Original Article

http://doi.org/10.1590/2317-6431-2017-1870

Audiology Communication Research
ISSN 2317-6431

Factors associated with tongue pressure in post-stroke patients

Fatores associados à pressão de língua em pacientes pós-acidente vascular cerebral

Grazielle Duarte de Oliveira[1], Amanda Freitas Valentim[2], Laélia Cristina Caseiro Vicente[3], Andréa Rodrigues Motta[3]

ABSTRACT

Introduction: The clinical practice of speech pathology in hospitals shows that there is a high prevalence of dysphagia in post-stroke patients. **Purpose:** To verify whether the time of occurrence, type of stroke, affected hemisphere, severity of neurological deficit, presence or absence of dysphagia, and degree of dysphagia interfere with tongue pressure in post-stroke patients. **Methods:** This study was conducted in 31 stroke patients. Three evaluations were performed, one of tongue mobility, another of dysphagia, and another of tongue pressure using the *Iowa Oral Performance Instrument*. Three measurements were performed of anterior and three of posterior tongue pressure. Data were analyzed using appropriate statistics, considering a significance level of 5%. **Results:** Only the presence of dysphagia was associated with tongue pressure. Post-stroke patients with dysphagia had lower anterior and posterior tongue pressure (mean and maximum) than those without dysphagia. The time of occurrence, type, and affected hemisphere of the stroke and severity of the neurological deficit were not associated with tongue pressure. Regarding the degree of dysphagia, of the 15 participants who had swallowing difficulties, 14 were classified with mild and one with moderate dysphagia. **Conclusion:** Dysphagia was the most important factor in the decrease of tongue pressure in post-stroke patients.

Keywords: Tongue; Muscle strength; Deglutition disorders; Stroke

RESUMO

Introdução: A prática clínica fonoaudiológica no ambiente hospitalar mostra que existe alta prevalência de disfagia em pacientes pós-acidente vascular cerebral. **Objetivo:** Verificar se o tempo de ocorrência e o tipo do acidente vascular cerebral, o hemicorpo acometido por hemiplegia, a gravidade do deficit neurológico, a presença e o grau de disfagia interferem na pressão de língua de pacientes internados pós-acidente vascular cerebral. **Métodos:** Estudo realizado com 31 pacientes. Foi aplicado protocolo da avaliação da disfagia, prova de mobilidade lingual e mediu-se a pressão de língua com o *Iowa Oral Performance Instrument* (IOPI). Foram realizadas três medidas da pressão anterior e três da pressão posterior. Os dados foram analisados por meio de estatística apropriada, com nível de significância de 5%. **Resultados:** Apenas a presença de disfagia se mostrou associada estatisticamente à pressão de língua, sendo que os pacientes pós-acidente vascular cerebral disfágicos apresentaram pressão anterior e posterior média e máxima da língua menor que aqueles sem a presença de disfagia. O tempo de ocorrência do acidente vascular cerebral, o tipo e o hemicorpo acometido e a gravidade do deficit neurológico não apresentaram associação com a pressão lingual. Dentre os 15 participantes que apresentaram a dificuldade de deglutição, 14 (93,3%) foram classificados com disfagia leve e um (6,7%) com disfagia moderada. **Conclusão:** Verificou-se que a disfagia, ainda que de grau leve, foi o fator preponderante para diminuição da pressão de língua em pacientes que sofreram acidente vascular cerebral.

Palavras-chave: Língua; Força muscular; Transtornos de deglutição; Acidente vascular cerebral

Work conducted at the Department of Speech and Hearing Therapy, School of Medicine, Universidade Federal de Minas Gerais – UFMG – Belo Horizonte (MG), Brazil.

(1) Postgraduate Program (Master's Degree) in Speech and Hearing Therapy, Department of Speech and Hearing Therapy, School of Medicine, Universidade Federal de Minas Gerais – UFMG – Belo Horizonte (MG), Brazil.

(2) Department of Bioengineering, Universidade Federal de Minas Gerais – UFMG – Belo Horizonte (MG), Brazil.

(3) Department of Speech and Hearing Therapy, School of Medicine, Universidade Federal de Minas Gerais – UFMG – Belo Horizonte (MG), Brazil.

Conflict of interests: No

Authors' contribution: *GDO* was responsible for the study conception and design, data collection and analysis, and manuscript preparation; *AFV* was responsible for the study conception and design, data analysis, and manuscript preparation; *LCCV* and *ARM* were responsible for the study conception and design, and guidance in all stages of the study and manuscript revision.

Corresponding author: Grazielle Duarte de Oliveira. E-mail: grazi_duarte@hotmail.com

Received: 4/6/2017; **Accepted:** 7/26/2017

INTRODUCTION

There are two types of stroke: ischemic ones, which are more frequent (70% to 80% of the cases), and hemorrhagic ones, which are usually more severe and have worse consequences[1]. Clinical speech pathology practice in hospitals shows that there is a high prevalence of dysphagia in post-stroke patients[2], a fact supported by the literature[3].

Dysphagia indicates a decline in the swallowing function, and its estimated prevalence can vary from 42% to 76% in patients with acute stroke[4,5,6]. The presence of dysphagia is associated with an increased risk of pulmonary complications from aspiration of saliva and/or food, malnutrition, dehydration, pneumonia, prolonged hospitalization, and death[7].

The tongue is a muscle that plays an important and significant role in the oral and pharyngeal stages of swallowing, since it acts in the formation, positioning, and manipulation of the food bolus during the oral preparatory phase, with the posterior transfer of the bolus, from the mouth to the pharynx[3,8]. Although impairment of this complex central system contributes to a decrease in the swallowing function, the restoration of this process after the stroke may also depend in part on the recovery of neuromuscular morphological factors, such as the strength of the intrinsic and extrinsic musculature of the tongue[9]. Abnormal tongue function may also favor the presence of oral residue, prolonged oral transit time[3], difficulty in bolus formation, and premature loss of food[10].

There is evidence that the greatest degree of tongue strength impairment occurs in patients with oropharyngeal dysphagia, compared with those with adequate swallowing[6,8,11]. However, there are few studies investigating patients after stroke, and there are no publications with data from the Brazilian population.

Thus, considering the high prevalence of dysphagia in post-stroke patients and the role of the tongue in the biomechanics of swallowing, it is important to identify and characterize the impairment of tongue pressure in this population, contributing to evidence in the area, which is still scarce.

In view of the above, the study aimed at verifying whether the time of occurrence and type of stroke, hemibody affected by hemiplegia, severity of neurological deficit, and presence and degree of dysphagia would interfere with tongue pressure after stroke.

METHODS

The research was characterized as an observational, cross-sectional, analytical study. The project was approved by the Research Ethics Committee of the *Universidade Federal de Minas Gerais*, under the number: CAAE-185643 13.0.0000.5149.

Thirty-one patients were evaluated, including 17 women and 14 men, with a mean age of 61.8 years. The inclusion criteria were: the patient should had suffered a stroke between 24 and 72 hours before the date of the evaluation, had tongue mobility preserved, had no other neurological or structural impairment of the head and neck, be aged between 40 and 87 years, had a Glasgow Scale above 12, and had given their own consent or from a family member to participate in the study, through the signing of the Free and Informed Consent Form. Participants who did not understand the order to perform the evaluations or who were unable to perform all the tongue pressure measurements were excluded.

The participants were selected using the stroke protocol adopted at *Santa Casa Misericórdia de Passos* (MG). The nurse at the emergency/urgency unit communicated to the Speech Therapy department about the hospitalization of the patients in the unit. In the hospital chart, there were data referring to the clinical and neurological conditions of patients with stroke in the acute phase and a request for speech therapy evaluation by the medical team, which was performed between 24 and 72 hours after the event.

In order to characterize the neurological deficit, the National Institutes of Health Stroke Scale (NIHSS) was used, which was in the participants' charts, and which classified the deficit as mild (1 to 3), moderate (4 to 10), and severe (above 15)[12]. Of the 31 participants, 23 (74.2%) presented a mild and eight (25.8%) presented a moderate neurological deficit.

The speech and hearing therapy and instrumental evaluations were carried out by the principal investigator, who is experienced in orofacial motricity and dysphagia and has previous training, in order to standardize the parameters used in the evaluations.

For the data collection, the investigation included the tongue mobility, the presence and degree of dysphagia, and three measurements of the maximal pressure at the anterior and posterior tongue. The following information was transcribed from the hospital chart: type of stroke, presence of hemiplegia, and side of the impairment.

The evaluation was performed with the post-stroke individual sitting on the bed with the headboard elevated. In the mobility test, they were asked to move their tongues up, down, and to the sides. This sought to guarantee the execution of the instrumental evaluation.

Swallowing was investigated using the Gugging Swallowing Screen (GUSS)[13], which is an instrument to screen for the risk of dysphagia, standardized and validated for patients with stroke and used at the bedside. The instrument comprises two steps: the first, called "indirect swallowing or swallowing of saliva test" and the second, "direct swallowing test." In the indirect evaluation of swallowing, the criteria established for dysphagia were vigilance, cough and/or voluntary throat clearing, saliva swallowing, drooling, and voice changes. The direct evaluation of swallowing is divided into three substeps, according to the consistency of the food to be evaluated, *i.e.*, pudding, liquid, and solid, in this order, with the volumes suggested in the original protocol. In the direct evaluation, the criteria

established for dysphagia were swallowing and oral transit time, involuntary coughing before, during, or three minutes after the pharyngeal phase of swallowing, drooling, and vocal changes. The dysphagia criteria were scored with a variation of 0 to 2 points for each item[13].

In accordance with the instrument, the evaluation steps were sequential and, at each stage, the score for the appropriate swallowing standard was 5. In order to proceed with the direct evaluation of swallowing of the consistencies, it is necessary that the patient first swallow the saliva successfully (obtaining 5 points). For the progression of the consistencies, a score of 5 is required for each consistency and, if the individual does not obtain said score, the next consistency assessment is interrupted. The total value of the GUSS scale is 20 points, indicating that the patient presents an adequate swallowing pattern of saliva and pudding, liquid, and solid consistencies. Thus, swallowing is classified as normal/without dysphagia (20), mild dysphagia, with a low risk of aspiration (15 to 19), moderate dysphagia with a risk of aspiration (10 to 14), and severe dysphagia, with a high risk of aspiration (0 to 9)[13].

An external evaluator independently repeated the clinical evaluation in 15% of the sample (five participants), on the same day as the investigator, and obtained exactly the same results.

Individuals with no change in mobility were followed up for instrumental evaluation of lingual pressure, performed using IOPI, a portable instrument that measures the tongue pressure exerted on an air-filled bulb positioned on the tongue, on the palate. This bulb, 3.5 cm long, is connected to a pressure transducer by means of a plastic tube and, as the air-filled bulb is pressed against the palate, values are measured in kPa and can be visualized on the device's LCD screen.

The bulb was placed in the mouth of each participant, in two regions, anterior and posterior. In order to investigate the pressure in the anterior tongue region, the IOPI bulb was positioned so that it would get stuck in the front teeth when pulled out of the mouth. Whereas, in the posterior region, the bulb was positioned 10 mm after the first measurement[14]. This sought to guarantee the reproducibility of the positioning of the instrument throughout the measurements. According to the literature, there is no need to randomize the order of testing[15].

After ten seconds of adjustment, the participant was asked to press the bulb against the palate with his tongue using the greatest strength they could and to maintain it for approximately two seconds[16], without visualization of the values obtained. The procedure was performed two times more, totaling three measurements, with one-minute intervals, in both the anterior and posterior regions.

Part of the instrumental evaluation was not repeated by a second evaluator since it presented good reproducibility[17].

For the analysis of the results, the highest value obtained between the three measurements (maximum pressure) was considered as the value of the individual's tongue pressure, as well as the average of the three maximum pressures (mean pressure), which, according to the literature, better reflects the characteristic pressure of the subject[8].

The information collected was typed into an Excel® database. For the statistical analysis, the STATA program, version 12.0, and a significance level of 5% were used.

The descriptive results were obtained using frequencies and percentages for the characteristics of the various categorical variables and measurements of central tendency (mean and median) and dispersion (standard deviation) for continuous variables.

For the comparison of the measurements, the nonparametric Mann-Whitney and Kruskal-Wallis tests were used, when there were more than two comparison groups.

RESULTS

With regard to the degree of dysphagia, among the 15 participants who presented swallowing difficulty, 14 (93.3%) were classified with mild dysphagia and 1 (6.7%) with moderate dysphagia, hindering the inferential statistical analysis.

The sample was described according to the mean and maximum anterior and posterior tongue pressure measurements in post-stroke patients, in relation to the variables for the presence and degree of dysphagia, the type and time of occurrence of the stroke, the severity of the neurological deficit, and hemibody affected by hemiplegia. It was possible to verify that acute post-stroke patients with the presence of dysphagia presented lower mean and maximum anterior and posterior tongue pressure than individuals without dysphagia, with this difference being significant (Tables 1 and 2).

Regarding the type and time of the stroke, as well as the side affected by hemiplegia, and the severity of the neurological deficit, no significant data were verified. However, it was observed that patients with hemorrhagic stroke had greater mean and maximum anterior and posterior tongue pressure in relation to those with ischemic stroke. It was also found that patients with stroke after 72 hours presented greater mean and maximum anterior and posterior tongue pressure in relation to patients with stroke after 24 and 48 hours and that, when the right side was affected, the pressure values were greater, compared with those not affected and with the impairments on the left side.

DISCUSSION

Patients with acute post-stroke dysphagia presented, on average, both mean and maximum pressure of the anterior and posterior tongue lower than those without dysphagia. Studies with post-stroke patients[6,18,19] also found that the mean and maximum tongue pressure was significantly lower in the dysphagia group. Thus, the decrease in tongue pressure observed in some cases of stroke was basically associated with the presence of dysphagia. Several studies in the literature

Table 1. Measurements of mean and maximum anterior tongue pressure in post-stroke patients

Tongue pressure (kPa)	n	Mean	Median	SD	Minimum	Maximum	p-value
Maximum anterior							
Without dysphagia	16	38.1	38.5	14.4	15.0	69.0	**0.028***
With dysphagia	15	27.5	26.0	10.5	12.0	48.0	
Mean anterior							
Without dysphagia	16	37.1	37.5	14.2	14.0	67.0	**0.030***
With dysphagia	15	26.4	24.0	10.7	11.0	48.0	
Maximum anterior							
Ischemic stroke	28	32.6	31.0	13.8	12.0	69.0	0.569*
Hemorrhagic stroke	3	36.7	37.0	13.5	23.0	50.0	
Mean anterior							
Ischemic stroke	28	31.5	29.0	13.7	11.0	67.0	0.570*
Hemorrhagic stroke	3	35.7	37.0	13.1	22.0	48.0	
Maximum anterior							
Stroke - 24H	18	31.3	31.0	11.6	12.0	50.0	0.689**
Stroke - 48H	8	33.8	26.0	16.6	20.0	69.0	
Stroke - 72H	5	37.6	36.0	17.2	12.0	57.0	
Mean anterior							
Stroke - 24H	18	30.6	29.5	11.4	12.0	48.0	0.770**
Stroke - 48H	8	32.3	24.5	16.5	18.0	67.0	
Stroke - 72H	5	36.2	35.0	17.4	11.0	57.0	
Maximum anterior							
Without R hemiplegia	17	31.1	29.0	11.1	12.0	49.0	0.619*
With R hemiplegia	14	35.2	33.5	16.3	12.0	69.0	
Mean anterior							
Without R hemiplegia	17	29.9	27.0	11.0	12.0	47.0	0.512*
With R hemiplegia	14	34.4	32.5	16.2	11.0	67.0	
Maximum anterior							
Without L hemiplegia	16	35.9	34.0	15.4	12.0	69.0	0.342*
With L hemiplegia	15	29.9	26.0	10.9	12.0	49.0	
Mean anterior							
Without L hemiplegia	16	34.9	32.5	15.4	11.0	67.0	0.294*
With L hemiplegia	15	28.7	25.0	10.9	12.0	47.0	
Maximum anterior							
Mild NIHSS	23	33.9	34.0	15.3	12.0	69.0	0.769 *
Moderate NIHSS	8	30.3	26.0	6.7	25.0	43.0	
Mean anterior							
Mild NIHSS	23	32.8	33.0	15.1	11.0	67.0	0.821 *
Moderate NIHSS	8	29.4	25.0	7.2	24.0	43.0	

*Significant values (p≤0.05) – *Mann-Whitney test, **Kruskal-Wallis test

Subtitle: SD = standard deviation; R = right; L = left; NIHSS = National Institutes of Health Stroke Scale

have related the decrease in tongue pressure to the symptom of dysphagia[10,20,21,22,23,24].

The results of this study indicated that tongue pressure in the subjects affected with stroke could trigger dysphagia. The tongue presents an active and fundamental function in the swallowing phases, with the exception of the esophageal phase. The actions of the tongue include capture, preparation, oral and pharyngeal propulsion, and protection of the inferior airway until the cleaning of the residues. Not only is the structure mobility important, but its strength and coordination promote an efficient and safe mechanism. The reduction in tongue pressure may lead to the following situations in dysphagic

Table 2. Measurements of mean and maximum posterior tongue pressure in post-stroke patients

Tongue pressure (kPa)	n	Mean	Median	SD	Minimum	Maximum	p-value
Maximum posterior							
Without dysphagia	16	35.1	36.5	14.7	12.0	69.0	**0.020***
With dysphagia	15	22.3	22.0	11.0	5.0	44.0	
Mean posterior							
Without dysphagia	16	34.4	36.0	14.8	11.0	68.0	**0.015***
With dysphagia	15	21.3	20.0	10.9	4.0	43.0	
Maximum posterior							
Ischemic stroke	28	28.2	26.0	14.7	5.0	69.0	0.284*
Hemorrhagic stroke	3	35.0	39.0	11.5	22.0	44.0	
Mean posterior							
Ischemic stroke	28	27.4	25.5	14.7	4.0	68.0	0.299*
Hemorrhagic stroke	3	34.0	38.0	11.5	21.0	43.0	
Maximum posterior							
Stroke - 24H	18	26.4	25.5	11.6	6.0	44.0	0.615**
Stroke - 48H	8	31.8	26.0	17.5	15.0	69.0	
Stroke - 72H	5	33.0	43.0	19.4	5.0	52.0	
Mean posterior							
Stroke - 24H	18	25.7	25.0	11.6	5.0	43.0	0.603**
Stroke - 48H	8	30.6	25.5	17.5	15.0	68.0	
Stroke - 72H	5	32.4	43.0	19.8	4.0	52.0	
Maximum posterior							
Without R hemiplegia	17	27.6	26.0	12.0	6.0	44.0	0.691*
With R hemiplegia	14	30.4	26.5	17.3	5.0	69.0	
Mean posterior							
Without R hemiplegia	17	26.8	25.0	12.1	5.0	43.0	0.706*
With R hemiplegia	14	29.5	26.0	17.3	4.0	68.0	
Maximum posterior							
Without L hemiplegia	16	30.6	26.5	16.6	5.0	69.0	0.514*
With L hemiplegia	15	27.0	26.0	11.9	6.0	44.0	
Mean posterior							
Without L hemiplegia	16	29.8	26.0	16.6	4.0	68.0	0.539*
With L hemiplegia	15	26.2	25.0	12.0	5.0	43.0	
Maximum posterior							
Mild NIHSS	23	29.3	27.0	16.0	5.0	69.0	0.856 *
Moderate NIHSS	8	27.5	25.5	8.8	19.0	43.0	
Mean posterior							
Mild NIHSS	23	28.6	26.0	16.1	4.0	68.0	0.786 *
Moderate NIHSS	8	26.5	24.5	8.9	18.0	42.0	

*Significant values (p≤0.05) – *Mann-Whitney test, **Kruskal-Wallis test

Subtitle: SD = standard deviation; R = right; L = left; NIHSS = National Institutes of Health Stroke Scale

patients: slowing down of the oral manipulation of the bolus, and consequently a time-consuming and sometimes inefficient preparation; increased oral transit time; delayed triggering of swallowing, or in lower regions of the pharynx; incomplete closure of the larynx; difficulty in cleaning oral and pharyngeal residues by vigorous swallowing.

For these reasons, pressure analysis of the tongue is useful for assessing the pathophysiology of swallowing in dysphagic patients with stroke[19]. In addition, it is a resource that can be used at the bedside and can predict the occurrence of pneumonia if the pressure is below 21.6 kPa[6]. Therefore, the analysis of the pressure of the tongue should be an aspect valuable

and approached therapeutically during rehabilitation from dysphagia, in addition to other alterations found.

Regarding the type and time of stroke, no significant data were observed. Although hemorrhagic stroke was considered more severe[1], there was no difference in tongue pressure in relation to patients with ischemic stroke. Similarly, the first hours after the stroke are considered the most critical, but there was also no difference in tongue pressure between patients after 24, 48, or 72 hours of the stroke. Although these are not variables addressed in the literature, they should not be disregarded in future research and investigations, since the present study was the only one found with an evaluation of the patients in the first days after the stroke. Tongue pressure may increase significantly after two weeks from the event[6]. Thus, it is important to monitor the tongue pressure gain over time, since patients who do not show an increase in tongue pressure, even with therapy, are at higher risk of developing pneumonia[6].

In the present study, when analyzing mean and maximum anterior and posterior tongue pressure in post-stroke patients, it was possible to observe that there was also no difference between those who presented hemiplegia on the right or left side. There are no studies in the literature relating hemiplegia and tongue pressure, but some authors[11,19,25] researched the pressure by comparing data from each half portion of the tongue, and observed lower values on the paralyzed side. This fact was not researched in the present study. When the right side was affected, the pressure values were higher, compared with nonaffected ones and with those with the left side impaired. This result should be analyzed with caution and with studies including larger samples, but it can be inferred that the tongue pressure remains greater on the dominant side, even in the presence of hemiplegia. Therefore, studies are required to verify the association between tongue pressure, hemiplegia with motor cortex lesion, and motor dominance. Studies such as these may reveal new directions for the rehabilitation of dysphagia in cases of hemiplegia. In this study, the affected hemisphere was not investigated, since data on the topographic diagnosis of stroke in all patients were not available.

Regarding the severity of the neurological deficit, there was no association between the results obtained with the NIHSS scale and tongue pressure. However, it was found that patients with mild NIHSS presented increased tongue pressure than those with moderate NIHSS, as evidenced in another study, where the lower the NIHSS, the higher the tongue pressure[6]. Thus, it is worth a more careful evaluation of the tongue pressure with worse neurological deficits in post-stroke patients.

No research measuring tongue pressure in Brazilian post-stroke patients was found. The results of anterior tongue pressure obtained in this study were similar to those found in studies using the IOPI in the Korean[26] and American[14] populations. Those with the posterior pressure were similar to a survey of Canadian subjects[27], however, lower than those previously mentioned, which shows that this data can vary according to the characteristics of each population.

The present study showed the important relationship between tongue pressure and dysphagia in post-stroke patients, indicating that in the hospital environment, the presence of dysphagia should be considered in these patients, and that rehabilitation of tongue pressure should be started while the patients are still in bed, if possible, so improvement is faster. Some authors have investigated the effectiveness of exercises on tongue pressure gain and found that in four to eight weeks of training, it was already possible to observe an increase in maximum pressure and also in swallowing pressure, both in healthy participants[28,29] and in post-stroke patients[14].

In 2013, the Toronto Rehabilitation Institute's Swallowing Rehabilitation Research Laboratory presented a tongue pressure profile training protocol developed specifically for the treatment of dysphagia affecting post-stroke patients[30] and, in 2016, this group published an article comparing the results of this training protocol, which involves muscular training and swallowing, along with another type of training, only muscular, without function training. After an average of 16 sessions, both post-stroke patients with dysphagia and those without dysphagia achieved significant strength gain, accompanied by an improvement in swallowing in some cases, but without a significant difference between the groups[27].

Some limitations could be verified in the development of this study, such as the size of some strata and, especially, the degree of dysphagia (absence of a patient with severe dysphagia). To date, most studies have been conducted with participants with Parkinson's disease, oculopharyngeal muscular dystrophy, or head and neck cancer. In each of these populations, the samples were still too small to indicate the typical values of these conditions. Surprisingly, there have been few studies in which IOPI has been used in patients with stroke, or in patients with other neurological diseases. Thus, there is a broad scope to establish the values of tongue pressure in these populations and to correlate the pressure with the biomechanical events of swallowing, through instrumental evaluations, such as videofluoroscopy, in patients with dysphagia.

CONCLUSION

Among the patients who suffered an acute stroke, dysphagic patients presented lower anterior and posterior tongue pressure than those without dysphagia. These results occurred for both mean and maximum tongue pressure. There was no relationship of tongue pressure with the type of stroke, time from stroke, severity of neurological deficit, and side of hemiplegia.

REFERENCES

1. Sacco RL. Patogênese, classificação e epidemiologia das doenças vasculares cerebrais. In: Rowland LP. Tratado de neurologia. Rio de Janeiro: Guanabara Koogan; 2007. p. 251-65.

2. Gagliardi RJ. Acidente Vascular Cerebral ou Acidente Vascular Encefálico? Qual a melhor nomenclatura? Rev Neurocienc. 2010;18(2):131-2. https://doi.org/10.4181/RNC.2010.1802.02p
3. Logemann JA. Evaluation and treatment of swallowing disorders. 2nd ed. Austin, Tx: Pro-ed; 1998.
4. Katzan IL, Cebul RD, Husak BA, Dawson NV, Baker DW. The effect of pneumonia on mortality among patients hospitalized for acute stroke. Neurology. 2003;60(4):620-5. https://doi.org/10.1212/01.WNL.0000046586.38284.60
5. Hinchey JA, Shephard T, Furie K, Smith D, Wang D, Tonn S et al. Formal dysphagia screening protocols prevent pneumonia. Stroke. 2005;36(9):1972-6. https://doi.org/10.1161/01.STR.0000177529.86868.8d
6. Nakamori M, Hosomi N, Ishikawa K, Imamura E, Shioshido T, Ohshita T et al. Prediction of pneumonia in acute stroke patients using tongue pressure measurements. PLoS One. 2016;11(11):e0165837. https://doi.org/10.1371/journal.pone.0165837
7. Martino R, Foley N, Bhogal S, Diamant N, Speechley M, Teasell R. Dysphagia after stroke: incidence, diagnosis and pulmonary complications. Stroke. 2005;36(12):2756-63. https://doi.org/10.1161/01.STR.0000190056.76543.eb
8. Clark HM, Henson PA, Barber WD, Stierwalt JAG, Sherrill M. Relationships among subjective and objective measures of tongue strength and oral phase swallowing impairments. Am J Speech Lang Pathol. 2003;12(1):40-50. https://doi.org/10.1044/1058-0360(2003/051)
9. Robbins J. The evolution of swallowing neuroanatomy and physiology in humans: a practical perspective. Ann Neurol. 1999;46(3):279-80.
10. Lee JH, Kim H-S, Yun DH, Chon J, Han YJ, Yoo SD et al. The relationship between tongue pressure and oral dysphagia in stroke patients. Ann Rehabil Med. 2016;40(4):620-8. https://doi.org/10.5535/arm.2016.40.4.620
11. Robinovich SN, Hershler C, Romilly DP. A tongue force measurement system for the assessment of oral-phase swallowing disorders. Arch Phys Med Rehabil. 1991;72(1):38-42.
12. Cincura C, Pontes-Neto OM, Neville IS, Mendes HF, Menezes DF, Mariano DC et al. Validation of the National Institutes of Health Stroke Scale, modified Rankin Scale and Barthel Index in Brazil: the role of cultural adaptation and structured interviewing. Cerebrovasc Dis. 2009;27(2):119-22. https://doi.org/10.1159/000177918
13. Trapl M, Enderle P, Nowotny M, Teuschl Y, Matz K, Dachenhausen A et al. Dysphagia bedside screening for acute-stroke patients: the Gugging swallowing screen. Stroke. 2007;38(11):2948-52. https://doi.org/10.1161/STROKEAHA.107.483933
14. Robbins J, Kays SA, Gangnon RE, Hind JA, Hewitt AL, Gentry LR et al. The effects of lingual exercise in stroke patients with dysphagia. Arch Phys Med Rehabil. 2007;88(2):150-8. https://doi.org/10.1016/j.apmr.2006.11.002
15. Vanderwegen J, Guns C, Nuffelen GV, Elen R, Bodt M. The influence of age, sex, bulb position, visual feedback, and the order of testing on maximum anterior and posterior tongue strength and endurance in healthy Belgian adults. Dysphagia. 2013;28(2):159-66. https://doi.org/10.1007/s00455-012-9425-x
16. IOPI Northwest. Iowa oral performance instrument: user's manual. Carnation, WA: IOPI Northwest; 2005.
17. Adams V, Mathisen B, Baines S, Lazarus C, Callister R. Reliability of measurements of tongue and hand strength and endurance using the Iowa Oral Perfomance Instrument with elderly adults. Dysphagia. 2014;29(1):83-95. https://doi.org/10.1007/s00455-013-9486-5
18. Hirota N, Konaka K, Ono T, Tamine K, Kondo J, Hori K et al. Reduced tongue pressure against the hard palate on the paralyzed side during swallowing predicts dysphagia in patients with acute stroke. Stroke. 2010;41(12):2982-4. https://doi.org/10.1161/STROKEAHA.110.594960
19. Konaka K, Kondo J, Hirora N, Tamine K, Hori K, Ono T et al. Relationship between tongue pressure and dysphagia in stroke patients. Eur Neurol. 2010;64(2):101-7. https://doi.org/10.1159/000315140
20. Utanohara Y, Hayashi R, Yoshikawa M, Yoshida M, Tsuga K, Akagawa Y. Standard values of maximum tongue pressure taken using newly developed disposable tongue pressure measurement device. Dysphagia. 2008;23(3):286-90. https://doi.org/10.1007/s00455-007-9142-z
21. Kays S, Hind J, Gangnon R, Robbins J. Effects of dining on tongue endurance and swallowing-related outcomes. J Speech Lang Hear Res. 2010;53(4):898-907. https://doi.org/10.1044/1092-4388(2009/09-0048)
22. Palmer P, Neel A, Sprouls G, Morrison L. Swallow characteristics in patients with oculopharyngeal muscular dystrophy. J Speech Lang Hear Res. 2010;53(6):1567-78. https://doi.org/10.1044/1092-4388(2010/09-0068)
23. Easterling C, Antinoja S, Cashin S, Barkhaus PE. Changes in tongue pressure, pulmonary function, and salivary flow in patients with amyotrophic lateral sclerosis. Dysphagia. 2013;28(2):217-25. https://doi.org/10.1007/s00455-012-9436-7
24. Fukuoka T, Ono T, Hori K, Tamine Ken-ichi, Nozaki S, Shimada K et al. Effect of the effortful swallow and the Mendelsohn maneuver on tongue pressure production against the hard palate. Dysphagia. 2013;28(4):539-47. https://doi.org/10.1007/s00455-013-9464-y
25. Hori K, Ono T, Iwata H, Nokubi T, Kumakura I. Tongue pressure against hard palate during swallowing in post-stroke patients. Gerondontology. 2005;22(4):227-33.
26. Kim HD, Choi JB, Yoo SJ, Chang MY, Lee SW, Park JS. Tongue-to-palate resistance training improves tongue strength and oropharyngeal swallowing function in subacute stroke survivors with dysphagia. J Oral Rehabil. 2017;44(1):59-64. https://doi.org/10.1111/joor.12461
27. Steele CM, Bayley MT, Peladeau-Pigeon M, Nagy A, Namasivayam AM, Stokely SL, Wolkin T. A randomized trial comparing two tongue-pressure resistance training protocols for post-stroke dysphagia. Dysphagia. 2016;31(3):452-61. https://doi.org/10.1007/s00455-016-9699-5
28. Lazarus C, Logemann JA, Huang CF, Rademrker AW. Effects of two types of tongue strengthening exercises in young

normals. Folia Phoniatr Logop. 2003;55(4):199-205. https://doi.org/10.1159/000071019

29. Robbins JA, Gangnon RE, Theis SM, Kays SA, Hewitt AL, Hind JA. The effects of lingual exercise on swallowing in older adults. J Am Geriatr Soc. 2005;53(9):1483-9. https://doi.org/10.1111/j.1532-5415.2005.53467.x

30. Steele CM, Bayley M, Pigeon M, Stokely S. Tongue pressure profile training for dysphagia post stroke (TPPT): study protocol for an exploratory randomized controlled trial. Trials. 2013;14(1):2-6. https://doi.org/10.1186/1745-6215-14-126