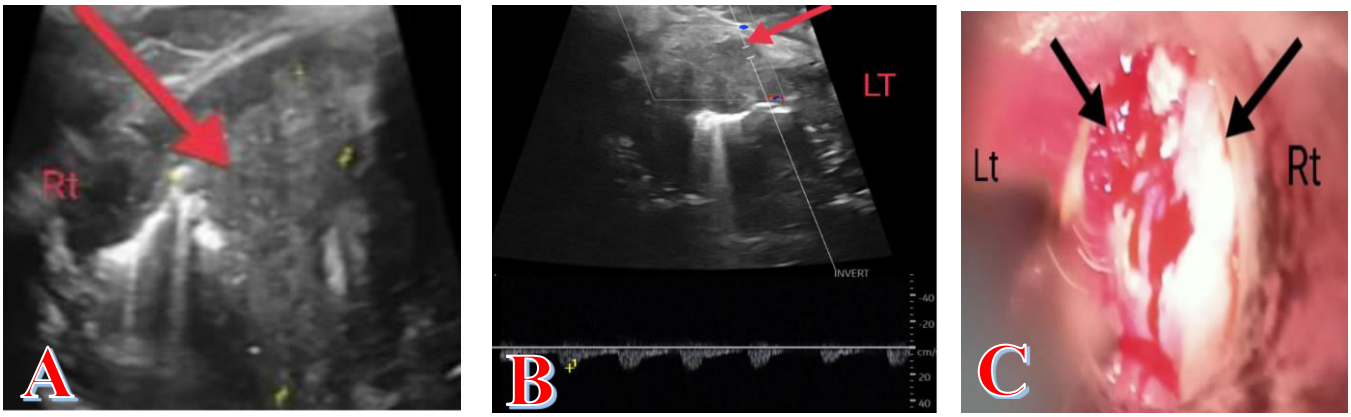

Fig.3. A male patient, 65y, heavy smoker, presented by hoarseness of voice and stridor for 3 weeks. **A:** US, right axial view, shows right VC irregular, heterogenous, isoechoic mass lesion, measures 30x20 mm with punctate calcifications **B:** US, left axial view, shows left VC irregular heterogenous isoechoic mass lesion, measures 20x18mm, with significant internal vascularity, **C:** Direct laryngoscope shows bilateral VC mass lesions.

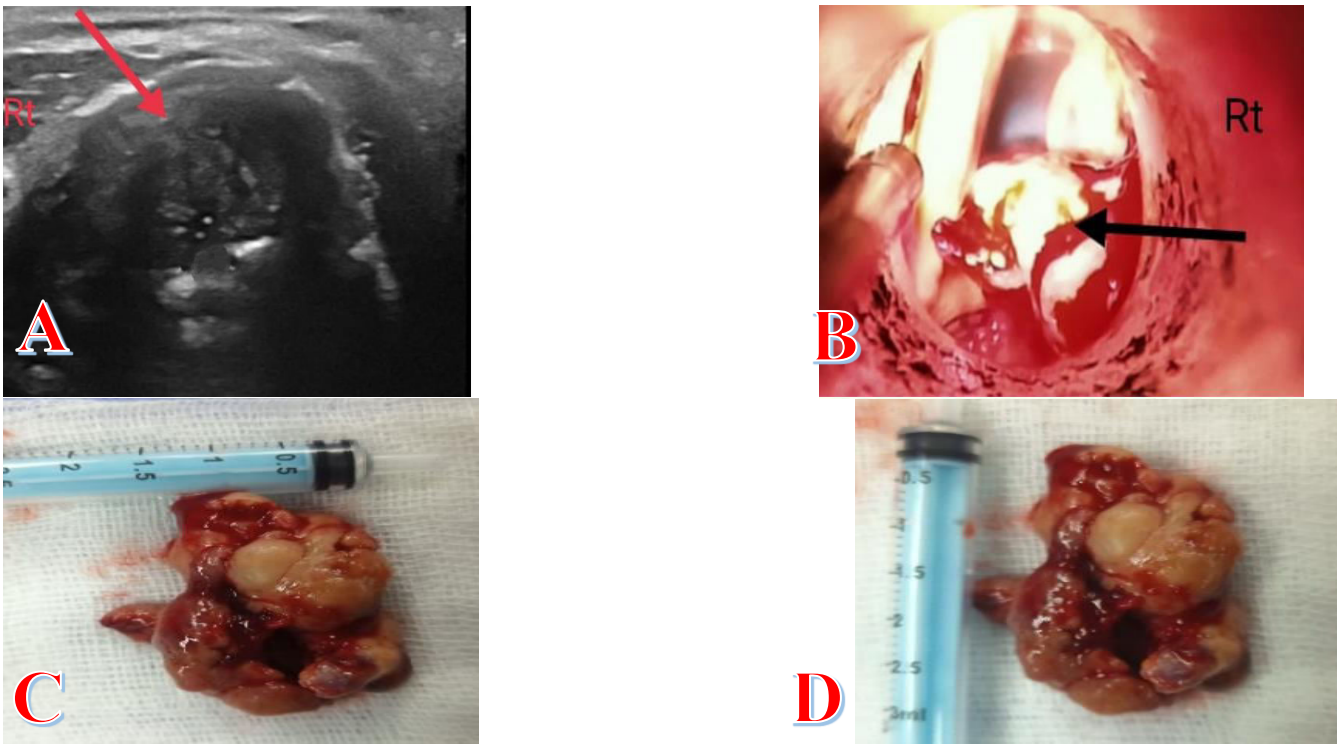

Fig. 4. A male patient, 69y, heavy smoker, presented by hoarseness of voice for 2 months**. A:** US shows right VC irregular, isoechoic, heterogenous mass lesion with punctuate calcifications, it measures 22x18 mm**. B:** Direct laryngoscope shows right VC irregular mass lesion. **C&D:** Excised specimen shows almost the same measurements that detected by US.

Discussion

Many studies have found that laryngeal ultrasonography is less expensive, more tolerable, and more reliable in evaluating the function and lesions of the vocal folds in comparison to laryngoscope. Over the last 4 decades, laryngeal ultrasound has evolved, and several researchers have evaluated its utility. On the anatomical structures reported by laryngeal ultrasound, some research has been published,**(Gadalla et al., 2022).**

In our study, paired comparison of laryngeal ultrasonography and direct laryngoscopy findings showed that There was a statistically difference in diagnosis of lesion by both US and laryngoscope The sensitivity of the laryngoscopy was 100% versus 88 % in laryngeal ultrasonography P value (0.000). Ultrasound could not detect laryngeal lesions in 6 patients, main limitations that we found difficulty in proper placing the probe over thyroid cartilage. Laryngeal cartilage calcification in some cases caused poor image quality and image distortion. This limitations also mentioned by, **(Nasser et al., 2020).**

The comparison of baseline characteristics and the ultrasound findings revealed that the false negative results being mainly reported in males (66.7% in males and 33.3% in females). This could be explained by the fact that thyroid cartilage calcifications were more common in males than females.

In this study, ,18 cases were diagnosed with left or right vocal fold polyp by direct laryngoscope while the ultrasound diagnosed 16 cases (88.9%) of them. 26 patients were diagnosed as glottal mass by direct laryngoscope while the ultrasound diagnosed 24 cases (92.3%) of them. While the sonographic criteria of all mass were malignant, Histopathology of

the excised masses revealed malignancy in two thirds of specimens, but one third of specimens revealed benign lesions. For vocal fold cyst, 4 cases were diagnosed by both direct laryngoscope and ultrasound. By direct laryngoscopy, bilateral vocal fold nodule was found in 2 cases. However, ultrasound couldn't diagnose any of them.

50% of laryngeal cancers include the vocal folds. Squamous cell carcinomas resemble more than 90% of vocal fold cancers. **(Schultz, 2011).**

In our study some masses had significant internal vascularity with peak velocity up to 15 cm/sec, some polyps showed minimal non-significant peripheral vascularity. The main limitation for doppler examination was failure of adequate breath holding by the patient.

(Gadalla et al., 2022). Also reported internal hypervascularity in mass lesion in their study.

The direct laryngoscopy of those patients who were negative by US revealed anterior commissure small polyp in 2 cases, anterior commissure mass in 2 cases, vocal cord nodules in 2cases. anterior commissure is a hidden area for US. The linear and convex curved transducers are not conforming to neck anatomy and thus contributing to limiting views. as well as thyroid cartilage calcifications that obscure underlying structures, so it could not be visualized by US, **(Nasser et al., 2020).** experienced the same limitations.

Old-aged male patients commonly showed cartilaginous calcification which causing posterior shadowing, which may reduce the accuracy of the examination or obscure the lesion, **(Abu El Noor et al., 2023). (Wang et al, 2020)**, conducted a cross-sectional study on 87 person who had postoperative pathology that showed VC polyps. The rate of detection of VC polyps by the laryngeal US was 88.0% for all laryngeal lesions. **(Sadek et al 2019),** noticed that laryngeal ultrasonography has a very lower sensitivity for bilateral vocal cord nodules.

HRUS failed to detect small laryngeal lesions, exactly 100% of vocal nodules and 50% of vocal polyps, **(Gomaa et al., 2013). (Khalil et al, 2010)**, could not detect vocal cord nodules in any of the patients. They claimed that because the vocal cord nodules are too small to be seen by the resolution of the probe, laryngeal ultrasound cannot detect them. As well as they lie along the air-soft tissue interface.

(Nasr et al 2013), found that laryngeal ultrasonography could be effective in detecting vocal cord polyps and cysts in all patients, laryngeal masses in 78.6% of patients and nodules in 27.3% of patients. The authors came to the conclusion that laryngeal ultrasound is thought to be very valuable for diagnosing various laryngeal lesions.

We had encouraging results regarding ultrasonographic assessment of laryngeal masses and we expect that with time, with increased research in the field of laryngeal ultrasonography, further advances of the ultrasound machine, and with growing experience in the field, laryngeal ultrasonography is expected to become complementary to laryngoscope in the diagnosis of different laryngeal lesion.

Limitations: The main limitations were presence of thyroid cartilage calcifications in some patients that prevent transmission of the ultrasound beam. Limited assessment of lesion in uncooperative patients with rapid breathing. Difficulty in proper placing of the transducer over prominent thyroid cartilage in some patients. As well as the anterior commissure is considered a hidden area for the US beam.

Conclusion

Ultrasonography can be used effectively in diagnosis of many laryngeal lesions with higher sensitivity to detect large lesions. It does not require extensive settings or preparation. It can complement laryngoscope in the work-up of patients with hoarseness of voice and suspected laryngeal masses. Ultrasound could be an effective alternative technique to indirect endoscopy in patients with a sensitive gag reflex and patients with jaw or neck diseases. The US has its own unique benefit of reducing the

additional medical cost and avoiding patient discomfort caused by Laryngoscope.

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