CLINICAL NOTE

Electrographic Evaluation of the Swallow

Riva Sorin, MHC; Michael D. McClean, PhD
Department of Speech Pathology, University of Toronto, Canada MSG 1L4

Frances Ezerer, DSPA; Barbara Meissner-Fishbein, MA
Department of Rehabilitation Medicine, Toronto Western Hospital, Toronto, Canada M5T 2S8

ABSTRACT. Sorin R, McClean MD, Ezerer F, Meissner-Fishbein B: Electrographic evaluation of the swallow.

• The feasibility of using the electrogastrograph (EGG) to record and measure aspects of the swallow was tested in six nonimpaired, two parkinsonian, and two dysphagic subjects. Low-frequency changes in tissue impedance across the neck were recorded with an EGG during deglutition. On six nonimpaired subjects, EGG waveform changes were consistently monophasic and appeared to be well timed with laryngeal height changes. The waveforms of the two dysphagic subjects differed markedly from those of the nonimpaired subjects, and their timing and shapes were consistent with videofluoroscopic descriptions of those of the dysphagic subjects. The two parkinsonian patients also showed aberrant waveform patterns. These observations suggest that use of the EGG has strong potential as a quantitative technique for swallowing evaluation, therapy, and research.

KEY WORDS: Deglutition; Larynx; PhonRX

The normal swallow is initiated by movement of the tongue, which forces the bolus posteriorly, triggering a stereotyped set of movements which further propel the bolus through the pharynx to the esophagus. 2,3 The time between onset of anterior tongue movement and passage of the bolus through the anterior faucial arch has been referred to as the oral stage of the swallow. 2 This oral stage is followed by a pharyngeal stage, which is more reflective in nature and involves velopharyngeal closure, laryngeal elevation and closure, downward movement of the epiglottis, and sequential contraction of the pharyngeal constrictor muscles. Disruption of the movement control processes underlying the oral and pharyngeal stages of the swallow is common in cases of dysphagia or swallowing disorder.

The principal methods currently used to describe and diagnose disorders of deglutition are ultrasound, manometry, and videofluoroscopy. Ultrasound is particularly effective in describing the oral stage of the swallow, but has limited value for description of the pharyngeal stage. 4 Manometry provides information on pressure variations throughout the upper airway and esophagus, but requires that subjects swallow tubing containing an array of pressure transducers. Fluoroscopic examination is presently the preferred method because it permits direct viewing of the upper airway structures involved in the swallow and provides information on the presence and etiology of aspiration; however, fluoroscopy exposes individuals to some amount of radiation, and thus, repeated use within brief time intervals must be avoided.

Noninvasive methods which permit frequent recording of swallowing kinematics in the same patient may facilitate dysphagia therapy. For example, Heinrich 5 describes methods for phonographic evaluation of the swallow that emphasize releasing of laryngeal elevation. In this type of therapy, it would be logical to provide biofeedback and routinely quantify laryngeal movement. Recently we have found that the electrogastrograph (EGG), an instrument designed to measure tissue impedance changes associated with vocal fold vibration, 6,7 may provide a reliable indicator of laryngeal elevation and depression. The EGG delivers a high-frequency current (300 kHz) across a pair of plate electrodes positioned on each side of the larynx. The carrier signal is modulated by low-frequency changes in tissue impedance. These changes can be displayed as voltages on an oscilloscope. In the case of vocal-fold motion associated with phonation, cyclic increases in impedance are produced by creases in the size of the glottis or air space between the vocal folds, since current flow is reduced with a greater air gap. During the swallow, we observe primarily increases in impedance which appear to be well timed with increases in laryngeal height. This might be explained by movement of the tracheal air space to a more superior position. This space has a great cross-sectional dimension than the glottis, which is closed during the swallow, and the relatively greater lateral air space will result in an increase in impedance.

Since laryngeal height changes are well correlated with the time course of the oropharyngeal aspects of the normal swallow, 5,6,7 we reasoned that the EGG might have good potential as a clinical and research tool for quantifying selected aspects of deglutition. The present report describes our initial use of the EGG to describe impairment changes within the neck that are associated with the normal and abnormal swallow.

METHODS

Subjects. Three groups of subjects were studied: (1) six nonimpaired subjects (N1-N6) aged 24 to 41 years, in good health and not taking any medication; (2) two dysphagic subjects; and (3) two parkinsonian subjects (P1 and P2) suffering from no swallowing difficulties.

Patient 1 was a 66-year-old man with pseudobulbar palsy of the left cranial nerve. A CT scan showed bilateral atrophy of the brainstem, cerebellum, and cerebral cortex. Initially, the patient had difficulty with swallowing and presented with right facial weakness, bilateral deafferentation of the quadrangularis function, right lingual paresis, and inconstant drooling.

Patient 2 was a 63-year-old man with a left hemisphere atrophy and possible myocardial infarction. He showed symptoms of dysarthria, dysphagia, and dysphonia. An oropharyngeal examination indicated bilateral cranial nerve disorder with right facial weakness, bilateral deafferentation of the quadrangularis function, right lingual paresis, and marked drooling.

Laryngoscopic examination of the swallowing behaviors of patients D1 and D2 were obtained. These were presented in relation to their EGG data.

Patient 1 was a 77-year-old man with parkinsonian signs and a left hand tremor, bradykinesia, and rigidity. Subject P2 was a 68-year-old man, also with parkinsonian signs which had severe tremor of the right hand.

Instruments and Instrumentation. An F-3 Electronics Model II EGG was used to record low-frequency changes in tissue impedance across the neck during the swallow. The current delivered at 300 kHz carrier signal to a pair of rectangular plate electrodes (16 x 24mm) positioned on each side of the larynx at the level of the thyroid laminae. The current B was measured at the output of the EGG, which provided a reference output with respective band widths of 30 to 40 kHz and 0 to 10,000 kHz. This second output was used since it was not suitable for transmitting the low-frequency changes associated with the swallow. The output from the EGG was passed to Tektronix 5111 storage oscilloscope. The metal electrodes and the skin overlying the larynx were cleaned with alcohol. The electrodes were covered with transmission cream, positioned on each side of the larynx, and secured in place by neckband.

The normal procedure of the examination was explained, and the subject was told to keep his head as steady as possible by looking at a particular point in the room. The subject was then given half a teaspoon of puree, told to keep the tongue stable, and not to swallow until told to do so. The oscilloscope switch was triggered and the subject was given the verbal command "swallow." A second trial was obtained on each subject, and approximately a minute was taken between each trial to photograph the EGG waveform. Analysis. Each photographed waveform was subsequently traced onto paper for analysis and measurement. The waveforms associated with the swallows of the nonimpaired subjects consisted of positive-going monophasic waves. The Y-axis of these waveforms represents an uncomplicated voltage that is proportional to impedance. An upward deflection represents an increase in impedance relative to the resting position prior to the swallow.

To quantify the temporal aspects of the tissue impedance changes, two phases in the EGG signal were identified: the initiation phase and the rapid laryngeal movement phase. Three lines were drawn on the tracing of each swallow waveform: one horizontal line superimposed on the pretrial baseline, one superimposed on the steepest segment of the rising slope of the waveform, and one superimposed on the steepest segment of the descending slope of the waveform (fig 1).

RESULTS

Nonimpaired subjects. The nonimpaired subjects (N1-N6) all showed impedance increases in association with the swallow (fig 2). The pattern of these waveforms was generally consistent between subjects and across repeated swallows. The command to swallow came one second after the beginning of the trace. The average duration in three trials of the initiation phase of the swallow ranged from 0.27 to 0.91 (t = 0.64) seconds. The range of the rapid laryngeal movement phase was 0.79 to 1.39 (t = 1.06) seconds.

Parkinsonian subjects. The superimposed waveforms on the two parkinsonian subjects (P1 and P2) tended to be more complex and somewhat less consistent in their timing across trials than those of the nonimpaired subjects (fig 3). Tremor at 4 Hz is evident in the recordings of subject P2.

---

Arch Phys Med Rehabil Vol 68, April 1987
SWALLOW EVALUATION, Sorin

DISCUSSION

The present study was undertaken as a preliminary evaluation of the use of the EGG for quantifying aspects of the rate of abnormal swallow. The signals obtained with this technique reflect impedance changes within the neck muscle fibers. The waveform pattern associated in normal swallow was a consistent positive-going normal wave. Given the low values of impedance electrodes, it seems likely that laryngeal height changes were the major factor determining the timing and magnitude of this wave. It should be emphasized that the EGG signal is not a perfect predictor of the occurrence of a swallow, since laryngeal elevation occurs without movement of the bolus to the esophagus.

It seems probable that the increased intraesophagus pressure developed in association with the swallow involved movement of the relatively large tracheal air space away from the electrodes during laryngeal elevation. The occurrence of such an increase in pressure at the approximate position of the mid laryngeal movement phase (subjects NS, PL, and D2) is associated with laryngeal adduction, which is thought to occur during the pharyngeal stage of the swallow. This finding might be tested by obtaining EGG records on order to technical models.

The suggestion that the impedance increases as the bolus primarily to laryngeal elevation is supported by a recent x-ray radiographic study of 48 men. Data from this study show a waveform pattern of laryngeal elevation during the 0.5-2 second period of intake, which is quite similar to the one seen here with the EGG. In this study, the average duration of the laryngeal movement phase in the nonimpaired subjects was 1.06 second. This is in close agreement with Fukukawa’s data, which has an average total duration of 0.96 second for his corresponding mean subject.

Relative to the normal subjects, the two parkinsonian subjects showed somewhat more complex waveform patterns of laryngeal elevation. A prolonged positive deflection then occurred. The duration of positive displacement of the signal appeared much longer than for the normal subjects, suggesting a prolonged pharyngeal stage to the swallow. These abnormal waveform patterns seen in subject D2 precluded measurement of the stages of the EGG signal.

Fig. 3—Superimposed EGG waveform recorded during three swallows of two parkinsonian subjects (PI, P2) and two dysphagic subjects (D1, D2). Arrows indicate increase in duration of laryngeal elevation phase.

ADRESSE REPRINT REQUESTS TO:
Michael D. McLean, PhD
Graduate Department of Speech Pathology
University of Toronto
88 College Street
Toronto, Ontario M5G 1A8
Canada

REFERENCES

Volume 1: First applications of new laryngograph. Med Biol

3. slutsky Laryngographic assessment of phonatory function. In
Lam A. Laryngographic analysis of swallowing in vocal fold patients. Rockville, MD, American
Institute of Voice Pathologists. Rockville, MD, American
5. Engstrom C and Hart M (eds.). Proceedings of the Conference on
Vocal Pathologies, 1981, pp 110–125


ABSTRACTS of selected literature


The adaptability of human skeletal muscle to increased (training) and decreased (detraining) exercise was studied in 11 athletes over a 42-month observation period. Biopsies were taken from the deltoid and the quadriceps muscle, together with measurements of maximal voluntary isometric torque, and the relative proportion of fiber types determined using computerized morphometry.

The results demonstrated that the relative proportion of type I fibers was increased by the physical training and decreased by detraining, while the proportion of type II fibers was decreased by physical training and increased by detraining. The relative proportion of type I and II fibers was similar before and after detraining, but the absolute fiber size was reduced in the type I fibers and increased in the type II fibers.

The present study suggests that the changes in fiber type proportions are not exclusively determined by physical activity level, but may also be influenced by environmental factors, such as physical activity level.


The adaptability of human skeletal muscle to increased (training) and decreased (detraining) exercise was studied in 11 athletes over a 42-month observation period. Biopsies were taken from the deltoid and the quadriceps muscle, together with measurements of maximal voluntary isometric torque, and the relative proportion of fiber types determined using computerized morphometry.

The results demonstrated that the relative proportion of type I fibers was increased by the physical training and decreased by detraining, while the proportion of type II fibers was decreased by physical training and increased by detraining. The relative proportion of type I and II fibers was similar before and after detraining, but the absolute fiber size was reduced in the type I fibers and increased in the type II fibers.

The present study suggests that the changes in fiber type proportions are not exclusively determined by physical activity level, but may also be influenced by environmental factors, such as physical activity level.