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"ROLE OF ULTRASOUND IN VOCAL CORD PALSY"

Radiodiagnosis

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KEYWORDS

INTRODUCTION AND ANATOMY

Phonation is beyond doubt one of the highest functions of the human larynx. The vocal cords, also known as vocal cords, as the name suggests are infolding of mucosa aligned horizontally. The phonatory process, or voicing, occurs when air is expelled from the lungs through the glottis, creating a pressure drop across the larynx. When this drop becomes sufficiently large, the vocal cords start to oscillate. The motion of the vocal cords during oscillation is mostly lateral, though there is also some superior component as well. However, there is almost no motion along the length of the vocal cords. The oscillation of the vocal cords serves to modulate the pressure and flow of the air through the larynx, and this modulated airflow is the main component of the sound. The sound that the larynx produces is a harmonic series. In other words, it consists of a fundamental tone (called the fundamental frequency, the main acoustic cue for the percept pitch) accompanied by harmonic overtones, which are multiples of the fundamental frequency .[(1)]

The vocal cords will not oscillate if they are not sufficiently close to one another, are not under sufficient tension or under too much tension, or if the pressure drop across the larynx is not sufficiently large. In linguistics, a phone is called voiceless if there is no phonation during its occurrence. In speech, voiceless phones are associated with vocal cords that are elongated, highly tensed, and placed laterally (abducted) when compared to vocal cords during phonation.[(2)]

Vocal cord palsy/paresis is a challenging entity encountered by Otorhinolaryngology specialists in clinical practice. It is a sign of an underlying pathology than a disease in itself. Vocal cord paralysis signifies loss of active movement of the "true" vocal cord, secondary to disruption of the motor innervations of the larynx. Disruption of innervations may occur along the length of the recurrent laryngeal nerves and may include damage to the motor nuclei of the vagus nerve. The causes are Idiopathic (38 %), Neoplastic (29%), Accidental trauma (22%), Mechanical trauma (6%), Neurological (2.7%) and may also be congenital. [(4)] The right side is more vulnerable to injury in thyroid surgery, especially thyroidectomy. [(5)] The most important symptoms of vocal cord paralysis include changes in voice, aspiration and respiratory problems.

The suspension laryngoscope introduced by Killian marked a milestone in the history of laryngology, but the instrument was difficult to use. [(6,7)] Today, a flexible laryngoscope has been used widely in otolaryngology outpatient clinics for endolaryngeal evaluation and has the following advantages: the image is larger, brighter, and clearer. [(8)]. Unfortunately, not all patients tolerate laryngeal telescopic examinations, especially those with a sensitive gag reflex, limited jaw and neck mobility, or patients with stridor. More so the scope is not readily available option especially in peripheral areas.

Laryngeal ultrasound can significantly improve the evaluation of anatomy, movement, and diagnosis of vocal cord paralysis. This diagnosing modality is simple, convenient and easy to do and is radiation free. Most importantly being non-invasive makes it more acceptable to patients who would have undergone laryngoscopy otherwise. Also the fact that anyone with basic ultrasound training can use this modality, to diagnose vocal cord palsy, makes it more feasible as compared to laryngoscopy, which requires specialised training.

AIM & OBJECTIVES

1. To evaluate the specificity and sensitivity of ultrasonography in diagnosing vocal cord palsy/paresis
2. To check efficacy of ultrasound to diagnose vocal cord palsy/paresis by examining the following parameters.
   a. Looking for position of vocal cords while breathing (symmetrical or asymmetrical)
   b. Mobility during phonation (by measuring posterior interarytenoid distance)
   c. Measuring vocal cords displacement velocity by Doppler.
3. To compare the results with laryngoscopy.

MATERIALS AND METHODS

The study was done in radio-diagnosis department on the patients coming to Maharishi Markandeshwar Institute of Medical Sciences and Research, Mullana, Ambala, Haryana. In this study, we included 50 consecutive patients who presented either with hoarseness/recent change of voice and patients with suspected vocal cord palsy clinically. We also did laryngoscopy in these 50 patients to compare the specificity and sensitivity of both ultrasonography and laryngoscopy. The prior approval for start of study was taken by the ethics committee of the hospital.

INCLUSION CRITERIA

1. Patient presenting with hoarseness/ recent change in voice suspected for vocal cord palsy.
2. Age group between 11 years- 80 years.

EXCLUSION CRITERIA

1. Age below 10 and above 80 years.
2. Patients with thyroid cartilage dense calcification.

USG was performed by using linear high frequency probe (5-12MHz) on USG machines (Philips affiniti 50G, Philips affiniti 30G).

Patient was asked to extend the neck in supine position after placing a pillow beneath the shoulder. We placed the probe in the submandibular region and used thyroid cartilage as a land mark to identify larynx.

The probe was then swiped superiorly and inferiorly such that the epiglottis and the posterior most part of vocal cords with arytenoids are visible in a single ultrasound frame. The patient was then asked to phonate. The system was then switched to pulsed doppler and the doppler gate was set on the vocal cord vibrating part followed by the contralateral vocal cord.

The vocal cords were examined in two parts:

A. During quiet breathing,
B. During phonation (by making a 'long e' sound), in which
1. Mobility of the vocal cords was assessed.
2. Doppler displacement velocity was assessed

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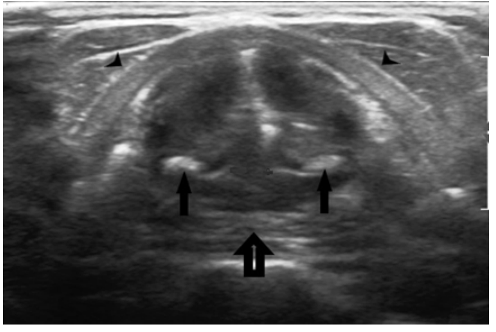
In the study group, the following were measured

I. Position of both vocal cords (whether symmetrical or asymmetrical),
II. Distance between both vocal cords at the posterior compartment near the arytenoids
III. Any gross space occupying lesion /mass

For the validation of study group, ultrasound was also done in 50 normal random individual in the same age group.

IMAGE 1 –DEMONSTATING NORMAL VISUALISATION OF LARYNGEAL CARTILAGES



Arrow head - Thyroid cartilage, Hollow arrow - Cricoid cartilage, Solid arrow –Arytenoid cartilage

IMAGE 2-GRAPHICAL REPRESENTATION OF LARYNX

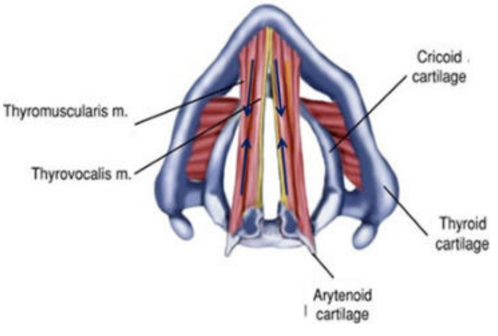


IMAGE 3 AND 4 – DEMONSTRATION OF VOCAL CORDS

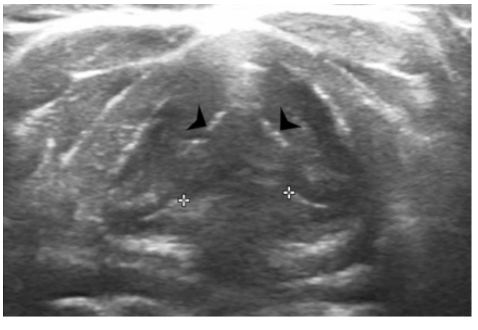


Image 3-Arrow heads showing two linear echogenic thin lines representing true vocal cords

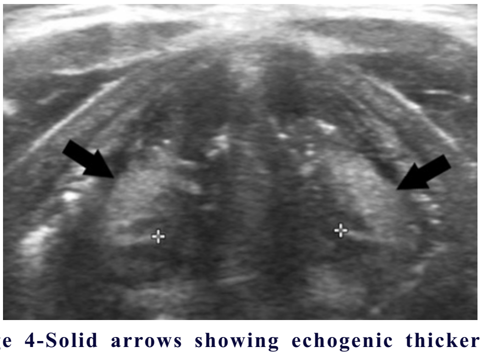


Image 4-Solid arrows showing echogenic thicker area representing the false vocal cords

IMAGE 5 & 6 SHOWING DOPPLER DISPLACEMENT VELOCITY OF VOCAL CORD ON APPLYING PULSE DOPPLER

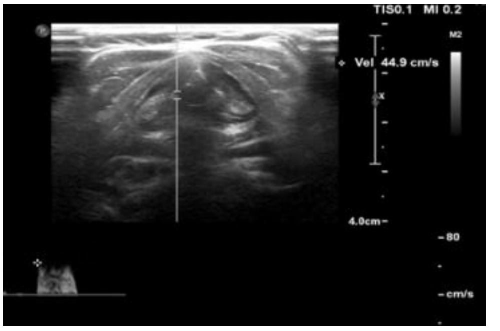


Image 5- Right sided doppler displacement velocity

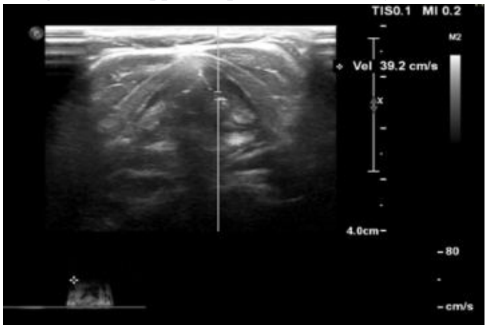


Image 6- Left sided doppler displacement velocity

CASE 1

Image 7-Showing left true vocal cord parasis in a patient presenting with hoarseness of voice

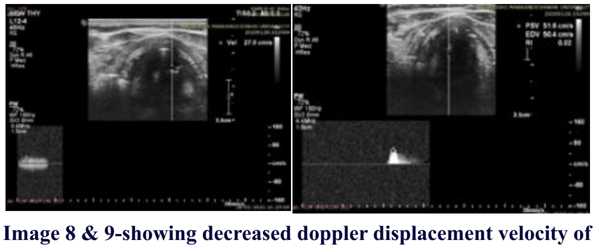


Image 8 & 9-showing decreased doppler displacement velocity of left side true vocal cords

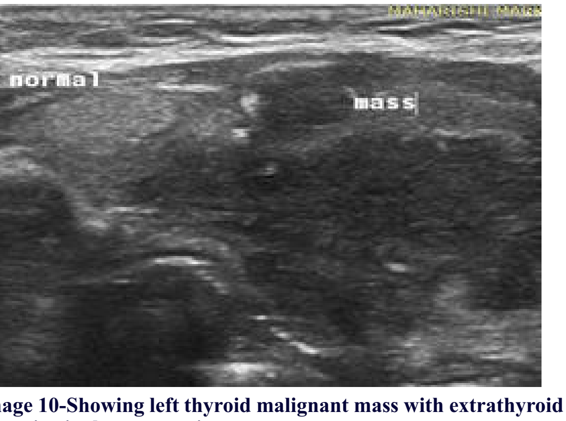


Image 10-Showing left thyroid malignant mass with extrathyroid extension in the same patient

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CASE 2

Image 11-Showing a well-defined hypoechoic mass lesion (M) along the right vocal cord

Image 12 And 13- Showing cervical lymph nodal metastatic deposit

CASE 3

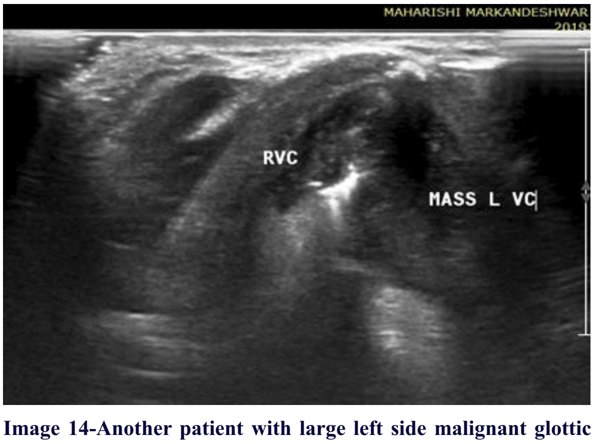

Image 14-Another patient with large left side malignant glottic mass replacing the normal cord tissue

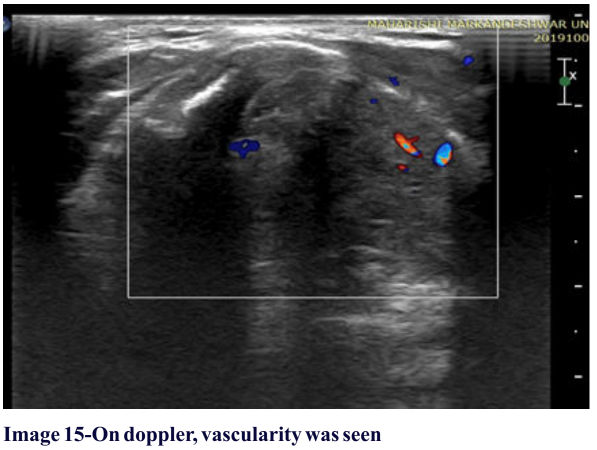

Image 15-On doppler, vascularity was seen

CASE 4

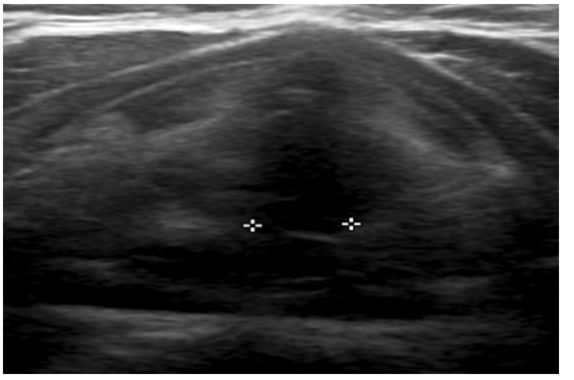

IMAGE 16

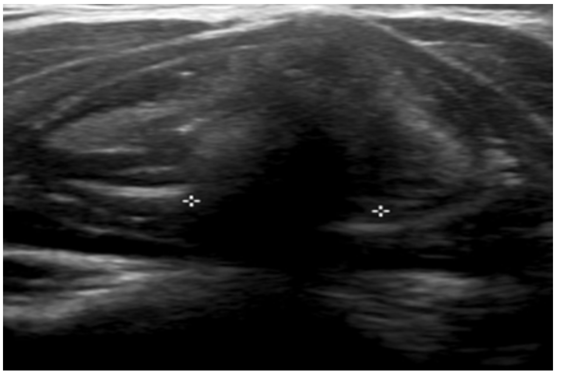

IMAGE 17

Image 16 and 17 showing decreased mobility of left vocal cord

CASE 5

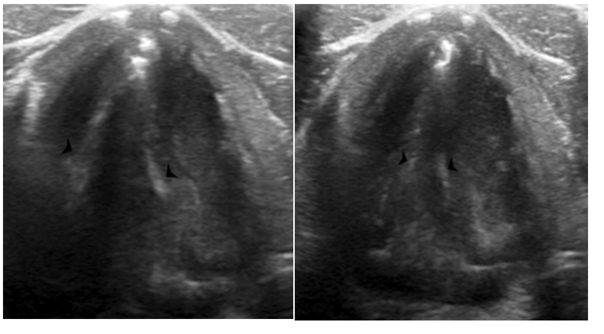

Image 31 And 32-Showing mild asymmetry of left vocal cord

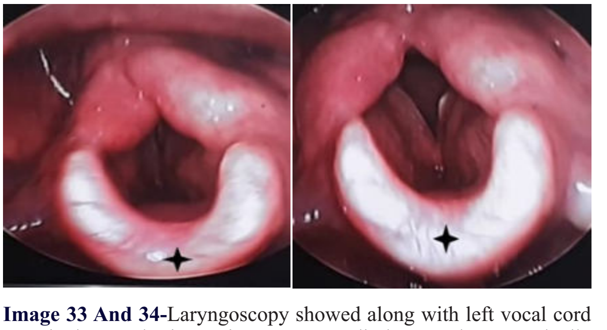

Image 33 And 34-Laryngoscopy showed along with left vocal cord paresis due to glottic carcinoma, post radiotherapy shows markedly oedematous epiglottis (marked as star) with positive omega sign consistent with acute epiglottitis

OBSERVATION AND RESULTS

In our study the maximum number of cases (n=20) were in the > 60 years' age group, followed by 51-60 age group (n=13), (n=7) each in 41-50 and 31-40 age and minimum number of cases (n=3) in < 30 years' age group. The eldest patient was 80 years old at the time of scan and the youngest patient being 17 years old.

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All the cases who presented with the complaint of hoarseness/change of voice were included in the study as mentioned earlier in the inclusion criteria. Other than this, dyspnea was present in n=9 (18 %) of cases. Swelling in neck was present in n=6 cases (12%). Miscellaneous symptoms like dysphagia and chest pain in n= 7 (14 %) and n= 4 (8 %), respectively.

In our study, the maximum number of cases had malignant eitiology, n= 31 (62%). This was followed by idiopathic, iatrogenic and traumatic causes with n=9(18 %), n=7(14%) and n= 3(6%) respectively. Out of all malignancies, bronchogenic carcinoma with resultant left side palsy was the most common cause followed by glottic carcinoma. This was followed by cervical deposits of unknown primary, thyroid malignancy, epiglottic carcinoma.

ULTRASOUND FINDINGS

Table 1: Vocal Cord Asymmetry On Grey Scale

	No. of cases	Percentage
Bilateral	4	8.0%
Left	31	62.0%
Normal	5	10.0%
Right	10	20.0%
Total	50	100.0%

In our study n=46 patients (92%) presented with unilateral vocal cord palsy whereas n=4 patients (8 %) presented with bilateral vocal cord palsy. 62 % of all were left sided palsy and 20 % were right sided palsy. n= 5 (10%) cases were normal on ultrasound. (TABLE 4& GRAPH 4)

Table 2: Posterior Interarytenoid Distance On Abduction In Cases

	CASES(in mm)	
	Mean	SD
Interarytenoid Distance On Abduction	8.99	2.25

Table 3: Posterior Interarytenoid Distance On Abduction In Controls

	CONTROLS (in mm)	
	Mean	SD
Posterior Interarytenoid Distance On Abduction	10.30	2.02

Table 4: Comparision Between Posterior Interarytenoid Distance On Abduction In Cases And Controls

	t	p-value
Posterior Interarytenoid Distance On Abduction	3.062	.003

In our study, posterior interarytenoid distance on abduction were compared in controls and cases. The mean posterior interarytenoid distance in the controls was 10.3 +/- 2.02 mm with a range of 7 to 13mm. The mean posterior interarytenoid distance in the cases was 8.99 +/- 2.25 mm with a range of 5 to 13mm. p value of posterior interarytenoid distance on abduction was significant (.003) (TABLE 2-4)

Table 5- Doppler Displacement Velocity Of Vocal Cord (on The Side Of Palsy- Proved On Laryngoscopy)

	CASES (N=54)			
	MAXIMUM (cm/s)	MINIMUM (cm/s)	MEAN (cm/s)	SD
DOPPLER DISPLACEMENT VELOCITY	76	6	25.72	16.1

In our study, doppler displacement velocity in the cases on the affected side had a mean velocity of 25.72 +/- 16.1 cm/s (TABLE 5) whereas the mean velocity in controls was 71 +/- 19.8 cm/s with a p value of 0.001.

In the left sided palsy, the mean velocity in n = 37 was 12.69 +/- 7.89 cm/s and in controls 71.5 +/- 20.51 cm/s. In the right sided palsy, the mean velocity in n = 17 was 11.8 +/- 7.53 cm/s and in controls 70.49 +/- 19.26 cm/s

Table-6-comparing The Vocal Cord Symmetry On Grey Scale Ultrasound (vci) And Laryngoscopy(vcl)

		VCL				Total
		Positive		Negative		
VCI	Positive	41	93.2%	1	16.7%	42
	Negative	3	6.8%	5	83.3%	8
Total		44		6		50

n = 50 patients presented with hoarseness of voice. Out of which, n= 44 cases were confirmed to have vocal cord palsy on laryngoscopy. n= 41 out of n= 44 were found to be positive on ultrasound. While n=3 patients had vocal cord palsy which could not be detected on ultrasonography. Thereby, laryngoscopy is still a gold standard for diagnosis

Out of n=50 patients, it was found that n=6 patients who presented with hoarseness of voice did not have vocal cord palsy on laryngoscopy, only n=5 could be detected on ultrasound while n=1 out of n=6 who did not have vocal cord palsy were falsely diagnosed to have vocal cord palsy on ultrasound. (TABLE-6)

Table: 7 Statistical Comparision Of Ultrasound And Laryn goscopic Findings

Statistic	Value
Sensitivity	93.18%
Specificity	83.33%
Positive Predictive Value	97.62%
Negative Predictive Value	62.50%

In our study, sensitivity and specificity of sonography compared to laryngoscopy was 93.1 % and 83.3 %, respectively. (TABLE 7)

DISCUSSION

The present study was designed to evaluate the role of ultrasound in cases of vocal cord paralysis. In this study fifty controls and fifty cases were compared. The cases were then subsequently compared with the laryngoscopic findings.

Since the first report, describing the potential use of TLUSG in detecting VCP in 1992, (Ooi 1992) [20] there have been several studies supporting its clinical role and application in both paediatric and adult populations. (Sidhu, Stanton et al. 2001)[12], (Vats, Worley et al. 2004).[21] However, the initial results in the adult population were not as promising as that of the paediatric population. Sidhu et al[12] reported one of the first adult series on thyroidectomy patients and reported the sensitivity and specificity of detecting vocal cord paralysis using TLUSG were only 62.0% and 94%, respectively. They concluded that it was not a reliable alternative to laryngoscopic evaluation.(Sidhu, Stanton et al. 2001) [12] However, with improvement in USG quality and technique over time, more recent studies have reported significantly better sensitivity and specificity than earlier reports, as will be discussed later.

Few of the parameters in the study like doppler displacement velocity and posterior interarytenoid distance in cases of vocal cord palsy have not been described much in any previous studies, making this study one of its kind.

The accessibility of vocal cords on sonography is limited in some cases as has already been proved in many previous studies. Thyroid cartilage calcification which is common in old age was a major limiting factor. A malignant mass completely replacing the vocal cord also limits the evaluation of vocal cord doppler velocity and visualisation of arytenoids. These cases were excluded from our study. Our study was focused on evaluating the sensitivity and specificity of sonographically accessible vocal cords on grey scale and studying the relatively newer parameters like doppler displacement velocity and posterior interarytenoid distance in vocal cord paralysis

In our study, the maximum number of cases were in the > 60 years' age group, followed by 51-60 years' age group. The study concluded that old age and male sex are the significant risk factors in vocal cord paralysis. This is in accordance with Shafkat Ahmad et al[4] . Shafkat ahmad et al[4] reported that hoarseness of voice was the most important clinical feature of vocal cord palsy present in 83.6 % of the cases. Dyspnoea, swelling in neck and dysphagia was present in 21.8 % ,5.4 % and 9.09 % of the cases, respectively. Benjamin C. Paul et al[15] also reported similar statistics with 80% of the patients presenting with hoarseness of voice and 20 % with dysphagia. In our study, we included all the patients presenting with the complain of hoarseness/change of voice. Other than hoarseness /change of voice, 18 % of cases had dyspnoea, 12 % of cases had Swelling in neck, 14 % of cases had dysphagia and 9 % of cases had chest pain.

Seyed Javad Seyed Toutounchi et al [26] reported that most (56.82 %) of the palsies were left sided. 36.36% of the cases had right sided palsy and only 6.82 % of the cases had bilateral vocal cord palsy. Similarly, Ko et al[27] reported that left side palsy was more common with 68 % of the cases. Our study is also in accordance with the above studies with left side unilateral palsy being more common with 64 % cases. Right side palsy was seen in 20 % of cases. This can be attributed to the longer intrathoracic course of left recurrent laryngeal nerve, hence being more prone to injury and involvement in malignancy. [5]

Table 8: Comparing The Sensitivity And Specificity Of Sonography On Grey Scale Imaging

	Sensitivity	Specificity
Tarek Khalil et al[28] (2010)	100%	100%
Amarjeet Kumar et al[197] (2018)	100%	93.40%
Woo JW et al(29) (2016)	92.90%	86.50%
Kai-Pun Wong et al [16] (2015)	88.89%	91.10%
Sidhu et al(2001) [12]	62.00%	94%
Present study	93.18%	83.33%

The present study has sensitivity (93.18%) and specificity (83.3 %) almost in accordance with study of Woo JW et al (2016) . However, the present study shows gross discrepancy with Sidhu et al (2001)[12]. This may be because the study done by Sidhu et al (2001)[12] was approximately 19 years ago. With improvement in USG quality and technique over time, more recent studies have reported significantly improved results.

In present study, three patients had vocal cord palsy but could not be detected on ultrasonography and were confirmed on laryngoscopy. All these patients had partial vocal cord palsy and showed some movement on grey scale sonography which may be the reason for negative sonography results. One patient was falsely diagnosed with vocal cord palsy on sonography which may be attributed to technical/observer error.

Three studies were found explaining the range of normal doppler displacement velocities of vocal cords on phonation.

Table 9: Range Of Maximum And Minimum Doppler Displacement Velocity

	MAXIMUM	MINIMUM
Amarjeet Kumar et al(47) (2018)	150	80
T Y Hsiao et al(26)(2001)	78	58
Marek Dedecjus et al [53](2010)	140	65
Present study	109	23.5

In our study, the doppler velocity was ranging from 23.5 to 109 cm/s. This is in accordance with the previous studies however, a little variation in both maximum and minimum velocities were found. This can be explained as the patients were asked to phonate in the most comfortable voice, the intensity and pitch of phonation varied from person to person. It is also a known fact that vocal cord stiffness greatly affects its vibratory movement in phonation[10] which can vary from person to person and might be another reason for such variation. In the control group, the mean value of the velocities was calculated as 71.03 ± 19.8 cm/s which were than used to compare the mean values of cases In our study, the mean of Doppler displacement velocity in cases were 25.72 ± 16.1 cm/s with statistically significant difference when compared with mean of controls with a range of 6 to 76 cm/s. To the best of our knowledge, this is the largest study group applying this parameter on cases of vocal cord palsy. Dedecjus et al. (2010) evaluated VF movements in 50 thyroidectomy patients preoperatively with both USG and laryngoscopy.[23] . He studied two patients with cord paralysis the displacement velocity decreased below 30 cm/s compared to pre thyroidectomy velocity. Similar study was done by Amarjeet et al[19] (2018) in which two patients diagnosed with palsy on laryngoscopy had a significant decrease in mobility postoperatively with the displacement velocity of 16.8 cm/s after surgery and 21.2 cm/s preoperatively.

In our study, posterior interarytenoid distance was measured on abduction in normal individuals/controls and then the findings were compared with cases. The mean posterior interarytenoid distance in the controls was 10.3 +/- 2.02 mm with a range of 7 to 13 mm and in cases was 7.6 +/- 1.09 mm with a range of 5 to 13mm. It was concluded that there was statistically significant decrease in the posterior interarytenoid distance in cases of vocal cord palsies.

Table 10: Interarytenoid Distance In Cadeveric Studies

Cadaveric studies	Male	Female
Shirshendu Ganguly et al[18]	11.16 - 16.68mm	8.38 - 13.88mm
Gursel Ortug et al [24]	6.55-10.07 mm	6.2-10.03 mm

There were some cadaveric studies to measure posterior Interarytenoid distance. Shirshendu Ganguly et al in 150 fresh cadavers measured the inter-arytenoid distance and found a range of 11.16mm to 16.68mm in males and 8.38mm to 13.88 mm in females.[18] Gursel Ortug et al in 100 cadavers calculated the mean value of the posterior interarytenoid space which was 8.31 ± 1.76 mm in males and 8.13 ± 1.90 mm in females. [24]

Table 25: Comparing Posterior Interarytnoid Distance

	Controls	Cases
Diaa El Din Mohamed El Henawi et al[17] (2015)	10.5	5.1
Present study	10.3	7.6

To the best of our knowledge, application of posterior interarytenoid distance in cases of vocal cord palsy has not been studied much except by Diaa El Din Mohamed El Henawi et al (2015) in which he took 135 controls and 35 cases . Mean of the interarytenoid distance in controls in their study was similar to the mean distance in controls of our study.[17] Though a small variation was seen in the interarytenoid distance of cases of our study. However, a significant decrease in the distance in cases was found in both the studies.

The most important drawback of the parameter is that isolated posterior interarytenoid distance can only hint towards a probable palsy but can never confirm the side of palsy. Therefore, it can only be used as an adjunct to grey scale imaging and not an isolated tool.

A major advantage of sonography is that, it can evaluate extralaryngeal spread of masses which cannot be done by laryngoscopy. In about 30 percent of cases, sonography was able to evaluate non laryngeal diseases like cervical lymphadenopathy, carotid plaques, malignant thyroid masses, parotiditis, thyroiditis, thyroid adenomatous nodule etc.

Shafkat Ahmad et al reported that most common cause of vocal cord paralysis was under idiopathic category (38%) followed by malignancy, trauma, iatrogenic, neurogenic and congenital.[4] Yumoto et al. stated iatrogenic namely post thyroidectomy injury (42.7%) as the most important cause of palsy followed by malignancy, idiopathic and traumatic [30] Seyed Javad Seyed Toutounchi et al (2014) reported similar cases of malignancy and idiopathic category (31%).This was followed by iatrogenic cause [26].

In present study, significantly high rates of malignant aetiology with up to 62 % cases. This was followed by idiopathic, iatrogenic and traumatic aetiology. Higher incidence of malignancy was seen in the present study as it was conducted at the level of tertiary care centre with a smaller sample size.

CONCLUSION

In the present study, we concluded that sonography can be used as an alternate modality to diagnose vocal cord palsy. It can not only evaluate the intraluminal pathologies but also the extraluminal laryngeal pathologies. Incidental findings like findings pertaining to thyroid, salivary glands, cervical lymphadenopathy and major neck vessels etc. can also be evaluated by sonography. The depth of malignant masses and cervical nodal deposits can be evaluated by sonography which cannot be done by laryngoscopic evaluation. It can also be used in the cases where laryngoscopy is not possible either due to severe gag reflex or inadequate mouth opening.

We propose that all the patients coming for sonography of neck for evaluation of thyroid, lymphadenopathy or any other neck pathology, must routinely be evaluated for vocal cords.

The present work is an early experience especially while evaluating doppler and posterior interarytenoid distance and its results must be confirmed by studying a larger group of patients. Several questions remain unanswered and several technical problems await solution before standardizing the technique. However, we have decided to present this work as pilot study outcome, assuming the great potential of clinical applications of the presented technique. Further studies must concentrate on definition of the doppler displacement velocity and posterior interarytenoid distance cut off value for laryngeal nerve palsy diagnosis.

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