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Oropharyngeal Transition during Swallowing between Stroke and Head and Neck Cancer Survivors

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1. Abstract

1.1. Objective: The purpose of this study was to analyze three oropharyngeal bolus transition timings, Oral Transition Time (OTT), Pharyngeal Transition Time (PTT), and Duration of Upper Esophageal Sphincter Opening (DUESO), using videofluoroscopic swallowing examinations (VFSEs) between stroke survivors and head and neck cancer survivors to determine differences between the two populations.

1.2. Methods: Means and standard deviations of OTT, PTT, and DUESO were determined from analyzing two 5ml thin liquid swallows exhibited by each of the 15 stroke survivors and 15 head and neck cancer survivors from the VFSEs. Statistical analyses were made using one-way analysis of variance (ANOVA) using the two groups with the statistical level set at $p < .05$.

1.3. Results: OTT was longer in head and neck cancer survivors compared to stroke survivors; however, these results were not significant. Stroke survivors exhibited significantly longer PTT and DUESO when compared to head and neck cancer survivors.

1.4. Conclusions: Head and neck cancer survivors have more difficulties in the oral swallowing stage. Stroke survivors have more difficulties in the pharyngeal swallowing stage.

2. Introduction

Dysphagia is a disorder of swallowing that typically involves structural damage to the oral cavity and pharynx. This can be due to trauma or post-surgical tissue ablation and/or damage to the neuropathways, or both. Over 50% head and neck cancer survivors have dysphagia, and of individuals who have had a stroke, between 30% and 50% have pharyngeal dysphagia [1, 2]. Swallowing disorders may lead to serious medical consequences, such as dehydration, malnutrition, aspiration pneumonia, and potentially death [3, 4].

Dysphagia is a common occurrence in the first hours and days following a stroke. However, for some stroke survivors, a swallowing disorder may persist. Many times, risk of aspiration is high due to a loss of sensation in the pharyngeal and laryngeal areas. Previous research has stated that the severity of the laryngeal sensory deficits will impact the likelihood of aspiration [5]. It has been assumed the cause of dysphagia in stroke survivors is due to damage to the cortex and subcortical structures, whereas recovery occurs from cortical reorganization [6, 7]. Impacts to the severity of dysphagia can be attributed to location of lesion and size of the damage. Many negative impacts after a stroke could arise from post-stroke dysphagia; pneumonia, choking, malnutrition and dehydration, reduced quality of life, and social isolation [6]. Tumor presence and medical intervention in head and neck cancer patients can negatively impact anatomical structures important to swallowing and speech production. Depending on the location and size of the lesion, medical intervention can damage swallowing structures increasing the likelihood of dysphagia [8]. Surgical removal of a prominent swallowing structure, an area of the tongue for example, can impact the efficiency of the swallow [9, 10]. Individuals that undergo surgical removal due to head and neck cancer, regardless of which structures are removed, will have to learn to compensate for that structure excision. After radiation and/or chemotherapy, structures may be preserved but structure function may not be fully intact [8, 11, 12]. Swallowing disorders in this population can lead to similar consequences as stroke survivors [13]. In our knowledge of literature, there are limited studies comparing these two populations using physiological measurements of swallowing. This study will provide important clinical information for patients who may suffer from head and neck cancer and later stroke, or the reverse.

Swallowing can be divided into three physiologic stages: oral, pharyngeal and esophageal [14]. Temporal measurements of the oral and pharyngeal stages have been shown to be reliable tools for distinguishing normal and abnormal swallowing [15-17]. This study uses the methodological approach to compare stroke and head and neck cancer survivors. Temporal measurements of videofluoroscopic swallowing examinations (VFSEs) provides direct observation of the extent of oropharyngeal transition of the bolus during swallowing; e.g., Oral Transit Time (OTT), Pharyngeal Transit Time (PTT), and Duration of Upper Esophageal Sphincter Opening (DUESO) [18].

The purpose of this study was to examine the difference of oropharyngeal transition times during swallowing between stroke and head and neck cancer survivors. The outcomes of this study will provide clinically relevant information for differential diagnosis of these populations with swallowing disorders.

3. Method

3.1. Subjects

Fifteen strokes and fifteen head and cancer survivors' videofluoroscopic swallowing examinations (VFSEs) were submitted for the analysis from the Ohio University Swallowing Laboratory database. Inclusion criteria consisted of the following:

- Both groups of survivors had no previous history of swallowing disorders, and
- VFSEs had to have a level of clarity to observe the oral and pharyngeal structures for the temporal measurements accurately. In total, this study included 30 survivors from a range of ages between 28 - 77 years. The mean age of participants is 61.4 years. Individuals in the groups were not age-matched due to the limited number of VFSEs for the head and neck cancer survivor group.

Stroke survivors presented with cortical lesions of the following areas: 8 left hemispheric and 6 right hemispheric lesions. 1 survivor had a cerebellar lesion. The cortical lesions included those in the frontal lobe (n=4), parietal lobe (n=4), middle cerebral artery (MCA) (n=4) and thalamic region (n=1).

Head and neck cancer survivors had cancerous lesions of the tongue (n=3), tonsils (n=1), nasopharynx (n=2), pharynx (n=4) and larynx (n=5). Specific lesions of oral cancer included tonsil cancer (n=1) and tongue base cancer (n=3). Survivors with pharyngeal cancer included, for example, total laryngectomy (n=2), supracricoid partial laryngectomy (n=2), and uvulopalatopharyngoplasty (UPPP) (n=2). The head and neck cancer survivors in this study can be separated by structure where cancer was present. Internal Review Board (IRB) approval was obtained for this investigation. All participants provided written informed consents to be included in order to collect the original x-ray swallowing evaluation.

3.2. Videofluoroscopic Swallowing Examination (Vfse) Procedure

The videofluoroscopic swallowing examinations (VFSEs) were collected from stroke and head and neck cancer survivors from the VFSE database at and Ohio University Swallowing Research Laboratory [19]. The procedure of the VFSE was as follows. The patient was seated upright in a wheelchair or stretcher chair for the examination. The VFSE was collected using a mobile C-arm X-ray and recorded with a Panasonic Super VHS PV-S7670 Pro Line Multiplex videocassette recorder with a 100ms digital video timer (TEL Video Products Model VC 436). The fluoroscopic tube was focused in the lateral plane on the oral cavity and the nasopharynx to below the UES area. For this investigation, each patient swallowed two 5ml boluses of thin liquid consistency. The thin liquid was a mixture of water and barium (E-Z-HD barium sulphate powder).

3.3. Procedures for Temporal Measurements of Oropharyngeal Transition Times

This study concentrated on the analysis of three bolus transit times in oropharyngeal swallowing: Oral Transit Time (OTT), Pharyngeal Transit Time (PTT) and Duration of Upper Esophageal Sphincter Opening (DUESO). Oral Transit Time (OTT) was measured as the time in seconds between the onset of the posterior movement of the bolus head and the bolus head passing the ramus of the mandible [20]. Pharyngeal Transit Time (PTT) was measured as the time in seconds between the head of the bolus passing the ramus of the mandible and the tail of the bolus passing the UES [20]. Duration of Upper Esophageal Sphincter opening (DUESO) was measured as the time between the head of the bolus passing through the UES and the tail of the bolus passing through the UES [20]. To accurately analyze each of the sequential temporal events, slow motion frame-by-frame analysis was performed using a 100ms video timer on the software Adobe Premiere Pro CS5.5 see (Figure 1). When choosing the VFSE clips to include, level of clarity was the most impactful factor in determining the inclusion of the video in the analysis. 60 total swallows were submitted for temporal measurements and statistical analysis measuring OTT, PTT and DUESO. Six swallows were missing for 3 stroke survivors and 3 head and neck cancer survivors.

Based on the images, OTT was calculated by subtracting Image A (onset of posterior movement of bolus head) from Image B (bolus passing ramus of mandible) across all participants. PTT was calculated by subtracting Image B from Image D (the tail of the bolus passing through the UES). DUESO was calculated by subtracting Image C (the head of the bolus passing through the UES) from Image D.

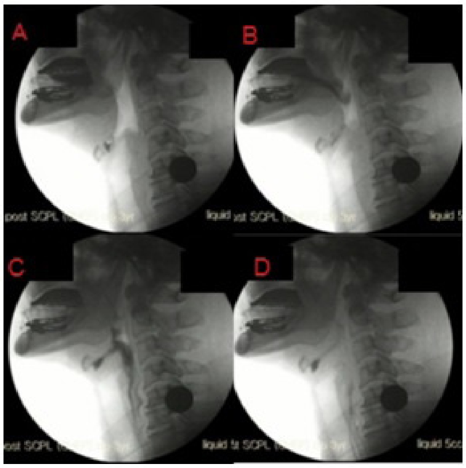

Figure 1: Four screenshots from VFSE used to determine bolus transition times. A- Initiation of posterior tongue movement with bolus. B- Bolus passing ramus of mandible. C- Head of bolus entering UES. D- Tail of bolus passing UES. Calculation of OTT: B-A. Calculation of PTT: D-B. Calculation of DUESO: D-C.

4. Results

4.1. Reliability

The first judge reanalyzed six survivors' swallows (n=12) for a second time for intra-rater reliability measures. Intra-reliability was measured using the Intraclass Correlation Coefficient (ICC). Intra-rater reliability was as follows: OTT ICC= .94, p<.001, PTT ICC= .99, p<. 001, and DUESO ICC=.95, p<.001. A second judge analyzed a different six survivors' swallows (n=11), as one survivor's second swallow was not included in the analysis. Inter-reliability was as follows: OTT ICC= .98, p< .001, PTT ICC= .95, p< .001, and DUESO ICC= .96, p< .001.

4.2. Oral Transit Time (OTT)

The means (M) and standard deviations (SD) of the two groups for OTT are shown in (Figure 2). There were no significant differences between stroke and head and neck cancer survivors for the OTT (F (1, 53) = .597, p = .443) Head and neck cancer survivors tend to have longer oral transition of the bolus than stroke survivors, but it was not significant.

4.3. Pharyngeal Transit Time (PTT)

The means (M) and standard deviations (SD) of the two groups for PTT are shown in (Figure 3). Stroke survivors were observed to have longer pharyngeal transit times (M= 1.125) than head and neck cancer survivors (M= .694). There was a significant result for the timing difference of the PTT between the two groups (F(1,53) = 27.058, p < .001)

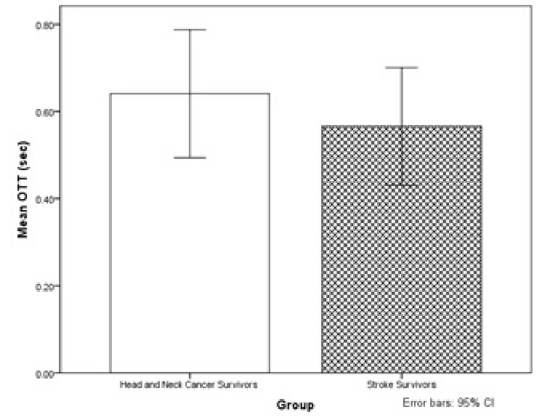

Figure 2: Mean and confidence intervals (95%) of oral transit time between stroke and head and neck cancer survivors.

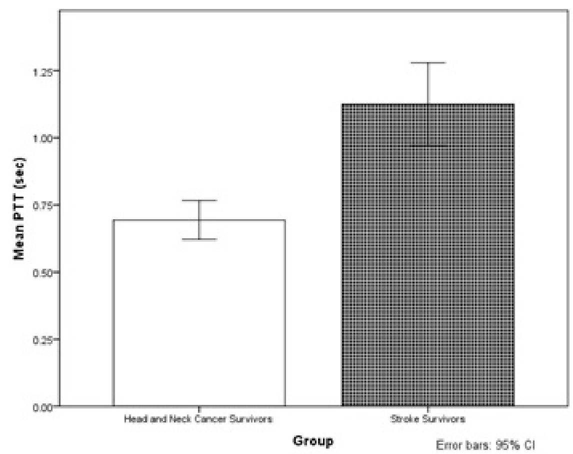

Figure 3: Mean and confidence intervals (95%) of pharyngeal transit time between stroke and head and neck cancer survivors.

4.4. Duration of Upper Esophageal Sphincter Opening (DUESO)

The means (M) and standard deviations (SD) of the two groups for DUESO are shown in (Figure 4). There was a significant difference of DUESO between the two groups (F(1,53) = 11.265, p = .001) Stroke survivors were observed to have longer UES opening (M= .580) than the head and neck cancer survivors (M= .468).

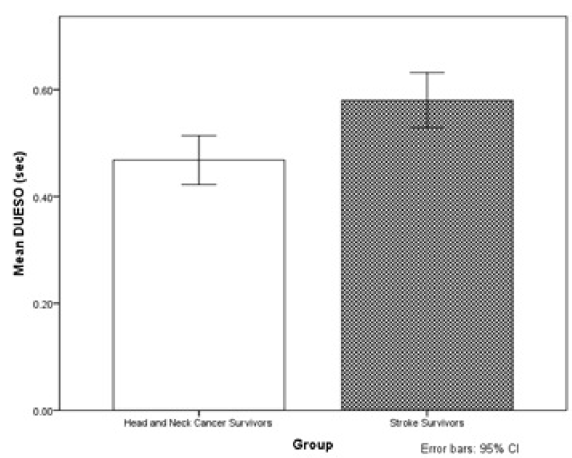

Figure 4: Mean and confidence intervals (95%) of pharyngeal transit time between stroke and head and neck cancer survivors.

5. Discussion

The purpose of this study was to determine differences across three oropharyngeal transition times between head and neck cancer survivors and stroke survivors. Results provided evidence for significantly longer Pharyngeal Transit Time (PTT) and longer Duration of Upper Esophageal Sphincter Opening (DUESO) in stroke survivors compared to head and neck cancer survivors. Head and neck cancer survivors presented with longer Oral Transit Time (OTT) compared to stroke survivors; however, these results were not significant.

The head and neck cancer group in this study presented with a longer OTT than the stroke survivors; although, this result was not significant. Overall, it is evident that the oral structures functioned more effectively in the stroke group than the other. A missing or affected structure in head and neck cancer survivors could play an important role in swallowing due to the type of cancer, as well as, the treatment methods used to remediate the cancerous lesions. Intervention methods for head and neck cancer consist of surgical removal of the tumor, radiation therapy, chemotherapy, or a mixture of these methods. Regardless of the type of intervention, oral and pharyngeal structures are significantly targeted. These structures could be targeted directly or peripherally, hence possibly causing a longer oral transition of the bolus in this population. There are several exceptions to this. In the head and neck cancer group, two survivors performed bolus transitioning through the oral cavity in less than 0.25 seconds. Both survivors had undergone surgical removal of a secondary swallowing structure, including a tonsillectomy and uvulopalatopharyngoplasty. This result provides evidence that surgical excision of oral structures can lessen the severity of swallowing deficits and transition timings when compared to primary structure excision, chemotherapy, radiotherapy, or a mixture of these methods. On the other hand, two of the stroke survivors had an OTT of longer than 1 second. This could be due to delayed sensory and motor functioning due to the severity of the neurological impairment by the cerebrovascular accident.

Neurological damage impacts sensory, motor, or mixed nerve functioning depending on the area of lesion [21]. This lack of sensation and motor functioning could explain the longer PTT as more residual bolus in the stroke survivor group compared to those in the other group. Stroke survivors did not show an effort to clear this residual bolus out of their pharyngeal cavity. This provides evidence for a sensory and motor deficit for the stroke survivor group, as previous research documented [22, 23]. With this lack of sensation, it makes it more difficult for these individuals to initiate the pharyngeal swallow. Previous research reported that in individuals with neurologic damage, increased PTT has been commonly noted due to a delay in triggering the pharyngeal swallow [24, 25]. This, in turn, impacts how these individuals interpret how much bolus is left after the first swallow is complete. Neuromuscular damage could also have a negative effect in the oropharyngeal muscles. If these muscles involved in the pharyngeal swallow are not working at full function, it can make the bolus transition process much longer. When compared to the head and neck cancer survivors (n=10), a limited number of stroke survivors attempted to clear the residual bolus out of the pharyngeal cavity (n=6). Longer DUESO has been previously reported when comparing swallows of stroke survivors and normal individuals [26]. Kim et al. suggested that the longer DUESO in stroke survivors could be attributed to the compensation for the already longer pharyngeal transit time. This could explain that the UES stays open longer for the increased length of bolus transit through the pharynx. UES opening could also be prolonged due to bolus length, as bolus length contributes to increased pharyngeal transit time [26]. It would be of relevance to assume that the duration of UES opening would be impacted by the PTT. As the bolus is moving through the pharynx, the bolus would start moving into the UES with an increased opening time in order for all bolus to completely go through.

Otherwise, although bolus residue was present in the head and neck cancer survivor group, most individuals attempted to clear the bolus residue with multiple swallows. Prior research has documented that this is a compensatory strategy to clear pharyngeal residue in head and neck cancer survivors after chemoradiation treatment [27, 28].

The other possible effect of longer pharyngeal transition could be due to age, as individuals in the stroke survivor group were relatively older than the other group. Previous research states that as an individual ages, they swallow more slowly due to an overall slowing of both the sensory and motor activities of the central nervous system [29]. Individuals in the stroke survivor group had a mean age of (M=69.13) and in the head and neck cancer survivor group, the mean age of survivors was (M=53.73). It can be assumed that some of this significant timing difference could be due to age progression and the natural deterioration of the nervous system over time. However, it is difficult to make an assumption about how much of an impact age has.

Although stroke survivors have significantly longer PTT and DUESO timings, it is important to note that timing deficits in the head and neck cancer group still may be present. Medical intervention may have an effect on oropharyngeal transition of the bolus during swallowing. Eight individuals in this study had undergone surgical removal of a prominent swallowing structure. Surgical removal impacts the duration of the oral preparatory, oral propulsive and pharyngeal stages [8]. Longer OTT in head and neck cancer survivors was observed compared to the stroke survivors, although this result was not significant. Head and neck cancer survivors typically have longer pharyngeal stage timings compared to normal controls. This can provide some evidence that the transition times for both groups in this study could be prolonged compared to normal individuals. It is important that researchers analyze the data from this study compared to normal control data in the future for more evidence.

Head and neck cancer survivors did exhibit residual bolus in the oral cavity. Tongue resection plays a major factor in the amount of residual bolus in both the oral cavity and pharyngeal cavity. Due to the lack of motor movement and lack of pharyngeal pressure, it makes it difficult for these patients to propel the bolus consistently throughout the swallow. One survivor in this study had undergone a near total glossectomy. This patient exhibited excessive oral and pharyngeal residue compared to the other individuals in the group. It provides evidence that the larger the degree of resection, the more impaired swallowing becomes.

A unique observation for the head and neck cancer group was the lack of pharyngeal pressure compared to the stroke group. Four individuals in this study had undergone surgical removal of areas of the larynx. Prior research provides evidence that individuals that undergo total laryngeal excision have a lack of proper pressure to propel bolus efficiently [30]. Another impact of this type of excision includes the discoordination of the pharyngeal constrictors and relaxation of the pharyngoespophageal segment [30]. This discoordination was clearly present in these swallows.

One individual in the head and neck cancer group presented with a lack of complete UES opening. This individual may have a significant lack of pressure to completely open the UES or there may be a muscular discoordination of the UES making it difficult for it to open fully.

Six individuals, three in either group, presented with aspiration. Each case of aspiration was due to a different explanation. Penetration was a common occurrence in both groups. Nine head and neck cancer survivors and ten stroke survivors had penetration occurrences. Since only one bolus volume and consistency was studied in this analysis, it is difficult to determine how common the tendencies of aspiration were for each of these six aspirators. The etiologies surrounding each group is vastly different, as well as the reasons for the swallowing deficiencies. Physiological bases of aspiration and penetration in the stroke survivor group could be explained by the motor and sensory deficits from the neurologic damage. In the head and neck cancer group, penetration could be explained by the negative effects of treatment undergone. The findings of this study will provide a general overview how two groups of survivors are different in oropharyngeal transition of the bolus during swallowing. Since only one bolus volume and consistency was studied in this analysis, it is difficult to determine how common the tendencies of aspiration were for each of these six aspirators. In addition, the larger the bolus, the easier it would be for the survivors to sense the excess residual bolus. If swallows with a bolus of larger volume or higher consistency were compared to the 5ml swallow, there would have been a clearer understanding about the sensation deficits of the survivors.

This study provided evidence that post-stroke survivors and post-treatment head and neck cancer survivors showed high risk of swallowing difficulties depending on the varying etiologies. Stroke survivors developed different swallowing disturbances depending on the location of the lesion. Head and neck cancer survivors' swallows differ based on the site of cancer, as well as the intervention method [8]. It is important to note the relevance of these differences to effectively treat patients with swallowing disorders clinically. Another important consideration could be the presence of both disorders across a person's lifespan. Studying swallowing differences across both populations is warranted when treating patients that have undergone a stroke and have been treated for head and neck cancer. Specific swallowing differences for each group have been noted. Patients may present with differences that are common to each specific group. Clinicians should understand these distinct trends and disturbances across both types to accurately treat patients.

There are several limitations to this study. The individuals in this study were not age-matched due to the limited number of head and neck cancer survivor clips. This makes it difficult to determine the similarities or differences based on gradual natural deterioration of the swallowing mechanisms as individual's age. The head and neck cancer group consisted of many different types of survivors. As previously stated, individuals in this group had cancerous lesions in the tongue (n=3), tonsils (n=1), nasopharynx (n=2), pharynx (n=4) and larynx (n=5). Along with varying cancerous lesion locations, different interventions were utilized for these patients and length of post-treatment ranged from 1 month to 9 years. This makes it difficult to generalize head and neck cancer differences as a whole when compared to stroke survivors.

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