Otolaryngology—Head and Neck Surgery

UPDATE II

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OTOLARYNGOLOGY— HEAD AND NECK SURGERY

UPDATE II

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Preface

Just as the four-volume *Otolaryngology—Head and Neck Surgery* text was evolved in an attempt to fill the need for a contemporary definitive text in our specialty of otolaryngology—head and neck surgery, this second *Update* is an attempt to bridge the informational gap created by the passage of time. What we have attempted to do is highlight specific areas within our specialty that have experienced a rapid evolutional rate of growth, have opened entirely new areas for diagnosis or treatment, or were inadvertently overlooked in the four-volume text. Again we have called on experts within our specialty and from other disciplines to provide a volume that addresses these identified aspects of progress.

It is our hope that this will serve successfully to keep our readership fully "up to date" in the time periods between major revisions of the four-volume text.

The Editors

COLOR PLATES, facing p. 84

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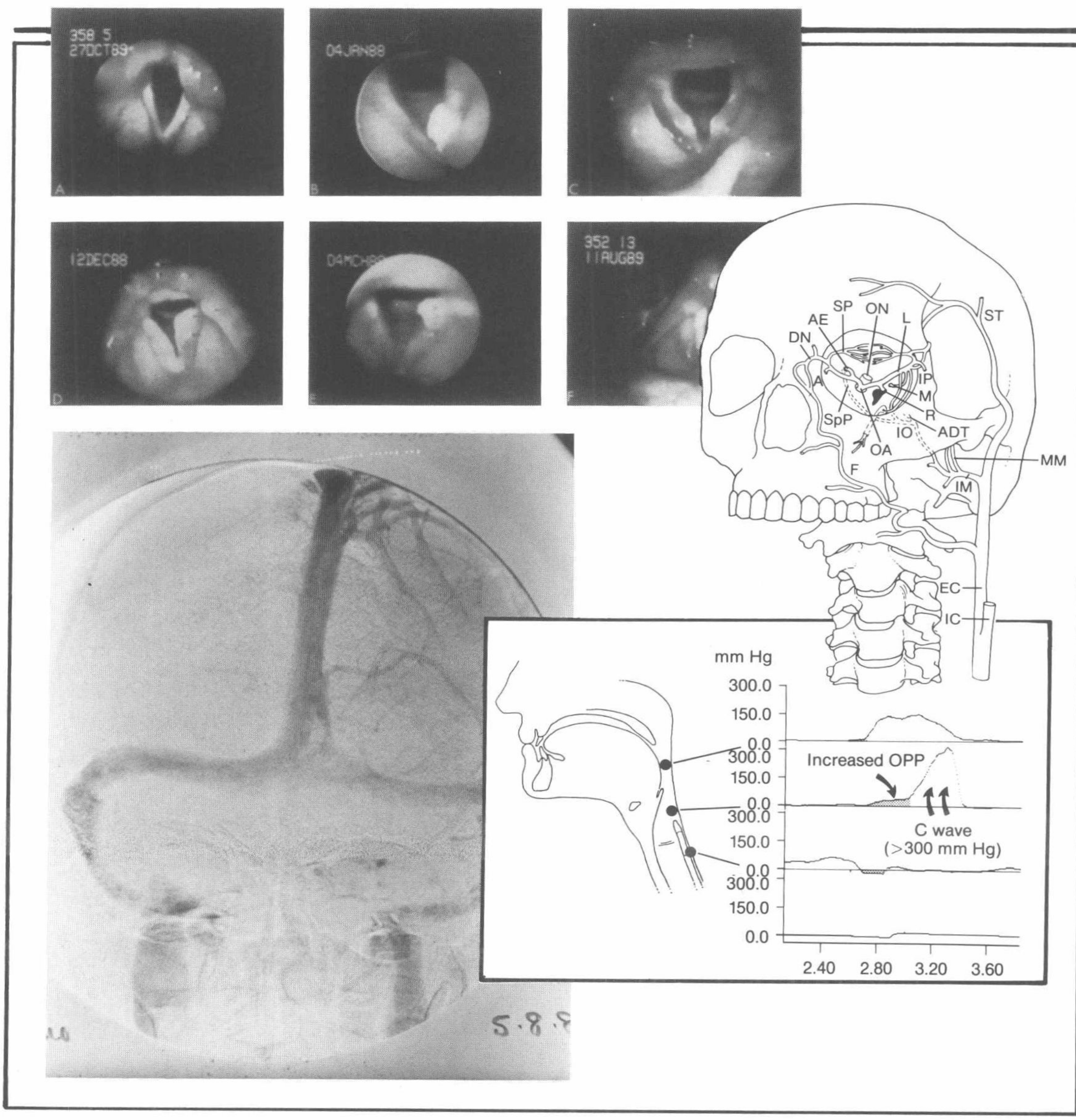
Diagnostic Developments



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1 Objective Assessment of Laryngeal Function

George A. Gates and Colin Painter

Vocal dysfunction is a common health problem. Those forming a large segment of the population depends on a healthy voice for their career. Teachers, clergy, lawyers, telephone operators, sports coaches, salesmen, and a wide range of performers such as classic, pop, rock, jazz, and gospel singers as well as actors all need optimal and even maximal vocal performance. What might ordinarily be a considered minor pathologic problem has major consequences for them. Voice medicine (known as phoniatry or phoniatrics in Europe and Japan) is reemerging as an important part of performing arts medicine, akin to sports medicine for the athlete.

Vocology is the body of clinical and basic knowledge about the human voice, and the voice lab is the common meeting ground of the four groups of professionals who are concerned with people with voice disorders: the surgical vocologist, that is, the laryngologist who specializes in phonosurgery; the rehabilitative vocologist, the speech pathologist who corrects vocal dysfunctions through behavioral modification therapy; the habilitative vocologist or voice teacher, a relative newcomer to the clinic, who trains, retrains, and develops voices. More and more voice teachers are becoming credentialed in speech pathology after appropriate course work; they combine the best of instruction and therapy and are essential, in our opinion, to the ideal vocology group. The clinical voice scientist is an integral member of the team with responsibilities varying from scientific consultant on the one hand to the principal staff of the lab. In many instances the scientist maintains the lab, may perform testing under medical direction, and may conduct its clinical research program.

In many clinical settings the voice lab is housed in the otolaryngology department for a variety of reasons, not the least of which is the anatomic focus, by laryngoscopy, of the laboratory. The complete lab features acoustic, aerodynamic, and electrophysiologic measures as well as sophisticated imaging by videolaryngostroboscopy.

The voice lab has developed from the need to quantify vocal dysfunction. To be sure, experts have a good "ear" to hear abnormalities in the voice, but communicating these findings to others in an objective manner is difficult. Nonexperts are often not sure of what they hear, and vocologists in training need a method for learning. Thus there are multiple needs for objective assessment of the voice and multiple opportunities for use of these measures. Although many descriptors of vocal function are available, none gives a comprehensive, unimodal measure. Like the blind men feeling the elephant, each gives a bit of information but none adequately describes it entirely.

Assessment in the voice lab is essential for preoperative and postoperative documentation of the patient's voice. Such documentation is necessary for accurate description of progress in monitoring therapy, for training of physicians in the care of patients with vocal dysfunction, and for medicolegal purposes. The voice lab is essential for staffing of patients among the surgical and (re)habilitative vocologists in order to plan optimal therapy.

LARYNGEAL EXAMINATION

The principal method of inspection of the larynx since the time of García has been indirect laryngoscopy, which employs a mirror placed in the back of the pharynx upon which the examiner's eye and a bright light source are focused. Indirect laryngoscopy is widely used and is unlikely to be replaced as a routine part of the head and neck physical examination.

Three principal problems have led to the development of supplemental methods of examination. They are patient intolerance attributable to gagging or anatomic problems such as an overhanging epiglottis, lack of a permanent record of the examination, and the need to resolve the rapid motion of the vocal folds so that detailed inspection can be done.

The flexible fiberoptic endoscope has largely eliminated the problem of patient intolerance. In thousands of examinations we have yet to find a patient in whom fiberoptic laryngoscopy could not be done because of gagging, whereas with the mirror the vocal cords cannot be seen in about 20% of patients and in 50% a thorough inspection could not be done. In addition, the manipulability of the endoscope effectively negates the problem of epiglottic overhang. The fiberscopic image suffers from graininess (newsprint effect), size distortion from the wide-angle view, and possible bias from angulated positioning. With experience and with improving equipment these problems are reduced but not eliminated. Many direct laryngoscopic examinations under general anesthesia have been avoided by use of the fiberscope for patients in whom mirror laryngoscopy could not be performed. This represents a substantial saving in health care costs and more than justifies the additional charge for this examination.

With brighter light sources, particularly the xenon cold-light source, and more sensitive video recording devices, satisfactory recordings can be made through the fiberoptic endoscope though the rigid telescopes provide the clearest images. The need to see the vocal folds in slow motion, at first addressed with high-speed cinematography, has been largely resolved with stroboscopy. The equipment for high-speed filming is expensive, cumbersome, noisy (i.e., does not permit simultaneous recording of the voice) and is seldom used today. In contrast, videostroboscopy has become a routine mainstay of laryngeal imaging in the contemporary voice lab. The stroboscopic images are in reality disconnected glimpses of segments of the vocal-fold vibratory cycle displayed over multiple cycles. Variability within a cycle will not show consistently, and thus stroboscopic images may differ from high-speed films images where each cycle is displayed in its entirety.

The widespread availability of videotape recording technology has virtually eliminated the need to decide between still and dynamic recording of the larynx. Printers are now developed to the degree that either black and white or color still images can be generated from a videotape recording at a cost of 2 cents each for black and white or 50 cents for color. These are most useful for display in the chart, in letters to referring physicians, in medicolegal documentation, in clinical research, and for review with the anesthesiologist before intubation in cases where phonosurgery is indicated. We find it invaluable for the voice team members to review the videorecording together. Last but not least, the recording is effective in demystifying the pathologic condition for the patient.

Technique

To display the anatomy of the larynx fully we use the fiberscope passed transnasally into the upper hypopharynx and later into the vestibule. The patient inspires deeply for maximum fold abduction, phonates "hee . . . hee . . . hee" several times, first slowly then fast and then staccato, utters "ee" at several pitches, coughs, whistles, and laughs, reads a passage, and in some instances produces inspiratory phonation. These maneuvers are recorded on videotape along with the patient's voice for subsequent analysis. Before recording the phonatory measures, one should inspect the entire pharynx and larynx carefully to exclude a nonglottic pathologic condition as well as to study the vocal pathologic condition. In our clinic the voice lab is an integral part of the cancer treatment program as is used both for initial evaluation and follow-up study.

The rigid telescope is used next. The patient should be seated with the hips back, shoulders forward, and chin elevated. The tongue tip is wrapped in gauze and held forward by the examiner with the thumb on top. The scope is passed by the examiner using the thumb for support. The uvula can be turned aside without discomfort, but the back of the tongue, the faucial pillars, and the back wall of the oropharynx are sensitive and may trigger the gag reflex. Once gagged, the patient may not relax fully again during that session. Topical anesthetic spray (10% lidocaine or 20% benzocaine) helps reduce gagging. The examiner's manner must reduce apprehension.

Some patience and adjustments may be necessary here, for depending on the pharyngeal configuration the scope may have to be passed more vertically than usual and it may be necessary to use both the 90-degree and the 70-degree telescopes to find the proper combination of scope and position to display the larynx optimally. To center the image in a more posterior position, one may use the 70-degree telescope held more horizontally, with the patient's shoulders back and the tip of the scope held near the posterior pharyngeal wall rather than at the tip of the uvula. A high tongue position, a U-shaped or retracted epiglottis, or gagging, singly or in combination, preclude the use of the telescope. The larynx is examined during phonation and other exercises with and without the stroboscope. Connected speech is not possible with the rigid telescope.

Fogging of the scopes by the patient's breath is common. Generally, wetting the lens with the patient's mucus is adequate for defogging. Dipping the scope in warm water works but requires additional equipment and care not to overheat the scope and damage it or the patient. Antifog sprays may also be useful.

With the stroboscope the phonatory wave is displayed to advantage and if recorded can be studied closely. Fixation of the mucosa to the underlying substance of the muscle or lamina propria will produce harshness. Such a finding can be demonstrated only with the stroboscope. Irregular waveform motion is also seen in patients with paresis of the cricothyroid muscle (superior laryngeal nerve lesion) and, similarly, is seen to greatest advantage by stroboscopy. Stroboscopic images are less bright, particularly through the fiberscope, and are best seen with the telescope. However, in many instances one must depend on the fiberscope, for reasons outlined above, and it behooves one to determine whether the images are bright enough to be recordable when one is testing equipment for purchase.

With this equipment and these maneuvers one can assess vocal-fold motion well. Gross paralysis as well as subtle dysfunction are readily detected. The degree of abduction during phonation is noted, particularly when one is looking for hyperfunction or pressed phonation typical of the tense voice user. The cause of breathiness can be noted and the location of the abnormally wide glottic chink may be seen. Identification of vocal-fold lesions is, of course, the primary reason for laryngoscopy. One can evaluate the presence or absence of nodules and determine their size and character (edematous, hemorrhagic, cystic, epithelial thickening, or fibrous). Other common lesions such as polyp, granuloma, leukoplakia, and early carcinoma can be both seen and studied. Other maneuvers, such as straining and swallowing, can be performed to determine the cause of the abnormality. Inspection of the posterior commissure looking for hyperemia or reflux of gastric contents with straining is useful in cases of contact ulcer and granuloma (Fig. 1-1).

A physician's dictated procedure note or handwritten commentary should accompany the visual images for interpretation of the findings for the patient's record.

Equipment

No specific recommendations are made because of the wide variety of equipment, prices, and vendors. Technologic process has been so rapid that specific recommendations might be outdated by the time this update is published. One wishing to buy equipment is advised to look carefully at in-

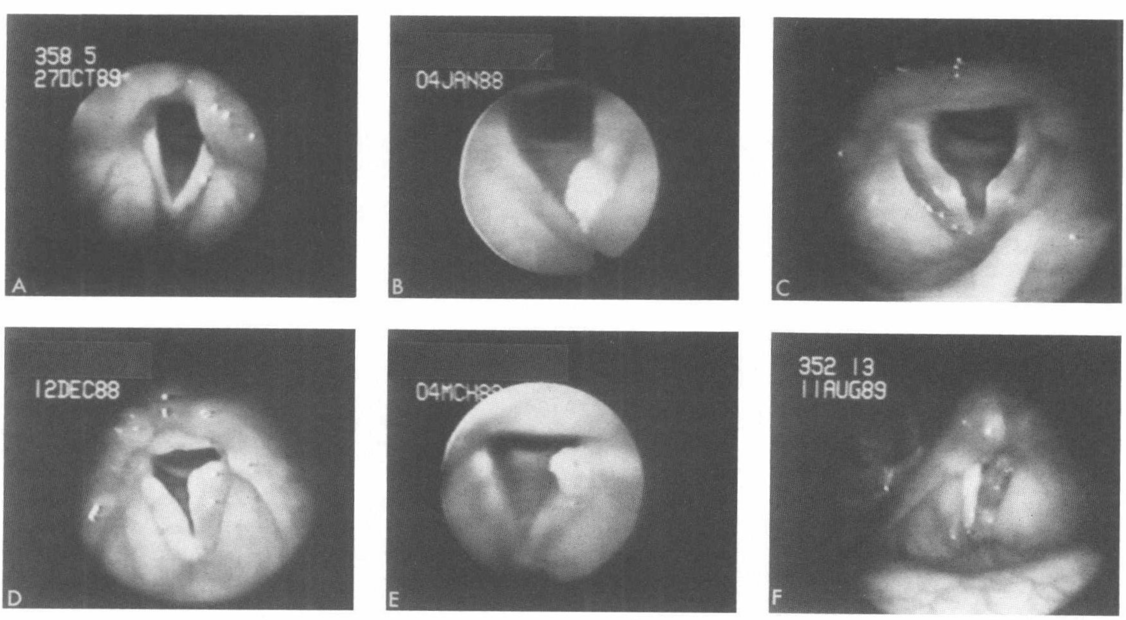

Fig. 1-1. Abnormal larynges for clinical diagnosis. **A,** Vocal fold paralysis. **B,** Keratosis. **C,** Nodules. **D,** Polyps and edema. **E,** Intubation granuloma. **F,** Adverse reaction to Teflon.

dustrial exhibits at conferences and to make sure that separate items to be purchased are truly compatible.

System requirements

The minimum system is a cold-light source and a flexible fiberoptic nasopharyngolaryngoscope. Even though clearer pictures are possible with the rigid telescope, the wider applicability of the flexible scope makes it the first instrument of choice. To implement documentation ability, one would need to supplement the aforementioned with a home video camera and one-half inch videocassette recorder (VCR) and a television monitor.

A comprehensive system can be achieved when one adds 90-degree and 70-degree rigid telescopes, a stroboscope for examining vocal fold motion in apparent slow motion, a black-and-white video printer for in-house documentation, a color videoprinter with or without a video floppy disk unit for frame grabbing, a video laser disk for very clear pictures and rapid search capability, a still camera made for laryngeal photography, a movie camera, a frame-by-frame cine projector, a three-fourths inch videocassette recorder for playback versatility as well as for editing and copying capability and a mixer to permit superimposition of multiple inputs onto the videotape (e.g., the patient's face and the electroglottographic tracing may be displayed adjacent to the image of the larynx).

The stroboscope illuminates the vocal folds with brief, 14 μsec flashes of light. When the folds are vibrating at, e.g., 100 times a second, and the area is illuminated at about 99 times per second, the offset images are evenly spaced through what looks like one cycle of vibration each second. This is slow enough for the eye to resolve and since images remain on the retina for 200 msec they will merge. A 1.4 Hz difference between phonatory frequency and flash frequency is good for stroboscopy. A useful feature of good stroboscopes is the ability to vary the phase of the difference to make the vocal folds appear stationary in any given position. The stroboscope costs around $16,000 but does contain its own light source. Several companies produce quality stroboscopy equipment. It is wise to determine that the stroboscopic images obtained through the fiberscope are bright enough to be recordable on the video equipment. Only recently have combinations of stroboscope, fiberscope, adapter, lens, and camera become available that will permit useful videorecordings of stroboscopy through the nose.

The basic system can be purchased for around $3,000, whereas a comprehensive system will cost $30,000 or more depending on accessories. One may start with a basic system and add items incrementally as the practice grows. The buyer should determine the range of illuminance of the equipment being considered. *Illuminance* is measured in luxes and it is important that all components have a similar lux range.

Space

For a comprehensive system a 9 × 8 foot area is desirable as a minimum. A larger area is necessary if several members of the team are present at the same time or if student observers and fellows

Fig. 1-2. The voice laboratory. Equipment for larynx examination, *on left;* equipment for voice evaluation, *on right.*

are present (Fig. 1-2). The patient's chair is situated in front of the video equipment so that the examiner can see the monitor over the patient's left shoulder. This may require special bifocals for older examiners with a small distance lens at the top for monitoring and plain glass at the bottom for direct views of the patient. The examiner may sit or stand according to preference if an adjustable chair is used. The short length of the fiberoptic cables (which should be integrated with the scope and in which light reduction is proportional to length) partly dictates the physical layout.

To the examiner's left, there is a table for remote controls, adapters, pharmacy supplies, a flashlight, and reading passages. Audio equipment is behind the patient's right shoulder with the microphone on a boom close to the mouth. The video chart is behind the patient's left shoulder, and the laryngoscopy cart and voice evaluation charts are on the examiner's right.

The oscilloscope, microphone and earphones, sound-level meter, filters, sine-wave generator, and pulse generator are grouped together on the examiner's right. To the patient's right are the pitch and intensity meter, an electroglottograph, airflow and air-pressure meters, and an inverse filter for glottal airflow.

Because of the number of electrical devices, a plentiful supply of power outlets on multiple circuits is desirable to avoid outages because of the heavy power load. The laboratory should be in proximity to the clinic offices and the voice therapist's area to reduce travel time, particularly if the lab is busy.

VOICE EXAMINATION

The voice may be evaluated by a variety of objective techniques depending on the needs of the examination. These techniques assess phonation duration, pitch, intensity, jitter, shimmer, glottal airflow, airflow at the lips, estimated subglottal air pressure, glottal resistance, vocal efficiency, vocal-fold contact area, and vocal-fold velocity.

Acoustic measures

Phonation frequency (F) and intensity (I) are measured for all patients at their most comfortable pitch and loudness levels. The full pitch and intensity range may be measured if indicated. Vocal roughness may be assessed by measurement of jitter. and shimmer, which indicate the extent to which the pitch and loudness of the voice vary during a sustained tone.

Spectral analysis may be done as well. This complex and expensive measure displays the various frequency components of the voice. Although useful for research purposes, it provides little information not available from the other tests. The Interactive Laboratory System (ILS) is a commercially available computer program for real-time data acquisition and analysis that permits a wide range of acoustic applications.

Psychoacoustic measures

Psychoacoustic evaluation remains an important part of the examination, even though it is nonstandardized and varies with the perceptual skill and experience of the listener. Development of a good "ear" is important for all vocologists and is the sine qua non of the voice teacher and phonetician.

Aerodynamic measures

Phonation duration is the simplest physiologic measure to obtain. Short times reflect rapid airflows (as with breathy voices) or low effort. A patient with a paramedian fold secondary to recurrent laryngeal nerve injury would be unable to sustain phonation for a full 20 seconds, e.g., because of high airflow secondary to incomplete glottic closure.

Respiratory function testing (spirometry) is useful for many patients. Considering that the voice is supported by the breath—i.e., normal voicing depends on adequate pulmonary function—tests of pulmonary function, particularly the timed vital capacity, are important. Trained singers have low functional residual capacity (FRC), whereas the untrained can benefit from exercises, practice, or medication to decrease the FRC and thus improve breath control. Pulmonary function tests before and after bronchodilators may assist in the diagnosis of bronchospastic disorders (Fig. 1-3).

Airflow at the lips (U) and subglottal air pressure (Psg) are, among other parameters, measures for estimating glottal resistance (Psg/U) and vocal efficiency (I/Psg·U). Many research laboratories have multichannel systems for data collection and analysis, but only one instrument of this kind is commercially available. One is the Nagashima phonometer distributed under the name "Phonatory Function Analyzer," models PS-77E, PS-77H, and SK-83. The last gives a print-out based on four channels of data input: phonatory frequency, intensity, airflow at the lips, and estimated subglottal pressure.

The Recording and Research Center of the Denver Center for the Performing Arts will analyze voice recordings upon specific arrangements using custom-developed hardware and software. Several commercially available software packages for the analysis of speech and voice have been developed and are becoming increasingly available for personal computers. However, standards have not been developed.

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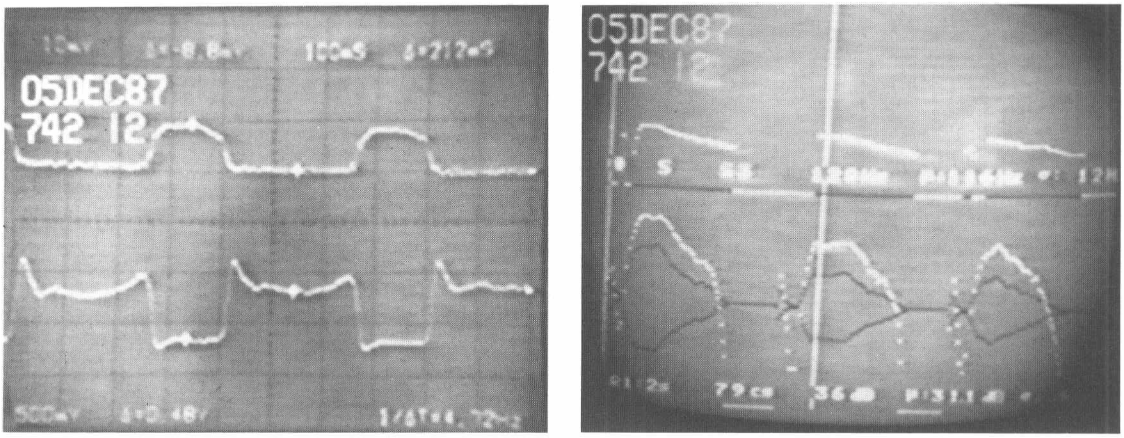

B

Fig. 1-3. Physiologic and acoustic data for voice evaluation. **A,** Oral pressure *(top tracing)* and air flow at lips *(bottom tracing)*. Patient has uttered "pah . . . pah . . . pah." Pressure peak is measured at 8.8 mV, which is equivalent to 5.28 cm H_2O. The air flow is measured at 480 mV, which is equivalent to 326 cc/sec. **B,** *Top tracing,* phonation frequency; *middle tracing,* intensity; *dark tracing,* acoustic envelope. Patient has uttered "pah . . . pah . . . pah." Low falling intonation pattern is seen to begin at 128 Hz. Intensity measured at 50 cm from lips to microphone is seen to be 36 dB above a 45 dB baseline. 81 dB at 50 cm is moderately loud.

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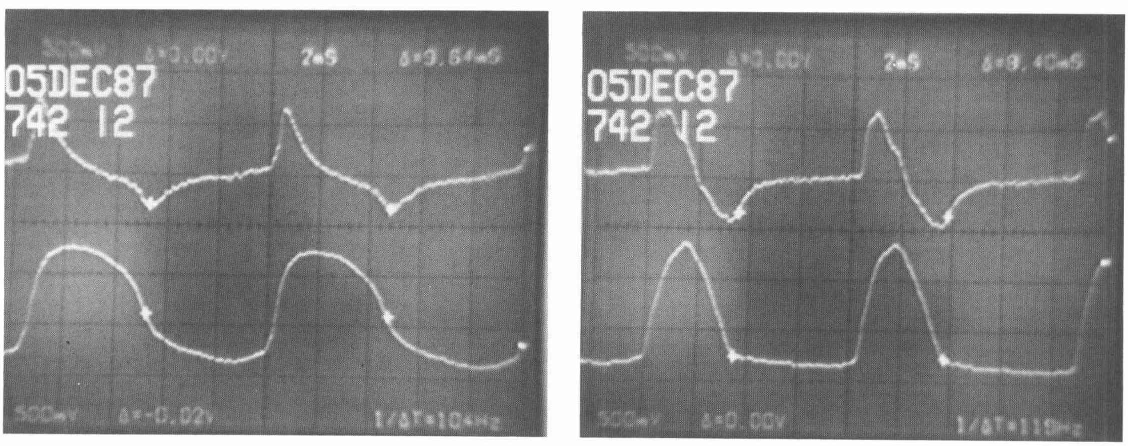

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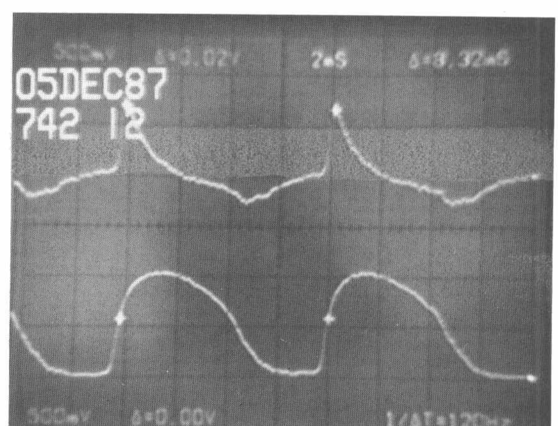

C

Fig. 1-4. Electroglottographic data for voice evaluation. **A,** Normal voice. **B,** Moderately breathy voice. **C,** Moderately pressed voice. *Bottom tracings,* Time course of vocal-fold contact area with the vocal folds together at the peaks and apart in the valleys; *top tracings,* instants when the vocal folds first come together (positive peaks) and move completely apart (negative peaks). Amplitude of peaks shows velocity of these gestures. These photographs differ largely in the closed/open ratio, 10:14 for normal voice, 7:15 for breathy voice, and 13:8 for pressed voice.

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