

OBSERVATIONS ON THE PHYSIOLOGY OF HOARSENESS

PAUL MOORE

This report is composed of a commentary on certain voice disorders and their relationships to laryngeal physiology, and a motion picture film entitled "The Function of the Pathologic Larynx" produced by my colleague, Dr. Hans von Leden and me at the Institute of Laryngology and Voice Disorders.* The comments presented in this paper introduce the film and direct attention to certain kinds of vocal cord vibration that are related to defective voice.

Linguists, phoneticians, phoniatrists, physicians and others attending this Congress are acquainted with laryngeal function in the normal larynx and probably have formed specific concepts about vocal cord vibration. It is probable that information pertaining to the pathologic larynx and defective voice will add to the traditional concepts. My experience indicates that a study of the abnormal often contributes to an understanding of the normal.

Many names may be found in the literature to designate voice defects caused by functional deviations or pathologic conditions of the larynx. These terms are not specifically descriptive; consequently, there is confusion and misunderstanding about the meanings of many of them. This report does not propose a solution to the problem of nomenclature, but the difficulty of terminology makes it necessary to present brief descriptions of the voice disorders discussed in this report so that there may be mutual identification.

Two phonatory deviations that are heard frequently may be called breathiness and hoarseness. In the former, the voice cannot be made as loud as a normal voice, the tone lacks clarity and there is a separately audible component, which is similar to the sound of a true whisper. In hoarseness, as the term is being used here, the primary characteristic of the voice is the presence of relatively prominent high frequency noise superimposed upon lower pitched sound that is rough, or may resemble somewhat the noise of bubbling liquid. There are different degrees of these audible voice defects in both the extent to which the faulty sound differs from the normal, and the proportion of vocalization during which the deviation is present. That is, breathiness or hoarseness may be so prominent that the defect is evident to every listener,

* The investigation which is reflected in this film received support from the National Institutes of Health, Department of Health, Education, and Welfare, Bethesda; and Institute of Laryngology and Voice Disorders, Chicago.

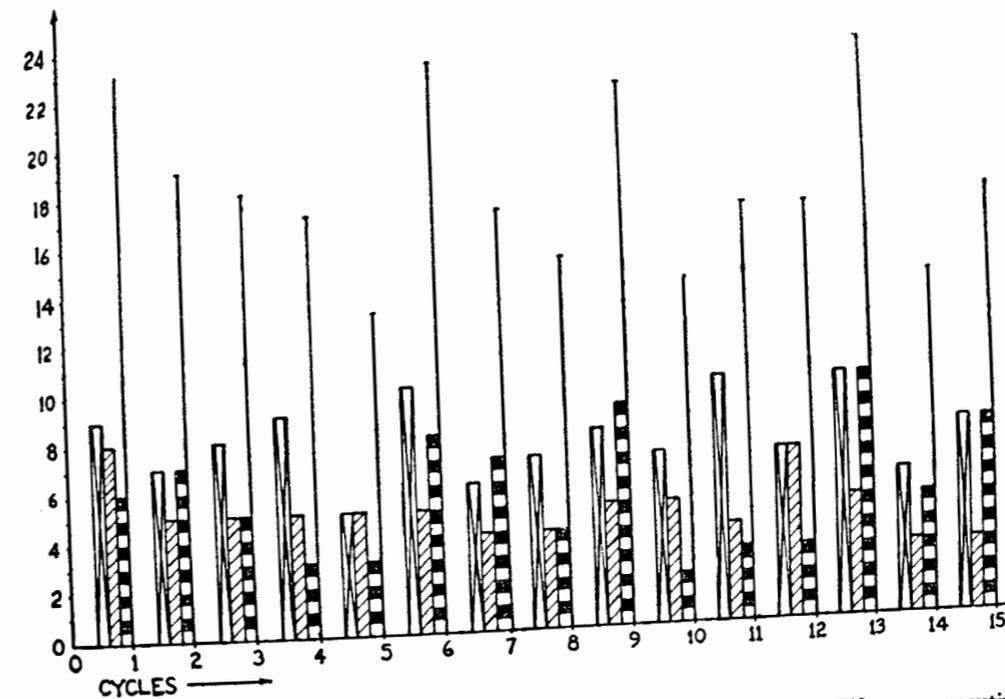


Fig. 1. Variability of consecutive vibratory cycles associated with hoarseness. Fifteen consecutive cycles of ventricular cord movement measured in high speed film frames. Column at the left in each cyclegroup indicates length of opening phase, center column represents closure and third column shows closed phase. Vertical line demonstrates length of cycle; i.e. sum of the three phases.

or so slight that only a trained ear can hear it. Similarly, these vocal types may be present constantly or intermittently. "Normal" as the term is used here means non-defective; the voice is clear and recognized as good in relation to the age, sex and culture of the individual.

Ultra high speed motion picture studies of normal vibration of the vocal cords have demonstrated three components which are always present: (1) each cycle has an opening, closing and closed phase; (2) variability in the periodicity of consecutive cycles is small and predictable; and (3) there is a relatively consistent similarity between the opening phases, the closures and the closed phases of consecutive cycles. Analyses of vocal cord vibration in the pathologic larynx where voice deviations are present, reveal patterns of motion that are different from normal. The vibration cycle of the breathy voice has an opening and a closing component, but no completely closed phase. Periodicity of cycles and regularity of the two phases follow the normal patterns. When hoarseness occurs, the principal deviations in the vibration are irregularity in the duration of consecutive cycles, variability from cycle to cycle of the lengths of the three phases within the cycle and irregularly varying amplitude from cycle to cycle.

Figure 1 demonstrates the variability in duration of 15 consecutive cycles of

ventricular cord vibration as revealed in ultra high speed film. This film was analyzed because the vocal sound produced by this subject is classified as extremely hoarse. Each group of vertical columns on the chart represents one vibratory cycle. Within the groupings the first bar indicates the time of the opening phase of the glottis measured in consecutive images of ultra high speed motion picture film. The opening phase is designated as the period extending from the initial opening of the glottis to the maximum lateral excursion of the vocal cords.

The second bar designates the period of closure which begins immediately after the instant of maximum glottal opening and extends until the glottis is closed. The third bar represents the time during which the vocal cords are in contact and while there is no visible glottal opening. The vertical line at the right edge of each cycle group indicates the total number of film frames in the designated cycle. The duration of the individual cycles ranges from 13 film frames (approximately .0036 sec., or 275 c.p.s. if the cycles were repetitive) to 25 frames which represents about .007 sec., or 145 c.p.s. The greatest variation from one cycle to the next is 10 frames which designates a frequency difference of 120 c.p.s. if the cycles were repetitive.

The variability of the phases within the several cycles reflects the instability of the total cyclic pattern noted previously, but the duration of the individual phases does not correspond with total cyclic changes and presents no predictable pattern. It can be observed that the duration of the closing phase is the least variable portion of the cycle throughout the sequence, that the opening phase (with the exception of cycle 5) is longer than the closure and that it tends also to be longer than the closed phase. These trends lead to interesting speculations about air flow and physiology but these considerations must be excluded from this discussion.

In addition to the irregularities in the duration of consecutive vibrations mentioned previously, there is also an unpredictable variability in the amplitude of the vocal cord movements associated with hoarseness. There is a tendency for amplitude to correspond with length of the cycle; i.e., a long cycle is apt to display a wide amplitude. With but few exceptions, the ratio of cycle duration to glottal amplitude remains relatively constant which suggests that the unit rate of lateral and medial movement is approximately the same from cycle to cycle regardless of the duration of the cycle.

Another example of irregularly variable vocal cord vibration and hoarseness appears in a section of film showing relatively insignificant edema on the margin of one vocal cord. In this second example the healthy cord moves through its cycle approximately twice while the edematous fold oscillates once. When the medial movements of both vocal cords occur at the same time, a tighter and longer closed phase occurs than during the intermediate cycle in which the medial movements are not in phase. In this situation the healthy fold taps the diseased member lightly. The irregular cyclic occurrence can be illustrated in a count of film frames in 15 consecutive vibrations as follows: 8, 13, 9, 21, 8, 14, 8, 14, 8, 13, 8, 14, 8, 22, 8.

SUMMARY

This discussion has been introduced to emphasize two observations related to the physiology of voice deviation: (1) when there is a breathy voice there is no closed phase in the accompanying vibratory action of the larynx; and (2) that hoarseness is present when there are irregularly variable consecutive vibrations of the vocal cords. This variability is present in the durations of the cycles, in the three phases of the cycle, and in the amplitude of movement. Detailed study is in process to determine which specific factor or combination of factors in the vibratory cycle is responsible for the auditory sensation of hoarseness.

*University of Florida
Gainesville, Florida*