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Biofeedback in the Treatment of a Selected Dysphagic Patient

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Abstract. Electromyography and biofeedback techniques are well established in the disciplines of physical medicine for the retraining of muscle groups to approximate functional performance. This report documents the application of biofeedback techniques to the treatment of swallowing dysfunction in a selected dysphagic patient.

Key words: Biofeedback — Electromyography — Carcinoma therapy — Deglutition — Deglutition disorders.

Case Report

A 40-year-old woman presented with a history of recurrent oral and lymphatic carcinoma. In September, 1987, she was diagnosed as having squamous cell carcinoma of the tongue and she underwent subsequent wide local excision of the right tongue and restorative grafting. In May, 1988, the patient underwent a right radical neck dissection for treatment of a metastatic recurrence in the lymphatic system. A third recurrence was diagnosed in February, 1989. Subsequent surgical treatments included excision of the recurrence in the right upper neck, dissection and preservation of the right facial nerve, lateral lobectomy of the right parotid gland, ligation of the external carotid artery, and marginal mandibulectomy of the right vertical ramus. The patient received radiation therapy after surgery bilaterally from the base of the skull posteriorly to the supraclavicular region, anteriorly to include the tongue, and posteriorly to include the posterior cervical region. She received a large plane dose up to 5800 rads and an increased boost of 6480 rads to limited fields at high risk of recurrence. After the surgery and radiotherapy, she experienced increasing difficulty with speech and swallowing and was subsequently diagnosed as having lower lobe pneumonia, dysphagia, and anorexia. In April, 1989, she began to receive nasogastric tube feedings as her sole means of nutritional support and required frequent suctioning of thick, copious oral and pharyngeal secretions. In May, 1989, the patient was referred by her oncologist for evaluation of her speech and swallowing and appropriate therapy.

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Evaluation of Speech and Swallowing

Initial evaluation revealed severely to profoundly impaired speech and swallowing. The patient presented with total aphonia secondary to right vocal fold paralysis from vagus nerve trauma. She initially communicated through well-articulated whispers and writing. Evaluation of her swallowing function using a modified barium swallow examination revealed severe dysphagia with aspiration below the level of the true vocal folds. The pharyngeal swallow was delayed approximately 8 s, with pooling bilaterally in the valleculae and pyriform sinuses. Upon initiation of the swallow there was severe impairment of laryngeal elevation, with subsequent severe deficits in epiglottic closure, combined with vocal fold paralysis, which resulted in an open airway during all stages of the swallow. She exhibited moderate pharyngeal pooling after the swallow. Aspiration occurred both during and after the swallow. The patient exhibited a strong reflexive cough upon aspiration, but this was ineffective in clearing the laryngeal areas. The epiglottis was edematous and immobile, as was the arytenoid cartilage. The patient showed no esophageal dysfunction. The patient struggled with thick, copious oral and pharyngeal secretions. She required frequent suctioning throughout the day, approximately every 10 min, to manage secretions and prevent aspiration of her own fluids.

Speech and dysphagia therapy was initiated on an outpatient basis at the rate of three sessions weekly. Specific therapy techniques included adduction exercises for vocal fold closure, palatal strengthening exercises, thermal stimulation, and vibration to the laryngeal and pharyngeal areas. The direct techniques of chin tuck, head turn, and supraglottic swallow were also used [1]. Biofeedback was incorporated as a critical component of this patient's treatment.

Biofeedback Protocols

A Hyperion Bioconditioner 11, Model 4081 (Hyperion, Inc., Miami, FL) was utilized for this patient's treatment. Selected

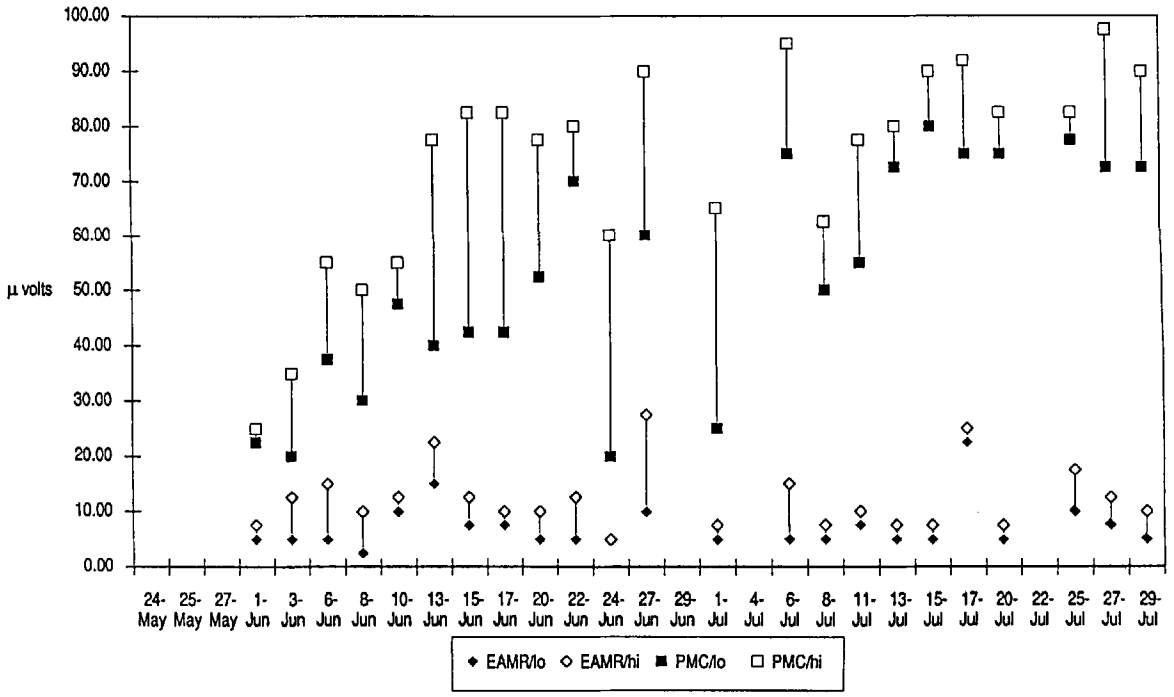

Fig. 1. Summary of Valsalva technique across sessions. *EAMR/lo,* electrical activity in the muscle at rest; low reading. *EAMR/hi,* electrical activity in the muscle at rest; high reading. *PMC/lo,* peak of muscular contraction; low reading. *PMC/hi,* peak of muscular contraction; high reading.

from the menu were the following functions and settings. A single channel was used, with a sensitivity of 100 microvolts and a band width of 100–1000 Hz. Audio modulation was set for frequency feedback with incremental audio response. The threshold was set for straight line readings to target the patient's muscular responses. The integration time constant for the biofeedback machine used was 0.45. Foam-pad-style disposable surface sensors (Biomedical Instruments, Inc., Warren, MI) were selected. Since surface electrodes are generally used to record information from a larger area, they were placed vertically under the patient's chin to record not the electrical output from specific muscles but a combined output from what are referred to as the collected suprahyoid muscles responsible for laryngeal elevation during the swallow [2]. This muscle group would specifically include the anterior belly of digastric muscle, the stylohyoid muscle, and the mylohyoid muscle. Standard acceptable procedures were followed to ensure reliable electromyographic (EMG) output without interfering background activity.

Biofeedback was used in this patient's treatment as an adjunct to two standard treatment modalities. The Valsalva technique is a strategy in which the patient is instructed to "hard swallow" as a means of increasing the strength of the pharyngeal swallow and clearing pharyngeal cavities of residual post-swallow pooling. The Mendelsohn maneuver facilitated cricopharyngeal sphincter opening late in this patient's treatment; for this strategy the patient was instructed to identify the height of laryngeal elevation during the swallow and hold that position for several seconds before releasing muscular control and completing the swallowing cycle. The Valsalva technique and the Mendelsohn maneuver were taught and practiced with biofeedback monitoring. The patient was initially instructed in the nature and purpose of these treatment strategies. The therapist demonstrated the strategies with biofeedback monitoring in place. The patient observed the therapist completing the strategies as well as the video monitoring of EMG information. Both strategies were easily visualized on the video monitor. After the electrodes were placed, as described above, the patient was asked to attempt the strategies and use the feedback on the video monitor to adjust her behavior. For the Valsalva technique, the patient was encouraged to make high peaks of short duration on the video monitor. For the Mendelsohn maneuver, she was encouraged to shape "boxes" on the video monitor with prolonged elevation of the feedback line off of baseline. The biofeedback monitor used can vary a subjectively placed threshold line with pure tone audio feedback given each time the threshold is exceeded and for the duration of threshold achievement. Initially, expected thresholds of peak muscular contractions were low. The expected threshold increased slowly to shape the patient's swallowing behavior.

Treatment Course

This patient's first 9 weeks of treatment are presented in this study, beginning with the initial evaluation session and ending when the patient was able to support full oral intake diet and have supplementary feeding sources removed. Objective data recorded by biofeedback measures and results of modified barium swallow procedures are presented, as well as subjective reports by the patient regarding her perceived progress. Figure 1 shows biofeedback tracings taken before the application of treatment for each studied session. One set of readings indicates the electrical activity present in the muscles at rest with both low and high readings (EAMR-lo; EAMR-hi) for each day. The second set of readings indicates the peak of muscular contractions elicited by the patient during the swallow, with both low and high readings (PMC-lo; PMC-hi) for the day.

During the initial week of treatment, full diagnostic evaluation of speech and swallowing was completed and the results

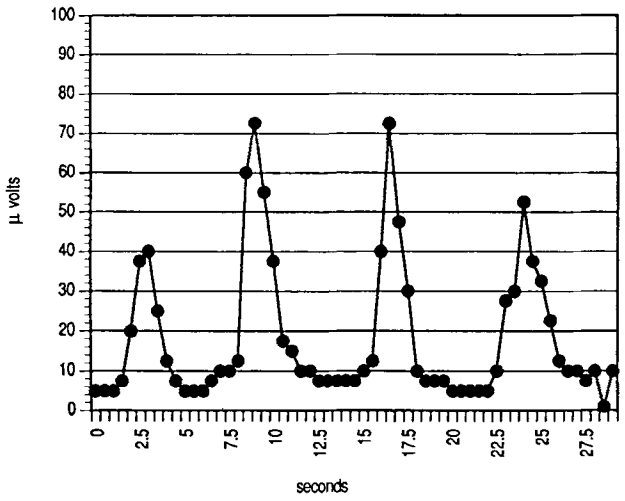

Fig. 2. Mendelsohn maneuver, June 17, 1989.

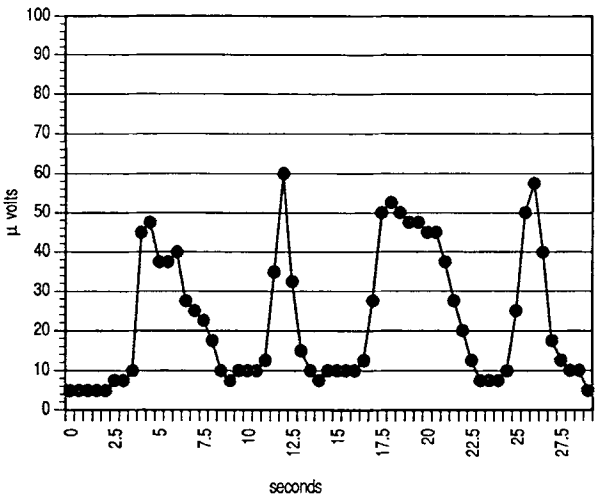

Fig. 3. Mendelsohn maneuver, June 22, 1989.

were discussed at length with the patient. The patient appeared to be very bright and demonstrated a complete understanding of information presented. Treatment was initiated with instruction in the techniques of adduction exercises, thermal stimulation, and chin tuck. In addition, the patient began receiving vibration to the external pharyngeal areas. The patient reported immediate successful results with the chin tuck strategy, resulting in decreased choking during swallowing of secretions and somewhat less dependence on suctioning to clear secretions from the oral and pharyngeal areas.

The patient continued during week 2 with an active home program of the previously learned swallowing exercises and strategies. There was an observed increase in the intensity of attempted vocalizations secondary to vocal adduction exercises. Vocal quality continued to be breathy, but was improved. Vocal loudness registered a 4 on the vocal loudness indicator, a device that provides visual feedback in the form of activation of small lights and an objective numerical reading (1–10 scale) in response to audio input. Biofeedback training was initiated early in this week, with the readings presented in Figure 1. Within the week there was an increase in the upper reading of peak muscular contraction from 25 to 55 μv. The patient reported continued decreased dependence on suctioning.

The patient continued with the home program during week 3 with observable results. Therapy continued with recommended strategies. The patient demonstrated increasing loudness of vocal attempts, registering a 7 on the vocal loudness indicator. The patient reported increased incidents of "breakthrough phonation." Biofeedback monitoring registered an increase of 27.5 μv from the initial reading at the beginning of the week to the initial reading at the end of the week (from 50.0 to 77.5 μv) (Fig. 1). The patient was presented with small boluses of fruit nectar, which she swallowed with no indication of aspiration; however, she required up to five consecutive swallows to clear the pharynx. Subjectively, she reported that her swallows "felt different," describing that "food got caught above the epiglottis," which may have correlated clinically with vallecular pooling as the patient was experiencing a return of sensation.

Vocal adduction exercises continued to yield positive results during week 4. The patient was able to produce voicing with vocal adduction exercises on 95% of trials. During connected speech, she was able to elicit partial vocal adduction with voicing approximately 75% of the time. Biofeedback monitoring registered high peak muscular contraction values between 77.5 and 82.5 μv (Fig. 1). The patient reported a significant change in her perception of the swallow, as well as decreased dependence on suctioning. A repeat modified barium swallow was conducted to document changes radiographically and to negotiate needed changes in the patient's treatment plan. Significant clinical findings included resolution of delayed pharyngeal swallow, much improved but persisting decreased laryngeal elevation, and continued paralysis and edema of the epiglottis. Significant new findings included an abnormal "humping" of the posterior aspect of the tongue, thought to be a manifestation of fear of aspiration, and significantly decreased cricopharyngeal opening with pyriform sinus pooling, which placed the patient at risk for overflow aspiration. No aspiration was identified on this examination; mild penetration of pudding-textured barium into the laryngeal vestibule was observed.

Given the results of this examination, several treatment changes were initiated. Thermal stimulation was discontinued, given the resolution of delay in the swallow. Use of the Mendelsohn maneuver was initiated to address the symptom of decreased cricopharyngeal sphincter opening and pooling of the barium in the pyriform sinuses. Biofeedback monitoring was used to assist in teaching the patient to use the Mendelsohn maneuver during the fluoroscopic examination. Figure 2 presents the patient's initial attempts to prolong the cricopharyngeal sphincter opening by use of the Mendelsohn maneuver. Radiographic study of this technique supported its effectiveness.

Vocalizations continued to strengthen through vocal adduction training in week 5. Measures of peak swallowing performance indicated an increase from 80.0 to 90.0 μv during the week (Fig. 1). Treatment relied strongly on an educational approach using biofeedback to teach and monitor improvement of the Mendelsohn maneuver. Figure 3 represents the patient's attempts to use this swallowing strategy. As indicated, the apex of the swallow during this maneuver on the initial trial registers 50 μv, with a prolongation of the swallow of 4.5 s. On earlier swallows of liquid, the patient required numerous swallows to clear the bolus subjectively from the pharynx. Using this maneuver, the patient was able to decrease the number of swallows to an average of 1 or 2 per bolus, with very infrequent reports of discomfort.

Vocal quality continued to improve during week 6, but not at such a dramatic pace. The patient was able to produce audible

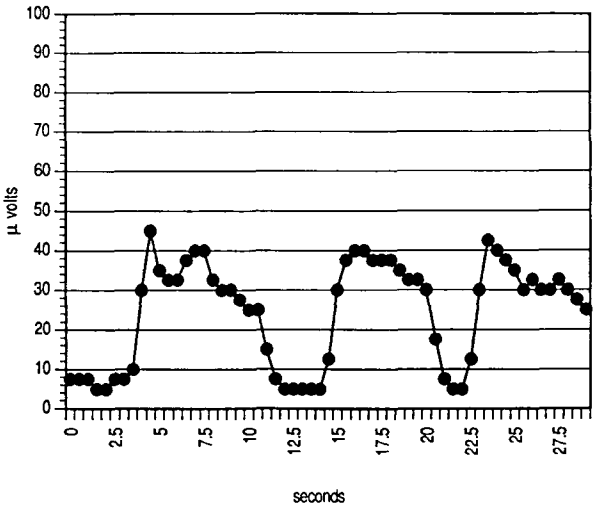

Fig. 4. Mendelsohn maneuver, June 29, 1989.

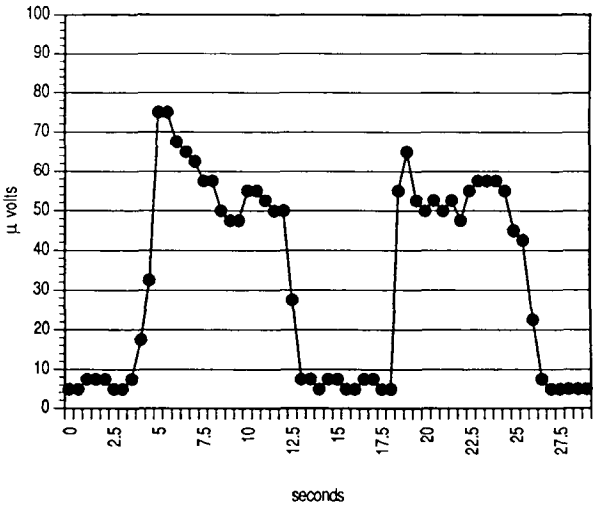

Fig. 5. Mendelsohn maneuver, July 13, 1989.

voicing in 100% of connected spontaneous speech, and registered a reading of 8 on the vocal loudness indicator. Swallowing was improved to the extent that the patient was able to consume thin pureed fruits and thicker pudding with close supervision and use of swallowing strategies. Biofeedback readings ranged from 65.0 to 95.0 μv for the patient's dry swallow (Fig. 1). Biofeedback values for the Mendelsohn maneuver indicate an increase to 8 s of prolonged swallow, with a peak of 45 μv (Fig. 4).

The patient continued her steady progress toward vocalized speech during week 7. She was able to vocalize for greater lengths of time without fatigue deteriorating her vocal quality. She reported positive feedback from friends and co-workers regarding the intelligibility of her speech. Regarding swallowing, the patient made excellent progress during this week. Repeated use of the Mendelsohn maneuver appeared to have a cumulative effect since she no longer had to use this strategy on all swallows. The patient consumed two-thirds of a mechanical soft diet without incident. The patient reported decreased difficulty with management of pharyngeal secretions, with significantly decreased suctioning required during therapy sessions.

Treatment during week 10 began to focus on varying the intensity and frequency of voicing. Recorded biofeedback readings continued to peak within a range of 77.5–90.0 μv for dry swallows (Fig. 1). Recordings of the patient's Mendelsohn maneuver revealed peaks at 75 μv with an extension of the swallow for 10 s (Fig. 5). The patient was rewarded this week by visiting a favorite restaurant for a hamburger, fries, and cola, which she reportedly consumed without difficulty when alternating solid bites with liquid and intermittently employing swallowing strategies.

The patient reported being pleased with changes in her voicing during week 9. She produced voicing on 100% of trials but a pronounced breathy, strident quality persisted. Biofeedback was used primarily as an exercise tool to assist the patient in maintaining the strength of her pharyngeal swallow. Biofeedback tracings of dry swallows persisted at 82.5 μv.

During week 10, orders were received to discontinue the patient's Dobhoff feeding tube when the patient and therapist were comfortable that the patient was receiving adequate nutrition orally. On Saturday, July 29, 1989, the patient removed her nasogastric tube. By this date she was able to consume almost all food textures safely with no difficulty and maintained caloric intake. Biofeedback tracings indicated peaks of 90.0–97.5 μv. A follow-up modified barium swallow was completed on August 1, 1989, which revealed minor persisting deficits that appeared to be asymptomatic. This patient was discharged from direct therapy on November 4, 1989. Her final weeks of therapy focused on improving vocal quality and monitoring swallowing function.

Implications and Summary

Several authors have made significant strides towards the investigation of oral pharyngeal dysphagia through electromyographic instrumentation. Curtis et al. presented a detailed account of specific muscle pairs responsible for pharyngeal muscular movement, which provides a detailed resource for the clinician to refer to in planning clinical treatment [2]. Palmer presents an excellent review of electromyography of the muscles involved in swallowing as well as a comprehensible explanation of electromyography and muscle potentials in general [3]. Certainly more research of this nature is indicated to gain a better understanding of swallowing function and dysfunction. Also warranted is extensive research into the clinical application of biofeedback for the management of dysphagic patients.

This report has presented the treatment course of a woman with oral carcinoma with lymphatic system involvement who initially showed severe to profound dysphagia with aspiration. Biofeedback monitoring was used in conjunction with other accepted treatment modalities to assist the patient to full return of her swallowing function. The patient regained swallowing function and returned to full oral intake diet after 10 weeks of treatment focusing on biofeedback monitoring.

Biofeedback provided several critical elements

that would have been lacking otherwise. Video monitoring allowed this patient to view the swallow as it occurred. This may prove to be particularly helpful in patients with neurogenic dysphagia, whose cognitive deficits prohibit their good understanding of swallowing function. On-screen monitoring converts a previously automatic skill of which there is generally little awareness to a visually represented task that can be monitored cognitively and altered. In addition, biofeedback allowed the patient to realize the effects of specific swallowing compensations and therapeutic strategies. For this study the Valsalva technique and Mendelsohn maneuver were easily visualized and enabled the patient to target a more effective performance of this strategy. Third, biofeedback monitoring allowed the clinician to plan stages of treatment and provide visible, realistically attainable goals for the patient. Finally, in times of restrictions by third-party payers, biofeedback provided measurable, hard-copy data to document the patient's progress.

As with any treatment protocol, the clinician is unable to delineate specifically the factors responsible for a patient's progress. Spontaneous recovery, conventional therapy techniques, and patient motivation all played critical roles in this patient's achievement of therapy goals. The purpose of this report is to illustrate the use of biofeedback as an adjunct to standard therapy and the benefit reported by this patient in terms of understanding specific therapy expectations. It should be clear from this study that biofeedback cannot be used to the exclusion of other treatment modalities. Swallowing therapy techniques are used to effect a change in the physiology of the oral and pharyngeal swallow. Biofeedback is proposed as a patient aid in visualizing and documenting these changes.

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