Does Epiglottic Deflection Contribute to Airway Protection in Patients Living With Dementia?

La bascule de l'épiglotte contribue-t-elle à protéger les voies respiratoires chez les patients atteints de démence?

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Abstract

Epiglottic deflection is thought to help prevent airway invasion by sealing off the laryngeal vestibule during a normal swallow. This study examines epiglottic deflection and its relationship with airway protection in patients living with dementia. Through a retrospective analysis of videofluoroscopy swallowing studies, thin liquid swallow trials from 44 participants (age range 46–100 years) were extracted and analyzed in duplicate by blinded raters. The raters judged epiglottic deflection using the Modified Barium Swallow Impairment Profile (Martin-Harris, 2018) and airway invasion during the swallow using the Penetration-Aspiration Scale (Rosenbek et al., 1996). We converted epiglottic deflection and Penetration-Aspiration Scale scores to binary variables in order to conduct chi-square tests to compare airway invasion versus no airway invasion and complete versus incomplete epiglottic deflection. Analyses revealed no significant differences in swallow safety based on epiglottic deflection. We conducted post hoc analyses to determine the reason for incomplete epiglottic deflection based on previous literature suggesting that epiglottic movement is dependent on hyoid movement, base of tongue retraction, laryngeal vestibule closure, and/or reduced pharyngeal constriction. Binary logistic regression analysis demonstrated that epiglottic deflection was only influenced by hyoid movement in this sample. This study suggests that the epiglottis does not play a vital role in airway protection in patients with dementia, and its deflection is solely related to hyoid displacement in this population. Future research should investigate the physiological impairments interfering with mechanisms of airway protection and the kinematics related to epiglottic deflection in patients with dementia.

Abrégé

On suppose que la bascule de l'épiglotte, lors d'une déglutition normale, aide à prévenir l'entrée de corps étrangers dans les voies respiratoires en scellant le vestibule laryngé. La présente étude a examiné la relation entre la bascule de l'épiglotte et la protection des voies respiratoires chez les patients atteints de démence. Dans le cadre d'une analyse rétrospective d'examens vidéofluoroscopiques de la déglutition, des essais de liquides clairs réalisés auprès de 44 participants (âgés de 46 à 100 ans) ont été extraits et analysés à l'aveugle à deux reprises par des évaluateurs. Ceux-ci ont utilisé le *Modified Barium Swallow Impairment Profile* (Martin-Harris, 2018) et la *Penetration-Aspiration Scale* (Rosenbek et al., 1996) pour évaluer, respectivement, la bascule de l'épiglotte et l'entrée d'un corps étranger dans les voies respiratoires. Les scores du *Modified Barium Swallow Impairment Profile* et de la *Penetration-Aspiration Scale* ont été convertis en des variables binaires afin d'être en mesure de réaliser des tests du khi carré qui comparent la présence versus l'absence d'un corps étranger dans les voies respiratoires et la bascule complète versus incomplète de l'épiglotte pendant la déglutition. Les résultats de ces analyses n'ont révélé aucune relation significative entre la protection des voies respiratoires et la bascule de l'épiglotte. En s'appuyant sur les résultats d'études antérieures suggérant que la bascule de l'épiglotte dépend du mouvement de l'os hyoïde, du mouvement de rétraction de la base de la langue, de la fermeture du vestibule laryngé et/ou d'une constriction pharyngée diminuée, des analyses *post hoc* ont également été réalisées afin de déterminer les raisons pouvant expliquer la présence d'une bascule de l'épiglotte incomplète. Les résultats de la régression logistique binaire réalisée ont montré que la bascule de l'épiglotte était seulement influencée par le mouvement de l'os hyoïde dans notre échantillon. Les résultats de la présente étude suggèrent ainsi que la bascule de l'épiglotte ne joue pas un rôle essentiel dans la protection des voies respiratoires chez les patients atteints de démence et que seul le déplacement de l'os hyoïde y serait lié dans cette population. Les recherches futures devraient investiguer les déficits physiologiques interférant avec les mécanismes de protection des voies respiratoires et avec le mouvement lié à la bascule de l'épiglotte chez les patients atteints de démence.

An effective swallow must encompass two things: (a) safe transport of the bolus from the oral cavity and into the esophagus without entering the airway and (b) efficient travel of the bolus through the oropharynx and into the esophagus while leaving minimal residue behind. During a normal swallow there are multiple defense mechanisms involved in closing off the airway: hyolaryngeal excursion, epiglottic deflection, approximation of arytenoids to the epiglottic petiole, and closure of the true and false vocal folds (Vose & Humbert, 2019). Laryngeal vestibule closure (i.e., the area located above the vocal folds and below the laryngeal inlet where the arytenoid cartilages approximate with the epiglottic petiole and the epiglottis fully inverts) is described as the first line of defense for prevention of material from entering the airway during the swallow (Vose & Humbert, 2019). In order to keep foreign material from entering the laryngeal vestibule, the arytenoid cartilages must approximate with the base of the epiglottis and the epiglottis must then invert over the inlet (Shaker et al., 1990). The function of this mechanism is to deter material from entering the airway.

The prevalence of dysphagia ranges from 84%–93% amongst patients who are diagnosed with dementia (Affoo et al., 2013). A major consequence of dysphagia is aspiration, or the action of material entering the laryngeal vestibule and passing below the vocal folds, which can increase the risk of developing a lung infection. It is widely recognized that the comprehensive colonization of aspirated material in the lungs can place a patient with dysphagia at an increased risk of aspiration pneumonia (Langmore et al., 1998). People who are living with dementia are at high risk for acquiring pneumonia (Lipsky et al., 1986). To reduce the risk of acquiring pneumonia, Logemann et al. (2008) analyzed the effectiveness of using thin liquids with a chin-down posture versus nectar-thickened liquids versus honey-thickened liquids in patients with dementia and Parkinson's disease. They found that patients aspirated significantly more on thin liquids with a chin-down posture than with nectar- or honey-thickened liquids. Kuhlemeier et al. (2001) also reported highest aspiration rates for patients with thin liquids versus thicker liquid consistencies. However, even though thickened liquids may reduce the rates of airway invasion, patients report dissatisfaction with liquid modifications subsequently resulting in noncompliance with compensations (King & Ligman, 2011). As such, it may be helpful to better understand the mechanisms of impaired swallow safety in order to improve swallowing of thin liquids through rehabilitation, rather than compensating for the problem through the use of thickened fluids. Given that several mechanisms are thought to contribute to swallow safety, it is important that each mechanism is analyzed individually to understand its unique contribution to normal swallowing function. One such mechanism is epiglottic deflection. Lack of epiglottic deflection may lead to reduced airway protection, further increasing the risk of aspiration pneumonia.

Previous studies examining airway protection have assessed epiglottic movement and/or timing (Ekberg & Sigurjónsson, 1982; Kang et al., 2010), citing the importance of epiglottic movement in protecting the airway. Other research, such as a study by Leder et al. (2010), has suggested that epiglottic deflection is not a critical part of airway protection. Leder et al.'s study analyzed airway protection in three head and neck cancer patients post-epiglottectomy and found that all participants exhibited successful swallowing with all food types even in the absence of an epiglottis. Their work suggested that perhaps the epiglottis is not an essential mechanism contributing to airway protection when neuromuscular functioning remains intact. Previous literature has also suggested that epiglottic deflection is linked to laryngeal vestibule closure, base of tongue retraction, hyoid movement, aryepiglottic muscle contraction, and pharyngeal constriction (Vose & Humbert, 2019).

Given this information, the intent of this study was to uncover the relationship between epiglottic deflection and airway safety, and better understand the physiologic mechanisms contributing to epiglottic inversion. In order to provide skillful care for patients living with dementia, we must identify the physiological impairments interfering with airway protection and create effective therapeutic rehabilitation protocols. As such, the purpose of this study was to uncover the role of the epiglottis in airway protection for people living with dementia. Given previous research with patients living with dementia suggesting decreased epiglottic inversion (i.e., Feinberg et al., 1992; Suh et al., 2009) despite reports of airway invasion (Finucane et al., 1999; Kuhlemeier et al., 2001; Namasivayam-MacDonald & Riquelme, 2019), we hypothesized that epiglottic inversion would not play a vital role in reducing the risks of laryngeal penetration and/or aspiration by closing off the airway in this population.

Method

This study involved a retrospective analysis of videofluoroscopic swallowing study (VFSS) recordings from an acute care hospital and was approved by the institutional research ethics boards at NewYork-Presbyterian Brooklyn Methodist Hospital (#1142588) and Adelphi University (#122117).

Participants

This study included any patient with a medical diagnosis of dementia, per a neurologist as recorded within their medical record, who was referred to speech-language pathology for a swallowing consult and subsequently required an instrumental assessment from January 2016 to December 2017. Given the retrospective nature of this study, the type and severity of the dementia diagnosis was unknown. We only included VFSS that trialed thin liquids as a part of the clinical protocol. We excluded VFSS that were of poor quality (i.e., unable to discern swallowing-related anatomy due to artifact) or swallows where airway invasion occurred before or after the swallow. We were interested only in swallows where there was no airway invasion or airway invasion during the swallow, in order to easily tease apart the role of the epiglottis in airway protection during the swallow. Based on these inclusion and exclusion criteria, 44 participants (age, *M* = 84 years, range = 46–100; 19 women) with a total of 153 thin liquid swallows were included in the analysis of epiglottic deflection and airway invasion. The amount of trials examined per participant varied from one to 10 based on the available data. Thin liquids were chosen as they pose the greatest risk for aspiration.

Data Collection

VFSS were conducted using a KayPentax Digital Swallow Workstation recording system, with the fluoroscope in lateral view at 30 pulses per second and were captured and recorded at 30 frames per second. Each participant performed a series of swallowing tasks with varying bolus sizes and consistencies. For the thin liquid tasks, participants were instructed to self-administer a single sip of the thin liquid from a cup in their usual manner, therefore exact volume of the liquid boluses was not documented. Standardized 40% weight/volume thin liquid barium from Varibar (Bracco Industries; International Dysphagia Diet Standardisation Initiative level 0) was used for all thin liquid swallowing tasks. The exact volume of the liquid boluses administered was not documented, given that these were clinical videos and natural sip sizes were encouraged.

Data Processing

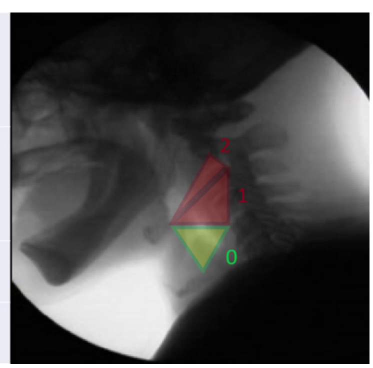
The clinical VFSS were first spliced into bolus-level clips, each containing the swallowing events for the administration of a single bolus, using Corel Video Studio Pro, and were assigned an alphanumeric code. For each of the thin liquid bolus-level clips available in the dataset, the number of subswallows was recorded. These bolus-level clips contained the swallowing behaviours and swallowing sequence elicited after providing the patient with a single bolus trial. A subswallow was considered to be a single swallow within the swallow sequence captured within the bolus-level clips.

VFSS Rating

Two trained and blinded research assistants analyzed the bolus-level clips frame-by-frame using ImageJ software. These raters were second year clinical Master's students studying speech-language pathology. Prior to analyzing the data for the current study, they had completed extensive training in VFSS analysis that included practice ratings, comparison of ratings, and meetings to address any discrepancies. Both students had 8 months of experience in analyzing videos before conducting the current study and had completed the Modified Barium Study Impairment Profile (Martin-Harris, 2018) student training, with scores over 75% on the Reliability Zone. The current study used the ASPEKT method (Analysis of Swallowing Physiology: Events, Kinematics and Timing) to analyze the VFSS recordings (Steele et al., 2019). Only the initial swallow of each thin liquid bolus trial was judged. Per the ASPEKT guidelines, a swallow is qualified as such when at least one of laryngeal elevation, hyoid excursion, and/or pharyngeal constriction *and* upper esophageal sphincter opening is present. Epiglottic deflection was judged at the frame of peak hyoid excursion as per Component 10 of the Modified Barium Swallow Impairment Profile: Epiglottic Movement (Martin-Harris, 2018; see **Figure 1**). The frame of peak hyoid excursion was defined as the frame where the hyoid appears to be in the most anterior-superior position. Airway invasion was judged using the 8-point Penetration-Aspiration Scale (PAS; Rosenbek et al., 1996). A score of 1 indicates no airway invasion, whereas scores of 2 and higher indicate presence of airway invasion with varying degrees of depth of airway

Figure 1

Component 10 - Epiglottic Movement
0 = Complete Inversion
1 = Partial Inversion
2 = No Inversion



Rating options for Component 10 of the Modified Barium Swallow Impairment Profile: Epiglottic Movement, where a rating of 0 is considered normal and ratings of 1 and 2 are considered disordered.

invasion, responses to this invasion and efficiency of the response (Rosenbek et al., 1996). More specifically, scores of 2 to 5 indicate penetration (airway invasion to the level of the vocal folds or above) and scores of 6 to 8 indicate aspiration (airway invasion below the level of the vocal folds).

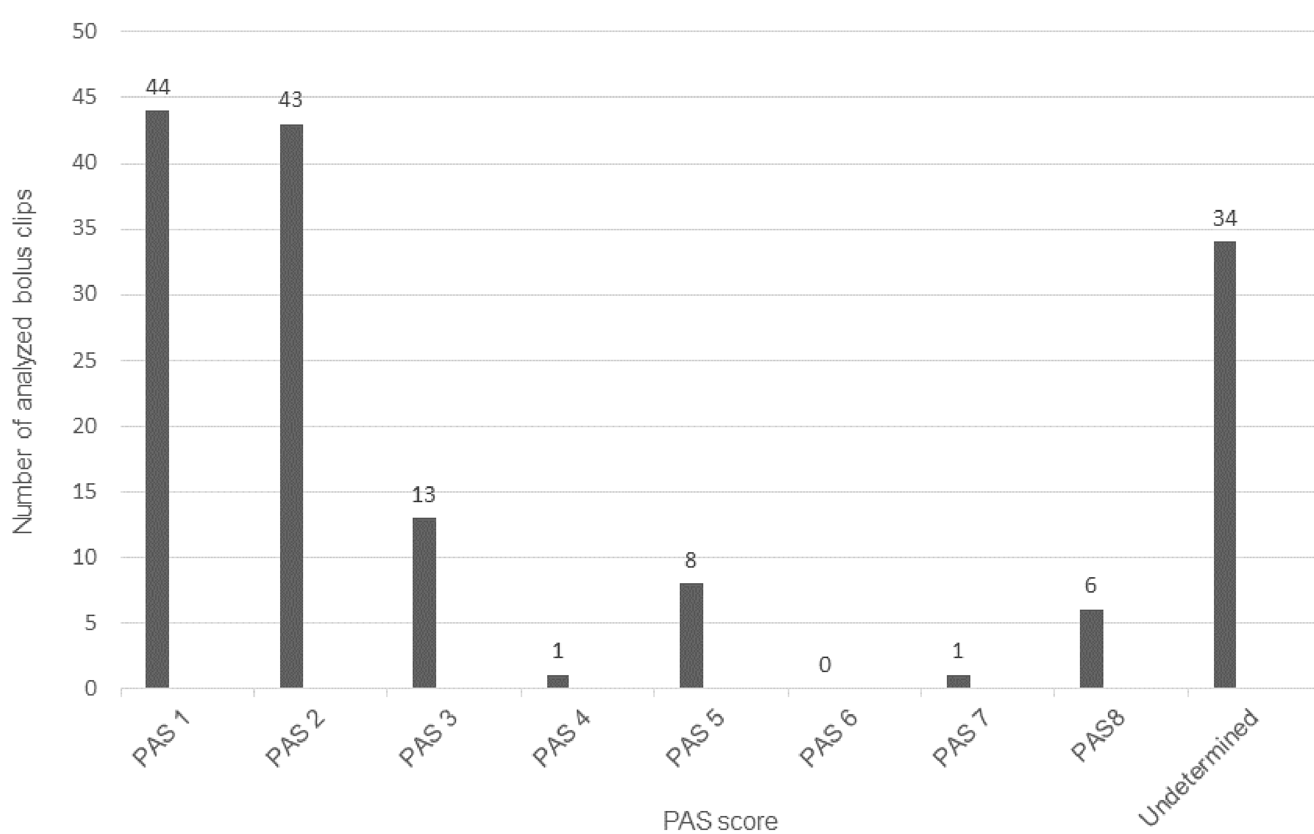
Analyses

Two-way mixed intraclass correlation coefficients were used to determine interrater reliability using a random selection of 20% of the swallows in the dataset. Descriptive statistics were used to describe the frequency of each rating of epiglottic movement and each PAS score in this dataset. The highest PAS score, indicating the worst score, for each trial was used during analysis. Both epiglottic movement and PAS scores were converted to binary variables. For epiglottic movement, the variable was divided into scores reflecting complete deflection (score of 0) versus incomplete deflection (score of 1 or 2). Airway invasion was divided into PAS scores reflecting no airway invasion (score of 1) versus presence of airway invasion (scores of 2–8; Rosenbek et al., 1996). Using these binary variables, chi-square tests were used to determine if a relationship existed between complete epiglottic deflection and airway protection. All analyses were performed using SPSS (Version 25).

Results

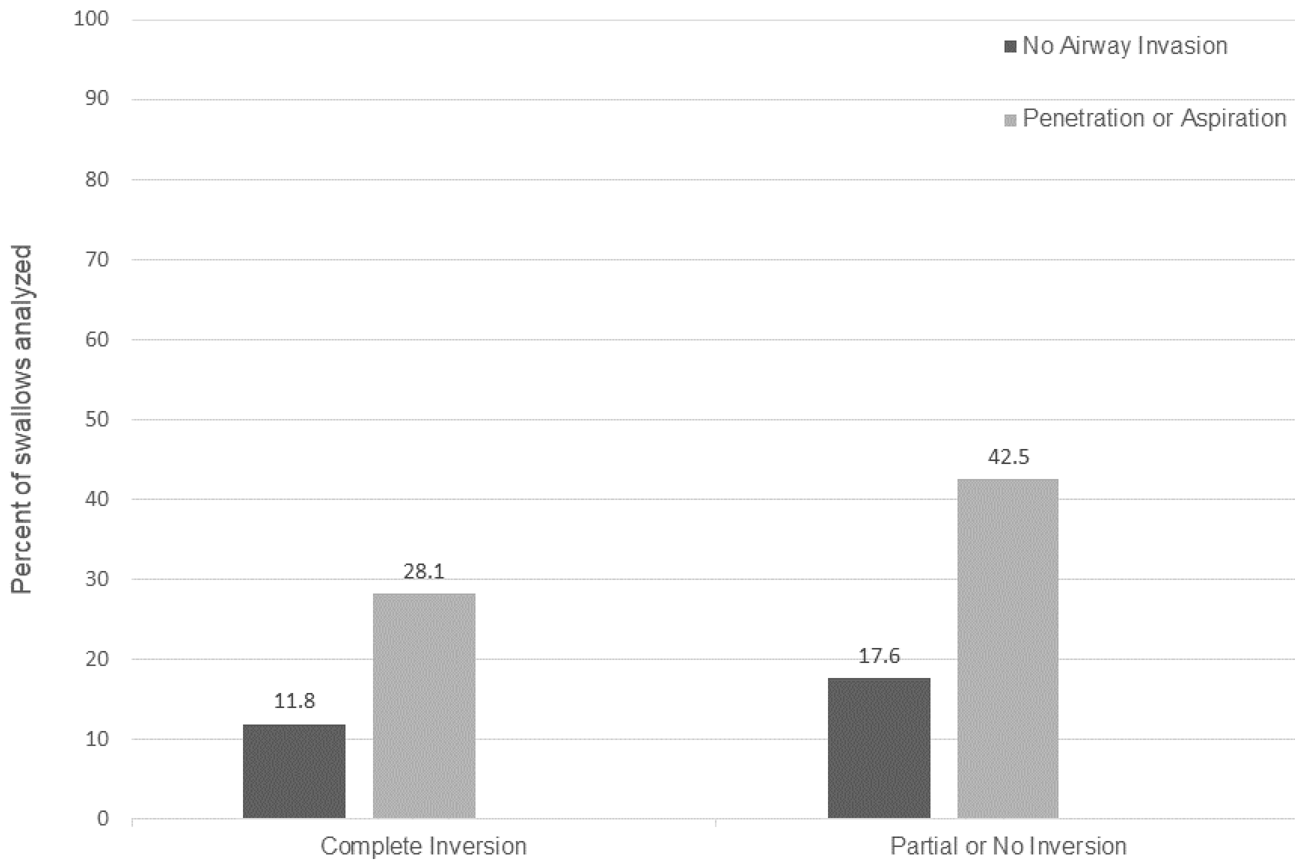
Two-way mixed intraclass correlation coefficients demonstrated interrater reliability between 0.92 and 1.00 with 95% confidence intervals reflecting excellent agreement, using a random selection of 20% of the swallows in the dataset. **Figure 2** displays the range of PAS scores (1–8) that define the swallows trials included in this dataset. Descriptive statistics for ratings of epiglottic deflection and PAS can be found in **Figure 3**. This figure shows the relationship between epiglottic deflection and airway invasion in this population. A total of 153 swallows were

Figure 2



Number of analyzed bolus clips vs. PAS score. Graphic display of the range of Penetration-Aspiration Scale (PAS) scores (1–8) that define the swallows trials included in this dataset. Scores that were "undetermined" indicate that airway invasion clearly occurred but video quality prevented raters from confidently provided a final PAS score.

Figure 3



Relationship between epiglottic inversion and airway inversion in patients living with dementia.

analyzed, of which 61 (39.9%) showed complete epiglottic deflection at the frame of peak hyoid excursion. Forty-three of the 61 swallows (70.5%) with complete epiglottic deflection also demonstrated airway invasion during the swallow. Conversely, 92 of the 153 swallows analyzed (60.1%) showed incomplete epiglottic deflection at the frame of peak hyoid excursion, of which 27 (29.3%) demonstrated no airway invasion. A chi-square test revealed no clear relationship between epiglottic deflection and airway invasion, X2(1) = 0.00, p = .983. In other words, incomplete epiglottic deflection did not always result in airway invasion and complete epiglottic deflection did not always result in airway protection from foreign material. These results suggest the influence of other defense mechanisms involved in airway protection aside from epiglottic deflection, including hyolaryngeal excursion, approximation of the arytenoids to the epiglottic petiole, and closure of the true and false vocal folds.

Post Hoc Analysis

Given the null findings from our original research question, we became interested in better understanding epiglottic deflection in the dementia population. More specifically, the large number of swallows that displayed incomplete epiglottic deflection led us to question why this might be occurring. Previous literature has suggested that epiglottic deflection is linked to laryngeal vestibule closure, base of tongue retraction, hyoid movement, aryepiglottic muscle contraction, and pharyngeal constriction (Vose & Humbert, 2019). Therefore, we conducted post hoc analyses to determine if the incomplete epiglottic deflection seen in 60% of the swallows initially analyzed was the result of other impaired physiology. Binary logistic regression analyses were performed to examine the factors contributing to epiglottic deflection. Variables included in the regression analysis were selected and extracted for inclusion based on previous dysphagia literature and a priori reasoning. The ratings of the following variables were included: complete laryngeal vestibule closure, complete base of tongue retraction, peak hyoid movement, and maximum pharyngeal constriction.

As outlined by the Modified Barium Swallow Impairment Profile, *complete laryngeal vestibule closure* is defined as complete approximation of the arytenoid cartilages to the epiglottic petiole, with no consolidation or airspace remaining in the laryngeal vestibule (Martin-Harris, 2018). Laryngeal vestibule closure was judged using this criterion at the height of the swallow during the frame of peak hyoid position. A total of 116 swallows were analyzed where scores were converted into binary variables: complete laryngeal vestibule closure versus incomplete laryngeal vestibule closure.

Complete tongue base retraction is defined as posterior retraction of the tongue resulting in approximation of the tongue base with the superior and middle posterior pharyngeal wall with no consolidation or airspace remaining between the tongue base and posterior pharyngeal wall (Martin-Harris, 2018). This component was judged at the frame of maximum retraction of the tongue base. A total of 138 swallows were analyzed where scores were converted into binary variables: complete tongue base retraction versus incomplete tongue base retraction.

The *frame of peak hyoid excursion* was defined as the earliest frame in which the hyoid reached its most superior-anterior position. Peak hyoid position was then measured as a percentage of the C2–C4 reference scalar at this frame using ImageJ software. The anatomical scalar was defined by Molfenter and Steele (2014), who found that superior hyoid displacement, hypotenuse displacement, and maximal XY position of the hyoid is dependent on a person's cervical spine length and the "size-of-the-system" when the anterior-inferior corner of the C4 vertebra is the origin, anterior inferior corner of the C2 vertebra is the Y vector, with the Y-axis defined parallel to the spine. This measurement of peak hyoid position at the frame of peak hyoid excursion was then compared to normative values that were based on a healthy sample (Steele et al., 2019) to ascertain if hyoid excursion was indeed sufficient. Based on this comparison, scores were converted to binary variables: complete (sufficient) hyoid excursion versus incomplete (insufficient) hyoid excursion. A total of 81 swallows were analyzed to determine if there was a relationship between peak hyoid excursion and complete epiglottic deflection.

As per ASPEKT methodology (Steele et al., 2019), anatomically normalized pixel-based measures of maximum pharyngeal constriction were expressed as a percentage of the squared C2–C4 reference areas. The frame of maximum pharyngeal constriction was defined as the earliest frame in which there was the least amount of bolus flow and/or airspace in the pharynx; before the upper pharynx began to relax; before the laryngeal air column began to descend; and before the hyoid began an inferior, posterior movement from its most superior-anterior position. At this frame, pixel-based measures of bolus residue and/or any visible air space in the pharynx were made using ImageJ software. The following boundaries were used to define the pharynx: the posterior pharyngeal wall as the posterior boundary, a line perpendicular to the spine connecting the top of the C2 vertebra to the tongue base as the superior boundary, the pit of the pyriform sinuses, superior to the upper esophageal sphincter as the inferior boundary, and the base of tongue and pharyngeal surface of the epiglottis, connecting the base of the epiglottic petiole to the arytenoid cartilage as the anterior boundary. The pharyngeal area measurements were normalized using the squared C2–C4 length to account for pharyngeal size differences (Molfenter & Steele, 2014). The measurements were then compared to normative cutoff scores that were based on a healthy sample (Steele et al., 2019) and scores were converted to binary variables: impaired maximum pharyngeal constriction versus maximum pharyngeal constriction within normal limits. Data was available for 74 swallows in order to analyze for the relationship between maximum pharyngeal constriction and complete epiglottic deflection.

Once all ratings were complete, backwards binary logistic regression analyses were performed to examine the factors contributing to epiglottic deflection within our post hoc analysis. Variables included in the regression analysis were selected and extracted for inclusion based on previous dysphagia literature and a priori reasoning. The ratings of the following variables were included: complete laryngeal vestibule closure, complete base of tongue retraction, peak hyoid movement, and maximum pharyngeal constriction. The probability threshold for removal was set at .05.

Post Hoc Analysis Results

The model for epiglottic deflection explained 22% (Nagelkerke R2) of the variance and correctly classified 64% of cases. As seen in **Table 1**, the epiglottis was 4.09 times more likely to fully invert when the hyoid was able to reach its peak position. Complete laryngeal vestibule closure, complete tongue base retraction, and maximum pharyngeal constriction did not add significantly to the model. In other words, these factors were not found to increase the likelihood of epiglottic deflection.

Table 1

Results of Binary Logistic Regression to Identify the Determinants of Epiglottic Deflection in Patients Living With Dementia

Variable	Parameter estimate	95% CI		*p*
		LL	*UL*	
Complete laryngeal vestibule closure	1.71	0.39	7.44	.474
Complete base of tongue retraction	0.33	0.03	3.85	.373
Maximum pharyngeal constriction	0.00	0.00	0.00	.999
Peak hyoid movement	4.09	0.95	17.56	.048*

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.
* = statistically significant change.

Discussion

The purpose of our study was to investigate the relationship between epiglottic deflection and airway invasion during the swallow in patients with dementia during thin liquid swallows. In contrast to previous studies that suggested the necessity of the epiglottis for airway protection (Ekberg & Sigurjónsson, 1982; Kang et al., 2010), we hypothesized that epiglottic deflection would not correlate significantly with airway protection during the swallow. The results of our study support our hypothesis and suggest that epiglottic deflection alone is not a critical component of airway protection for thin liquid boluses in patients living with dementia. That is not to say that epiglottic inversion does not play a role in airway protection but that it can be an additional, contributing component to airway protection, rather than an essential, first line of defense in protecting foreign materials from entering the airway. Our findings align with those of Leder et al. (2010) who also supported the non-essential nature of the epiglottis for airway protection. As mentioned previously, the researchers examined three patients with isolated epiglottectomies (one due to trauma, one surgery, and the other cancerous erosion) who all reached success swallowing thin liquid, puree, and solids without aspiration.

We also pursued post hoc analyses to examine the physiology suggested to contribute to epiglottic deflection after considering the outcomes of our initial study question and the literature supporting the relationship between epiglottic deflection and laryngeal vestibule closure, tongue base retraction, hyoid excursion, and pharyngeal constriction. Our analyses indicated no relationship between epiglottic deflection and laryngeal vestibule closure, tongue base retraction, nor pharyngeal constriction, but a significant relationship with peak hyoid movement. This is in line with Vandaele et al.'s (1995) research and suggests that these factors may not be the primary biomechanical impairments associated with reduced epiglottic inversion in this population.

Studies examining epiglottic deflection generally classify its movement into two phases: the first from its resting upright position until it reaches horizontal, and the second, subsequent movement from the horizontal position to full inversion. A retrospective study by Pearson et al. (2016) assessed hyoid excursion, pharyngeal constriction, tongue base movement, and laryngeal movement during pharyngeal swallowing of thin and pudding consistencies to determine the relationship between functional anatomy and impaired epiglottic movement. Participants included patients with etiologies or comorbidities of dysphagia including head and neck cancer, neurological disorders, gastroesophageal reflux disease or globus sensation, and respiratory diseases. Contrary to our findings, Pearson et al. found reduced laryngeal elevation and reduced tongue base retraction as the basis of impairment in both the first and second movements of the epiglottis, when in the presence of functional hyoid movement. This suggests that the effects of underlying anatomy on epiglottic movement may vary with patient etiologies and comorbidities of dysphagia. Vandaele et al. (1995) used laryngeal microdissection and videofluoroscopy of 20 human cadavers to examine the movements of the epiglottis as it relates to the movements of other laryngeal and pharyngeal structures. Essentially, they found the first movement of the epiglottis in direct relationship with tongue motion and the second movement of the epiglottis the result of passive forces generated by movement of the hyoid bone and thyroid cartilage. Interestingly, Ekberg and Sigurjónsson (1982) determined the second movement was a result of peristalsis of the pharyngeal muscles in a constricting manner. We decided to examine epiglottic deflection at the point of peak hyoid position because once the hyoid begins to descend in a posterior, inferior fashion, pharyngeal constriction reduces. It was expected that at the point of the hyoid's most superior, anterior position and the pharynx's tightest constriction, the epiglottis would be at its most complete inversion. However, our study found no significant relationship between maximal pharyngeal constriction and epiglottic deflection in the dementia population. This again suggests that differences in underlying etiologies and comorbidities can affect the impact of underlying anatomy on epiglottic movement.

The current study found that reduced hyoid movement was the only factor found to significantly contribute to reduced epiglottic inversion in this sample. Vandaele et al. (1995) also asserted the impact of hyoid and thyroid cartilage displacement on the second movement of the epiglottis, while Ekberg and Sigurjónsson (1982) determined that the first movement of the epiglottis was a result of hyoid elevation and approximation of the thyroid cartilage to the hyoid bone. Anecdotally, it is common to see clinical reports citing poor epiglottic deflection as a qualifier for penetration or aspiration events identified via VFSS. Given the depth of literature with overwhelming agreement that epiglottic movement is the result of other anatomical events, it is necessary to consider poor epiglottic movement as merely a passive symptom of decreased function in other areas. As such, it is of great clinical significance for clinicians assessing swallow function to focus not just on the structures and their movement, but to think critically regarding the biomechanical causes of these observed movements.

Limitations

Despite our novel findings in patients with dementia, some limitations of the current study need to be acknowledged. The effects of bolus size on epiglottic movement and presence of airway invasion could not be assessed due to the retrospective nature of our study. Previous research has demonstrated that bolus size, in addition to bolus viscosity, can affect the timing of supraglottic closure and/or pharyngeal constriction, subsequently affecting epiglottic inversion (Logemann et al., 1992). Future work should take into consideration these factors to confirm and tease apart the role of the epiglottis in airway protection. The current study also did not consider whether any airway invasion was subsequently ejected due to laryngeal vestibule closure or patient effort during, and/or if ejection occurred during or after the swallow.

The type and severity of dementia from the participants in this study is also unknown and therefore could not be controlled for in both the initial and post hoc analyses. Previous work has suggested that dysphagia differs based on type of dementia (Alagiakrishnan et al., 2013), so future work should attempt to parse out these differences in more detail and account for the presence of other chronic medical conditions that may influence swallowing. Participants' ages may have also influenced the findings in this study as previous work has found differences in maximum hyoid excursion based on patient age (e.g., Kang et al., 2010). This study was also limited by the use of VFSS for analysis as there are other factors associated with impaired epiglottic inversion that cannot be accurately surmised by visualization alone, including ayepiglottic muscle contraction and calcification of the epiglottis. Finally, the study was limited by the use of epiglottic inversion as a binary variable. Considering the previous research addressed that characterized epiglottic movement as two components, future work should consider differences in incomplete movement, inversion to horizontal, and complete inversion.

Conclusions

In this study, we provide a detailed assessment of the relationship between epiglottic deflection and airway protection during the swallow in the dementia population with thin liquid trials. We also compared the behaviour of four physiological components with epiglottic deflection in the same population. This data revealed a significant relationship between peak hyoid movement and epiglottic deflection. Further assessment should be given towards the effectiveness of therapies that target suprahyoid muscles, longitudinal pharyngeal muscles, and thyrohyoid for improving hyoid excursion and laryngeal elevation to analyze the impact this may have on airway protection for thin liquid boluses in people living with dementia. This will ultimately help to determine the optimal rehabilitative exercises to improve swallowing function and reduce airway invasion, and potential risk for aspiration pneumonia, in this population.

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Disclosures

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