The Use of Coordination Training for the Onset of Intramuscular Stimulation in Dysphagia

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Abstract

Intramuscular stimulation can aid laryngeal elevation and could augment airway protection in dysphagia. Swallowing is complex, involving multiple sensory and motor events prior to the pharyngeal phase, making automatic triggering difficult. Our purpose was to determine if patients with severe dysphagia could improve airway protection during swallowing after training to coordinate swallowing onset during the pharyngeal phase with intramuscular stimulation. Comparisons were made between: a) airway protection during baseline swallowing without intramuscular stimulation before training versus swallowing coordinated with stimulation after training; b) airway protection during swallow without intramuscular stimulation before versus after training; and c) airway protection with and without stimulation after training. Percutaneous hooked wire electrodes were inserted into submental and extrinsic laryngeal muscles and stimulation onset was controlled by a button press. The resulting swallows were recorded during videofluorography. The degree of airway protection was scored by judges blinded to condition and patient identity. Significant improvements in swallowing performance occurred between baseline pre-training to post-training with stimulation (p=.002) and between post-training sham and stimulated swallows (p=.045). By training patients to coordinate intramuscular stimulation with swallowing, they can improve their airway protection with intramuscular stimulation, and may also augment their volitional swallowing control through practice.

1. INTRODUCTION

Previous muscle stimulation approaches during swallowing have either used continuous stimulation for prolonged periods during swallowing training, which can lead to muscle fatigue [1], or have attempted to use surface electromyography (EMG) of the submental muscles to detect activity [2]. Submental EMG signals, however, are often confounded by chewing activity that takes place during the oral phase of swallowing. We have previously demonstrated in normal volunteers that intramuscular stimulation can provide elevation of the hyo-laryngeal complex [3], and that normal volunteers can easily learn to accurately synchronize a button press to trigger intramuscular stimulation coincident with the onset of the pharyngeal phase of swallowing [4].

Severe pharyngeal dysphagia reflects problems with volitional control of swallowing. Often aspiration (the entry of a bolus into the trachea) occurs because of either a delay in the initiation of the pharyngeal phase of swallowing, reduced elevation of the hyolaryngeal complex to provide airway protection, or incomplete clearance of the bolus from the pharynx. Our aim is to improve a patient’s volitional control of the onset of the pharyngeal phase of swallowing and augment hyolaryngeal elevation by training patients to press a button to trigger intramuscular stimulation during the pharyngeal phase of swallowing.

This study tested the following hypotheses: a) airway protection would improve with intramuscular stimulation during swallowing following training; b) swallowing training would improve a patient's airway protection during swallowing without stimulation; and, c) airway protection would be improved during
stimulated swallows over sham stimulation swallows post training.

2. METHODS

2.1. Subjects

Ten patients with severe chronic dysphagia who were unable to feed orally were selected for a feasibility study of the effects of intramuscular stimulation on airway penetration and aspiration during swallowing. Prior to participation in the study, the patients underwent testing to determine if they could press a button or signal the time of onset of the pharyngeal phase while attempting to swallow a small (2-3 ml) amount of water from a syringe.

2.2. Experimental Methods

During the study, hooked wire electrodes were inserted into submental and extrinsic laryngeal muscles (mylohyoid, geniohyoid, hyoglossus and thyrohyoid). The accuracy of the location of the electrodes was verified by observing the movement induced during monopolar electrical stimulation 3-7 mA at 30 Hz using 200 µs biphasic pulses for 4 s. Videofluorographic images during stimulation at rest determined which combination of muscle stimulation was most effective for inducing hyolaryngeal elevation without swallowing.

A bolus of 3-10 ml of liquid barium was administered to obtain a sample of swallowing without any training or intramuscular stimulation. Following this, the patient underwent five (5) trials of training to coordinate their onset of the pharyngeal phase of swallowing with stimulation onset. The patient attempted to swallow 3 ml of water at the same time as stimulation. After training, videofluorography was used to record trials of intramuscular stimulation (stimulated trials) randomly ordered with trials without stimulation (sham trials) while swallowing 3-10 mls of liquid barium.

2.3. Data Analyses

Four speech pathologists used a scoring system to measure the number of occurrences of aspiration of liquid passing through the vocal folds into the trachea, and whether there was pooling in the vallecula, penetration of liquid into the laryngeal vestibule either from the oral or hypo-pharynx, pooling in the pyriform sinuses and entry of food through the upper esophageal sphincter on each trial. All scoring was done with the speech pathologists blinded to subject identity and condition (baseline, stimulated or sham trials before and after training). A total score was derived to represent risk of aspiration during swallowing for each trial; a lower score represented less risk of aspiration.

A Mean Total Score was derived for each patient for pre-training baseline swallows, and post-training stimulation and sham trials. Repeated ANOVAs tested each directional hypothesis: 1) that a reduction occurred in the Total Score between baseline and post training stimulation; 2) that a reduction occurred in the Total Score between baseline pre-training and post-training sham trials, and that 3) a reduction occurred between stimulated and sham swallows post training.

3. RESULTS

3.1. Pre-Experimental Training

All of the patients with chronic pharyngeal dysphagia were able to meet the pre-experimental criterion of accurately synchronizing a button press with their attempts to initiate the pharyngeal phase of swallowing on at least 5 consecutive trials and had an 80% overall accuracy during 20 training trials.

3.2. Comparison of Baseline Non-stimulation Pre-training with Post-training Stimulation.

The repeated ANOVA demonstrated a significant reduction in Total Score between pre-training baseline and post training stimulation swallows (F=11.36; df=1,9, p=0.002). The Total Score was reduced in all but one of the ten patients; only the least affected patient did not reduce his risk of aspiration during swallowing on his Total Score (Figure 1).

Figure 1. Individual patient pre-training baseline Total Score representing degree of risk
of aspiration during swallowing and post-training Total Score during coordination of intramuscular stimulation with swallowing.

3.2. Comparison of Pre-training Baseline Non-stimulated Swallowing with Post-training Swallowing with Sham Stimulation.

Repeated ANOVAs between baseline pre-training and post-training sham trials were available for comparison in 8 patients and were not statistically significant (F=1.783, df=1,7, p=0.112) but showed modest improvement in 5 patients. (Figure 2).

![Figure 2](image)

Figure 2. Individual patient pre-training baseline Total Score representing degree of risk of aspiration during swallowing and post-training Total Score during coordinating swallowing without intramuscular stimulation.

3.3. Comparison of Post-training Swallowing with and without Stimulation

When post-training sham and stimulated swallows were compared, a significant reduction in aspiration risk was found with stimulation (F=3.718, df=1,8, p=.045).

4. DISCUSSION AND CONCLUSIONS

Although these results are preliminary, they indicate that training patients to coordinate intramuscular stimulation with their own swallowing provides improved airway protection during swallowing in severe chronic dysphagia. Each of these patients had previously undergone extensive therapy for dysphagia immediately following the onset of their dysphagia (post stroke, in Parkinson disease, traumatic brain injury or following surgery for a brain tumour). In spite of early intervention, each patient had remained at significant risk of aspiration six months post onset and had continued to require enteric feeding. Most could not handle their own saliva and some required suctioning for saliva control. The improvement in airway protection with intramuscular stimulation in comparison with baseline swallowing was encouraging in all but the mildest patient improved. What was unexpected was the modest improvement in swallowing without stimulation post training in comparison with measures of baseline swallow. This suggested that with five training trials to improve the coordination between stimulation and the patients’ attempts at volitional control of the pharyngeal phase of swallowing, some degree of therapeutic benefit may have occurred besides the augmentation of hyolaryngeal movement improvement by intramuscular stimulation in persons with chronic pharyngeal dysphagia.

These patients have brain injury that may either disrupt the central pattern generator for swallowing in the medulla or produce a disconnection between cortically based volitional control of swallowing and their swallowing pattern generator in the medulla. These preliminary results suggest that by training a patient to coordinate their own swallowing with intramuscular stimulation, their central volitional control might also be improved.

Because many patients have expressed a desire for control over their own movement in spite of their difficulties, provision of a patient controlled device to onset electrical stimulation for movement may serve to both augment airway protection and improve volitional control of swallowing.

References


Acknowledgements

The research was supported by the National Institute of Neurological Disorders and Stroke of the National Institutes of Health, project number Z01 NS 02980.