

# *The Relationship Between the Maximum Time for Phonation, Fundamental Frequency and Protection of the Lower Airways in Patients with Neurological Dysphagia*

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## SUMMARY

- Introduction:** In a speech therapy approach of oropharyngeal dysphagia, the clinical evaluation is common and valuable.
- Objective:** The objective of this piece of research is to clarify the patterns of the phonation maximum time, the fundamental frequency and the relationship between them and the protection of the lower air passageways in patients with neurogenic dysphagia.
- Method:** A research was performed in 31 adult patients between the age of 26 and 91 years-old with neurogenic dysphagia and found the relation between the phonation maximum time and the risks of aspiration. For this research were used a form elaborated by the researcher, an analysis of the vocal signal of the phonation maximum time and an analysis of fundamental frequency related to the air passageways protection in deglutition, compared to the results of a video-fluoroscopy.
- Results:** When compared with the vowel phonation maximum time and with the type of aspired material was possible to conclude that 10 patients that aspired liquid/liquefied material showed values of phonation maximum time of less than 9 seconds, and only 1 patient showed a phonation maximum time above 8 seconds; in the patients that aspired only liquids, 9 showed values less than 8 seconds and 9 patients showed values above 8 seconds. For the 2 patients that didn't aspire any material showed values of phonation maximum time above 8 seconds.
- Conclusion:** This research comes to the conclusion that phonation maximum time has a great matter of importance on deglutition evaluation as a vocal parameter, being referred to as an alert for serious complications on deglutition.
- Key words:** phonation, deglutition, laryngeal.

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## INTRODUCTION

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In the human respiratory system, the larynx exercises a dynamic role in its physiological operation upon sharing an area common to the digestive and airways' systems. The human larynx performs three important functions: protection of the airways, breathing and phonation. The structures that integrate the larynx play a role in the assistance of the life supporting function: the breathing. And the vocal chords, the vestibular folds, the aryepiglottic folds, among others, were designed to protect the airway from foreign substances. When the protecting mechanism of the larynx presents a dysfunction, the patient can aspirate. The aspiration degree and its clinic reverberations will indicate the need of a clinic or surgical treatment.

The deglutition breathing coordination is vital during the ingestion of food because both physiological mechanisms use the same passage way and the prevented aspiration. Thus, breathing is inhibited during deglutition and in other processes, such as the closing of the vocal chords and the larynx rising.

With regard to the protection of the airways SHAKER (1) states that the mechanisms against the aspiration are multi factorial and comprise an interaction between the breathing and digestive tracts, that is, a perfect synchronism of events that allows the subject to perform deglutition without aspirating boluses to the airways and impairs the reflow of the boluses from esophagus.

The factors that protect the inferior airways of aspiration are basically the following: apnea during breathing, larynx raising and the action of the aryepiglottic folds directing the boluses to the sides for the pyriform recesses (2).

The swallowing action occurs in the expiratory phase of breathing and the expired air, after deglutition, acts in the cleaning of the food remains. CARRARA DE ANGELIS and col (3) states that the accumulation of the stasis in the valleculas or pyriform recesses are indication of penetration and/ or aspiration, which might be associated with alteration in breathing, present in the noisy breathing and alteration in the breathing flow, such as decrease of the voice intensity (asthenia), that is, the alteration of the breathing organs may be associated with deglutition difficulties.

The deglutition is a dynamic neuromuscular process that comprises the transportation of the boluses from the mouth up to the stomach and it is didactically studied in five phases: anticipatory, pre-oral, oral (voluntary), pharyngeal and esophageal (involuntary), as proposed by LEOPOLD and KAGEL (4).

The deglutition disturbances are frequent in the neurological patients, being an important cause of morbidity and mortality. The aspiration pneumonia is a trouble often associated to dysphagia and the study of the swallowing and phonator organs is essential for the diagnose and treatment of this and other breathing difficulties.

The dysphagia is a swallowing difficulty derived from an acute or progressive process that interferes in the transportation of the boluses from the mouth to the stomach (5). Pursuant to BUCHHOLZ (6), it is referred that the dysphagia can derive from a weakness of the lips muscles, tongue, veil, palatine, pharynges and esophagus due to a cortical, sub cortical injury or an injury in the brain stem. There may be added to these alterations the lack of coordination of movements, failure in the sensitiveness of the oral and pharyngeal regions that interfere with the voluntary and reflex phases of deglutition.

One of the clinic signs considered in the dysphagia assessment protocols is the alteration of the voice quality. The changes in the voice quality in the dysphagic patient are noticed in a hoarse and whiffing voice quality, associated with a incomplete closing of the vocal chords, the presence of a "humid voice", when there is a secretion in the laryngeal vestibule or pyriform recesses, among other data of hyper nasality or changes in the sound sign.

With regard to the speech-hearing approach in the oropharyngeal dysphagies, the clinic assessment comprises the most common and valuable method. The vocal assessment as a supplementary instrument offers comparison and care parameters through the vocal acoustic and hearing perceptive analyses, in the issue regarding the assessment of the dysphagia and its troubles.

Clinic characteristics such as the presence of a "humid voice" and the alteration of the vocal quality have been mentioned in many works in the speech-hearing area. However, the relations of these characteristics with the dysphagia have been interpreted differently in literature and in the clinic practice. It is required to identify works that points to vocal parameters in dysphagic patients in their base pathologies. Within this perspective of better knowing and establishing the vocal parameters of the dysphagic patient, the objective was to deepen and discuss the relationship between MPT and with the larynx tracheal protection.

The objective of this research was the establishment of the standards of the Maximum Phonation Time and the relation with the protection of the airways in patients with neurogenic dysphagia. Taking into account: the Maximum Phonation Time (MPT); the Critical Frequency (CF) and the

correlation of the MPT and CF with aspiration findings through the videofluoroscopy.

## METHOD

This research was submitted to the Committee of Ethics in Research (CEP) of *Universidade Tuiuti do Paraná*. Of. CEP-UTP n° 030/2006 approval protocol. All subjects involved agreed with the development of this research and the disclosure of their results pursuant to Resolution 196/96 (BRAZIL. Resolution MS/CNS/CNEP No. 196/96 of October 10<sup>th</sup>, 1996. After the execution of the agreement, the assessment was carried out.

### Casuistic

31 subjects participated of this research with the diagnose of neurogenic dysphagia, being 16 of male gender and 15 of the female gender, from 26 to 90 years of age and the average was 55 years old.

The sample was characterized with 12 patients with diagnose of a base disease with PARKINSON; 07 had a diagnose of cerebral vascular accident (CVA); 06 had encephalic skull traumatism (EST); 06 had Amyotrophic Lateral Sclerosis (ALS).

Out of the patients with Parkinson diagnose, they presented 3-5 clinical staging pursuant to the modified Hoehn and Yahar Scale (7), with diagnose period of the disease occurring from 5 to 10 years, pursuant to the previous neurological assessment, in use of Levodopa.

The group of diseases by CVA, presented ischemic CVA, assessed 30 days after the access.

From the EST group, they were also assessed after 60 days from the neurologic trauma.

With regard to the ALS group, they were assessed with a period of diagnostic of the disease between 1 to 3 years.

#### Inclusion criteria:

1. Patient with deglutition troubles.
2. Unmodified conscious level that answer to the oral commands and/or other stimulus.

#### Exclusion criteria:

1. Impossibility to get all protocol data.
2. Mechanic oropharyngeal dysphagia, after surgery in head and neck.

### Collection of demographic data

The demographic variables to be assessed are the following:

1. Age.
2. Gender.

### Methods

#### Collection of clinical data

Extracted from the patient's card and record:

1. Clinical history.
2. Type and neurologic access.
3. Access time.

The patients were submitted to vocal assessment and videofluoroscopy exam of deglutition at Centro de Imagem Computadorizada - CETAC, in the City of Curitiba.

#### Collection of vocal data

For the collection of the vocal data, it has been use a pre-established standard questionnaire, developed by the researchers of this study and the patients were submitted to the vocal acoustic analysis protocol.

For the acoustic analysis of the sound sign, with the verification of the maximum phonation term (MPT) and critical frequency (CF), it has been requested the sustained emission of vowel /e/, before the deglutition endoscopic exam was carried out. The acoustic parameters analyzed were the following:

- 1 . Maximum phonation time (MPT).
- 2 . Critical frequency (CF).

Patient remained in the dorsal decubitus or seated position and there shall be used the recording equipment Oregon Scientific - Digital MP 305, China , and the software Multi-Speech for the analysis of the issuance of the sustained vowel /e/.

#### Deglutition data collection

The diagnose of the neurogenic dysphagia was performed through the videofluoroscopy of deglutition (VFC). The videofluoroscopy device used in this study was the Rx device, Philips model, and TV and video, from January to July 2006.

In order to carry out the videofluoroscopy, the patient presented himself with a 4-hour fasting and maintenance of the dental prosthesis, when its use was required. The patient's position during the exam is supine. Those in wheel chairs remained seated. Initially, the

patient's assessment was carried out in lateral position and, then, in the antero-posterior position. During the accomplishment of the videofluoroscopy, the speech therapist responsible could assess the efficiency of the introduction of therapeutic, compensatory or postural maneuvers, assessing the volume, positioning and course of boluses along the airway-digestive tract in their several consistencies.

For the dynamic assessment of the deglutition, there has been used food in the liquid, liquid-pasty and pasty consistency, plus the inorganic colorant aniline in blue color to contrast with the rose color of the mucosa. In the preparation of the liquid consistency, it uses the aniline colorant in blue in 5 mL of water, and for the liquid-pasty consistency, it adds 3 g of instantaneous food thickener to 100 mL of water. For the preparation of the liquid-pasty and pasty consistencies, the it has been used the instantaneous food thickener of the make Thick&Essy (Hormel Heath Labs. Swiss), composed of amide, and presenting as nutritional composition per 100 g, 375 Kcal, 100 g of carbohydrates and 125 mg of sodium. At manufacturer's instruction, the pasty consistency is obtained upon mixing 2 soap spoons of amide to 100 mL of water.

For each food consistency, it has been requested three swallowing of a 5 mL volume, with a 2 – minute interval between each deglutition. The food in the liquid consistency was offered in a plastic glass or syringe. The liquid-pasty and pasty food consistencies were administered with a spoon or syringe.

For each consistency offered to patient, he was directed to keep it in his mouth during some seconds, to check the oral containment and the occurrence of advanced escape in the pharynxes / larynx region. Next, the patient was requested to swallow, being observed the nasal regurgitation, estase within the posterior wall region of the pharynxes, the laryngeal face of the epiglottis, valleculas of epiglottis and pyriform recesses. The occurrence of laryngeal penetration, the tracheal aspiration, the efficiency of the cough reflex and the required number of swallows for clearing the food consistency.

### Comparative analysis

The comparative analysis of the videofluoroscopy and vocal analysis and its rALStion with the protection of the airways in deglutition, in patients with neurogenic dysphagia, was carried out in the Voice Laboratory of Universidade Tuiuti do Paraná.

The data was typed on an Excel spreadsheet and transferred into the Statistic application, release 5.0, in order to develop tables and graphs. It was calculated the

**Table 1. Maximum phonation times of vowel /e/ compared to the type of aspired material.**

MPT	Liquid	Liquid/Pasty	Does Not Aspire	Total
< 4.00	01	01	00	02
4.01 to 5.60	02	03	00	05
5.61 to 7.20	04	03	00	07
7.21 to 8.80	02	03	00	05
8.81 to 10.40	04	01	01	06
10.41 >	05	00	01	06
Total	18	11	02	31

averages and the Confidence Interval (IC) that represent the reproduction of the findings in a similar sample, in case it was studied again in the same methodology, with 95% confidence.

For the analysis of the significance of values obtained in the averages of the acoustic parameters between male and female subjects, the Test t of Student was carried out for the independent sample, considering  $\alpha = 0.05$  (5%), if  $p < 0,05$  significant difference.

The Sphinx application was used in the development of graphs and simultaneous comparison of averages and confidence intervals. Based on the data provided in the table, the associated calculations were made.

## RESULTS

With regard to the main food way, 20 patients presented oral way (VO), 6 patients with the use of a nasogastric tube (SNE) and 5 using the endoscopic percutaneous gastrostomy (PEG).

In the videofluoroscopy exam, it was noticed that 18 patients aspired liquid, 11 aspired the liquid/pasty consistency, while 2 patients did not aspire any consistency.

As defined in Table 1, when the MPT values of vowel /e/ is compared with the aspired material, it has been noticed that in the range below 4 seconds, it was obtained 1 patient who aspired liquid and 1 who aspired liquid and pasty; from 4.01 to 5.60 seconds, 2 patients aspired liquid and 3 aspired liquid – pasty; from 5.61 to 7.20, 4 aspired liquid and 3, liquid – pasty; from 7.21 to 8.80, 2 aspired liquid and 3, liquid-pasty; from 8.41 to 10.40, 4 aspired liquid and 1, liquid-pasty, from 10.41 up, 5 aspired liquid and no person aspired liquid-pasty. In total, we found 18 patients who aspirated liquid, 11 aspired liquid/ pasty and 2 did not aspirate any consistency.

**Table 2.** Critical compared frequency per gender.

CF	Female	Male	Total
< than 133.58	00	09	09
133.59 to 154.87	00	03	03
154.88 to 176.15	00	02	02
176.16 to 197.43	03	01	04
197.44 to 218.72	07	01	08
218.73 >	05	00	05
Total	15	16	31

With regard to the findings of the critical frequency (CF) compared per gender, which are provided in Table 2, it is evidenced that in the range inferior to 133.58 Hz, there is no female patient and 9 male patients. From 133.58 Hz to 154.87 Hz there are just 3 patients of male gender; from 154.88 to 176.15 Hz there are 2 male patients and no female patient; from 176.16 to 197.43 Hz there are 3 female patients and 1 male patient; from 197.44 to 218.72 there are 5 female patients and no male patient.

When the findings for the maximum phonation time and critical frequency are compared to the list of basic diseases, Table 3 shows that in the Parkinson Disease, the MPT had a 5 s average and the CF average was 177.40 Hz. When the patients that suffered CVA were assessed, it was observed a MPT average of 8.6 s and CF of 187.43 Hz. In the patients with EST, the MPT average was 7.7 s and the CF was 153.69. And in the patients with ALS, the MPT was 7.6 s and the CF was 166.80 Hz.

## DISCUSSION

With regard to the speech therapy approach in the oro-pharyngeal dysphagias, the clinical assessment is the most common and valuable method. Clinic characteristics such as the presence of a “humid voice” and the alteration of the vocal quality are being mentioned in several works. However, the relation of this characteristic with the dysphagia is being interpreted differently both in literature and in the clinical practice.

The vocal sign reveals itself as an important indicative of the relevant events in the superior airway-digestive region, mainly those that refer to the breathing and deglutition coordination. It establishes, thus, the importance of the integrated approach of the breathing, deglutition and phonation mechanisms in the speech clinic, as well as requires the extension of the studies and a better understanding of this relation and its effects in the dysphagias.

The relation of the maximum phonation time (MPT)

**Table 3.** Maximum phonation time of vowel /e/ and critical frequency compared with the basic disease.

Disease	MPT Average /e/	CF
Parkinson	5 seconds	177.40 Hz
CVA	8.6 seconds	187.43 Hz
EST	7.7 seconds	153.69 Hz
ALS	7.6 seconds	166.80 Hz

and the protection of the airways with the silent aspiration in patients with neurogenic dysphagias, consolidates paradigms related to the alteration of this maximum phonation time as a relevant point of care in the silent aspiration issues. The vocal assessment as a supplementary instrument offers comparison parameters and care with regard to the assessment of the dysphagia and its troubles.

For SHAKER (8), the protective mechanisms of the airways against aspiration are multi factorial and comprise an interaction between the respiratory and digestive tracts, with a perfect synchronism that allows subject to swallow without aspirating the boluses to the airways and they do not allow the reflow of this boluses from the esophagus.

The inferior airways are protected from aspiration by apnea during breathing, larynx raising and the action of the aryepiglottic folds (9). In the attempt to discuss the importance of understanding the MPT values and their correlation to the findings of the laryngeal – tracheal aspiration, this research was carried out and next there shall be discussed the findings of the analysis of the vocal sign, with the relation of the MPT of the vowel /e/ and the critical frequency measures, correlated to the findings of the videofluoroscopy, emphasizing the presence of the laryngeal - tracheal aspiration and of the type of material aspired.

The research with 31 patients with deglutition troubles under investigation by videofluoroscopy did not evidenced a statistical significance in the gender variable with regard the MPT.

When the MPT of the vowel /e/ is compared to the type of material aspired, it was possible to notice in this research that 10 patients who aspired liquids and pasty presented a MPT with values inferior to 9s, and just one patient presented MPT above 8s; in the patients who aspired only liquids, 9 presented values inferior to 8 s and 9 patients presented values superior to 8s. From the patients who did not aspirate, both of them presented MPT values above 8 s.

Thus, the data provided make us think that the relation of the MPT with the type of aspirated material has an important correlation, and it is based on the fact that the gravity of the aspirated material is associated with the severity of the dysphagia and, thus, it points to the decrease of subject's capacity to protect the inferior airways.

In the studies of the liquid/ pasty consistencies, the findings for penetration and aspiration confirm a significant number of 20 patients (64.52%) and, in the liquid, the alteration recorded is 9 patients (29.03%) and, pursuant to DANIELS and col. (10) these aspiration episodes are events that often occur in patients with neurogenic dysphagia.

With regard to the vocal quality, BEHLAU (11) designates that it is the set of characteristics that identify the voice. In the vocal quality, it is possible to detect biological aspects of anatomic and physiologic characteristics. Further, the synchrony of the operation of the components of the larynx, of the larynx with the resonance boxes and the whole body.

In the acoustic analysis data, we notice a minimum frequency of 115 Hz and the maximum of 252 Hz, the parameters below the indexes established for the man - 131 Hz - and 220 Hz for the woman, pursuant to RUSSO (12).

The critical frequency is the speed under the form of a wave that is repeated per unit of time, resulting from the length of the vocal chords. It is the reflex of the biodynamic characteristics of the vocal chords and its relation with the glottology pressure. A certain emission is physiologically determined by the number of cycles that the vocal chords make per second. (11).

For COLTON and CASPER (13), the maximum phonation time (MPT) is the maximum duration that a person can bear a sound in an extended expiration. But, for BEHLAU (11), this value is obtained by the maximum phonation time measure that a subject manages to support a sound emission or enchainned speech, in one sole expiration, and allows a quantitative and qualitative investigation of phonation.

The importance of the maximum phonation time of being around 14 s for woman and 20 s for man. In the maximum phonation time of vowel /e/ it has been recorded, upon the emission of the vowel /e/, a longer time within the range 8 to 12 s.

In the relation between the maximum phonation time and the food way with VO diet, there is a larger number in the 8-10s range. It is noticed that in the issue regarding the alterations in the neurological diseases, the maximum phonation term does not exceed 12s.

The results obtained with the said research, carried out with 31 patients with diagnose of neurogenic dysphagia and the relation between the maximum phonation time (MPT) in the emission of the vowel /e/ in the protection of the airways showed alteration in values.

It has been established 14 s for the female gender, and, for the male gender, 20s. Thus, the values obtained in the maximum phonation time in the neurologic diseases do not exceed 12 s, with the VO patients.

In the relation of the maximum phonation time (MPT) the aspirated material, the research points out that 9 patients presented aspiration during the videofluoroscopy within the 8-10 s range; from 10 to 12 s, there were 8 patients and from 3-8s there were 10 patients. We can notice that the short MPT is present in patients that aspirate.

When data is compared according to the basic disease, we notice that the averages per disease are closer, remaining between 5 and 8 seconds.

The vocal assessment surely offers comparison and care parameters through the vocal perceptive analysis and hearing perceptive analysis, in the issue regarding the assessment of the dysphagia and its troubles.

We suggest new researches are encouraged, mainly with specific studies at each basic disease, taking into account the peculiarities of each disease and its manifestations with regard to the swallowing process.

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## CONCLUSION

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In this research, the following findings were obtained in relation to MPT.

With regard to the maximum phonation time (MPT) the aspirated material, the research disclosed that there were 9 patients who presented, during the videofluoroscopy, aspiration from 8 to 10 seconds; from 10 to 12 seconds, there were 8 patients and, from 3 to 8 seconds, there were 10 patients. We can notice that the maximum time and the short phonation (MPT) is present in the patients that aspirate.

The above mentioned values can be considered important data in the alteration of the maximum phonation time (MPT) as a vocal parameter in the risks of trouble in deglutition.

This research made us conclude that the MPT is an important indicative in the assessment of the deglutition as

a vocal parameter, being referred to as an alarm for the risk of trouble in deglutition.

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