Clinical Voice Evaluation

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Abstract

Voice can be considered as a multidimensional measurable event. The various events include frequency, amplitude and quality. Voice becomes multidimensional as human vocal folds are capable of vibrating at various frequencies and amplitudes. This amazing quality of human vocal folds makes it very special and the events are to be measured in order to get an accurate knowledge about the vocal function. This article discusses the highlights clinical voice evaluation as conducted at the All India Institute of Speech & Hearing, Mysore.

Key words: Clinical Voice, Multidimesional, Evaluation

Introduction

Voice is the primary means of expression. The first cry of the newborn heralds its arrival. Voice continues to change throughout life reflecting one’s culture, personal habits, health condition, and age. Brackett (1971) defines voice as laryngeal modulation of the pulmonary airstream which is further modified by the configuration of vocal tract. Therefore voice production is dependent on three factors: (a) pulmonic air pressure, (b) laryval fold vibration, and (c) transfer function of vocal tract. Each of these can be measured. Thus, voice can be considered as a multidimensional series of measurable events, i.e. a single phonation can be measured in many different ways. The development of technology has allowed the acoustic analysis of voice. The purpose of voice evaluation are to determine the (a) cause, precipitating and maintaining factors, (b) degree and extent of cause, (c) severity of the problem, (d) prognosis, and (e) to develop a therapeutic program (Nataraja, & Savithri, 1990).

Physical units and measures in voice according to Titze (1994) are as follows:

" If we consider the adult female voice to be the standard voice then:

The vibrating vocal fold length is in the order of 1 cm.
The vibrational amplitude is in the order of 1 mm.
The mass of vocal folds is in the order of 1 gram.
The smallest period of vibration is on the order of 1 ms.
The surface wave velocity on the vocal folds is in the order of 1m/s
Maximum peak-to-peak airflow in phonation is in the order of 1 liter/second.
The maximum rate of change of airflow in the larynx is on the order of 1 m3/s.
The maximum aerodynamic power in phonation is in the order of 1 watt.
The lung pressure for loud conversational speech is on the order of 1 k Pa.
The maximum lung pressure obtainable is in the order of 100 k Pa.
The maximum active stress in vocal fold muscle tissue is on the order of 1,000 k Pa” (Titze, 1994)

Case History and Oral mechanism examination
A brief case history is obtained by eliciting information from the patient/care giver regarding his/her voice problem. Following this oral mechanism is examined for the structural and functional status, which, sometimes, may be related to the voice problem.

**Evaluating the functions of respiratory system**

Abnormalities in the respiratory system may lead to voice problems as they affect the expiratory air necessary for voice. Hence, it is essential to evaluate the functions of respiratory system. There are qualitative and quantitative tests. But only quantitative tests are described in this article. **Vital capacity** is the maximum volume of air which can be exhaled after a deep inhalation. It provides an estimate of potentially available air for voice production. The normal vital capacity is 2500 CC and 1500 CC in Indian males and females, respectively. **Mean airflow rate (MAFR)** is the amount of volume of air per unit time used in phonation and provides information on the functioning and coordination of the respiratory and laryngeal systems. The normal MAFR is 80 cc/sec to 200 cc/sec. Reduced vital capacity indicates abnormality in the respiratory system, and normal vital capacity with very high or low MAFR indicates abnormal laryngeal functioning. For example, high MAFR is obtained in patients with vocal fold paralysis and low MAFR is obtained in patients with spastic dysphonia. MAFR in various clinical groups (Nataraja & Savithri, 1990 - based on studies conducted at AIISH, Mysore) is shown in table 1.

<table>
<thead>
<tr>
<th>Sl. NO.</th>
<th>Clinical group</th>
<th>MAFR (cc/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Functional voice disorders</td>
<td>202</td>
</tr>
<tr>
<td>2.</td>
<td>Vocal nodules</td>
<td>310</td>
</tr>
<tr>
<td>3.</td>
<td>Vocal cord paralysis</td>
<td>332</td>
</tr>
<tr>
<td>4.</td>
<td>Chronic laryngitis</td>
<td>255</td>
</tr>
<tr>
<td>5.</td>
<td>Other organic conditions</td>
<td>192</td>
</tr>
</tbody>
</table>

Table 1: MAFR (cc/sec) in various clinical groups.

**Evaluating the functions of the laryngeal system**

Evaluating the laryngeal system becomes essential as it affects voice. **Modal frequency** is the frequency often used by an individual. Usually modal frequency is measured by instructing the patient to phonate vowels /a/, /i/ and /u/ and speaking/ reading. The normal modal frequency in males is between 80-180 Hz and in females it is 180-280 Hz. Table 2 and figure 1 shows the modal frequencies in various age groups (Nataraja & Savithri, 1990 - based on studies conducted at AIISH, Mysore).

<table>
<thead>
<tr>
<th>Age group in years</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-7</td>
<td>233</td>
<td>248</td>
</tr>
<tr>
<td>7-11</td>
<td>255</td>
<td>238</td>
</tr>
<tr>
<td>11-13</td>
<td>247</td>
<td>240</td>
</tr>
<tr>
<td>14-15</td>
<td>177</td>
<td>244</td>
</tr>
<tr>
<td>16-25</td>
<td>139</td>
<td>224</td>
</tr>
<tr>
<td>26-35</td>
<td>142</td>
<td>230</td>
</tr>
<tr>
<td>36-45</td>
<td>147</td>
<td>243</td>
</tr>
<tr>
<td>46-55</td>
<td>148</td>
<td>258</td>
</tr>
<tr>
<td>55-65</td>
<td>150</td>
<td>235</td>
</tr>
</tbody>
</table>

Table 2: Modal frequency (Hz) in various age groups.

**Frequency range** is the difference between the lowest and the highest frequency one can produce. An octave and a half in males and two octaves in females is considered in normal and is measured by
instructing the subject to phonate starting from the lowest frequency to the highest frequency possible. Figure 2 illustrates the frequency rage in a female.

Maximum phonation duration (MPD) is the maximum duration one can phonate after taking a deep breath and depends on the age of the subject. It is the simplest test that demonstrates the status of respiratory system and the relative efficiency of the interaction of respiratory and laryngeal system.
Laryngeal pathologies are associated with short MPDs as space between vocal folds results in leakage of air. Normal MPD ranges from 15 to 30 seconds and can be measured by using any of the software or even a mobile. **Optimum frequency** is the frequency most suitable for a particular vocal fold. This along with the modal frequency gives an estimate of how much the subject is deviating from the optimum and is useful for modeling in therapy. **S/Z ratio** is the ratio between the sustained /s/ and /z/. This can be obtained by instructing the subject to sustain /s/ and /z/ and measuring the duration of sustained /s/ and /z/. Normal S/Z ratio is 0.9 to 1. Phonation of /z/ is reduced in case of laryngeal pathologies which results in increased S/Z ratio. **Frequency and amplitude perturbations refer** to cycle-to-cycle variations in frequency and amplitude, respectively. As the vocal folds are mucous filled membranes, there will be variations in frequency and amplitude between cycles. Normal perturbations are 3 Hz and 3 dB, respectively for frequency and amplitude. Increased perturbations indicate abnormal vocal fold vibrations.

**Intensity** is measured in sustained phonation, speech and or reading. Normal amplitude is about 50 dB. Decreased amplitude indicates conductive hearing loss, vocal fold paralysis. Increased amplitude indicates sensorineural hearing loss. Intensity range is the difference between the lowest and highest sound pressure levels an individual can produce at a comfortable phonation and is measured in phonation or speech. Normal intensity range is 40 to 8 sdB and may be reduced in case of vocal fold paralysis, weakness of muscles of respiration etc.

**Measurement of vocal fold vibration:** The vocal fold vibrations/ contact can be measured by inverse filtering or by using Electroglottogram (EGG). At AIISH, EGG is used to measure the vibrations/ contact of vocal folds. There are two electrodes which are placed on the surface of neck. One of the electrodes transmits high frequency low voltage and the other receives which is depicted as a waveform. The receiving of the signal depends on the contact of the vocal fold. For example the received voltage is lowest when vocal folds are open and highest when closed. EGG waveform is usually triangular with a skew to the left in normal vocal fold vibration. Figure 2 shows the EGG waveform.

![EGG waveform in normal vocal fold vibration](image)

**Specific EGG associated with the vocal folds because of vibration is affected. reverse pattern (right paralysis, a steady vocal fold and fuzzy laryngitis. Figure 3 various clinical EGG**
waveforms.

Figure 3: Various clinical EGG waveforms.

H/N ratio is the ratio between the sound pressure level of the harmonics to noise in a glottal signal which is obtained by measuring the intensity of the harmonics and noise. The number of harmonics visible can also be calculated. Noise level increases with increase in breathiness and hence the number of harmonics visible reduces. Figure 4 illustrates the number of harmonics in normal, mild hoarse and severe hoarse voice. One can visualize 18, 14 and 9 harmonics in normal, mild hoarse and severe hoarse voice.

![Illustration of the number of harmonics in normal, mild and severe hoarse voice.](image)

Evaluation of the resonatory system

Nasalance is a ratio of oral to nasal airflow and can be measured by instructing the subject to sustain vowels or utter words into a mouthpiece with oral/nasal division. The normal ratio is around 30. Higher nasalance indicates hypernasality (degree depending on nasalance) and lower ratio indicates hyponasality. Figure 5 shows nasalance for sustained vowel /a/ in a normal individual. Figure 6 shows nasalance for sustained /m/ in a normal individual and figure 7 shows nasalance for sustained /a/ and /m/. The lower screen shows the nasalance in percent.
Figure 5: Nasalance for sustained vowel /a/ in a normal individual.

Figure 6: Nasalance for sustained /m/ in a normal individual.
Look at this book with us. It's a story about a zoo. That is where bears go. Today it's very cold out of doors, but we see a cloud overhead that's a pretty white fluffy shape. We hear that straw covers the floor of cages to keep the chill away; yet a deer walks through the trees with her head high. They feed seeds to birds so they're able to fly.

Figure 7: Nasalance for sustained /a/ and /m/ in a normal individual.

Multi-Dimensional Voice Profile (MDVP) is obtained on phonation of vowel /a/, in which dimensions of voice - frequency perturbations, amplitude perturbations, variations in F0, noise to harmonic ratio, voice turbulence Index, soft phonation Index, tremours in frequency and amplitude, degree of subharmonics, and degree of voicing apart from the frequency and amplitude - are reflected. Figure 5 shows MDVP in a normal voice.

MDVP graphically depicts 19 parameters. Numerical values are also depicted. In the graph one can see a circle filled with green and a line is projecting for each parameter depicted. All parameters are within green circle in figure 8 reflecting that all parameters of voice are normal.
Figure 8: MDVP in a normal voice (Upper screen shows a waveform, second screen F0, lower right screen the MDVP).

Figure 9 shows MDVP in a hoarse voice. There are several parameters projected in red out of the green circle. These include frequency perturbation (\(\text{Jita}, \text{Jit}, \text{RAP}, \text{PPQ}, \text{rPPQ}, \text{vF0}\)), amplitude perturbation (\(\text{ShdB}, \text{Shim}, \text{APQ}, \text{sAPQ}, \text{vAm}\)), noise to harmonic ratio (NHR), voice turbulence Index (VTI), amplitude tremor Index (ATRI), and degree of voicing (DUV). High frequency and amplitude perturbations indicate improper vocal fold vibrations; high NHR reflects air passing through the glottis; high ATRI indicate tremors in amplitude owing to improper vocal fold vibrations; high DUV indicate unvoicing in between. Perceptually, voice is hoarse.
Figure 9: MDVP in a hoarse voice (Upper screen shows a waveform, second screen F0, lower right screen the MDVP).

Figure 10 shows MDVP of a breathy voice. One can observe variations in F0 (vF0), high amplitude perturbations (ShdB, Shim, APQ, sAPQ, vAm), soft phonation index (SPI), and high degree of Subharmonics (DSH). Perceptually voice is heard breathy.
The Speech-Language Pathologist integrates the information from case history, oral mechanism examination, and the results of the above tests to diagnose the problem and the cause. Laryngeal pathology should be ruled out before considering the patient for voice therapy and s/he can be referred to other evaluations when necessary.

References

Author’s Biography
Dr. Savithri completed her undergraduate [B.Sc (Speech & Hearing)], post graduate [M.Sc (Speech and Hearing)], and Ph.D (Speech and Hearing) degree from the All India Institute of Speech and Hearing, Manasagangothri, Mysore. She was also awarded the Vidwat degree in Naveena Nyaya (Sanskrit) by the Karnataka Board in 1978.

She has over 28 years of experience in teaching. Her special areas of interest include speech production, speech and language perception, suprasegmentals, fluency and prosody. She has guided 83 masters and 11 doctoral students for their Dissertations and Thesis.

She has published 140 scientific papers and 5 books in national and international journals. She had 7 extramural projects funded by several funding agencies. Prof. Savithri has received the Young...
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