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Swallowing sounds profile of a post stroke group using electronic stethoscope software

Perfil dos sons da deglutição de um grupo pós-AVC fazendo uso de software de estetoscópio eletrônico

Perfil de los sonidos de deglutición de un grupo pós-AVC que hace uso del software del estetoscopio electrónico

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Abstract

Introduction: Cervical auscultation is a complementary evaluation to dysphagia clinical evaluation. **Objective:** To establish the swallowing sounds profile in post-stroke patients' group. **Methods:** Clinical cross-sectional study, whose collection and acoustic analysis was performed through the electronic stethoscope of the Littman brand (model 4100) and clinical evaluation of dysphagia, with the collection of 45 swallows of liquids and 9 swallows dried. **Results:** Sample composed of nine post stroke individuals with an average age of 54.33-year-old; 55.6% of patients with swallowing disease. The frequency varies between 20-500 Hz; the dry swallowing frequencies occurred in 250 Hz in swallowing without alteration, and between 20 Hz and 249 Hz in disease. For the swallowing of liquids, between 20Hz and 249 Hz without alteration, and 250 in Hz disease. The average dry swallowing time was given in 110.3 ms (SD ± 38. 6 ms) and with liquids in 111.6 ms (SD ± 36.5 ms). The average time between the dry swallowing events was 125 ms (SD ± 54.74 ms) in swallowing without alteration and of 98.60 ms (SD ± 18. 66 ms) in disease; in liquid swallowing it was 100.20 ms (DP ± 31.01 ms) without alteration, and 120.68 ms

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Larissa Lopes Branco: participated in the idealization of the study, analysis and interpretation of the data and writing of the article. Maria Cristina de Almeida Freitas Cardoso: participated, as a counselor, in the idealization of the study, analysis, interpretation of the data; writing and reviewing the article.

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(SD ± 38.52 ms) in the swallowing disease. **Conclusion:** The digital stethoscope showed itself as an instrumental possibility for the collection, but for the acoustic analysis it is not productive. The results of the dry and liquid swallowing were: average time around 110 ms and at low frequency, varying between 20 Hz and 500 Hz for both consistencies, with post stroke patients.

Keywords: Deglutition; Deglutition Disorders; Stethoscopes; Stroke.

Resumo

Introdução: A ausculta cervical caracteriza-se como um exame complementar à avaliação clínica da disfagia. **Objetivo:** Estabelecer o perfil sonoro dos ruídos da deglutição de um grupo de pacientes pós-AVC. Método: Estudo clínico de caráter transversal, cuja coleta e análise acústica foram realizadas através do estetoscópio eletrônico da marca Littman (modelo 4100) e avaliação clínica da disfagia, com a coleta de 45 deglutições de líquidos e nove deglutições secas**. Resultados:** Amostra composta por nove sujeitos pós-AVC com idade média de 54,33 anos; 55,6% dos pacientes com alteração de deglutição. As frequências variaram entre 20-500 Hz, as frequências da deglutição seca ocorreram em 250 Hz na deglutição sem alteração e entre 20 Hz a 249 Hz na alterada; para a deglutição de líquidos entre 20 Hz a 249 Hz sem alteração e de 250 Hz na alterada. O tempo médio da deglutição seca se deu em 110,3 ms (dp ±38,6 ms) e com líquidos em 111,6 ms (dp ± 36,5 ms). O tempo médio entre os eventos de deglutição seca foi de 125 ms (dp ± 54,74 ms) na deglutição sem alteração e de 98,60 ms (dp ± 18,66 ms) na alterada; na deglutição líquida foi de 100,20 ms (dp ± 31,01 ms) sem alteração e de 120,68 ms ± 38,52 ms na deglutição alterada. **Conclusão:** O estetoscópio digital mostrou-se como uma possibilidade instrumental para a coleta, contudo para a análise acústica se mostrou pouco objetivo. Os resultados encontrados com a deglutição seca e com a consistência líquida foram: tempo médio em torno de 110 ms e em frequência baixa, variando entre 20 Hz e 500 Hz para ambas as consistências, junto aos pacientes pós-AVC.

Palavras-chave: Deglutição; Transtornos da Deglutição; Estetoscópio; Acidente Vascular Cerebral.

Resumen

Introducción: la auscultación cervical se caracteriza como un examen complementario de la evaluación clínica de la disfagia. **Objetivo:** establecer el perfil sonoro de los sonidos de deglución después de um accidente cerebrovascular. **Método:** estudio clínico de carácter transversal, cuya colección y análisis acústico se realizó a través del estetoscopio electrónico de la marca Littman (modelo 4100) y evaluación clínica de la disfagia, con la recolección de 45 degluticiones de líquidos y nueve degluticiones secas. **Resultados:** muestra compuesta por nueve sujetos después de um accidente cerebrovascular, con una edad promedio de 54,33 años; 55,6% con cambio de deglución. Las frecuencias variaram entre 20-500 Hz, de la deglución seca ocurrieron en 250 Hz en tragar sin alteración y entre 20 Hz el 249 Hz en alterada; la deglución de líquidos entre 20 Hz el 249 Hz sin alteración y 250 Hz en la deglución alterada. El tiempo medio de deglución en seco se dio en 110,3ms y con líquidos en 111,6ms. El tiempo promedio entre los eventos de deglución seca fue 125 ms en la deglución sin alteración y de 98,60 ms en la deglución alterada. En la deglución líquida fue 100,20 ms sin alteración y 120,68 ms en la deglución alterada. **Conclusión:** el estetoscopio digital se demostró como posibilidad instrumental de la colección, pero para el análisis acústico demostró poca meta. Los resultados de la deglución seca y com líquidos encontrados fueron: tiempo promedio en la deglución alterada de 110 ms y a baja frecuencia, variando entre 20 Hz y 500 Hz para ambos consistencias, con pacientes después de um accidente cerebrovascular.

Palabras claves: Deglución; Trastornos de la deglución; Estetoscopios; Accidente cerebrovascular.

Introduction

Dysphagias are characterized by a disorder in the transportation of foods or saliva from the mouth to the stomach. [1,2] For its assessment, objective evaluations and clinical evaluation composed by the following phases are presented: anamneses, oral sensory-motor system evaluation, masticatory function evaluation, swallowing and phonetic articulation[1,2], as well as its complementation through auscultation and pulse oximetry. [2]

For swallowing investigation, the consistency of foods and the quantity ingested are checked, devices and forms of administration, as well as the autonomy for feeding.[1] During the evaluation, the oral contention of foods and the movements are observed in their transference from mouth to stomach to establish clinical signs that lead to the definition of swallowing disease. With the conjunction of these data, alteration due to lack of control or oral sensory-motor deficits or even the possibility of laryngeal penetrations and larynx tracheal aspirations.[1,3]

The symptoms and complications of neurogenic dysphagia's, disorders in swallowing or feeding processes caused by neurologic illness or trauma are due to alterations in cortical and sensory-motor control of musculature involved.[4] In most cases, neurogenic dysphagia's involve the compromising of oral and pharyngeal phases of swallowing named oral pharyngeal dysphagia's.[5]

Cervical auscultation is characterized by audible sounds of swallowing through an amplification instrument. This procedure is used for evaluating the pharyngeal sound of swallowing, whose main items to be conferred are integrity of airways protection mechanism and the timing of these sounds related to swallowing. Failures in the functioning of this protection mechanism or timing alterations adequate to this process may result in aspiration and secondary medical complications. [3,6] It is one of the instrumental resources used in the speech and language clinical approach of feeding.[7]

The adequate position of the stethoscope for cervical auscultation is the lateral part of the larynx and trachea junction anterior to the carotid.[3,6] Defined as a subjective evaluation, cervical auscultation aims to auscultate the swallowing sounds. For its performance, the stethoscope is placed in the thyroid cartilage, in its lateral portion, auscultating in a first moment the air passage, in respiratory inspiration and then, the noises related to swallowing, that is, of the bolus through the pharynx. [8] It is an exam performed in the act of swallowing, whose sounds are detected through a stethoscope or acoustic detector, established as consistent with normal swallowing or without alteration.[9]

According to Almeida[3] and McKaig[6], in a non-dysphagic swallowing, in general, there are three typical noises when the bolus is transferred to the pharynx, two audible clicks, followed by an expiratory blow. Cichero and Murdoch[10] first established a hypothesis conveyed in the literature on the origin of the three swallowing noises, comparing them to the sounds perceived in cardiac auscultation. Thus, according to these authors, the first noise stands for the closing of vocal folds and the posterior movement of tongue while the second noise would be related to the opening of the upper esophageal sphincter, associated to the flux resulting from the emptying of the pharynx. The authors suggested that the third swallowing noise would be related to the opening of the laryngeal airway due to minor vibrations of this structure. [10,11]

The places of origin of the two last noises were confirmed by the study of Morinière, Beutter and Boiron[12] from visual software conceived and developed for the analysis. The authors say that the two signals are not synchronized. For the conclusion, they had performed an analysis from the images of the acoustic signal collected by a pre-amplified microphone attached to a video plaque and concomitant to the X-ray image, performed by a camera attached to the computer.[12]

Through the use of computer programs, it is possible to digitalize the sounds and process the sounds already produced by swallowing through visual representations whose format allows exact measures, and, accordingly, a more accurate description of the sounds.

The acoustics data could serve as a basis for comparison for swallowing to provide a better understanding of its physiology.[11-13]

Auscultation allows exacting the frequency of the timing of pharyngeal swallowing sound and their correspondence to the position of the bolus and the anatomic structures involved in its transference from the mouth to the stomach. [11] The three components of this noise found were: the sound of the larynx raising when the bolus is found at the oropharynx and/or hypopharynx; an opening sound corresponding to the transit of the

bolus through the pharynx esophageal transition; and the sound of larynx freeing, corresponding to the noise of the larynx opening when the bolus is in the esophagus.[12]

Based on these data, this study aims to establish the swallowing sounds profile in post-stroke patients' group.

Methods

It consists of a cross-sectional and quantitative clinical observational study whose studied factor is the digital cervical auscultation and the outcome of the sound pattern of swallowing. It was performed in the facilities of an Integrated Clinics in the city of Porto Alegre/RS and approved by the Ethics Committee in Research under the protocol n. 100/2011, according to the guidelines of the national health commission.

Inclusion criteria were being accredited and assisted by the Integrated Clinics team, being over 18-year-old, presenting post-stroke sequels with exclusive oral intake, without any consistency's restriction. In agreeing to participate, the subjects signed an informed consent form as established in human being research.

The exclusion criteria were being assisted by other clinical care services, having impairment of language comprehension or diagnosed for basic diseases as Orthopedic, Parkinson Disease, Cerebral Palsy, neurological syndromes, sclerosis or dystrophies or in use of tracheostomy tube.

The individuals were in different time between stroke and data collection. Their time of stroke was more than a year and they were tested by dysphagia clinical evaluation. The collecting data took in about 30 minutes.

The clinical evaluation was performed through the Speech-language Neurogenic Dysphagia Evaluation (SNDE)[14]. This protocol was developed to analyze swallowing disease in neurogenic patient and its data are composed by a brief anamnesis directed to the relevant aspects which could interfere in swallowing. Then, an evaluation of swallowing was performed from data collection on sensitivity and mobility of oral facial structures, the quality of masticatory and swallowing functions, phonetic articulatory aspects, pneumo-phono-articulatory coordination, presence of oral reflexes; the swallowing consistencies test are: dry (only saliva), liquid (10 ml of water[15,16]), pureed and solid food (bread); and the collection of swallowing sounds through cervical auscultation[17]. The cervical auscultation was performed by positioning the stethoscope laterally between thyroid and cricoid cartilages of the unaffected side. As a conclusion, the protocol classifies the swallow in normal or dysphagia.

For this study and according to protocol SNDE[14] the consistencies evaluated were dry (only saliva) and liquid (10 ml of water [15,16]).

The collection of four liquid and one dry swallowing's was performed by the participants based on protocol data in auscultation through the Doppler Sonar device, as suggested by Santos and Macedo Filho[18] and performed by Moriniére, Beutter and Boiron[12] in establishing the physiological characteristics of swallowing sounds through digital acoustic analysis captured by an acoustic radiologic video plaque.

Swallowing sounds at cervical auscultation were collected during a dry (one swallow) and four liquid controlled swallowing's (10 ml portions of water each) by a Littman electronical stethoscope[19] model 4100.

After noise collection, the noises were transferred to a computer by Bluetooth followed by the analysis of the data collected in the Littmann Sound Analysis Software for Heart Sounds[19], establishing a peak of noise frequency, mean time of occurrence of the first swallowing episode and the difference between the times of occurrence of each peak of the swallowing event (clicks). The time established by the software of the digital stethoscope is stipulated by 100, thus establishing values in milliseconds (ms).

Data analysis was performed from data conferred in the electronical stethoscope's diaphragm, since it covers frequencies ranging from 20-2.000 Hz. The analysis was performed between the acoustics data with the conclusions of clinical evaluation through the SNDE protocol.

The quantitative variables were described by mean and standard deviation. Categorical variables were described by absolute and relative frequencies. To assess the association among qualitative variables, Pearson Chi-square test was applied and to compare the means (medians X categories) the "T-student" test (parametric test) or one-way variance analysis (ANOVA), non-parametric test were used.

The significance level adopted was 5% ($p \leq 0.05$), and the analyses were performed in SPSS (Statistical Package for the Social Sciences) version 21.0.

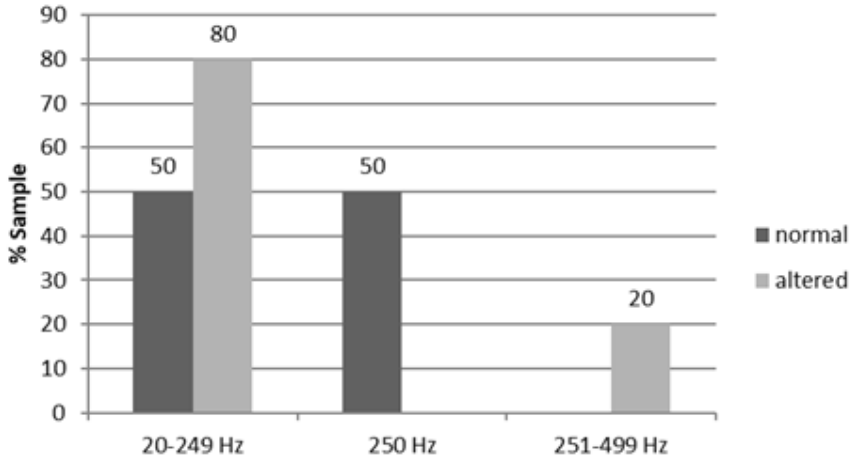
Results

This study comprised nine subjects with a neurologic diagnosis of stroke, mean age of 54.33 (Sd ±15.30 years), 77.3% female and 22.2% male.

In clinical evaluation, 55.6% had an established alteration in swallowing, with the following signs and symptoms: multiple swallowing (more than two swallows), suggesting the early escape of liquid and altered cervical auscultation with lowered click.

The sounds collected through digital cervical auscultation in dry swallowing were grouped in the frequencies between 20-249 Hz, 250 Hz, and 251-499 Hz; those collected in liquids swallowing were grouped in frequencies between: 20-249 Hz, 250, 251-499 Hz and 500 Hz. The total amount of dry swallowing was of 9 noises and that of liquids was 45 (9 subjects X 5 swallowing's).

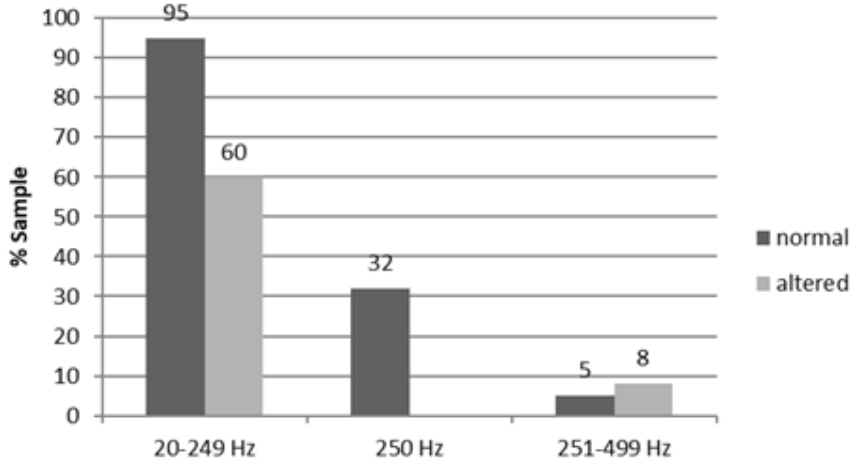
The correlation between the frequencies of noises and the result of clinical evaluation (SNDE conclusion) in dry consistency was 250 Hz in unaltered swallowing, and between 20-249 Hz in swallowing disease. These data do not present statistically differences (p=0.165). They are displayed in Figure 1.



Pearson Chi Square Test; P=0.165

Figure 1. Association between mean frequency of swallowing sound and clinical evaluation of dry swallowing.

The correlation between the frequencies of noises and the result of clinical evaluation (SNDE conclusion) in liquid consistency was 20-249 Hz in unaltered swallowing and 250 Hz in swallowing disease. These data present statistically differences (p= 0.015), displayed in Figure 2.



Pearson Chi Square Test; P=0.015

Figure 2. Association between mean frequency of swallowing sound and clinical evaluation of liquid swallowing.

In relation to the variable dry swallowing, a mean time of occurrence of the event was established in 110.3 ms (Sd ± 38.6 ms) and that between the peaks of swallowing in 1.33 ms (Sd ± 0.58ms). Concerning the event of swallowing of liquids, the mean time was 111.6 ms (Sd ± 36.5ms) and that between the peaks of swallowing was 1.29 ms (Sd ± 0.47 ms). These data do not present statistically significant differences (p = 0.927) and can be visualized in Table 1.

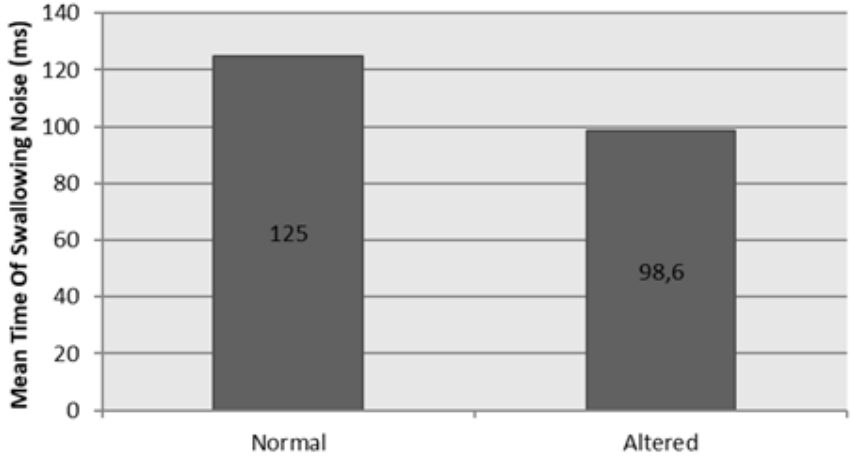
The correspondence between the mean frequency of swallowing noises and dry and liquid consistencies do not present a significant difference (p=0.835) and can be visualized in Table 1.

Table 1. Comparison between liquid and dry swallowing

Variables	Liquid (n=45)	Dry (n=9)	p
Mean time of swallowing sounds (ms) – Mean/Sd	111.6/± 36.5	110.3/± 38.6	0.927
Average frequency of swallowing sound – n(%)			0.835
20 Hz – 249 Hz	34 (75.6)	6 (66.7)	
250 Hz	8 (17.8)	2 (22.2)	
251 Hz – 499 Hz	3 (6.7)	1 (11.1)	

T-Student test or one-way variance analysis (ANOVA).

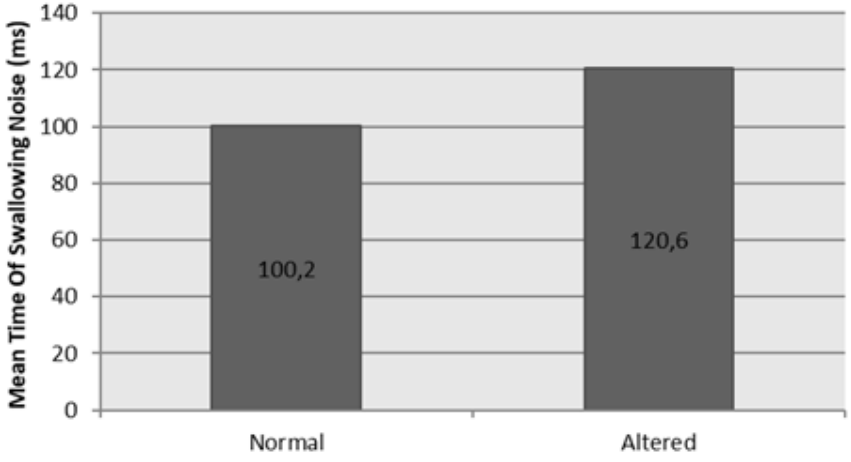
The correspondence between mean time of dry swallowing events and clinical evaluation was 125 ms (Sd ± 54.74ms) in unaltered swallowing noises and 98.60 ms (Sd ± 18.66ms) in altered swallowing. These data do not present statistically significant differences (p= 0.341) and can be visualized in Figure 3.



Pearson chi-square test; p= 0.341

Figure 3. Comparison of mean times of swallowing sound according to clinical evaluation of dry swallowing.

The correspondence between the mean time of swallowing events of liquid consistency and the clinical evaluation is 100.20 ms (Sd ± 31.01 ms) in unaltered swallowing noises and 120.86 ms (Sd ± 38.52 ms) in altered swallowing, whose data evidence a statistically significant difference between the variables (p = 0.060) and are exposed in Figure 4.



Pearson chi-square test; p = 0.060

Figure 4. Comparison between mean times of swallowing sound according to clinical evaluation of liquid swallowing.

Discussion

During the evaluation of swallowing, the patient's oral contention is examined as well as, through cervical auscultation, the occurrence of indirect signs of premature loss of bolus and, thus, the alteration of oral sensory-motor control, as stasis and laryngeal penetrations or larynx tracheal aspirations or both. The presence of stasis in the oral and/or oral pharynx should be observed, which reflects the alteration in the control or ejection (or both) of the bolus and deficits in sensitivity.[1]

Swallowing seen as normal occurs soon after oral transit, followed by a period of apnea and expiration when "clear and clean" sounds are auscultated.[20] In this study, into clinical evaluation, an alteration of premature loss, cervical auscultation with lower click and multiple swallowing's were found. These data are confirmed in the literature as swallowing alteration.

The mean adult age found in subjects assessed was corroborated by data in literature, considering that this frequency was found in a study of 10.900 persons of various countries from the theme "Aging, Health, and Well-Being", performed by the Pan-American Health Organization. [21]

The relative number established to the variable gender (more in female than male) and the swallowing disease established in more than 50% of the participants through clinical evaluation, even in a small sample, have diversified bases in literature, since there are studies that point to a mean significance of 54% men and 46% women[22] and others, analyzing "stroke patients" with or without swallowing difficulties, observed the absence of significant difference in relation to age, gender, and stroke type.[23]

By assessing the prevailing sequels in post-stroke patients, authors[2] found in clinical evaluation, the presence of dysphagia in 42.3% of cases researched, concluding that this is the typical sequel.

In virtue of the current moment of the search for an evidence-based science, in relation to clinical evaluation of dysphagia, data are divergent in literature. [2,24] The use of bedside clinical evaluation of swallowing alone, without instrumental evaluation, is considered superior to objective exams, despite of presenting limitation. [24]

In relation to digital cervical auscultation, data are found using different instruments of noise capturing: the use of digital acoustic analysis via Doppler Sonar [18] employing software with visualization, and recording of two synchronized captured signs[12]; microphone[25] or accelerometer[3]. At the same time, there are reports on the use of coupled microphones and the use of the accelerometers for capturing acoustic signs with further computer analysis.[7] In relation to the sounds heard, Morinière, Beutter e Boiron[12] presented a physiological comparison of established sounds, as the sound of larynx ascension, the opening sound of pharynx esophageal transition and the sound of larynx liberation, often researched throughout the last decades.

According to Santos and Macedo Filho[18] the initial peak of swallowing presents the frequency of 905 Hz for dry consistency and 910 Hz for liquid consistency for heathy adults. Morinière, Beutter and Boiron[26] said that the mean frequency of the swallowing peak presents 540 Hz noises for female sex and 750 Hz for male sex in timing of 710 ms in heathy human. A discrepancy is observed yet with data found in literature in relation to the frequency of swallowing sounds. The frequency of swallowing peak in dry consistency found between 20-250 Hz, the occurrence of swallowing peaks in low frequencies was observed.

The swallowing peaks of participants with post-stroke sequels for liquid consistency are found in frequencies between 20-250 Hz, below what was found in literature by Morinière, Beutter and Boiron. [26] Cardoso[17], who collected swallowing sounds with the same instrument in an elderly population with mean age of 74.72 years (Sd ± 7.41), found the occurrence of swallowing peaks in frequencies higher than 500 Hz, no significant differences being found between these variables of frequency, gender and age group in the elderly. The low frequency evidenced in the study analyzed suggests the commitment of impulsion force of the bolus through pharynx esophageal transition, being established with a lower frequency.

In relation to the duration of the swallowing noises, the acoustic signs in occurrence time are differentiated in the literature. Santos and Macedo Filho[18] dry swallowing time has a mean of 1.331s and liquid swallowing (10 ml), a mean of 1.679 s. In Morinière, Beutter and Boiron[12] the mean of sound duration is 106 ms for liquid swallowing.

In this study, differences are found between the sounds of dry and liquid swallowing varying around 1 ms, suggesting an approximation in the

transit time of the bolus through the pharyngeal phase in patients with post-stroke sequels when means assessed for dry and liquid swallowing are compared. In facing them with literature data, no possibilities of conclusion were found, the means of the study do not approximate.

Cardoso and Gomes[27] found that it is possible to observe cervical auscultation in dry, liquid, and pureed consistencies in adults without complaints of swallowing alteration or presenting a mature or adapted swallowing, of different characteristics concerning the pharyngeal phase of sound frequency and intensity, once the sounds occur in high and low frequencies, of strong and weak intensities, single, double, and no noises. Those data do not corroborate those found in this study, concerning the existence of difference between dry and liquid cervical auscultation, since the results obtained show a minimal difference.

The acoustic characteristics of dry swallowing depend on saliva production, which may interfere in the time of occurrence of swallowing.[26] This factor also appears in this study, since the report of dryness or absence of saliva informed by the participants is evident in the absence or delay of sound in dry consistency swallowing. This finding could be related to the presence of xerostomia by medication for patients' post-stroke.[28]

In this research, the results of digital auscultation frequency in dry swallowing related to the clinical evaluation of unaltered swallowing remained mostly in 20-249 Hz. On the other hand, the results of swallowing clinical evaluation with disease, in the same proportion, remained between 20-249 and 250 Hz. The results of digital auscultation frequency in liquid swallowing, related to the clinical evaluation of swallowing disease remained mostly between 20-249 Hz. The results of swallowing clinical evaluation with disease remained mostly in 250 Hz. Through statistical significance, predominance is perceived in swallowing sounds for dry and liquid swallowing along with post-stroke sequels carriers in lower frequencies found in literature concerning the frequency expected to normal swallowing, as shown in Figure 2.

Acoustics signals of cervical auscultation shows that men and elderly persons produced higher peak intensities and peak frequencies than women and younger persons.[29] The same could not be verified in this study.

Youmans and Stierwalt [29] found that thin liquids were produced with more intensity than more viscous boluses, and with greater frequency than solids. Larger volumes resulted in greater peak frequency values.

Comparative data between cervical auscultation frequency and clinical evaluation are not referred in literature, and the analysis of the results between the mean time of swallowing and clinical evaluation evidenced a significant trend for liquid consistency.

The clinical evaluation of swallowing involves the aspects of structures and functions expected for an adult pattern with the possible presence of information of the possibility of occurrence of dysphagia. For the determination of dysphagia, a joint instrumental evaluation is fundamental, including cervical auscultation in order to detect the swallowing sounds, determining the integrity of airway mechanisms and the timing of these sounds associated to swallowing.

The subjective character of cervical auscultation, by the establishment of presence or absence of sound and its physiological meaning and auditory-qualitative characteristics, is still a question and base of investigation among researchers.

By using of the electronic stethoscope for collecting the sounds showed itself as an instrumental possibility, but for the acoustic analysis through the software, it did not show itself productive because there is no possibility of specific frequencies.

Through digital cervical auscultation, the establishment of swallowing occurrence time, its frequency and identification of the moment in which the bolus reaches pharynx esophageal transition with mathematically established measures and followed by a representation through which the swallowing sounds can be visualized, then turning a subjective data into an objective one, and this still needs to be further clinically explored.

Conclusions

The digital stethoscope showed itself as an instrumental possibility for the collection, but for the acoustic analysis it is not productive. The results of the dry and liquid swallowing were: average time around 110 ms and at low frequency, varying between 20 Hz and 500 Hz for both consistencies, with patients with post-stroke sequels. Comparative data between the frequency of cervical auscultation

and clinical evaluation were not to be found in literature, and the analysis of the clinical evaluation results evidence a significant tendency.

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