

Glottal Parameters and Some Acoustic Measures in Patients with Laryngeal Pathology

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In the last several years, researchers have shown that certain acoustic measures such as rapid perturbation in the fundamental periods^{1,2} or short term modulations in the envelope amplitude³ of speech are sensitive to some pathologies in the larynx. Further, they have thought that these acoustic measures may be useful in detecting certain laryngeal diseases such as neoplasms.⁴ Very few studies, however, have been presented in relation to the patho-physiological mechanisms which account for these acoustic phenomena in the larynx. There seems to be an evident need for studying the mechanisms in larynges with varied pathologies, if these acoustic measures are to be applied to clinical fields. As a step in such a study, we have attempted to relate some acoustic measures to some physiological parameters in the larynx.

The method of obtaining the data is shown in Figure 1. The image of the larynx was exposed with a laryngeal mirror, and was photographed by a high speed camera. The acoustic signal picked up by a contact microphone was displayed on an oscilloscope and photographed onto the same film as the laryngeal images.

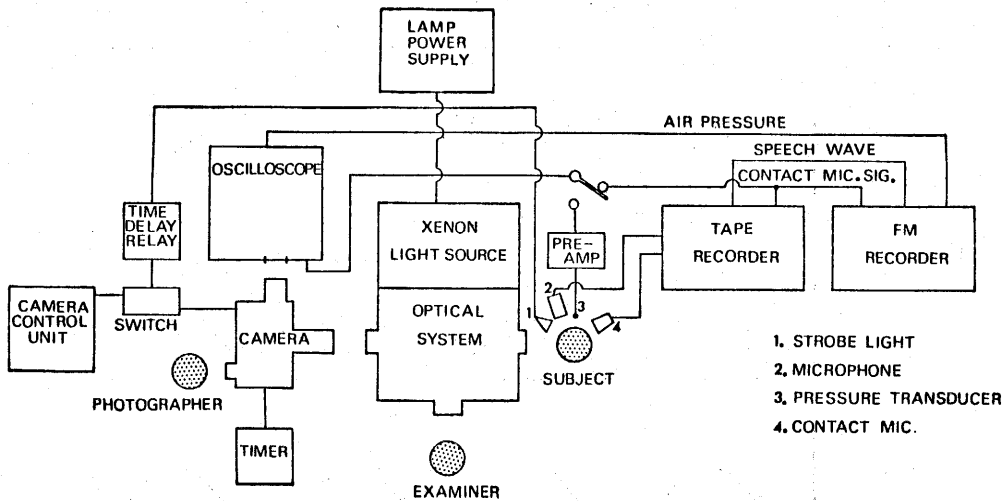


Fig. 1

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* This study was done when we were at the Speech Communication Research Laboratory, Inc.

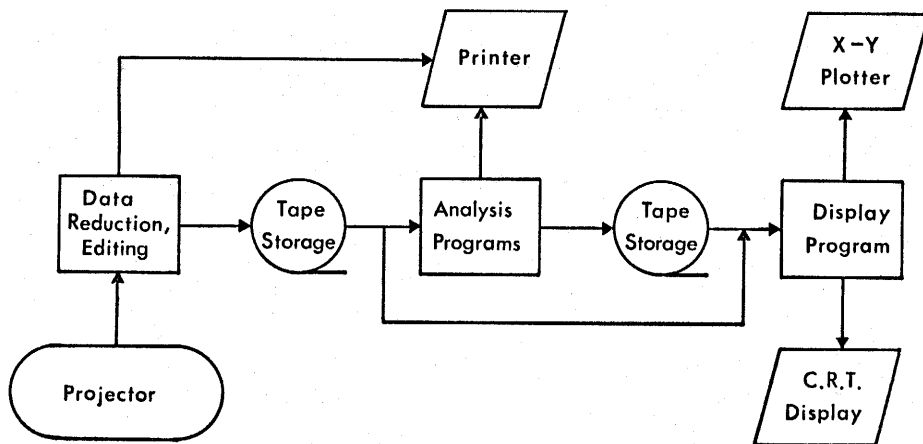


Fig. 2

The data on the film were then reduced with a semi-automated reduction system as illustrated in Figure 2.

First, a frame of film is projected directly onto the front surface of a CRT

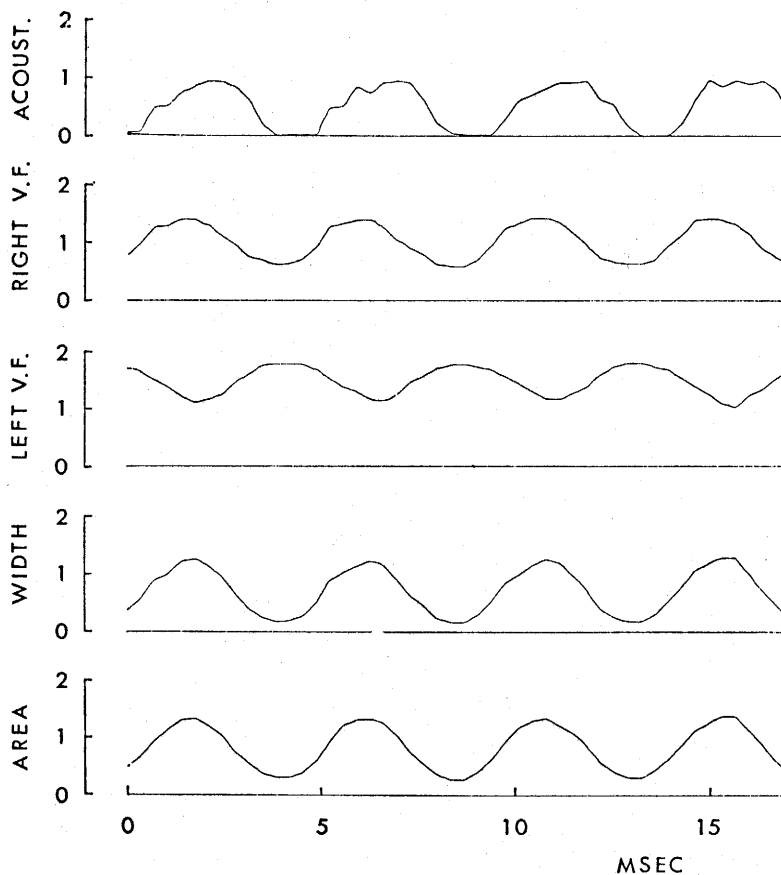


Fig. 3

screen connected to a computer. A program generates and displays some light markers which can be located at any desired position on the screen, by means of commands conveyed over a keyboard control. The X and Y coordinates of the markers are then stored on a digital tape. This procedure was repeated, frame-by-frame, for approximately 300 frames for each patient studied. From the stored digital coordinates, an analysis program then computed the amplitude of the acoustic signal, the excursion contours of the right and the left vocal folds, the glottal width, and the glottal area. The results of these computations were stored on a second digital tape, and were displayed on the data display screen or plotted on an X-Y plotter with the aid of a general display program. The computed data were also printed out as a series of integers. Some examples of the displayed data are shown in Figures 3 through 5. The abscissae of these figures indicate time in msec., and the ordinates indicate arbitrary linear units. The tracings on each figure denote a time function, from top to bottom, of: 1) the amplitude of the acoustic signal picked up by the contact microphone, 2) the excursion contour of the right vocal fold, 3) the excursion contour of the left vocal

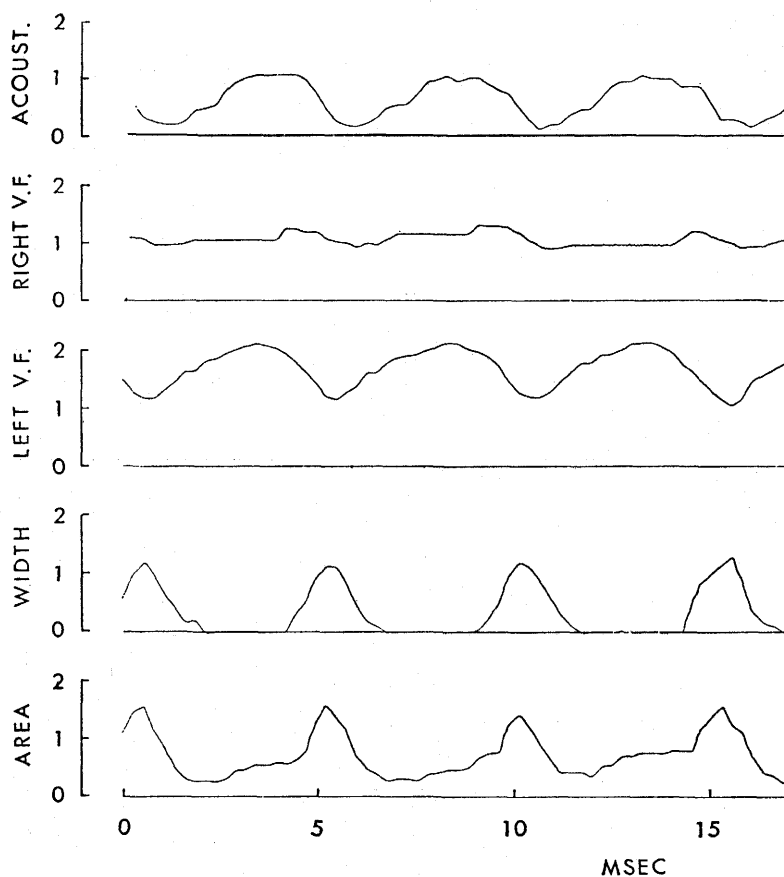


Fig. 4

fold, 4) the transverse diameter of the glottis at the median points of the vocal folds, and 5) the glottal area.

Figure 3 illustrates the data obtained from a patient with unilateral incomplete paralysis of the recurrent laryngeal nerve. A moderate discrepancy is observed between the excursion contours of the right and the left vocal folds. It seems interesting to note that the paralyzed fold tends to lag behind the normal fold during the vibratory cycle. The discrepancy between the two folds becomes more apparent in some cases as is observed in Figure 4. The right fold of this patient is affected by a benign tumor, and the mobility of the right fold is quite limited. Figure 5 demonstrates data from a patient with glottic cancer. The laryngeal behavior of this patient reveals some interesting differences from that of a normal subject. For example, there is an evident difference between the glottal width function and the glottal area function, while in normal subjects these functions are alike.

In fact, many previous researchers^{5,6} have used the glottal width function in lieu of the area function, perhaps because of the difficulty of measuring area

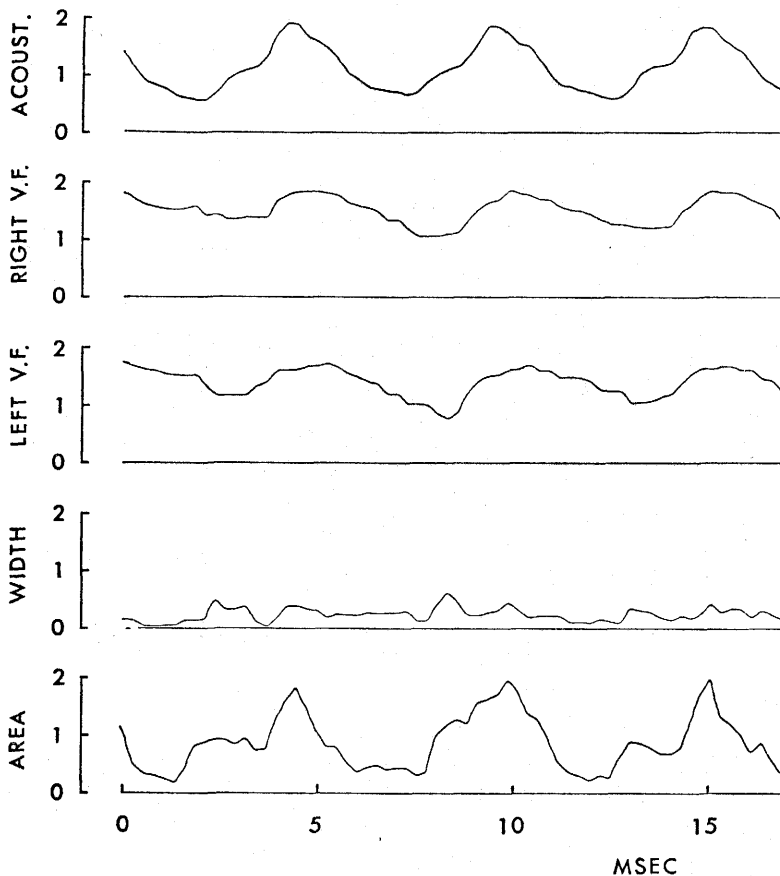


Fig. 5

Table 1.

Case No.	Pathology	Acoustic Period		Area Period	
		Mean	S.D.	Mean	S.D.
1	vocal polyp	14.05	1.54	14.05	1.01
2	benign tumor	19.60	1.72	19.47	1.19
3	cancer	20.07	0.62	20.00	0.78
4	unilateral paralysis	13.18	0.67	13.19	0.52

values for a large number of frames. It is apparent, however, that such a substitution cannot hold true in the study of some larynges with pathologies. This finding further suggests a limitation of certain types of "glottographs," which simply measure the distance between the two folds to estimate the glottal area.

The average fundamental period values measured from the acoustic signal and from the area signal on the same utterance for patients with various pathologies are summarized in Table I, along with the sample standard deviations to show the variability of the period measures. The unit of measurement is the number of frames. The average fundamental period obtained from the acoustic signal is almost identical to that from the area signal for each patient, and the dispersions of the two period measures also seem to be quite close. Not only the over-all period measures above mentioned, but also a period-by-period difference between the acoustic and the area measures was computed for each patient. The averaged period-by-period differences were found to be negligible. This coincidence seems to indicate a close relationship between the acoustic and the physiological parameters, at least in terms of period measurement, and to provide some basic information for the potential applications of acoustic measures for detecting some of the laryngeal pathologies.

SUMMARY

High speed motion pictures of larynges with different pathologies were taken simultaneously with recordings of the acoustic signals picked up by a contact microphone coupled to the neck. The acoustic signals were displayed on an oscilloscope and photographed onto the same film as the laryngeal images. A semi-automated digital reduction system was employed to reduce the acoustic data and glottal dimensions into digital information. The amplitude of the pressure signal and laryngeal parameters such as glottal area, glottal width, and excursion contours of both folds were calculated and displayed by computer programs. A good agreement was observed between the periodicity of the contact microphone signal and that of glottal area, though the phase relation between the two parameters varied considerably from patient to patient. Relations among the glottal area and other laryngeal parameters mentioned above were considered. It is pointed out that the glottal width function does not represent the glottal area

function in many cases with pathologic larynges. The validity of the contact microphone technique for extraction of the fundamental periods of speech is discussed in reference to the acoustic approach to detection of laryngeal pathology. [This study was supported by USPHS Grants NS 08177 and NS 08036.]

REFERENCES

1. Lieberman, P.: Some Acoustic Measures of the Fundamental Periodicity of Normal and Pathologic Larynges, *J. Acoust. Soc. Amer.* 35, 344-353, 1963.
2. Smith, W.R. and Lieberman, P.: Studies in Pathological Speech Production, *AFCRL-64-379*, Data Sciences Laboratory, Air Force Cambridge Research Laboratories, Office of Aerospace Research, L.G. Hanscom Field, Mass., 1-69, June 1964.
3. Koike, Y.: Vowel Amplitude Modulations in Patients with Laryngeal Diseases, *J. Acoust. Soc. Amer.* 45, 839-844, 1969.
4. Crystal, T.H. and Jackson, C.L.: Extracting and Processing Vocal Pitch for Laryngeal Disorder Detection, *J. Acoust. Soc. Amer.* (A) 48, 118, 1970.
5. Timcke, R., von Leden, H., and Moore, P.: Laryngeal Vibrations: Measurements of the Glottic Wave, Part I. The Normal Vibratory Cycle, *Arch. Otolaryng.* 68, 1-19, 1958.
6. von Leden, H., Moore, P., and Timcke, R.: Laryngeal Vibrations: Measurements of the Glottic Wave, Part III. The Pathologic Larynx, *Arch. Otolaryng.* 71, 16-36, 1960.

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