Main Article

ACOUSTIC ANALYSIS OF SUBJECTS WITH VOCAL CORD PARALYSIS

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ABSTRACT: *Theoretically, there should be a close relationship between the vibratory pattern and acoustic output. The study aims at differentiating unilateral vocal cord paralysis (VCP) from normal subjects and also between right VCP and left VCP based on the acoustic analysis of the subjects voice. The study also aims at comprehensively investigating the phonatory disturbance resulting from VCP on the Indian population.*

Results indicate that statistically significant differences were found among the following acoustic parameters: fluctuation per sec. in fundamental frequency (fo), fluctuation per sec. in amplitude, extent of fluctuation in fo, extent of fluctuation in amplitude, jitter ratio, jitter factor, shimmer, Psigma and maximum phonation duration in differentiating unilateral VCP from normal subjects. Also the acoustic parameters: fluctuation per sec. in fo, extent of fluctuation in fo and Psigma could statistically differentiate between right VCP and left VCP. It can be concluded that the above parameters can be successfully used for diagnosing VCP and also the type of VCP. This is of particular significance in difficult to visualize patients and to monitor the therapeutic outcomes of vocal rehabilitation, following unilateral vocal cord paralysis. These results need to be further clinically validated by using a larger number of subjects.

Key Words: *Unilateral recurrent laryngeal nerve paralysis, Right vocal cord paralysis, Left vocal cord paralysis, Acoustic parameters*

INTRODUCTION

Vocal cord paralysis is the most common laryngeal anomaly. A paralyzed fold implies disruption of neuromuscular innervation. The right and the left recurrent laryngeal nerves innervate the right and the left vocal cords respectively. These laryngeal nerves differ significantly with regard to their origin and pathway. There are also etiological differences between the two branches of recurrent laryngeal nerve. Among the specific etiologies the left side is most vulnerable to cardiothoraic surgery, carcinoma of bronchius, tuberculosis. The right side is more vulnerable to thyroid surgery, especially thyroidectomy.[1]

The dysphonia resulting due to vocal cord paralysis is known as Paralytic Dysphonia.[2] Paralytic dysphonia is usually characterized by a weak, breathy and hoarse voice, with an increase in the fundamental frequency, and decrease in maximum phonation duration. Individual expends an abnormally high amount of physical energy in his/her attempts to compensate for phonatory ineffectiveness.

A paralytic falsetto, abnormally high funndamental speaking frequency of the voice occurs when the mobile vocal fold over compensates while closing the chink, to eliminate breathiness, but it is stretched so tightly that its frequency of vibration is elevated above normal.[3]

The vibratory pattern of vocal cords in unilateral vocal cord paralysis, was studied by von Leden and Paul Moore in 1953.

Since the phonatory behavior usually manifests itself in abnormal oscillatory movements, the measurement and analysis of the vibratory pattern of vocal folds has the potential to provide detailed information on the pathophysiology of vocal folds during phonation. It is generally thought that the observed correlation arise from the causal chain linking of the pathological condition, the mechanical setting of the larynx or the physical properties of its tissues, and by the resulting modulation of the airstream by the glottis. The use of acoustic tests allows reliable and valid assessment of subtle changes in the voice function as the 'meter of voice'. Traditional methods of diagnosing VCP have been heavily dependent upon visual inspection of vocal folds and subjective descriptions of perceptual judgements of patients voice quality. Often it is difficult to visualize the subjects' vocal folds because of overhanging epiglottis or because of severe gag reflex. In these difficult to visualize cases, it becomes essential to use non-invasive procedures to obtain the status of the vocal cords. This study evaluates the use of acoustical

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measurement system for use of clinical diagnosis.

The purpose of the study is to obtain an acoustical profile or correlates of the resulting physiological disturbances due to vocal cord paralysis and also whether differential acoustical profile exist for right vocal cord paralysis and left vocal cord paralysis. The study also aims at comprehensively investigating the phonatory disturbance resulting from VCP on the Indian population.

METHODOLOGY

Thirty-one subjects having isolated unilateral vocal cord paralysis of recent origin were selected from among the various hospitals in Mumbai. Most recording were done one week post onset of vocal cord paralysis. An indirect laryngeal examination was performed on each subject to diagnose vocal cord paralyses. Also selected were thirty-one normal control group of subjects who were free from any detectable medical condition and were matched to the experimental group in terms of age, sex and preferably the mother tongue. The distribution of the total number of subjects and their ages is indicated in Table 1.

Prior to the voice recording a brief history regarding the demographical data, duration of onset of the problem, cause of the problem, details of illness or surgery was obtained from each patient. The subjects were comfortably seated in a quiet air-conditioned room for the voice recording. The instrument used for acoustic analysis was Vaghmi. Subjects were asked to phonate modelled steady vowels /a/, /i/ and /u/ each in isolation for 3 seconds duration into a microphone. As the subjects voice was very weak the microphone was held close to the subjects mouth and the gain control of Vaghmi was kept on full on position. Three on-line trials were given before recording the voice on off-line.

Analysis: Multiple analysis of Variance (MANOVA) was used to analyse the statistical difference in the study.

These MANOVA were performed for all of the following acoustic parameters viz.: fundamental frequency (fo), fluctuation per second in fo, extent of fluctuation in fo, mean amplitude (Ao), fluctuation per second in Ao, extent of fluctuation in Ao, jitter ratio, jitter factor, shimmer, Psigma, maximum phonation duration, open time, close time, open quotient and leakage quotient. Subjecting the data to MANOVA one can analyze the main effects and the interaction effects among the various factors. But for the purpose of this study only the main effects will be considered. The 0.05 level of significance was selected as the error rate. Post-hoc analysis was conducted using the paired t-test. Statistical analysis was performed using SPSS (PC+, Version 4) package.

Table 1: Age and sex distribution of subjects with vocal cord paralysis and of the control group

Type of VCP	Right		Left		Total
Sex	Male	Female	Male	Female	
Number	4	4	14	9	31
Age Range	32-59	25-30	23-59	20-75	
Control	4	4	14	9	31
Subjects					62

RESULTS

Table 2 shows the means of the acoustic parameters that statistically differentiate voice of normal subjects from subjects having vocal cord paralysis. In general, the acoustic parameters fluctuation per second in fo, extent of fluctuation (fo), fluctuation per second Ao, extent of fluctuation Ao, jitter ratio, jitter factor, shimmer, Psigma are greater in subjects with vocal cord paralysis than in normal subjects. The maximum phonation duration is shorter in VCP than in subjects in normal subjects.

Table 3 shows the means of the acoustic parameters that can statistically differentiate between subjects having right and left cord paralysis. In general the acoustic parameters fluctuation per second fo, extent of fluctuation fo and Psigma are greater in subjects having right cord paralysis than subjects having left cord paralysis.

DISCUSSION

The results revealed several points of interest. The case history data reveals that vocal cord paralysis is more common with advancing age, which is in agreement with Benninger

Table 2: Means of the acoustic parameters differentiating normal subjects from subjects with vocal cord paralysis.

Parameters	Normal	VCP
Fluctuation per sec.fo	3.367 (1.91)	26.64 (27.32)
Extent of fluctuation fo.	3.43 (0.93)	14.54 (17.12)
Fluctuation per sec Ao	0.20 (0.35)	3.86 (5.31)
Extent of fluctuation Ao	0.97 (1.43)	3.36 (1.31)
Jitter Ratio	8.67 (2.65)	221.39 (145.7)
Jitter factor	0.84 (0.40)	26 (17.44)
Shimmer	0.21 (0.14)	1.38 (1.01)
Psigma	1.56 (0.55)	16.08 (19.27)
MPD	14.88 (1.41)	3 (3.96)

Table 3: Means of the acoustic parameters differentiating right VCP from left VCP

Parameters	Right VCP	Left VCP
Fluctuation per sec. fo	39.16 (45.63)	22.28 (16.38)
Extent of fluctuation fo	24.66 (20.62)	11.02 (13.50)
Psigma	29.84 (27.11)	11.30 (13.32)

et al 1994. Considering the sex distribution males are more prone to have vocal cord paralysis than females with the incidence of subjects manifesting with right vocal cord paralysis being still lower than left vocal cord paralysis as is also reported by (Ballengere 1985). The data also reveals, that the predominant cause for subjects with right vocal cord paralysis is surgical trauma due to thyroidectomy; with left vocal cord paralysis having viral infection, pulmonary disorders, tuberculosis and heart anomalies as their predominant cause, as is also reported by Berry and Eisenson, 1950.

Majority of the subjects with vocal cord paralysis in this study manifested voice quality similar to the 'acute phase' as described by Shipp et al (1971) or 'Type 4 voice' quality (Dedo, 1992); where there is a large glottic chink and voice is extremely breathy and sounds like a whisper. That is, the disturbance in voice is of severe nature. This severe nature of the disturbance in voice may be attributed to the selection criterion of the study; as patients with one week post onset were selected. The resulting phonatory disturbance could have been different and / or less severe, if voice recordings were done at a longer post-onset duration.

There is a general agreement that subjects with vocal cord paralysis have higher fundamental frequency according to earlier investigators (Arnold 1955; Sanderson & Maran 1992; Dedo 1992). But table 3 in the study indicates that there is a general tendency of subjects with vocal cord paralysis having higher fundamental frequency than normal subjects, but no statistical significance was obtained in the study. This could be due to the severity of dysphonia of subjects with vocal cord paralysis, because of which the fo reliability decreases as is reported by Bielanowiz, 1996.

Fluctuations per second in fo, extent of fluctuation in fo, fluctuation per second in Ao, extent of fluctuation in Ao, jitter ratio, jitter factor, shimmer, Psigma are greater in subjects with vocal cord paralysis than normal subjects because of asynchronous vibrations of the vocal cords and phonatoty gap in cases of vocal cord paralysis. Maximum phonation duration is less in vocal cord paralysis than in normal subjects because of air escape through the open glottis.

Mean amplitude does not statistically differentiate between subjects with vocal cord paralysis and the control group and also between the type of vocal cord paralysis. This is in agreement with various researches who do not report mean Ao values for indexing the vocal function.

Smith et al, 1992 & Murty et al 1992 report that open quotient increases in subjects with vocal cord paralysis than the control group. Contrary to the belief none of the inverse filtering parameters in the study viz.: open time, close time, open quotient and leakage quotient, could statistically differentiate between the control group and subjects with vocal cord paralysis. This could be because of the acute severity of dysphonia where Hanson et al (1983) reports that more the abnormal voice, the more difficult it becomes to choose the proper inverse filtering parameters. Consequently the application of this method for the study of dysphonics require further refinement of techniques.

Fluctuation per second fo, extent of fluctuation fo and Psigma have been significantly greater in subjects with right vocal cord paralysis than left vocal cord paralysis. This significant difference could be attributed to the different course of the right and the left recurrent laryngeal nerves, with right being shorter and more superficial than the left recurrent laryngeal nerve. The higher readings in subjects with right vocal cord paralysis could also be due to the etiological differences where the right vocal cord paralysis was mainly because of surgical trauma, which may have lead to more destruction of the motorneurons, resulting in an increase in the above parameters. Contrary to these subjects with left vocal cord paralysis mainly had as their cause; pulmonary infection or cardiac disorders. Thus with the resolving infections, the prognosis could have been better, resulting in less severe disturbance in voice quality than subjects with right vocal cord paralysis.

Based on the above results and discussion it can be concluded that an acoustic profile of subjects with unilateral vocal cord paralysis of recent origin having hoarseness of acute nature have been obtained in the study. But from clinical point of view, differentiating between normal and pathological voices is not of particular importance. Some statistically significant acoustic parameters that can possibly differentiate right vocal cord paralysis from left vocal cord paralysis have also been found in the study. But whether they are clinically significant needs to be further validated by obtaining a larger sample of subjects with vocal cord paralysis at different stages of severity, of dysphonia.

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