Evaluation of teflon injection therapy for paralytic dysphonia

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II. MEDICAL APPLICATIONS

A. EVALUATION OF TEFALON INJECTION THERAPY FOR PARALYTIC DYSPHONIA

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Abstract

In the critical evaluation of voice therapy procedures objective documentation is important. A case of paralytic dysphonia treated by teflon paste injections is reported. Two types of analysis were used to assess the voice improvement: air flow measurements and acoustic analysis providing Long-Time-Average-Spectra. Their usefulness for clinical purposes is stressed.

Introduction

The recurrent laryngeal nerve may be injured by disease or trauma. In most cases regeneration takes place, within 6 months usually. The regeneration of the nerve may or may not lead to restoration of normal mobility of the vocal fold (Boles & Fritzell, 1969), but as long as regeneration occurs, the muscles of the larynx remain in good shape and keep their tonus. In these patients, there are usually no serious voice problems, in most of them voice returns to normal or near normal.

In a few cases, regeneration does not take place. This leads to atrophy of the affected laryngeal muscles and indirect laryngoscopy reveals a bowed vocal fold usually in an intermediate position. The arytenoid cartilage of the paralytic fold may be tilted forward, obscuring the view. In these patients, apposition of the vocal folds during the closed phase of the vibratory cycle cannot be achieved. Glottis remains open throughout phonation and the voice is very breathy. The air consumption during speech is considerable and often inspiration is audible. For all patients, this voice disorder is a severe social handicap and for patients who are professionally depending on their speaking or singing voice, it is a disaster.

A number of surgical procedures have been developed to improve the voice in these patients, all of them aiming at increasing the volume of the atrophic vocal fold and positioning its edge in the midline, making vocal fold closure possible during phonation. A technique for the injection of paraffin in the vocal fold was originally designed by Brünings (1911).

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During the last decade, this technique has gained wide-spread use for the injection of teflon paste, as described by Arnold (1962). The results have been encouraging, but the methods of evaluating the results have been largely subjective. Obviously, if teflon procedures are to be compared with other methods to restore voice in these patients, subjective judgements must be complemented by recordings which permit detailed qualitative and quantitative analyses. Von Leden et al (1967) reported how pre- and postoperative motion picture filming, aerodynamic recordings and acoustic analysis by means of a sonograph could be used to demonstrate the results. The present report will describe another technique for the assessment of voice improvement following teflon injections.

Case report

The subject was a 49-year old male with a permanent paralysis of his left recurrent nerve following thyroidectomy performed 14 months before he was admitted for teflon procedures. He had had 56 sessions of voice therapy by an experienced speech therapist without much effect. His voice was very breathy and weak.

As a test, 0.4 ml of glycerol was injected into his paralytic vocal fold according to the technique described by Arnold (1962) and immediately following the operation, there was a voice improvement, which lasted for a few days. Five weeks later 0.6 ml of teflon paste was injected. His voice improved, but not enough, and for this reason another 0.5 ml of teflon paste was injected 6 weeks later. After a series of voice therapy sessions his voice was near normal, he spoke in a sonorous chest register with a few short voice breaks. With time these breaks disappeared and at the final visit 2 1/2 years after the teflon injection the patient had no voice problems any longer.

Methods and results

At several occasions air flow measurements during voicing and acoustic tape recordings were made. For the air flow measurements, the patient phonated into a stiff tube attached to a Fleisch pneumotachograph with his lips tightly closed around the tube and his nostrils pinched. The flow signal, as transmitted through a differential pressure transducer, was recorded on paper by means of an ink recorder, Mingograf 81.
A sound recording was made simultaneously. At each occasion the patient made ten successive phonations at a comfortable intensity level. The mean air flow during the middle third of each phonation was calculated (Fig. II-A-1) and so was the average over the ten phonations.

In Table II-A-I the results of the air flow measurements are presented. A considerable decrease of air flow during phonation was observed over the treatment period, from an amount of almost 1 liter a second to approximately 1/3 of a liter. The normal value for males is 0.08-0.18 l/s according to Isshiki & van Leden (1965).

<table>
<thead>
<tr>
<th>DATES</th>
<th>INJECTION</th>
<th>AIRFLOW liters/second</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 8</td>
<td></td>
<td>0.95 s.d. 0.11</td>
</tr>
<tr>
<td>June 9</td>
<td></td>
<td>0.96 s.d. 0.12</td>
</tr>
<tr>
<td>June 10</td>
<td>Glycerol 0.4 ml</td>
<td>0.77 s.d. 0.12</td>
</tr>
<tr>
<td>June 11</td>
<td>Teflon 0.6 ml</td>
<td>0.37 s.d. 0.04</td>
</tr>
<tr>
<td>July 14</td>
<td>Teflon 0.5 ml</td>
<td>0.35 s.d. 0.07</td>
</tr>
<tr>
<td>August 30</td>
<td></td>
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<tr>
<td>August 31</td>
<td></td>
<td></td>
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<tr>
<td>November 17</td>
<td></td>
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</tbody>
</table>

The acoustic tape recordings were made during various speech tasks, among them the reading of a selected text, always the same. The recording conditions - microphone distance, recording equipment and settings - were kept constant over the different recordings. The reading part of the tapes, of approximately 40 seconds' duration, were analyzed by means of a technique providing Long-Time-Average-Spectra (LTAS). Such spectra were obtained from an equipment developed at the Department of Speech Communication, Royal Institute of Technology (KTH), Stockholm (Blomberg & Elenius, 1970; Jansson & Sundberg, 1973). This equipment consists of a computer statistically processing the output of a filter bank. The input can be a tape recorded signal. The resulting LTAS are plotted by an incremental plotter using a frequency scale corresponding to a technical mel scale (linear in the low frequency region and logarithmic in high frequencies).
Fig. II-A-1. A sample of the air flow recording, demonstrating how the measurements were made from the middle third of the phonation time. The calibrating signal indicates a flow of 1.4 liters a second.
The LTAS is a record of the averaged sound energy occurring in each of the band pass filters in the filter bank. The result is normalized with respect to the duration of the analyzed signal. When applied to speech, the overall slope of the LTAS up to around 3 kHz mainly depends on the acoustic characteristics of the sound generated by the vocal folds vibrations, i.e. the source spectrum. For an efficient normal voice the overall LTAS slope is flat provided that the preemphasis is engaged, which was the case in the present measurements. An LTAS of speech generally displays moderate peaks in the frequency regions covered by the vowel formants. These peaks stem from the amplification of source spectrum partials lying close to a formant. They are centered around the averaged frequencies of the formants (500 and 1500 Hz for the two lowest formants, approximately).

In normal voices the amplitudes of the source spectrum partials decrease with 12 dB/octave approximately provided that the vocal folds can close the rima glottidis efficiently. If the vocal folds do not close during phonation they vibrate almost sinusoidally. They generate a source spectrum containing a fundamental but very few and weak overtones (Rothenberg, 1974). Also noise is generated. Under these conditions the LTAS will predictably exhibit a clear peak in the frequency region of the fundamental and a very steep slope above this peak. The noise would excite the second formant mainly, as in whispering. Therefore, a peak can be expected in the frequency region of this formant. The amplitude of this peak would be rather small, though, since the noise amplitude is weak as compared with the fundamental.

The influences on an LTAS of changing the voice effectiveness can be studied in Fig. II-A-2. These records were obtained from a subject who read the same text twice, first with his normal voice and then with a very breathy voice. The normal voice yields a flat LTAS with two peaks at 500 and 1500 Hz, corresponding to the average frequencies of the two lowest vowel formants. The breathy voice, on the other hand, shows one single peak in the frequency region of the fundamental: 150 Hz, approximately. The peak corresponding to the first formant falls on the slope of the fundamental peak and is scarcely discernable. The peak corresponding to the second formant is centered around 1500 Hz and is about 15 dB weaker than in the case of the normal voice. These observations agree with the predictions just made.
Fig. II-A-2. Long-Time-Average-Spectra of a male voice reading the same text twice, with his normal, efficient voice (solid curve) and with a maximally breathy voice (dashed curve).
Fig. II-A-3 shows the LTAS obtained from the patient before and after teflon injection and training. The registration obtained before the treatment is similar to the case of the breathy voice shown in Fig. II-A-2: the LTAS exhibits one single peak which is located to the frequency region covered by the fundamental. After the treatment the fundamental peak has increased by about 6 dB in amplitude and a clear first formant peak can be seen to be centered around 500 Hz. In this frequency region the LTAS level has increased by 20 dB, approximately. This indicates that thepartials underlying the first formant have increased their amplitude by the same amount of dB. No clear peak can be seen in the frequency region of the second partial. This suggests that the source spectrum partials fall off at a rate slightly greater than 12 dB/octave. On the other hand, the partials underlying the second formant has increased in amplitude by about 15 dB as indicated by the level differences in this region in the two LTAS. Thus, the LTAS indicate that, after the treatment, the amplitude of the fundamental has increased by about 6 dB on the average, the partials underlying the first formant by about 20 dB and the partials underlying the second formant by about 15 dB.

Discussion and conclusions

Vocal behavior is very complex and variable. The objective assessment of vocal dysfunction in clinical practice is a highly desirable but difficult task. A number of parameters are available for recording and analysis. Thus, in voice pathology, insufficient closure of the vocal folds during the "closed phase" of the vibratory cycle is a most common phenomenon, leading to a phonatory air consumption above normal. Recurrent nerve paralysis offers the most extreme example of this deviation. In these cases, it is most appropriate to record air flow and use these measurements for assessment of the therapeutic procedures as demonstrated.

It should be pointed out that, in a given situation, air flow varies with vocal intensity, and ideal comparisons should be carried out at the same intensity level. When a considerable improvement of voice effectiveness takes place, as in the case reported here, this criterion cannot be met, however. The patient cannot match his previously recorded low intensity, he must be allowed to phonate at a comfortable level.
Fig. II-A-3. Long-Time-Average-Spectra of a patient reading the same text before (dashed curve) and after injection of teflon in the paralyzed vocal fold and training (solid line).
The high motion picture analysis used by von Leden et al (1967) provides excellent visual information about the vocal fold vibrations. However, since it is a difficult and expensive technique and the analysis very time-consuming, it can never be used routinely for clinical purposes.

Air flow measurements, like laryngoscopy and laryngeal photography, interfere mechanically with speech production. Laryngeal behavior and vocal fold vibrations are also more or less influenced by these manipulations. For this reason, one cannot be sure that observations made during examinations of this type reflect the normal function. This limitation, however, does not exist with acoustic analysis.

Spectrographic analysis of voice by means of the sonagraph has been available for many years. Attempts have been made to use it for clinical purposes, as demonstrated by the von Leden group (1967). Only short samples of speech can be analyzed at a time, however, and the analysis is time-consuming.

The Long-Time-Average-Spectrum analysis provides acoustic information from a long speech sample. The comparison between the pre- and post-therapy recordings of the case reported demonstrates a very clear difference of the sound spectrographic pattern, reflecting the considerable improvement of his voice. The similarity to the spectra of the two types of phonation produced by the normal speaker is striking.

It appears that LTAS can be very effectively used for objective documentation of voice improvement achieved by teflon injection, as well as by other therapies. With this method the clinician can supplement his impressions with detailed qualitative and quantitative analysis and arrive at more precise diagnostic and therapeutic measures. The LTAS technique requires a filter bank connected to a computer, thus a rather special and expensive type of equipment. The analysis is completely automatized and very quick, and one equipment could easily serve a large number of clinics. Also, the LTAS technique may perhaps be simplified. In the present study three parameters yielded the basic information: the averaged sound level in the frequency regions of a) the fundamental, b) the first formant, and c) the second formant. It seems likely that simpler devices can be constructed that provides this information.
Acknowledgments

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References


Rothenberg, M., personal communication, 1974.