Original Article

http://doi.org/10.1590/2317-6431-2016-1794

Audiology Communication Research
ISSN 2317-6431

Oral transit time and brain lesion laterality in stroke

Tempo de trânsito oral e lateralidade da lesão cerebral no acidente vascular encefálico

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ABSTRACT

Introduction: The oropharyngeal transit time changes according to several variables. **Purpose:** To compare the total oral transit time (TOTT) and laterality of brain lesion in the individual after stroke with oropharyngeal dysphagia. **Methods:** Analyzed 61 videofluoroscopic swallowing studies of individuals after unilateral cortical ischemic stroke. Participants were divided into two groups. Group 1 (G1) consisted of 30 individuals with right-side cortical lesion and group 2 (G2) of 31 individuals with left-side cortical lesion. Quantitative analysis of the TOTT was performed by two judges trained in the procedure by means of specific software and an analysis of the reliability between judges was performed. The Mann-Whitney test was used for the data analysis. **Results:** It was found TTOT longer than 2000 ms in 50% of the G1 and in 94% of the individuals of G2 with a significant statistical difference between the groups (p<0.01). In the comparison between G1 and G2 regarding TOTT, it was verified that there was significant statistical difference (p=0.001). However, there was no significant statistical difference in the comparison between G1 and G2 for both TOTT shorter than 2000 ms (p=1.000) and TOTT longer than 2000 ms (p=0.603). However, it was found that in G2 the TOTT average is longer than 2000 ms and was greater than in G1. **Conclusion:** There were TOTT shorter and longer than 2000 ms in both hemispheric cortical lesion. The frequency of individuals with TTOT are longer than 2000 ms and the average are greater in the left-side cortical lesion in stroke.

Keywords: Deglutition; Deglutition disorders; Stroke; Software; Quantitative analysis

RESUMO

Introdução: O tempo de trânsito orofaríngeo se modifica de acordo com inúmeras variáveis. **Objetivo:** Comparar o tempo de trânsito oral total (TTOT) e a lateralidade da lesão cerebral no indivíduo após acidente vascular encefálico (AVE), com disfagia orofaríngea. **Métodos:** Foram analisados 61 exames de videofluoroscopia da deglutição de indivíduos pós-AVE hemisférico unilateral e isquêmico. Os participantes foram divididos em dois grupos: O Grupo 1 (G1) foi composto de 30 indivíduos com lesão cortical direita e o Grupo 2 (G2), de 31 indivíduos com lesão cortical esquerda. A análise quantitativa do TTOT foi feita por dois juízes treinados no procedimento, por meio de *software* específico e foi realizada a análise da confiabilidade entre julgadores. Para a análise dos resultados, utilizou-se o teste Mann-Whitney. **Resultados:** Verificou-se que, no G1, o TTOT foi maior que 2000 ms em 50% dos indivíduos e, no G2, em 94% dos indivíduos, ocorrendo diferença estatística significativa entre os grupos (p<0,01). Na comparação entre G1 e G2, para o TTOT, observou-se diferença estatística significativa (p=0,001). Entretanto, não houve diferença estatística significativa na comparação do G1 e G2, tanto para o TTOT menor que 2000 ms (p=1,000), como para o TTOT maior que 2000 ms (p=0,603). Contudo, verificou-se que, no G2, a média do TTOT maior que 2000 ms foi superior, quando comparada ao G1. **Conclusão:** Houve tempo de trânsito oral total maior e menor que 2000 ms, em ambos os hemisférios corticais lesionados. A frequência de indivíduos com tempo de trânsito oral total maior que 2000 ms, bem como a média desse tempo, foram maiores na lesão cortical à esquerda no AVE.

Palavras-chave: Deglutição; Transtornos de deglutição; Acidente vascular cerebral; Software; Análise quantitativa

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Financial support: *Fundação de Amparo à Pesquisa do Estado de São Paulo* (FAPESP), process n. 2014/03848-3.
Conflict of interests: No
Authors' contribution: *TCA*, *RRDS*, *AGJ* and *ARG* contributed in planning, execution and analyses. *PCC* and *RGS* contributed in planning, execution, analyses and corrections of the study.
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Received: 11/6/2016; **Accepted:** 7/26/2017

INTRODUCTION

The involvement of the brain cortex in the modulation of oropharyngeal swallowing has been studied in dysphagia, with the objective of understanding the cortical representation of swallowing, as well as of contributing information to motor learning present in the rehabilitation of dysphagia[1,2,3]. Neuroimaging studies have investigated the importance of the brain cortex to activate the oral and pharyngeal stage of swallowing, but the cortical side that is dominant for each stage of swallowing is still controversial in the literature. For some authors, the representation of swallowing in the cortical region in healthy individuals, using brain mapping techniques, shows that the execution of the oral phase activates more the cortical region to the left, while the following stage, the pharyngeal phase, activates the cortical region to the right[4]. This research hypothesis has been strengthened by the current studies with magnetoencephalography and magnetic functional resonance[5,6].

Thus, while the relationship between swallowing and the brain cortex is investigated and the oral stage of swallowing appears represented by the left hemisphere[7,8], studies of the oral stage of swallowing using temporal analysis methods advance slowly.

The quantitative analysis of the oral transit time is among the variables less studied in the literature and the most controversial[9,10], due to the voluntary component present at this stage, which makes the definition of start and finish markers more difficult. Besides that, the stroke population has been often studied in the surveys using temporal quantitative analysis, but these studies have concentrated on measuring the temporal values of each swallowing event and have rarely related this with other swallowing findings[11,12,13]. However, only a few studies have analyzed the relationship between the laterality of brain lesion and swallowing times in this population[6,14].

However, with the objective of understanding the relationships between the laterality of brain lesion and the findings found in swallowing measures times at their different stages, this study aimed to compare the total oral transit time (TOTT) with the laterality of the brain lesion in the stroke with oropharyngeal dysphagia.

METHODS

This is a transversal clinical study approved by the Research Ethics Committee of *Universidade Estadual Paulista "Júlio de Mesquita Filho"*, protocol no. 0976/2014, in accordance with the ethical criteria of Resolution nº 196/96, of October 10, 1996.

Sixty-one videofluoroscopic swallowing exams of individuals after unilateral hemispheric ischemic brain stroke were analyzed, and the neurological diagnosis was confirmed by clinical neurological and neuroimaging evaluation, such as computerized tomography and/or magnetic functional resonance. The sample included exams of individuals from both genders, 33 females and 28 males, aged between 40 and 101 and 64.4 in average, standard deviation = 14.75. All individuals had oropharyngeal dysphagia and were ranked between the mild and severe levels[15], with *ictus* between 0 and 30 days (with an average of eight days). The exams were divided into two groups of individuals in accordance with the laterality of the cortical lesion. Group 1 (G1) comprised 30 individuals with right-side cortical lesion and Group 2 included 31 individuals with left-side cortical lesion. As for gender and age, G1 comprise 12 males and 18 females, with an average age of 62.2 and standard deviation = 15.43. G2 included 17 males and 14 females, with an average age of 66.2 and standard deviation = 14.08.

All the exams analyzed were done in individuals with stable level of consciousness and stable clinical status. Exams done in individuals after hemorrhagic brain strokes, with brainstem strokes, with bilateral strokes and those with low-quality images were excluded. It should be stressed that none of the individuals in this survey was submitted to brain reperfusion therapy.

The anatomical limits observed for the videofluoroscopic swallowing exams were from the oral cavity to the esophagus[16]. The exams were done with an acquisition rate of 29.97 frames per second, and could thus evaluate the position of the food bolus around every 33 milliseconds.

Each exam selected for this survey was analyzed during the first swallowing of 5 ml of fine gummy consistency food offered in a spoon. The following materials were used for standardized preparation of this consistency: disposable plastic cup, disposable 20 ml syringe to measure component volume, filtered water, barium sulphate (BaSO4), food thickener and disposable 5 ml plastic spoon. The instantaneous food thickener used was made from modified corn starch and maltodextrine, and each 100 g contained 373 Kcal, 92.6 g of carbohydrates and 174 mg of sodium. The fine gummy consistency was prepared using the food thickener with the measuring gage supplied by the manufacturer, added to 40 ml of water, 15 ml of barium sulphate and around 1g of Diet juice with a non-citric flavor.

After that, all 61 exams were digitized and analyzed using specific software which allows for quantitative analysis of swallowing times in milliseconds[17]. This software analyses the exam *frame by frame*, automatically, and the evaluator sets only the start and finish of the quantitative parameter chosen. Thus, the duration of the stage in milliseconds was obtained by means of the counting of the frames.

As a parameter for temporal quantitative analysis, as described by Gatto et al.[18], based on Logemann et al.[19], the total oral transit time (TOTT) was defined as an interval in milliseconds (ms) between the first frame showing the food inside the oral cavity and the first frame showing the head of the bolus in the end of hard palate and begin of soft palate (posterior nasal spine) and the point where the lower margin of the mandible ramus. As a further parameter for analysis, following the studies found in the literature about the variation

of the TOTT in various populations, in this study groups G1 and G2 were subdivided into times shorter and longer than 2000 ms[20].

The exams were analyzed separately by two judges working in the field of oropharyngeal dysphagia and with training in swallowing videofluoroscopy and trained in the use of the software. It should be stressed that the judges did a blind analysis regarding the laterality of the brain injury in those individuals.

For measurement of the TOTT a statistical analysis of agreement among judges was undertaken. For the analysis of the reliability between judges the Intraclass Correlation Coefficient (ICC) with 95% of interval was applied. The test showed very good agreement (ICC =1.00). After the ICC test, the TOTT time used in this study was the statistical average obtained between the judges' analyses.

For the analysis of the data, the G1 and G2 groups were compared regarding the distribution of the relative frequency (percentages) and the Equality of Two Proportions test was used for this. TOTT was compared between the G1 and G2 groups and also for times smaller and greater than 2000 ms, using the Mann-Whitney test. All tests considered the significance level of 5% or the corresponding value of p.

RESULTS

After a quantitative analysis of TOTT it was found that 15 (50%) of the individuals in G1 showed TOTT below 2000 ms and 15 (50%) showed TOTT greater than 2000 ms. In G2, TOTT lower than 2000 ms ocurred in 2 (6%) of the individuals and TOTT greater than 2000 ms were seen in 29 (94%), a statistical difference of (p<0.001). In the comparison within groups it was observed that in both groups there was significance; for TOTT lower than 2000 ms there was a higher percentage of individuals from G1 (88.2%) and, for TOTT greater than 2000 ms there was a lower percentage of individuals from G2 (65.9%) (Table 1).

Table 1. Frequency of individuals, per group, with Total Oral Transit Time below or above 2000 ms

	<2000 ms		>2000 ms		p-value
	n	%	n	%	
G1	15	88.2	15	34.1	<0.001*
G2	2	11.8	29	65.9	
p-value	<0.001*		0.003*		

*Significant values (p<0.05) – Equality of Two Proportions test
Subtitle: n = Number of individuals; G1= Group 1; G2 = Group 2

As for the TOTT average, G1, the right-side injury group, showed an average of 3662 ms. For individuals in G2, the left-side injury group, the TOTT average was of 6.091 ms. In the comparison between G1 and G2 regarding TOTT, there was a statistical difference of (p=0.001) (Table 2).

It was found that, in G1, individuals with TOTT lower than 2000 ms had an average of 1189 ms and individuals with TOTT greater than 2000 ms an average of 6135 ms. In G2, individuals with TOTT lower than 2000 ms presented an average of 1216 ms and individuals with TOTT greater than 2000 ms had an average of 6428 ms. There was no statistical difference in the comparison between G1 and G2 with TOTT lower than 2000 ms (p=1.000), or greater than 2000 ms (p=0.603). These values, as well as the standard variation, can be found in Table 3.

Figure 1 shows the distribution of total oral transit times for G1 and G2.

DISCUSSION

The results of this study have shown that there are individuals with TOTT lower and greater than 2000 ms, with both brain hemispheres lesion after strokes. The findings of a similar research on time variations done recently with a population of individuals who had suffered strokes were similar.

Table 2. Average, median and standard deviation of Total Oral Transit Time for G1 and G2

Groups	Average	Median	Standard deviation	CV	Q1	Q3	n	IC	p-value
G1	3.662	1.926	4.077	111%	1.234	3.895	30	1.459	0.001*
G2	6.091	4.616	5.034	83%	2.793	7.386	31	1.772	

* Significant values (p<0.05) – Mann-Whitney test
Subtitle: CV = Coefficient of variation; Q1 = 1st quarter; Q3 = 3rd quarter; n = Number of individuals; IC = Confidence interval; G1= Group 1; G2 = Group 2

Table 3. Average, median and standard deviation of Total Oral Transit Time shorter and longer than 2000 ms for G1 and G2

Groups		Average	Median	Standard deviation	CV	Q1	Q3	n	IC	p-value
<2000 ms	G1	1.189	1.207	447	38%	803	1.624	15	226	1.000
	G2	1.216	1.216	95	8%	1.183	1.250	2	132	
>2000 ms	G1	6.135	3.916	4.596	75%	2.924	7.319	15	2.326	0.603
	G2	6.428	4.683	5.034	78%	3.254	7.666	29	1.832	

Subtitle: CV = Coefficient of variation; Q1 = 1st quarter; Q3 = 3rd quarter; n = Number of individuals; IC = Confidence interval; G1= Group 1; G2 = Group 2

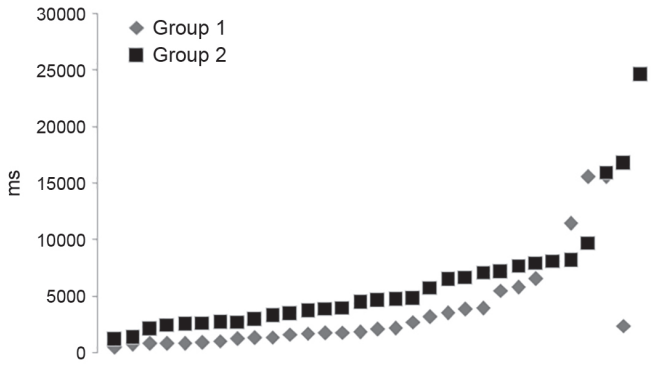

Figure 1. Distribution of total oral transit times for G1 and G2

Just like in this survey, the results have shown that there was variation in OTT in the different vascular areas involved in the lesion, without, however, any significant difference regarding cortical laterality[6].

On the other hand, in the study the individuals with left-side cortical lesion have shown TOTT above 2000 ms more often than individuals with right-side lesion. Surveys found in the literature reported that left-hemisphere brain strokes affected primarily the oral stage of swallowing, while right-hemisphere strokes involved, initially, pharyngeal dysfunction with laryngotracheal penetration or aspiration[4,21,22].

As for TOTT averages, it was found that it was longer in individuals with left-side lesion. Similar results were described in another research, which showed that, for paste consistency, the average OTT and the start of the pharyngeal response time were longer in left-side cortical lesion. However, we should note that the OTT parameters defined in the study were different from those used in the present study[23].

The results of this study also showed that there was a statistical difference in the comparison between G1, the group with right-side lesion, and G2, the left-side lesion group, regarding TOTT. However, upon subdividing TOTTs between times shorter and longer than 2000 ms, it was found that there were no significant differences.

As for brain lesion laterality and TOTT, these results are consistent with a study that investigated the ocurrence of post-cortical stroke oropharyngeal dysphagia. The authors have concluded that swallowing dysfunctions related to oral stage changes were more common in individuals with left-side lesion[22]. However, there are studies that have reported no correlation between the prevalence of oral and pharyngeal dysfunction and the location of the brain injury. These studies included individuals with bilateral and brainstem injuries, which may have compromised the analysis between both hemispheres. Besides that, this comparative study used only qualitative analysis employing videofluoroscopy[24].

A relevant discussion on the importance of the quantitative analysis of swallowing has concentrated on the fact that changes in these measurements may be related to many pulmonary and nutritional risk predictors in this population. Taking into consideration the results of this study, and independently of the brain hemisphere affected, the significant increase in TOTT is an example of these predictors, since, when present, it can compromise oral ingestion and the nutritional situation[25]. Besides that, a longer TOTT may influence the oral organization patterns, as well as the dynamics of the pharyngeal stage of swallowing, compromising the quality of ingestion, the increase of feeding time and the risks of bronchoaspiration[8,26].

All the considerations above must be appreciated in the context of post-stroke individuals not submitted to brain reperfusion using thrombolytic medicines, since a recent study has concluded that the alterations and, thus, the swallowing measures times, experience changes with this therapy[27]. Besides, there have been limitations in the study presented here, since the groups have not been analyzed regarding the topography of the brain lesion but only regarding its laterality. Moreover, some studies that related the topography of the brain lesion with the prevalence of dysphagia have found some correlation between the laterality of the brain lesion and the findings found in the different stages of swallowing[28,29].

CONCLUSION

There were total oral transit time shorter and longer 2000 ms in both lesion cortical hemispheres. The frequency of individuals with total oral transit time above 2000 ms and the average are greater in the left-side cortical lesion in stroke.

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ERRATUM

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