

QUANTITATIVE ANALYSIS OF SWALLOWING IN PARKINSON'S DISEASE BEFORE AND AFTER RIBOFLAVIN

Análise quantitativa da deglutição de parkinsonianos pré e pós-riboflavina

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ABSTRACT

Purpose: to verify the quantitative changes in the swallowing dynamics in patients with Parkinson's disease submitted to treatment with riboflavin, red meat and poultry removed during one year period. **Methods:** sixteen patients with Parkinson's disease participated in the study; the mean age was 67.25 years, the mean degree of disease severity was II to III, and the mean time since the diagnosis of the disease was 3.5 years. Videofluoroscopic evaluations were performed before and one year after treatment with riboflavin and diet with restriction of red meat and poultry. Analyzed were: presence of complaints related to swallowing and quantitative analyses of swallowing including computerized measurements of hyoid bone and cricoid cartilage displacement, opening of the superior esophageal sphincter and pharyngeal constriction. **Results:** decrease of complaints was observed after administration of riboflavin. About the quantitative measures after riboflavin, there were an increase in the opening of the superior esophageal sphincter for all consistencies offered, an increase in the pharyngeal constriction for the thickened liquid, a reduction in the hyoid bone displacement, and an increase or a reduction in the cricoid cartilage displacement for each consistency, with significant reduction for the liquid. **Conclusion:** quantitative measurements made in the movement of organs associated with swallowing showed no significant differences between pre-and post-riboflavin, and red meat and poultry removed.

KEYWORDS: Deglutition; Deglutition Disorders; Parkinson Disease; Riboflavin; Fluoroscopy

■ INTRODUCTION

Parkinson's Disease (PD) is the most common disorder of the extrapyramidal system, and it is a neurodegenerative disease resulting from a decrease in the dopaminergic transmission in the

basal ganglia¹. It is characterized by the typical history of a progressive neurological disorder, with resting tremor, muscle stiffness and hypokinesia².

In a study of the literature³ reported that neurodegeneration in patients with PD may result from an alteration in the riboflavin concentration (vitamin B2). The authors document a progressive and noticeable improvement of the motor capacity in 19 patients with PD, who started receiving riboflavin orally and had red meat and poultry removed from their diet for a period of six months. Biochemical data obtained from patients with sporadic PD indicate vitamin B2 deficiency in such patients⁴. Even though they kept a diet that includes riboflavin intake, 10-15% of London and Florence inhabitants presented low activity of two riboflavin-dependent enzymes. This figure might reflect the percentage of the world population with regards to the alteration in riboflavin absorption, and

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not only represents a specific alteration of a certain ethnic group⁵.

Swallowing disorders in Parkinsonism may be present at different levels, affecting oral, pharyngeal and esophageal phases⁶. Studies^{7,8} report that patients with PD often develop dysphagia in the course of their disease, having difficulties to start swallowing and occasionally pulmonary aspiration of liquids, what impairs the individuals' clinical, nutritional and hydration state and leads to complications such as malnutrition and aspiration pneumonia. Studies in the Parkinson's literature report that pneumonia is the most common cause of deaths among patients with PD^{9,10}.

About the motor gain presented by patients with PD submitted to the administration of riboflavin and restriction of red meat and poultry³, began this research to determine whether these gains could also be applied to swallowing, as there are changes in the dynamics of swallowing in PD

The purpose of this study was to analyze quantitative changes in the swallowing dynamics in patients with Parkinson's disease, who were

submitted to riboflavin intake and restriction of red meat and poultry for one year.

METHODS

This research was approved by the Federal University of São Paulo State/São Paulo Hospital *Comitê de Ética em Pesquisa* (Research Ethics Committee), Protocol 0360/06.

Sixteen PD patients participated in this study (8 men and 8 women), at an average age of 67.25 years, an average severity level of the disease from II to III according to the Adapted Hoehn & Yahr Scale¹¹ and the average PD diagnosis time of 3.5 years. At the beginning of the study, 14 patients had already been taking PD medication, and this was not interrupted for the study. No patient underwent speech therapy during the study period. After videodeglutogram were performed orientations when necessary, regarding food consistency and forms of offer.

Table 1 – Data relating to age, sex, disease duration and disease stage according to the modified scale of functionality Hoehn & Yahr¹¹

Patient	Sex	Age (years)	Disease duration (years)	Disease stage
1	F	75	4	IV
2	M	50	1	II
3	M	64	2	II
4	M	76	5	II to III
5	M	55	5	IV
6	F	67	9	II
7	M	55	4	II to III
8	F	74	8	V
9	F	67	1	II to III
10	F	64	5	II to III
11	M	66	4	II to III
12	F	72	1	II
13	F	76	1	II to III
14	F	79	2	II to III
15	M	65	1	II to III
16	M	71	4	II to III

The patients were referred to the doctor in charge of riboflavin administration before the beginning of this treatment. According to the doctor, each patient received 30 mg every eight hours, totaling 90 mg of riboflavin daily. Red meat and poultry restriction was mandatory during the study, and the patient was advised by the medical team to replace that diet with other protein sources. It is worth mentioning that, every three months, each patient's serum ferritin was analyzed by the medical team, so that it was possible to confirm that their iron reserves were within normal limits.

The patient was initially asked whether they had any swallowing-related complaints. Later on, the target swallowing study was conducted by means of the videofluoroscopic swallowing study (VFSS), following the Federal University of São Paulo State – Medicine School of São Paulo protocol¹². During the study, the patient was kept in a osthostatic, lateral and front positions. The test was carried out with the EDR-750B X-ray device, and the videos were recorded with an X690 Semp camcorder. In the analysis of this study, the following offers were considered: 5 ml of a thin liquid (water + barium) offered in a syringe; 5 ml of a thick liquid (pure barium) offered in a syringe; 5 ml of a semi-solid mixture (yogurt-like sweet *fromage frais* + barium) offered with a spoon; and a solid mixture (a small piece of cheese bread + barium).

A year after riboflavin intake, the patients were recalled and again submitted to the whole procedure above described, so that it was possible to analyze the development of the swallowing dynamics process.

In the analysis of the VFSS, swallowing-related structures were measured by means of an image processing program, the *ImageJ*¹³, developed by the National Institute of Health. For such analysis, appropriate lateral view images for each measurement were selected and digitalized. For program calibration, in order to get information on the distance or area selected in centimeters in each image, a metal marker was used – placed in the mastoid region –, thus allowing to provide the program with its diameter value. The measurements taken were:

- maximum displacement of the hyoid bone – image tracings were made on the resting-state images and at the moment of maximum excursion of the hyoid/laryngeal complex during swallowing. Initially, the intersection between a tangent line to the anterior portion of the hyoid bone and another tangent line to the inferior margin was considered. Next, a right angle was traced – always considering the same individual's cervical vertebrae. At a later time,

the resting-state image was overlapped with the maximum excursion image and a right line was then traced, thus joining both intersections of both situations;

- maximum displacement of the cricoid cartilage: tracing of resting-state images, as well as the moment of higher elevation of the hyoid/laryngeal complex, were made. Initially, two tangent lines were traced, one to the free border level of the vocal folds, and the other to the anterior wall of the trachea, a little below the larynx. The crossing of these two tangent lines with two other fixed lines was selected, thus comprising a 90° right angle in one of the cervical vertebrae, copying this selected image. Thereupon, the same procedure of tangent lines was carried out on the free border of the vocal folds and the trachea of the 90° angle, on the same vertebra used on the resting state, on the image of higher larynx elevation. At that moment, the selected resting-state image was overlapped, thus allowing the cricoid cartilage displacement to be measured;
- maximum pharyngeal constriction: measurement made between the difference of both pharynx in resting state and its area occupied either by air or food residues at the moment of pharynx higher constriction during swallowing. The tracing of the resting-state image started in the anterior tubercle of the atlas vertebra, following inferiorly towards the arytenoid cartilage and the upper part of the vocal folds. It followed superiorly, outlining the epiglottis, the base of tongue and the velum until it reached the posterior nasal spine of the horizontal plate of the palatine bone. As for the image for higher pharyngeal constriction, either the food residue area or the remaining air space was outlined;
- maximum pharyngoesophageal transition (PET): maximum opening for food passage during swallowing. For this measurement to be made, we chose the moment of higher opening of sphincter, in a 1-cm region below the level of the vocal folds, thus taking opening measurement by tracing a horizontal line in the extension of the entire food bolus column. Measurement of the upper esophageal sphincter was considered null in the resting state.

The authors understand by the terminology of functionality in the swallow, the occurrence of this function safely and effectively, without risking the protection of the lower airways, and at a time able to keep the nutritional aspects appropriately.

In order to analyze the results, significance (p) level of 5% (0,05) was adopted. Statistical significances is marked with an asterisk (*).

■ RESULTS

Sixteen patients participated in this study. However, due to the image quality of the VFSS which, at times, did not allow for reliable assessment of the results, a lower N occurs in some tables.

It is possible to observe in Table 2 the percentage of complaints in PD patients in the pre and post riboflavin moments. The analysis of the complaint was made by its presence or absence. The authors did not relate the specificity of complaints.

The maximum PET opening showed variations in comparing the two moments, with no statistical significance, with a slight increase at the post taking moment (Table 3) for all the consistencies analyzed. This comparison might suggest a more efficient

swallowing, since the PET opening is strictly related to the hyo-laryngeal complex raise, such as a lever system, and to the food bolus volume and consistency as well.

Variations in the maximum pharyngeal constriction percentage (Table 3) did not obtain statistical significance, and showed both values lower than or greater constriction, depend of the food consistency analyzed, when comparing the two moments.

The maximum displacement of the hyoid bone (Table 3) were difficult to read, due to the variety of its movement standards. A slight reduction in its displacement values was observed, with no interference in swallowing functional aspects.

Table 2 – Numerical and percentage distribution of patients according to the presence or absence of complaints related to swallowing, in the pre-and post-riboflavin ($p=0,257$).

Moment	Complaint		Total
	Absence	Presence	
	N (%)	N (%)	N (%)
Pre	6 (37,5)	10 (62,5)	16 (100)
Post	9 (56,25)	7 (43,75)	16 (100)

Legend: N= number of patients; %= percentage.

Table 3 – Numerical distribution, mean and standard deviation of the variable maximum PET, maximum pharyngeal constriction, maximum displacement of the hyoid bone and maximum displacement of the cricoid cartilage, in centimeters, for consistencies thin liquid, thick liquid, pasty and solid in pre and post-administration of riboflavin.

Consistency		Maximum PET				Pharyngeal constriction				Hyoid bone displacement				Cricoid cartilage displacement			
		N	\bar{x}	SD	p	N	\bar{x}	SD	p	N	\bar{x}	SD	p	N	\bar{x}	SD	p
L	pre	16	0,84	0,29	0,170	15	93,48	3,98	0,910	16	2,70	0,85	0,266	16	2,22	0,62	0,030*
	post	16	0,94	0,27		16	93,15	4,57		16	2,38	0,73		16	1,86	0,50	
TL	pre	15	0,89	0,18	0,394	13	87,41	10,92	0,311	15	2,71	0,65	0,932	15	2,12	0,68	0,691
	post	16	0,97	0,26		16	88,79	7,72		16	2,59	0,91		16	2,16	0,59	
P	pre	16	0,97	0,25	0,346	15	91,83	5,91	0,733	16	2,48	0,56	0,737	16	2,07	0,69	0,897
	post	16	1,03	0,31		15	91,66	5,82		16	2,44	0,64		16	2,13	0,65	
S	pre	16	1,20	0,39	0,660	15	91,12	5,14	0,363	16	2,83	0,79	0,979	16	2,25	0,56	0,623
	post	16	1,21	0,31		16	90,77	9,23		16	2,77	0,81		16	2,21	0,55	

Legend: \bar{x} = mean; N= number of patients; SD= standard deviation; p= significance; PET= pharyngoesophageal transition; L= thin liquid; TL= thick liquid; P= pasty; S= solid.

The cricoid cartilage displacement (Table 3) shows sometimes a slight increase of the displacement index, sometimes slight reduction. To the thin liquid consistency, a significant reduction in this displacement was found, although interference in swallowing functional aspects was not observed.

Table 4 shows the comparison of the data found in maximum opening of PET and displacement of the hyoid bone in this study, with data of normal literature¹⁴. Can be verify that the data of the patients in this study are higher compared with the normal

range, but this comparison may be questioned by the difference in the volume offered.

Data found were similar for all the study patients, even those that did not engage in using the medication for PD. Analyzing the tests in a qualitative way, according to the clinical practice of the authors, the swallowing of the patients in study were classified as normal both times. This finding suggests that the patients in this study did not show changes that could compromise the safety and efficacy of swallowing.

Table 4 – Comparison of the numerical distribution, mean and standard deviation of the variable maximum PET and maximum displacement of the hyoid bone in centimeters for thin liquid consistency, in the pre-and post-administration of riboflavin, with data from the literature¹⁴

Consistencies	Volume (milliliters)	PET			Hyoid bone displacement		
		N	\bar{x}	SD	N	\bar{x}	SD
L pre	5	16	0,84	0,29	16	2,70	0,85
L post	5	16	0,94	0,27	16	2,38	0,73
L literature	3	60	0,51	0,15	60	1,86	0,60

Legend: \bar{x} = mean; N= number of patients; SD= standard deviation; p= significance; PET= pharyngoesophageal transition; L= thin liquid.

■ DISCUSSION

Prevalence of dysphagia in PD demonstrates the need for speech therapy activity in these patients, and the understanding by this professional regarding the pharmacological interference in the pathophysiology of swallowing. According to the literature^{7,8}, the presence of dysphagia in PD is common, especially with the progression of disease, leading to clinical disorders, including the occurrence of malnutrition, dehydration and aspiration pneumonia, due to changes in swallowing function. According pesquisa¹⁵ performed, the average lifespan of PD patients after the onset of symptoms of dysphagia shall be 24 months.

As some studies report in the literature^{16,17} the swallowing-related complaints in patients with PD may not frequently be correlated with the process itself. The decrease of the complaints in this study in the post-riboflavin may suggest optimizing in the patients perceptions of symptoms presented, which does not indicate an improvement in the function itself.

Authors¹⁸ observed higher UES opening when more dense pure barium was swallowed than when less dense pure barium was swallowed. In another study¹⁹ the authors suggest to use thickened liquid in order to reduce tracheal aspiration of thin liquid.

In a research²⁰ the authors conclude that swallowing thickened liquid is safer than swallowing thin liquid for patients with PD. It was observed at VFSS of patients who participated in this study that this consistency presented more representative food stasis than the others, which might explain the fact that pharyngeal constriction occurs at a higher proportion in this consistency, aiming at inducing higher pressure for food bolus to go down.

In the literature, the analysis of the hyoid bone displacement is divided into anterior displacement and vertical displacement. Therefore, it makes comparison of data in this study difficult. In the studies, some authors²¹ state that the anterior displacement of the hyoid bone is more variable, whereas another authors²² report that the anterior displacement of the hyoid bone is less variable, as well as larger when compared with its vertical displacement. They also state that the amplitude of the vertical displacement of the hyoid bone varies according to food consistency.

Quando comparados com dados da literatura^{14,23-29} os valores das medidas de máximo deslocamento do osso hióide, máxima constrição da faringe, e máxima abertura da TFE encontraram-se maiores, mesmo na comparação com indivíduos não disfágicos. Tal fato pode ser decorrente de metodologias diferentes na realização das

medidas, impedindo uma comparação entre esses dados. A Tabela 4 demonstra a comparação de duas variáveis do estudo (abertura da TFE e deslocamento do osso hioide) com dado de literatura¹⁴.

Compared to the data in the literature^{14,23-29} the measurement values of the hyoid bone displacement, maximum pharyngeal constriction and maximum UES opening were found to be higher, even when compared to nondysphagic individuals. Such a fact may result from different methods to take measurements, thus preventing a comparison of these data. Table 4 shows the comparison of two variables in the study (PET opening and displacement of the hyoid bone) with data of literature¹⁴.

From a study in which higher hyoid bone displacement values for nondysphagic elderly people in comparison to young people were found, the authors³⁰ conclude that this deviation may be a result from a lower position of the larynx in elder people's necks.

The data of the significant reduction in the cricoid cartilage rise for the thin liquid consistency does not influence the functionality and efficiency of swallowing. It occurred possibly because of this consistency requires less pressure to swallow,

promoting lower strength, and consequent less displacement, by the individual.

The differences found before and after taking riboflavin, even though some differences had statistical significance, did not influence those patients' swallowing functional aspects, given that, a year after the study was conducted, those patients' swallowing was safe and efficient. In the study group, there was no influence on swallowing pattern displayed by patients with the use of riboflavin and restriction of red meat and poultry. It is believed that if the analysis performed in this study occurred in patients with PD who presented swallowing disorders more apparent, the results could be different. Thus, it is suggested to continuing studies of quantitative measurement in PD patients subjected to this intervention.

■ CONCLUSION

In conclusion, quantitative measurements made in the movement of organs associated with swallowing showed no significant differences between pre-and post-riboflavin, and red meat and poultry removed.

RESUMO

Objetivo: verificar as mudanças quantitativas na dinâmica da deglutição em pacientes portadores da doença de Parkinson, submetidos à administração de riboflavina e restrição de carnes vermelhas e de aves, no período de um ano. **Métodos:** participaram do estudo 16 pacientes com doença de Parkinson, com média de idade de 67,25 anos, média do nível de severidade da doença de II para III e com média de 3,5 anos de tempo de diagnóstico da doença. As avaliações videofluoroscópicas da deglutição foram realizadas antes e após um ano de administração de riboflavina e restrição de carne vermelha e de aves. Foram analisadas: presença de queixas relacionadas à deglutição e análise quantitativa por meio de medidas computadorizadas do deslocamento do osso hioide e da cartilagem cricóidea, abertura da transição faringoesofágica (TFE) e da constrição da faringe. **Resultados:** verificou-se redução no percentual de queixas relacionadas à deglutição no momento pós-administração de riboflavina. Com relação às medidas quantitativas, observou-se no momento pós um discreto aumento na abertura da TFE para todas as consistências oferecidas, aumento da constrição da faringe para a consistência líquido engrossado, discreta redução dos valores de deslocamento do osso hioide, e tanto discreta redução como discreto aumento dos valores de deslocamento da cartilagem cricóidea dependendo da consistência alimentar, sendo redução significativa para o líquido. **Conclusões:** as medidas quantitativas realizadas na movimentação dos órgãos relacionados à deglutição não demonstraram diferenças significantes entre os momentos pré e pós-riboflavina e a restrição de carne vermelha e de aves.

DESCRITORES: Deglutição; Transtornos de Deglutição; Doença de Parkinson; Riboflavina; Fluoroscopia

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