Timing of Events During Deglutition after Chemoradiation Therapy for Oropharyngeal Carcinoma

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ABSTRACT

Objectives:
To determine if changes occur in the timing of bolus movement and bolus movement coordination with swallowing gestures after treatment of oropharyngeal carcinoma with chemoradiation therapy.

Study Design:
Patients seen at least one year after treatment for Oropharyngeal Carcinoma with chemoradiation therapy were sequentially asked to participate in the study.

Methods:
The duration of bolus pharyngeal transit was measured for two liquid bolus size categories from modified barium swallowing studies in a group of 31 patients. The timing of bolus movement through the pharynx was determined. The timing of the 13 swallowing gestures, relative to the onset of the entrance of the bolus head into the oropharynx, was measured for each bolus size category. The mean and standard deviation of each measure were calculated. Study subject results were compared to those from an historical group of age matched controls without complaints of swallowing difficulty.

Results:
Mean bolus pharyngeal transit timing in the study population was normal for both bolus sizes. Analysis of gesture timing revealed significantly earlier opening of the UES in the patient population for a 1cc bolus. Patient gesture timing did not change to accommodate larger bolus sizes, as it normally does, resulting in a delay in airway protection for the 20cc bolus category.

Conclusion:
Despite tissue changes and xerostomia resulting from exposure to chemoradiation therapy, patients are able to move a liquid bolus through the pharynx in a timely manner. However, patients may be unable to modify swallowing gestures to safely protect the airway with larger boluses.

INTRODUCTION

It is well established that patients may develop dysphagia after chemoradiation therapy treatment for oropharyngeal carcinoma. Yet, little is known about the specific physiologic changes that occur in swallowing function. An understanding of such changes would aid in designing swallowing therapy protocols for patients during and immediately after chemoradiation treatment.

Normal deglutition requires the coordination of muscular movements to create driving pressures behind a bolus, open the esophagus and protect the airway. In order for structural displacement to be effective in moving a bolus safely through the upper aerodigestive tract, the displacement must be timed appropriately and coordinated with other gestures and bolus location. The purpose of this study is to evaluate the coordination of swallowing gestures with bolus movement in a group of 31 patients **one year after the completion of chemoradiation therapy for the treatment of oropharyngeal carcinoma**. The evaluation of swallowing gesture coordination relative to bolus transit enables us to identify cases in which gesture timing is altered, either secondary to pathology or as a strategy to overcome functional abnormalities.

Prolonged pharyngeal transit has been shown to increase the risk of aspiration pneumonia in patients after stroke, even when no aspiration or penetration is observed on the swallowing study.[1] In this study, the duration of bolus transit, along with swallow gesture timing, will be measured in the patient group and compared to age-matched historical controls with no history of dysphagia.

METHODS AND MATERIALS

Swallowing study recordings were made for liquid swallows of two 1cc and one 20 cc boluses. Timing information in 1/100 of a second increments was available for each frame of the study, allowing detailed timing measurements. All measures were obtained from lateral views.

B1 = onset of bolus transit through the pharynx. It is defined as when the bolus head passes the posterior nasal spine. ***BV1*** = bolus arrival at the base of the vallecula. ***BV2*** = the first exit of bolus material from the vallecula. ***BP1*** = bolus arrives at the upper esophageal sphincter (UES). **AEstart** = the aryepiglottic(AE) folds begin to elevate. **AEclose** = AE folds make contact with the down-folding epiglottis and close off the airway. **H1** = onset of hyoid displacement from a rest position. **H2** = hyoid reaches maximum displacement. **H3** = hyoid begins to return to the rest position. **Pop** = first opening of the lumen of the UES. **PES max** = greatest expansion of the UES. **Pcl** = closing of the lumen of the UES. **HLmax** = hyoid and larynx maximally approximate one another. **PA max** = boundaries of the pharynx are maximally constricted. **Em** = epiglottis return to its upright position.

RESULTS

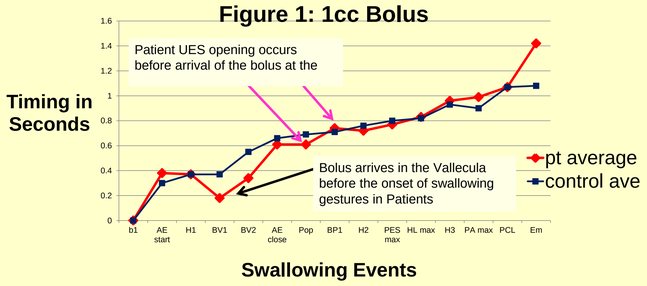
Subject age range: 51 to 78 years old. 4 = stage III, 27 stage IV. Tumor location = tongue base (10), tonsil (13), supraglottis (3), pharynx (2) and 3 patients had radiation to Waldeyer's ring for an unknown primary. Maximum radiation dose: 4000 to 7000 Gray. PEG = 27/31.

For the **1cc bolus** category, overall bolus transit time did not differ between the patients and control subjects (p=0.95) **(Figure 1)**. The only significant difference in timing between the patient population and control subjects was that patients propelled the bolus rapidly into the valleculae before the onset of hyoid and aryepiglottic fold elevation. Bolus arrival (BV1) and exit from the valleculae (BV2) occurred significantly earlier in this patient population when compared to the control group (p=0.002 and 0.046 respectively). In many of the patients, the UES was seen to open earlier than bolus arrival. Using Fisher's exact test to compare the likelihood of early opening between the two groups (defined as opening earlier than 0.03 secs before bolus arrival at the UES), a statistically significant increased chance of early opening was identified in the patient group compared to the controls (P=0.004).

For the 20 cc bolus category, overall bolus transit time did not differ between the patients and control subjects (p=0.998) **(Figure 2)**. In the patient population, the 20cc bolus to arrived at the vallecula before H1 and AEstart (p=0.029 and 0.037 respectively) and airway protection was delayed in the patient population compared to controls. Both the timing of aryepiglottic fold elevation (AEstart) and closure against the epiglottis (AEclose) were delayed (p=0.001 and 0.037 respectively). Airway closure timing is particularly relevant to the position of the bolus in the pharynx. When assessing the time interval between bolus arrival at the UES (BP1) and airway closure (AEclose), the patient population demonstrated delayed airway closure compared to the controls (p=0.04). Nine patients in the patient group closed the airway greater than 0.1 seconds after the arrival of the bolus at the UES.

Changes in swallow gesture timing are normally noted to occur with changes in bolus size. These changes likely represent accommodations made to handle larger bolus volumes while maintaining a constant duration of bolus pharyngeal transit. **(Figure 3)** In the patient population, however, no accommodation to a change in bolus size was observed **(Figure 4)**. This inability to speed up gesture timing resulted in the delay in airway closure and protection.

Figure 1: 1cc Bolus



1. Johnson ER, McKenzie SW, Seivers A. Aspiration pneumonia in stroke. *Arch Phys Med Rehabil.* 1993;74:1-4.

Figure 2: 20cc Bolus

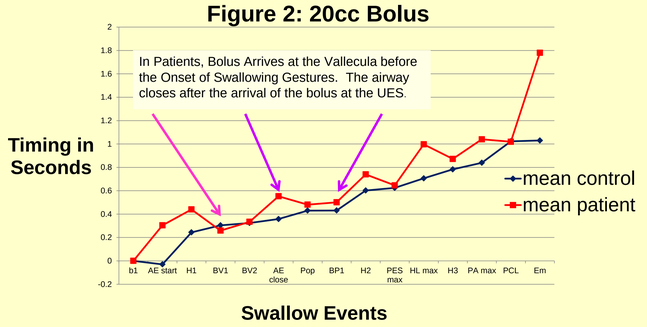


Figure 3: Comparison of Control 1 and 20 cc Bolus

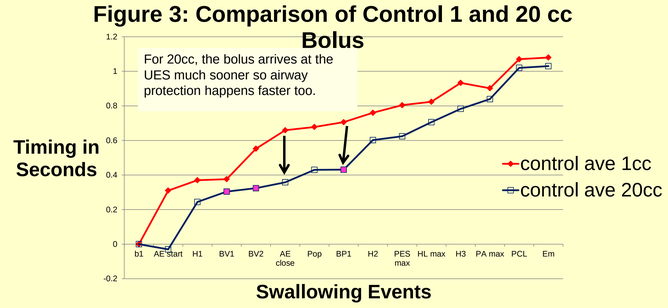
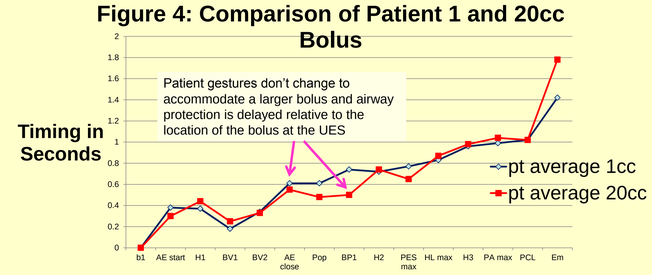


Figure 4: Comparison of Patient 1 and 20cc Bolus



DISCUSSION/CONCLUSIONS

One year after the completion of chemoradiation therapy for oropharyngeal carcinoma, patients demonstrate swallowing gesture coordination very similar to that of normal age-matched controls for a small bolus size. Bolus movement through the pharynx occurs in a timely manner and some patients appear to have developed a strategy of early UES opening. Early UES opening may create a vacuum that helps to move the bolus into the UES in the absence of other mechanisms of pressure generation, such as strong pharyngeal constriction.

On the other hand, patients are unable to adjust to larger bolus volumes with changes in gesture coordination that help move the bolus through the pharynx and protect the airway. Gesture timing during a 20cc bolus swallow in the patient population was unchanged from that observed during a 1cc bolus swallow and the timing of several swallowing gestures was delayed compared to controls. Despite this lack of accommodation, the bolus transit times are not significantly prolonged and because the gesture timing and coordination do not respond to the faster-moving larger bolus, a delay in airway protection occurs, resulting, in some cases, in frank aspiration.

For both bolus size categories, the onset of swallow gestures in the patient population was delayed until the bolus had entered the vallecula. This may be the result of sensory deficits that delay the initiation of the pharyngeal phase of swallowing.