Food in liquid consistency and deglutition: a critical review of the literature

Alimentos na consistência líquida e deglutição: uma revisão crítica da literatura

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ABSTRACT

The purpose of this literature review was to analyze international scientific papers published on the physiology of swallowing fluids in the oral and pharyngeal phases. The employed methodology involved the formulation of a question, the location and selection of studies, and a critical assessment of the manuscripts according to the concepts of the Cochrane Handbook. We identified 185 articles, of which 141 were excluded for not being directly related to the theme. Twenty-nine studies were analyzed. The researchers were strongly focused on ways to identify dysphagia and not on the features offered by swallowing various consistencies. Regarding the methodology employed in the reviewed articles, it was observed that there were no control groups in most studies. The studied groups were heterogeneous, especially when considering individuals with neurological disorders. In addition, the subjects were not paired by age. Thus, the findings of this review indicate that clinicians face great difficulty in applying these scientific findings in their daily practices, which, in turn, limits the use of evidence-based practice.

Keywords: Deglutition; Food; Drinking behavior; Deglutition disorders; Speech, language and hearing sciences

INTRODUCTION

Dysphagia refers to disorders resulting from changes in one or more of the swallowing phases and may be caused by neurological and/or structural aspects. Dysphagia may cause laryngotracheal aspiration, that is, the entry of food or liquids, including saliva and secretions, into the airways (below the glottis). Coughing, choking/suffocation, lung problems, dehydration, malnutrition, sepsis, weight loss, and death are typical results of aspiration as a result of dysphagia[1-3].

Numerous factors interfere with the swallowing efficiency, including the food bolus consistency, volume ingested, temperature, the anatomical features of the individual itself, and the integrity of muscles and nerves involved in swallowing[4-6]. International studies demonstrated that the physiological changes related to swallowing are a function of the consistency of the ingested food. Several authors designate liquid as the consistency that causes the most laryngeal penetration and aspiration, even compared with the swallowing of thickened liquids[7].

The aim of this systematic review was to survey international scientific texts that emphasized the physiology of swallowing liquids in the oral and pharyngeal phases.

The research method was established according to the concepts of the *Cochrane Handbook*[8]. The articles were selected from the PubMed database using the keywords "swallowing and liquid", and the search was limited to studies conducted on humans who were over eighteen years of age and studies conducted in the English language, which were published in the period from 2005 to 2010.

The researchers initially performed the database search for texts independently to minimize possible losses of citations. Citations in a language other than English were excluded, as were citations precluding access to the full text (from the CAPES [Coordination for the Improvement of Higher Level or Education Personnel] Journal Portal). Citations that were repeated by overlapping keywords were also excluded. From

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the full texts obtained, texts relating to case studies, literature reviews, letters to the editor, and texts indirectly related to the topic were excluded. The texts that were truly related to the proposed research were reviewed. The researchers conducted all stages of the study independently. Only texts for which the final decision was a consensus following a disagreement among the researchers were included. This study was not single-blind, given the nature of the research. The protocol for the bibliographical search conducted for the selection of texts for review is illustrated in Figure 1.

Following the bibliographical survey and selection of articles, the texts were reviewed regarding their aims, the type of text, the number and gender of participants, the age group, the assessment criteria, the control treatment, and the study results. Thus, 29 paragraphs regarding the review will be presented.

LITERATURE REVIEW

One study[9] was aimed at demonstrating whether adults with Parkinson's disease showed an altered breathing pattern while ingesting water. The mean age of the participants was 67.8 years, and it included 29 men and ten women with Parkinson's disease. The subjects were divided into two groups. The swallowing events were analyzed by videodeglutogram, and the breathing pattern was analyzed through a nasal cannula, which was responsible for marking the events according to the number of respiratory cycles. Thirty-nine individuals were assessed with five milliliters of liquid, which was consumed in ten swallows. The results indicated that expiration was the most frequent event before and after the swallowing apnea.

Several authors[10] investigated the pharyngeal and upper esophageal sphincter pressures during liquid swallowing. Nineteen elderly people participated in the research, of which there were nine men and ten women who did not have swallowing complaints, neurological changes, gastroesophageal reflux, complaints of dysphonia, or otorhinolaryngologic diseases. Two manometric sensors were positioned in a participant's pharynx and upper esophageal sphincter to characterize the liquid swallowing pressure. The authors found that the pharyngeal pressure was significantly lower in participants who aspirated liquids than in those who did not.

Another study[11] aimed to analyze the relationship between wet voice and episodes of penetration/aspiration of liquids. The authors classified voice quality according to the GRBAS (grade, roughness, breathiness, asthenia, and strain) scale (scale developed by the Committee for Phonatory Function Test of the Japan Society of Logopedics and Phoniatrics) during the objective swallowing test with videofluoroscopy during a task of consuming a liquid in four swallows. Aspects regarding aspiration/penetration and a closing of the airway were considered for analysis. The authors used recordings of sustained vowels and analyzed the jitter and shimmer to assess the post-swallow voice quality. A clear (not wet) voice quality was considered sufficient to characterize the absence of penetration and aspiration. The clinical assessment of wet vocal quality showed a high specificity and low sensitivity in the assessment of laryngotracheal penetration/aspiration.

One group of authors[12] conducted an experimental research study with humans, which was aimed at analyzing the effect of the food bolus volume on suprahyoid muscle activation. For this purpose, these researchers assessed liquid swallowing in healthy adults (eight men and four women) who were 19 to 29 years of age. The authors used a laryngeal sensor to detect displacement and surface electromyography (EMG) to detect suprahyoid muscle activation. Participants were instructed to swallow only once. The supply was conducted randomly with amounts of 10 ml, 13 ml, 16 ml, 20 ml, 25 ml, and 32 ml. The values differed in the mean peak amplitude of the surface EMG, with a higher volume indicating a higher duration of the peak of pharyngeal pressure. The duration measured by the laryngeal sensor did not vary with the difference in volume.

Other authors[13] investigated the characteristics of dual-axis accelerometry during the swallowing of different foods. Accelerometry measures the mechanical movement of hyolaryngeal structures during the oral and pharyngeal stages of swallowing. The subjects were 17 healthy adults (eight men and nine women) with a mean age of 46.9 years. The signals were acquired during the swallowing of a thin liquid, nectar, honey, and a thickened liquid. The study results proved that an increased food viscosity is directly related with prolonged swallowing times.

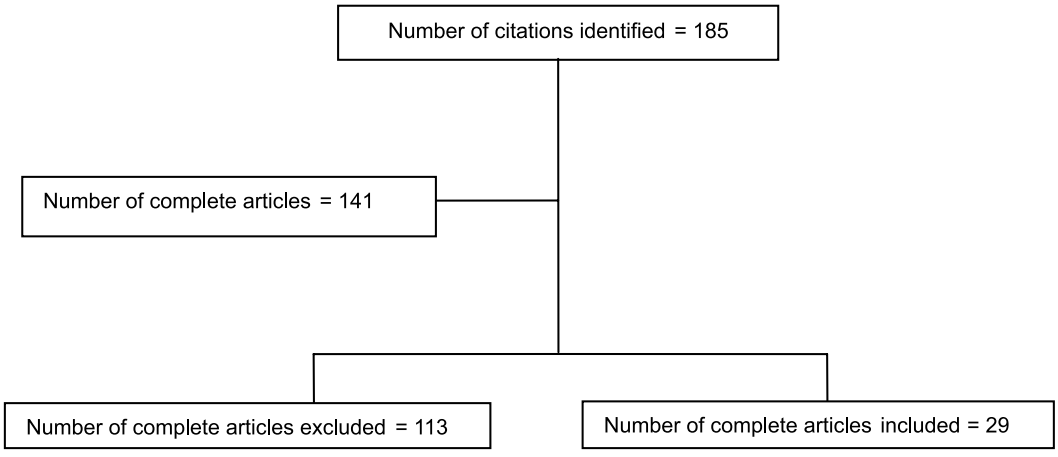

Figura 1. Percurso da busca realizada para seleção dos textos a serem analisados

In another study[14], the authors assessed swallowing by 149 adults, who were divided into the following two groups: healthy adults and adults with dysphagia caused by neurological disorders. The aim of this study was to investigate the presence of aspiration and penetration of different consistencies and volumes by using a videodeglutogram. Furthermore, the effect of age was analyzed. In total, 596 swallowing events were assessed, and an 11.4% penetration was found in healthy adults, which mostly occurred with the liquid consistency. The prevalence of penetration was 9.3% in the elderly, who were more than 65 years old. At the level of the vocal folds, 3.4% penetration with the liquid consistency and 1.3% penetration with the pasty consistency occurred.

Several authors[15] analyzed swallowing by 229 men who were over 66 years of age with complaints of dysphagia from various causes (stroke, neuromuscular, respiratory and cardiovascular diseases, head and neck cancers, and undefined causes). The aim of the study was to compare the risk of penetration/aspiration during the swallowing of different consistencies and volumes through a videodeglutogram. Therefore, 4 ml of pasty food with a pudding consistency, 4 and 10 ml of thin liquid (with barium), liquid in a cup (free swallowing), meat (8 g with barium), and 5 ml of liquid supplied concomitantly with meat were tested. The risk of penetration increased in the following order: pudding, meat, 4 ml of thin liquid, 10 ml of thin liquid, liquid supplied concomitantly with meat, and free swallowing thereafter. The risk of aspiration increased in the following order: meat, 4 ml of thin liquid, 10 ml of thin liquid, free swallowing, and liquid supplied concomitantly with meat. The authors concluded that the risk of laryngotracheal penetration/aspiration varied depending on the type of food. The use of a mixture of multiple consistencies should be used judiciously with dysphagia.

The differences in the tongue pressure modulation during the swallowing of thin and thickened (nectar consistency) liquids were assessed in an experimental research study with healthy human adults[16] (ten men and ten women) with an average age of 30 years. The tongue pressure was checked at three points, as follows: the anterior, medial, and posterior regions. The authors concluded that there were no differences in the tongue-palate pressure modulation during liquid or nectar swallowing. However, there was a difference in the point of contact of the tongue with the palate according to the consistency ingested.

Several authors[17] conducted an experimental study to determine the tongue pressure against the hard palate and tested the following three aspects: the absence of individual patterns of tongue pressure in liquid swallowing; the presence of significant negative pressures in the oral cavity during liquid swallowing; and pressure testing in the anterior-posterior region of the tongue. The study included four men and two healthy women with a mean age of 30 years. Three swallows of 10 ml of liquid from a cup on five separate days were tested. The results indicated a similar pattern of pressure during the liquid swallowing for the same participant on the different days tested.

A group of researchers[18] analyzed the acoustic characteristics of swallowing sounds (duration of swallowing and apnea) by 60 healthy adults who were divided into three groups of 20 subjects each according to age and paired by gender. The average ages of group A, group B, and group C were 26.5 years, 47.7 years, and 60 years, respectively. Eight adults with a history of stroke, one with Myasthenia Gravis, four with amyotrophic lateral sclerosis, and two with Parkinson's disease also participated in the study. The participants were assessed during the intake of solids, semi-solids, and thickened and thin liquids. There were significant differences in the duration of swallowing sounds for 10 ml of liquid when comparing healthy adults to individuals with a neurological disease, with the latter group showing prolonged swallowing.

Other authors[19] analyzed the larynx movement during liquid swallowing. Laryngeal movement and suprahyoid muscle activation were measured simultaneously using a sensor and surface EMG, respectively. The research was conducted with five men, who had a mean age of 20 years. The total time of liquid swallowing was four seconds. The study revealed four points of spatial displacement of the larynx during liquid swallowing and the time at which these displacements occurred, as follows: the first point was related to a slight movement in the superior-posterior direction at approximately 1.9 seconds upon the command to swallow; the second point was related to the beginning of the anterior-superior elevation at approximately 2.3 seconds; the third point was related to the beginning of the larynx movement to return to its usual position, which was observed 3.2 seconds after swallowing began; and the fourth and final point refers to the effective return of the larynx to its initial position, which was observed 4.1 seconds after the beginning of swallowing.

In another study[20], researchers assessed the suprahyoid muscle activation by means of surface EMG and videofluoroscopy during the swallowing of liquids (4 ml) and two foods with a pasty consistency and related the test results to changes in head posture. The participants were ten healthy adults with a mean age of 27.5 years. The authors detected the following significant linear relationships: between the tongue tip touching the palate and the peak of the electromyographic curve; between the passage of the bolus tail of the feces and the offset record of the electromyographic curve; between the passage of the food bolus tail through the upper esophageal sphincter and the peak of swallowing; and between the passage of the food bolus tail through the upper esophageal sphincter and the offset of the suprahyoid muscle activation. The results suggest that the duration, rather than amplitude, of the tongue and suprahyoid muscle activity increased with food consistency.

Several authors[6] compared liquid swallowing by asymptomatic men and women by means of a videodeglutogram. Eighteen men with a mean age of 61 years and 12 women with a mean age of 53 years participated in the study. The swallowing of 10 ml liquid and 10 ml of pasty food was assessed. The results indicated longer oropharyngeal transit times in the swallowing by women than by men.

Another study[21] assessed the effects of age and swallowing-related muscle activity based on stimuli detected by equipment combining the analysis of the displacement of swallowing-related structures and the electromyographic activity of muscles. The participants in the study were 15 adults

(seven women and eight men) with a history of dysphagia and neurological changes. The swallowing of thin liquid, nectar, honey, and pudding was assessed with an equipment sensor positioned in the submental region and nasal cannula. Upon reviewing the results, the onset of muscle activity was found to precede the onset of swallowing apnea.

One of the reviewed studies[22] aimed to determine a method that would be able to detect dysphagia in stroke patients and compared them to a group of healthy individuals. The authors analyzed the parameters of timing and duration of swallowing and clearance of swallowed liquids. In total, 42 post-stroke participants (40 men and two women) and 25 healthy subjects (23 men and 2 women) were assessed. The authors concluded that dysphagia could not be differentiated between the groups without testing for the swallowing of different volumes.

To determine the best consistency (liquid or pasty) to conduct swallowing screening tests, a group of authors[23] assessed 85 patients with dysphagia and 12 healthy subjects. Swallowing was assessed by means of a videodeglutogram during a swallowing series of 5 to 20 ml of liquid, nectar, and pudding-consistency foods. The voice quality and presence of a cough was checked in the clinical assessment, and the presence of residues in the oropharyngeal region was checked during the objective swallowing test. Pulse oxymetry was also performed. The study results showed 64.7% specificity and 83.7% sensitivity for the methodology applied to assess the penetration of the bolus through the larynx and 100% sensitivity for aspiration.

Other authors[24] compared the swallowing of a liquid and semi-solid food. The study included 27 patients (15 women and 12 men) at seven days after a stroke. The mean age of the participants was 63.5 years. The participants were evaluated prospectively regarding deficit severity, swallowing mechanisms, chest radiography examinations (30 days post discharge), and the post-stroke disability assessment according to the modified Rankin scale. The results suggest that water-swallowing tests showed the highest sensitivity for detecting issues in larynx protection, and the semi-solid food showed the highest sensitivity for the functional assessment of dysphagia.

One study[25] examined whether food texture and viscosity would change tongue pressure against the palate during swallowing. Eleven healthy adults with a mean age of 30 years participated in the study. The tongue pressure was determined by surface electromyography with a videodeglutogram performed concomitantly during the ingestion of liquids, thickened liquids, and semi-solids. The authors noted that the duration of the electromyographic peak during swallowing, and the area and duration between the onset, peak and offset of the tongue muscle electromyography increased with food consistency. The authors concluded that the food consistency increases the oral transit time and that increased viscosity also increases the pharyngeal transit time.

Several authors[26] sought to determine what would be the best strategy to prevent aspiration of liquid, including a change of head posture (chin-down) or use of thickened liquid, such as honey and nectar consistencies, in patients with Parkinson's disease and dementia. The study included 711 patients with a mean age of 72.5 years. The assessment was performed by videodeglutogram with all patients tested for the three conditions in a randomized order. The authors noted that aspiration was most effectively prevented when the thickened liquid with a honey consistency was tested, which was followed by the nectar consistency, and later when swallowing with a chin-down posture.

Another study[27] assessed the performance of 3000 participants of different ages and diagnoses in a screening test for dysphagia by means of an endoscopic assessment of swallowing with 3 oz of water. The screening test showed 46.4% specificity and a 53.6% false positive rate.

Several authors[28] performed the clinical and objective assessment of liquid swallowing in 30 elderly inpatients (mean age of 76.2), ten healthy elderly subjects (mean age of 69.6), and 20 healthy young subjects (mean age of 25.4). The goal was to determine whether elderly inpatients who were without swallowing complaints had dysphagia. The study found an increased risk for dysphagia in the elderly inpatients compared with the remaining groups studied.

A group of authors[29] assessed swallowing in 76 healthy adults by means of a videodeglutogram (reviewed frame by frame) and airflow assessment during the swallowing of 5 ml of liquid, aiming to correlate the food bolus progression in the pharynx with the hyoid bone movement and swallowing apnea. Of all of the participants assessed, 80% had a swallowing reflex after the bolus passage through the angle of the mandible.

In one study[30], the authors assessed the apnea duration and the relationship between swallowing and breathing in 26 patients after a stroke diagnosis. Measurements of breathing patterns combined with a videodeglutogram for the swallowing of 5, 10, 15, and 20 ml of thin and thickened (nectar) liquids were performed. The results enabled the identification of differences between the breathing patterns in the presence and absence of aspiration and the increased time of post-swallow inspiration, with the latter being proportional to the dysphagia severity.

In another study[31], the authors aimed to determine the relationship between the food bolus flow and larynx closure during swallowing in patients diagnosed with stroke. For this purpose, 90 post-stroke patients and 50 healthy adults were assessed by means of a videodeglutogram during the ingestion of a thin liquid by controlled swallows. The results indicated a correlation between the late laryngeal elevation and the aspiration severity in stroke patients.

Researchers[32] conducted a prospective study to determine the frequency and level of aspiration in subjects of different ages and genders during the swallowing of various food consistencies and volumes. Concomitantly, the presence of throat clearing and a cough was detected. The study was conducted with 98 healthy subjects (48 women and 50 men) who were between 20 and 94 years of age. The authors checked the swallowing of 1, 3, 5, and 10 ml of thin liquid, 3 ml of a semi-solid (pudding), 1/4 of a sweet cookie, and an apple bite by means of a videodeglutogram and the analysis of swallowing sounds. An increased frequency of laryngeal penetration was found in individuals over 50 years old. No relationship was found between gender and the frequency of laryngeal penetration. However, there was an increased penetration for liquids

when analyzing the variable consistency.

Other authors[33] presented the scintigraphy results for the swallowing of 5 ml of liquid using a Gaussian curve. For this purpose, 18 healthy adults participated in the study. The authors considered the pharyngeal transit time, entry of food into the pharynx, premature loss of food bolus, and pharyngeal stasis during liquid swallowing to be the main parameters for designing the Gaussian curve. The maximum pharyngeal transit time was 0.71 seconds. A premature bolus loss was also found in 3% of participants, and pharyngeal stasis was found in 9% of the sample.

A prospective study[34] was conducted to assess the pathophysiology and treatment of neurogenic dysphagia. The study included 46 subjects with neurodegenerative diseases and eight healthy adults. The participants' swallowing was assessed by means of a videodeglutogram for liquid, nectar, honey, and pudding consistencies. The healthy subjects' swallowing matched the standard parameters. The participants with neurodegenerative diseases showed aspiration during the liquid swallowing. The authors found that the increasing food viscosity decreased aspiration and promoted the delay in larynx closure and propulsion of the food bolus from the oral cavity to the pharynx.

In another study[35], the number of swallows, period of apnea, breathing frequency, and opening of the laryngeal vestibule after the swallowing of 50 ml of liquid from a cup was assessed by means of a videodeglutogram. Seventy healthy adults participated in the study. Expiration was the breathing pattern commonly observed after the swallowing. There was no significant difference in the laryngeal opening pattern due to age or gender.

Finally, a group of authors[36] described a correlation of the biomechanics of the surface electromyography signal during swallowing. To this end, a videodeglutogram and surface electromyography were concurrently conducted during the swallowing of 5 ml of liquid. The variables examined were the hyoid bone elevation, pharyngeal wall constriction, and larynx closure. All biomechanical events were strongly correlated with the electromyographic signals, especially for the hyoid bone elevation.

DISCUSSION

The studies cited in this review demonstrated that foods with a liquid consistency are more prone to larynx penetration in the various groups studied, which range from healthy adults to subjects with neurological changes and elderly people with and without dysphagia.

One of the studies[34] observed that increasing food viscosity decreases the possibility of aspiration but promotes a delayed larynx closure and food bolus propulsion from the oral cavity to the pharynx. In this same line of research, another study[25] argued that the food consistency increases the oral transit time, and an increased viscosity increases the pharyngeal transit time. Several studies demonstrated a correlation between an increased consistency and the consequent increase in time and pressure required for swallowing[13,15,20,25,34].

The objective swallowing test that was most often used to assess the laryngotracheal penetration and/or aspiration was videofluoroscopy[6,9,11,14,15,20,22,30,31,34-36]. However, the variety of complementary tests used by current studies, including accelerometry[13], EMGs[12,20,21,25,36], tongue use[16,17], and airway[9] pressure gauges, among others, should not be overlooked.

Regarding EMGs, which is a complementary test that has been widely used in speech-language pathology practices that favor the objective measurement of performance in this field and the use of evidence-based practices, a significant correlation was found between the biomechanical events of swallowing and the electromyographic signals[21,25,36], especially when determining the hyoid bone elevation[36].

Studies indicate that expiration was the breathing event during pre- and post- swallowing apnea that was noted by most studies on this matter[9,21,29]. Post-swallowing apnea inspiration was an important parameter for the characterization of patients with and without a risk of laryngotracheal penetration/aspiration[30]. The study linking the breathing events to EMGs showed that the onset of muscle activity occurred prior to the onset of swallowing apnea[21].

Regarding the age and gender of subjects studied, there seems to be no direct relationship between these variables and the laryngeal opening pattern.

A study aimed at defining the acoustic characteristics of swallowing sounds[18] should also be highlighted. Swallowing sounds have been used as clinical signs of swallowing for years, but the use of an acoustic analysis as a tool to aid this type of study is recent and can be considered a field of study that will provide considerable benefits to the body of knowledge concerning swallowing.

Finally, the use of sensors for measuring the pressure of the tongue, airways, and digestive system[9,16,17] also aligns with the current trends of using complementary tests in the study of swallowing. These tests provide a greater objectivity to the assessment and treatment of speech-language pathologies in addition to providing a relationship between the clinical findings, which are considered more subjective, and the physical examination findings, which are considered more objective. It is up to the speech-language pathologist to conduct these technical studies, participate in a multidisciplinary team, and effectively apply the speech-language pathology knowledge in both the clinical and academic fields.

FINAL COMMENTS

These research studies were strongly related to the identification methods for dysphagia and not to the effects of swallowing different consistencies. Most studies aimed to visualize the phenomenon of aspiration in dysphagic patients, and the detailed aspects of the physiology of swallowing in healthy individuals become secondary. Regarding the methodology employed in the articles reviewed, most studies lacked a control group. The groups were heterogeneous, especially when considering individuals with neurological disorders. Furthermore, there was no age pairing in most studies. Thus, the findings of the current review demonstrate the difficulty of clinically applying scientific findings, which hampers evidence-based practices.

RESUMO

O objetivo da presente revisão de literatura foi analisar artigos científicos internacionais publicados sobre a fisiologia da deglutição de alimentos líquidos nas fases oral e faríngea. A metodologia empregada envolveu a formulação da pergunta; localização e seleção dos estudos; avaliação crítica dos artigos; conforme os preceitos do *Cochrane Handbook*. Foram identificados 185 artigos, dos quais se excluiu 141 por não relacionarem-se diretamente ao tema e analisou-se 29 estudos. As pesquisas estão fortemente relacionadas às formas de identificação de disfagia e não as características proporcionadas pela deglutição de diferentes consistências. Quanto à metodologia empregada nos artigos analisados observa-se que na maioria dos estudos não há grupo-controle. Os grupos estudados são heterogêneos, principalmente quando considerando indivíduos com alterações neurológicas, além disso, não há pareamento de idade na maioria dos estudos. Dessa forma, os achados desta revisão demonstram que há dificuldade na aplicabilidade clínica dos achados científicos, dificultando a prática baseada evidências.

Descritores: Deglutição; Alimentos; Comportamento de ingestão de líquido; Transtornos de deglutição; Fonoaudiologia

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