



RESEARCH ARTICLE

IMPACT OF THE LARYNX MOVEMENTS ON THE PROTECTION OF AERIAL WAYS DURING THE DEGLUTITION

¹Michele Rocha da Silva and ^{*2}Maria Cristina de Almeida Freitas Cardoso

¹Post Graduation Program/Programa de Pós-graduação em Ciências da Reabilitação – linha Musculoesquelética/ Universidade Federal de Ciências da Saúde de Porto Alegre (UFCSPA) Porto Alegre/RS, Brasil

²Post Graduation Program/Programa de Pós-graduação em Ciências da Reabilitação – linha Musculoesquelética/Universidade Federal de Ciências da Saúde de Porto Alegre (UFCSPA) Porto Alegre/RS, Brasil

Received 28th March, 2018; Accepted 21st April, 2018; Published 18th May, 2018

ABSTRACT

Introduction: Deglutition, an essential act for the body's nutrition and hydration, is performed through a coordinated sequence of complex and interlinked neuromuscular events. This requires precise coordination among its phases, which will favor deglutition with no food or saliva entering the airways.

Aim: This study aims to analyze the laryngeal movements during deglutition and to verify its impact on airway protection.

Methods: This is a descriptive retrospective study approved by Ethical Committees in Research under protocol numbers 2013/008 and 362.826 that analyzes an image database from the correlation of two assessors, whose study objects are laryngeal movements during deglutition and the outcome of airway protection quality. Fifty-two deglutition video fluoroscopic swallowing studies were analyzed, 26 from males and 26 from females with average age of 76 years. The exams were carried out over one year at a Radiology and Imaging Service in a Primary Health Center, where two independent assessors evaluated laryngeal movements during deglutition, presence of dysphagia, and airway protection quality with liquid and pasty consistencies.

Results: The assessors agreed in all analyzes performed. Among the statistically significant laryngeal movements, inappropriate laryngeal elevation and anteriorization, i.e., lack of anteriorization, reduced elevation, and incomplete and repeated laryngeal elevation, were the most harmful for airway protection. Conclusion: The impact of the lack of or inappropriate laryngeal elevation and anteriorization movements affect the deglutition process and promote laryngeal penetration and tracheal aspiration, which leads to dysphagia.

Key words: Fluoroscopy; Deglutition Disorders; Deglutition; Larynx; Elderly.

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Citation: Michele Rocha da Silva and Maria Cristina de Almeida Freitas Cardoso, 2018. "Impact of the larynx movements on the protection of aerial ways during the deglutition" *International Journal of Current Research in Life Sciences*, 7, (05), 2071-2073.

INTRODUCTION

Deglutition is a complex, dynamic process that takes place with a sequential chain of sensory and motor events so as to transport material from the mouth to the stomach, thus hydrating and nourishing the body, with no particles of such material entering the airways. Deglutition phases are interrelated and can be divided into three phases, or four if the preparatory phase is added: preparatory, oral, pharyngeal, and esophageal phases (Marchesan and Furkim, 2003; Dantas *et al.*, 2009; Logemann, 1983; Cassiani *et al.*, 2011; Matsuo and Palmer, 2008; Logemann, 1998).

***Corresponding author:** Maria Cristina de Almeida Freitas Cardoso, Post Graduation Program/Programa de Pós-graduação em Ciências da Reabilitação – linha Musculoesquelética/Universidade Federal de Ciências da Saúde de Porto Alegre (UFCSPA) Porto Alegre/RS, Brasil.

The preparatory phase basically consists of mastication with its two or three phases (incision, grinding, pulverization), when the bolus is in salivated. It is placed between the tongue and the hard palate before voluntary deglutition begins. During all the preparatory oral phase, the soft palate is in a lower position, helping prevent the bolus from entering the pharynx before deglutition. The soft palate is lowered by the contraction of the palatoglossal muscle. The pharynx and larynx remain at rest. The airway is open and nasal breathing continues until deglutition has taken place (Matsuo and Palmer, 2008; Costa, 1996). The oral phase is called voluntary because it can be controlled. The pharyngeal and esophageal phases are involuntary. In the oral phase, the bolus is sent by the tongue into the pharynx, thus starting the pharyngeal phase of deglutition (Matsuo and Palmer, 2008; Costa, 1996). During the pharyngeal phase, which takes the food from the

oropharynx to the esophagus, a quick sequence of crucial events for deglutition begins, with the elevation and anteriorization of the larynx. This occurs through the contraction of the sub-mentonian muscles (mylohyoid, geniohyoid, and anterior digastric, besides the thyrohyoid), thus favoring the epiglottis inversion to occlude the airway. Simultaneously, the activity of the vocal fold adductor muscles increase, aided by the laryngeal constrictor muscles, which close the epiglottis, one of the most essential reflexes that enable deglutition without food, foreign bodies, or secretions being aspirated (Ludlow, 2005; Lynch, 2017). The hyoid-laryngeal complex excursion can provide important data for the observation of functional airway protection (Ludlow, 2005; Lynch, 2017). Video fluoroscopic swallowing study (VFSS), also known as modified barium swallow (MBS), enables visualizing all deglutition phases in real time. It allows the structures involved in this process, as well as penetration and laryngeal tracheal aspiration events, to be analyzed. It is considered an important evaluation method for its ability and reliability in observing events and associated structures, particularly the hyoid bone, given its high-density image. 10 This study aims to describe the laryngeal movements found during deglutition through video fluoroscopic swallowing study and to correlate these data with airway protection quality. Methods Fifty-two video fluoroscopic swallowing studies were selected between January 2010 and January 2011 from a Radiologic Center of one Hospital, 26 (50%) of which from males and 26 (50%) from females with average age of 76.85 years, standard deviation of 8.97. The whole sample had 113 exams, 30 of which were excluded for lacking complementary data, 21 for having only lateral plane images, and 10 for being from patients subjected to tracheotomy and/or cervical surgery.

The videofluoroscopic swallowing studies were performed in a shielded x-ray room using Prestilix 1600X radiological equipment from GE Medical Systems® coupled to a Philips® DVD recorder. After being recorded onto the DVD, the exams were sent to two speech therapist assessors, both with the same training and experienced in performing video fluoroscopic swallowing studies. The assessors analyzed three deglutition's with liquid consistency and three with pasty consistency using barium sulfate (BárioGel®) contrast medium with images taken in the lateral and anterior-posterior planes, which allowed the food to be visualized. For the result analysis, a Laryngeal Biomechanics protocol was created that considered laryngeal movements such as elevation and anteriorization, lack of elevation, incomplete and repeated elevations, lateral excursion, marked anterior excursion, and laryngeal lowering, as well as the presence of dysphagia, penetration, and aspiration. These data were later tabbed in a Microsoft® Excel (2010) spreadsheet. The data were summarized with mean, standard deviation, and absolute and relative frequencies. Age normality was verified through the Kolmogorov-Smirnov test and genders were compared using Student's t-test. The agreement between the assessors was verified through kappa coefficient. The associations between airway protection and laryngeal movements were analyzed through Fisher's exact test. The significance level adopted was 5%. All analyses were carried out using the software SPSS 19.0. This study was approved by the Ethical Committee in Research of the participant a Radiology and Imaging Service in a Primary Health Center under protocol number 2013/008, as well as by the Ethical Committee in Research of the proposed institution

under protocol 362.826. All patients had signed the informed consent of the hospital service.

RESULTS

Of the 52 exams analyzed, dysphagia was found in 45 subjects (86.53%) and normality, in seven (13.47%). Table 1 shows the analysis of laryngeal movements in relation to the presence of penetration and aspiration for the liquid consistency, After the agreement between the assessors was confirmed by kappa coefficient, Fisher's exact test was carried out using a 5% significance level ($p \leq 0.05$).

Table 1. Association among laryngeal movements and aspiration and penetration for liquid consistency

| Laryngeal Movements | (n) | Aspiration Liquid | | P _{value} | (n) | Penetration Liquid | | P _{value} |
|--------------------------------|-----|-------------------|--------|--------------------|-----|--------------------|--------|--------------------|
| | | YES (n) | NO (n) | | | YES (n) | NO (n) | |
| Altered Elevation | 20 | 6 | 14 | 0.156 | 20 | 16 | 4 | 0.009* |
| Adequate Elevation | 32 | 4 | 28 | | 32 | 13 | 19 | |
| Altered Anteriorization | 23 | 9 | 14 | 0.003* | 23 | 16 | 7 | 0.096 |
| Adequate Anteriorization | 29 | 1 | 28 | | 29 | 13 | 16 | |
| Reduced Elevation | 31 | 10 | 21 | 0.003* | 31 | 23 | 8 | 0.002* |
| Adequate Elevation | 21 | 0 | 21 | | 21 | 6 | 15 | |
| Lack of Elevation | 4 | 1 | 3 | 1.000 | 4 | 4 | 0 | 0.120 |
| Adequate Elevation | 48 | 9 | 39 | | 48 | 25 | 23 | |
| Incomplete/repeated Elevations | 26 | 9 | 17 | 0.011* | 26 | 21 | 5 | 0.001* |
| Adequate Elevation | 26 | 1 | 25 | | 26 | 8 | 18 | |
| Lateral Excursion | 3 | 1 | 2 | 0.481 | 3 | 2 | 1 | 1.000 |
| Lack of Lateral Excursion | 49 | 9 | 40 | | 49 | 27 | 22 | |
| Laryngeal Lowering | 6 | 1 | 5 | 1.000 | 6 | 3 | 3 | 1.000 |
| Adequate Position | 46 | 9 | 37 | | 46 | 26 | 20 | |

Fisher's exact test - $p < 0.05$ marked with *

Table 2 shows the analyses of laryngeal movements in relation to the presence of aspiration and penetration for pasty consistency. Associations ($p < 0.05$) were found for the consistencies analyzed between the presence of dysphagia and altered laryngeal elevation, and between dysphagia and incomplete elevation and repeated movements. A relation between dysphagia and reduced laryngeal elevation was only found for the liquid consistency.

Table 2 . Association among laryngeal movements and aspiration and penetration for pasty consistency

| Laryngeal Movements | (n) | Aspiration Pasty | | P _{value} | (n) | Penetration Pasty | | P _{value} |
|--------------------------------|-----|------------------|--------|--------------------|-----|-------------------|--------|--------------------|
| | | YES (n) | NO (n) | | | YES (n) | NO (n) | |
| Altered Elevation | 16 | 6 | 10 | 0.002* | 16 | 10 | 6 | 0.001* |
| Adequate Elevation | 36 | 1 | 35 | | 36 | 5 | 31 | |
| Altered Anteriorization | 27 | 7 | 20 | 0.010* | 27 | 14 | 13 | 0.000* |
| Adequate Anteriorization | 25 | 0 | 25 | | 25 | 1 | 24 | |
| Reduced Elevation | 27 | 6 | 21 | 0.101 | 27 | 13 | 14 | 0.002* |
| Adequate Elevation | 25 | 1 | 24 | | 25 | 2 | 23 | |
| Lack of Elevation | 3 | 2 | 1 | 0.044* | 3 | 1 | 2 | 1.000 |
| Adequate Elevation | 49 | 5 | 44 | | 49 | 14 | 32 | |
| Incomplete/repeated Elevations | 18 | 5 | 13 | 0.041* | 18 | 11 | 7 | 0.000* |
| Adequate Elevation | 34 | 2 | 32 | | 34 | 4 | 30 | |
| Lateral Excursion | 2 | 0 | 2 | 1.000 | 2 | 1 | 1 | 0.498 |
| Lack of Lateral Excursion | 50 | 7 | 43 | | 50 | 14 | 36 | |
| Laryngeal Lowering | 5 | 2 | 3 | 0.129 | 5 | 3 | 2 | 0.137 |
| Adequate Position | 47 | 5 | 42 | | 47 | 12 | 35 | |

Fisher's exact test - $p < 0.05$ marked with *

DISCUSSION

Of the 52 exams evaluated, 45 (86.53%) showed dysphagia. This value may be explained by the fact that an image database was used and most patients were referred to a VFSS based on clinical signs or symptoms of dysphagia. This study analyzed, with two independent assessors, three deglutition's for the liquid consistency and three deglutition's for the pasty consistency using barium sulfate as contrast medium. A minimum of three deglutition's for each consistency is recommended to guarantee that individual differences will be observed (Lof and Robbins, 1990). However, some studies have evaluated a single deglutition of each bolus type (Molfenter and Steele, 2012). Another important detail is that participant's age was 76.85 years. Studies have shown an increasing number of adults over 60 years old in the last decade's (IBGE, 2000; Chen *et al.*, 2009).

In the present study, the substantial number of elderly referred to dysphagia investigation compared to younger people is pointed out. Researches that assessed aging-related deglutition disorders show 16% to 22% of the population above 50 years of age with dysphagia, a number that reaches 70% to 90% among elderly people (Chen *et al.*, 2009; Nogueira and Reis, 2013; Ney *et al.*, 2009; Costa, 2013) The participant's gender in this study had a balanced distribution: 26 (50%) male and 26 (50%) female. Little is found in scientific studies in terms of evaluations and analyses of anomalous laryngeal movements such as lack of elevation, lateral excursion, incomplete and repeated elevations, and laryngeal lowering (Logemann *et al.*, 1992). One of the most commonly studied pharyngeal deglutition alterations is reduced laryngeal elevation. It is stated that the reduction in the larynx's vertical excursion contributes to the incomplete airway closure, which leads to a risk of aspiration and that a reduction in laryngeal anteriorization contributes to a reduction in the opening of the esophagus (Logemann *et al.*, 1992; Jacob *et al.*, 1989) Likewise, this study found a significant relation ($p < 0.005$) between laryngeal aspiration and penetration with the reduction in these movements for both the liquid and pasty consistencies. Regarding the lack of laryngeal elevation, a significant association ($p = 0.044$) was found with aspiration only for the pasty consistency, which contrasts with the studies that report that the pasty consistency is the safest and easiest. The incomplete and repeated laryngeal elevation movement, still little studied, was shown to be significant for the two consistencies studied for both aspiration and penetration, with a total of 44 occurrences, 9 of which of aspiration and 31 of penetration.

The other movements, such as lateral excursion and laryngeal lowering, express a trend towards statistical significance ($P > 0.05$). Since they are anomalous movements, they need a larger sample (n) so that these events can be better analyzed. The incomplete and repeated laryngeal elevation movement, still little studied, was shown to be significant for the two consistencies studied for both aspiration and penetration, with a total of 44 occurrences, 9 of which of aspiration and 31 of penetration. The other movements, such as lateral excursion and laryngeal lowering, express a trend towards statistical significance ($P > 0.05$). Since they are anomalous movements, they need a larger sample (n) so that these events can be better analyzed.

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