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Case Report
Relato de Caso

Immediate effect of neuromuscular electrical stimulation on deglutition after treatment of laryngeal cancer: a case report

Efeito imediato da estimulação elétrica neuromuscular na deglutição após tratamento do câncer de laringe: relato de caso

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Keywords

Laryngeal Neoplasms
Chemotherapy
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ABSTRACT

The objective of this study was to verify the immediate effect of sensory and motor neuromuscular electrical stimulation (NMES), in the oral and pharyngeal phases of deglutition, in a 64 year male patient after laryngeal cancer treatment. Videofluoroscopy was performed during deglutition of 5 ml of honey and pudding, under three conditions: without stimulation, with sensory NMES, with motor NMES, randomly defined. The degree of dysfunction of deglutition (DOSS), the presence of food stasis (Eisenhuber scale), laryngeal penetration and laryngotracheal aspiration (PAS) and oral and pharyngeal transit time were evaluated. An evaluator without knowing about the applied stimulus. On the DOSS scale there was improvement with sensory and motor stimulation. In the PAS scale, there was improvement, both for the sensorial and motor stimulus in the honey consistency, but the worsening of the motor stimulus for the pudding consistency was observed. There was reduction of the residues in the base of the tongue with sensorial and motor stimulus for the consistency of pudding and honey; worsening motor stimulus in the posterior wall of the pharynx for honey consistency. There was no difference between stimulation levels regarding to oral and pharyngeal transit time. The results showed that NMES at the sensory and motor levels improved the degree of dysphagia in an individual after the treatment of laryngeal cancer, with greater benefits of the sensory level in relation to the motor regarding to the presence of penetration and residues.

Descritores

Neoplasias Laríngeas
Quimioterapia
Radioterapia
Transtornos da Deglutição
Estimulação Elétrica

RESUMO

Este trabalho teve por objetivo verificar o efeito imediato da Estimulação Elétrica Neuromuscular (EENM) sensorial e motora, nas fases oral e faríngea da deglutição, em um homem de 64 anos, após tratamento de câncer de laringe. Foi realizado exame de videofluoroscopia durante a deglutição de 5 ml de mel e pudim, em três condições: sem estimulação, com EENM sensorial, com EENM motora, definidas de forma randomizada. Foi classificado o grau da disfunção da deglutição (DOSS), a presença de estase de alimentos (escala de Eisenhuber), de penetração laríngea e aspiração laringotraqueal (PAS), além da medida do tempo de trânsito oral e faríngeo, realizadas por uma avaliadora sem conhecimento sobre o estímulo aplicado. Na escala DOSS, houve melhora com a estimulação sensorial e motora. Na escala PAS, verificou-se melhora, tanto para o estímulo sensorial quanto motor na consistência mel, porém observou-se piora no estímulo motor para a consistência pudim. Houve diminuição dos resíduos em base de língua com estímulo sensorial e motor para as consistências pudim e mel; piora no estímulo motor na parede posterior da faringe para a consistência mel. Em relação ao tempo de trânsito oral e faríngeo, não foi observada diferença entre os níveis de estimulações. Os resultados demonstraram que a EENM em nível sensorial e motor melhorou o grau da disfagia em um indivíduo após o tratamento de câncer de laringe, com maiores benefícios do nível sensorial em relação ao motor no que diz respeito à presença de penetração e resíduos.

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INTRODUCTION

Mechanical dysphagia and its severity are related to the size and location of the tumor, the structures involved, as well as the modality of treatment used[1]. Some proposals for the rehabilitation of dysphagia after head and neck cancer treatment are described in the literature, such as protective and facilitating maneuvers[2], vocal exercises[3] and orofacial myofunctional exercises[2].

Neuromuscular electrical stimulation (NMES) has been described as a coadjuvant modality in the treatment of oropharyngeal dysphagia and can be applied to increase weak muscle contractions, improve the movement of structures that are controlled by these muscles[4], as well as stimulate sensory pathways effects, taking into account the effects of sensory stimulation on the long-term reorganization of the human cortex[5].

In the literature, few studies have been found that used NMES in cases of head and neck cancer, with heterogeneous casuistry in relation to tumor location and antineoplastic treatment employed. Some authors have found improvement in clinical outcomes in the group submitted to motor NMES associated with conventional therapy when compared to those receiving conventional single therapy[6]. Another study found worsening of the deglutition function for two groups after chemoradiotherapy, when compared to the pretreatment, but the group that received the highest number of NMES applications on motor level associated with conventional exercises presented better results for the level of oral ingestion in relation to the group that received fewer applications[7]. Finally, another study found worse scores on the penetration and aspiration scale for the group that received motor NMES associated with an exercise protocol compared to the group that performed the same protocol, but with placebo stimulation[8].

There are still few studies that describe the use of NMES in mechanical dysphagia, and no studies have been developed in Brazil or even considered different levels of NMES (sensory and motor) in specific cases of laryngeal cancer. Therefore, the present study aimed to verify the immediate effect of sensory and motor NMES, in the oral and pharyngeal phases of deglutition, in a case after the treatment of laryngeal cancer, with the hypothesis that NMES in the deglutition function will reduce the signs of mechanical oropharyngeal dysphagia.

CLINICAL CASE PRESENTATION

The study was approved by the Research Ethics Committee under the number CAAE 43930215.0.0000.5417 and performed through the agreement of the recruited individual, who was clearly informed about the use of its data for research purposes and signed a free enlightened consent term.

A 64-year-old male patient with a medical diagnosis of laryngeal keratinizing squamous cell carcinoma, referred to the speech therapy department of a higher education institution after 7 months of chemotherapy (7 sessions), radiotherapy (39 sessions) and (partial horizontal laryngectomy), with no prior history of speech-language rehabilitation and with the following complaints according to the Eat Assessment Tool (EAT-10) questionnaire[9]: my swallowing problem does not let me eat out from home, I have to force myself to swallow solid food, my swallowing problem takes away the pleasure of eating, my food gets stucked in my throat, I cough when I eat and swallowing makes me stressed. The NMES was applied to the patient of the present study with the objective of investigating the immediate effect of such adjuvant therapy modality, considering the commitment in the pharyngeal phase of deglutition and the limited results obtained through the protective maneuvers and facilitators tested.

The videofluoroscopy examination was used to evaluate the deglutition dynamics during the different stimulation conditions (NMES). For this purpose, an arcoscope was used as instrument for the exam, consisting in a closed-circuit television, an X-ray apparatus with image intensifier and a video-recording system (BV Surgical Arc - Philips' Pound). During the examination, the patient remained seated, and the deglutition evaluation was performed in the lateral view. The anatomical limits for the visualization of the videofluoroscopy images were: upper and lower limits that range from the oral cavity to the esophagus, in which the lips were observed as the anterior border, pharyngeal wall, posteriorly, nasopharynx, superiorly and cervical esophagus, inferiorly.

For the NMES, a two-channel system with a current pulse at a fixed pulse rate of 80 Hz and a pulse duration of 700 μs (VitalStim, model 5900, Chattanooga Group) was used. The electrodes were cut and fixed individually on the skin in the neck region of the participant, according to the anatomical characteristics, allowing the following positioning: a channel aligned horizontally above the hyoid bone (in the milo-hyoid muscle region) and the second channel aligned horizontally between the hyoid bone and the thyroid cartilage, inferior and slightly medial to the posterior horn of the hyoid bone (in the region of the thyrohyoid muscle)[10].

Electrical stimulation was applied in sensory and motor level to verify its immediate effect on deglutition with possible subsequent therapeutic application. Sensory and motor amplitude levels were determined prior to the deglutition exam. The participant was instructed to describe the sensation generated by the stimulation, while the amplitude was increased in steps of 0.5 mA, starting from zero until reaching the maximum level of tolerance. The level of the patient's sensory stimulus was 9 mA, defined as 2 mA below the motor level (feeling of tightening of the throat or pulling the muscles of the neck). The level of the motor stimulus was 18 mA, set at 2 mA below the maximum tolerance level[10].

During the deglutition videofluoroscopy examination, the presentation sequence of the stimuli (zero amplitude, sensorial and motor) and consistency (pudding and honey) was chosen by means of a draw, respecting one minute interval between the different levels of stimulation. In the following order: (1) amplitude zero (honey and pudding - 5 ml); (2) sensory stimulation (pudding and honey - 5 ml); (3) motor stimulation (pudding and honey - 5 ml). Therefore, 6 types of swallowing

were evaluated. During the examination, the effect of NMES on the deglutition of fluid was not evaluated because of safety concerns, since the patient presented significant laryngotracheal aspiration for this consistency. In addition, the patient's sensation among the different types of swallowing was not investigated so the results would not suffer influence.

The degree of dysphagia was classified according to the Dysphagia Outcome and Severity Scale - DOSS scale[11], which classifies the degree of dysphagia at levels ranging from 7 (normal in all situations) to 1 (severe dysphagia: nothing orally - unable on safely oral route), from the analysis of the images of the videofluoroscopy examination of deglutition.

The presence of laryngeal penetration and laryngotracheal aspiration was evaluated according to the Penetration and Aspiration Scale (PAS)[12] for each food offered at different levels of NMES. PAS contains eight points based on three variables: whether the food was aspirated or penetrated; level of the airway invasion, and whether or not it was expelled from the airway. The level of measurement is ordinal, and increasing numbers indicate greater severity of dysphagia.

In the classification of food stasis, the Eisenhuber scale[13] was used considering the pyriform sinuses and the root of the tongue, the latter due to the absence of valleculae, due to the surgical procedure for resection of the tumor. The presence of residues in the oral cavity, posterior wall of the pharynx and upper esophageal sphincter (0 = absence of residues, 1 = presence of a fine line of contrast, 2 = presence of little residue, 3 = presence of a lot of residue).

Finally, the oral and pharyngeal transit time (in seconds) was measured using the markers of the Kinovea Video Editing Program - 0.8.15 (Copyright© 2006-2011 – Joan Charmant and Contrib).

All classifications and measurements were performed by an oropharyngeal examiner with a doctorate in the area of oropharyngeal dysphagia, with no knowledge of the stimulus applied in each deglutition.

The results showed that there was an improvement in the DOSS scale with sensory and motor stimulation, from level 3 (moderate dysphagia) to level 4 (mild/moderate dysphagia).

Regarding classification in the penetration and aspiration scale, the results for each individual, in the different levels of neuromuscular electrical stimulation and consistencies, are described in Table 1. From the results, was found improvement, both for the sensory and motor stimuli in the honey consistency, but the sensorial was better than the motor, as the aspiration was eliminated. On the other hand, there was worsening in the motor stimulus for the pudding consistency, since during deglutition with motor stimulation the food entered the airway and was ejected, whereas in the absence of stimulation the food did not reach airway.

Table 2 shows the results of the evaluation of food stasis from the application of the Eisenhuber scale for the sensory and motor NMES, considering the different consistencies, as well as the evaluated structures. The findings of the scale of residues demonstrated decreased residues in the root of the tongue with sensory and motor stimuli for the consistency of pudding and honey; in the posterior wall of the pharynx, there was worsening in the motor stimulus for the honey consistency.

Table 3 shows the results regarding oral and pharyngeal transit time, considering the different stimulations applied and tested consistencies. The results showed no change in oral and pharyngeal transit time for the levels of stimulation applied during the deglutition of different consistencies.

Table 1. Individual result obtained through the evaluation of the PAS scale, aspiration penetration, in the different levels of neuromuscular electrical stimulation applied and in the different consistencies tested

	PAS Scale		
	Without Stimulation	Sensory Stimulation	Motor Stimulation
Pudding	1	1	2
Honey	7	4	6

Table 2. Individual result obtained through the evaluation of food stasis, considering the different consistencies offered during the application of sensory and motor stimulation

	Eisenhuber Scale						Residues presence					
	Root of Tongue			Pyriform sinus			PPW			UES		
	WS	SS	MPS	WS	SS	MPS	WS	SS	MPS	WS	SS	MPS
Pudding	3	0+	0+	3	3	3	1	1	1	3	3	3
Honey	3	0+	0+	3	3	3	1	1	3-	3	3	3

WS = without stimulation; **SS =** sensory stimulation; **MPS =** motor stimulation; **PPW =** pharynx posterior wall; **UES =** upper esophageal sphincter; **+** better; **-** worse.

Table 3. Result (in seconds) of oral and pharyngeal transit time in the different tested consistencies and applied stimuli

	Oral Transit Time (s)			Pharyngeal Transit Time (s)		
	WS	SS	MPS	WS	SS	MPS
Pudding	0.83	-	0.76	0.76	0.73	0.63
Honey	-	0.76	0.63	-	0.96	0.93

WS = without stimulation; **SS =** sensory stimulation; **MPS =** motor stimulation; **S =** seconds.

DISCUSSION

Head and neck cancer can cause several sequelae, including oropharyngeal dysphagia. Neuromuscular electrical stimulation represents a recent technique for the treatment of dysphagia in individuals undergoing oncological treatment, being found in the literature studies that used the NMES in short[6,7] and long[8] term in patients with head and neck cancer, whose results were variable and did not make it possible to understand the impact of NMES on mechanical dysphagia. In this sense, understanding the immediate effect of NMES and its impact on deglutition may help in the selection of stimuli (sensorial X motor) to be applied from food supply before being submitted to short-, medium- and long-term therapy. Thus, the present study sought to describe the effects of sensory and motor NMES during the deglutition of food of different consistencies via videofluoroscopy in a patient after the treatment of laryngeal keratinizing epidermoid carcinoma with moderate oropharyngeal dysphagia.

In the present study, it was possible to verify that the NMES resulted in an improvement in the DOSS scale, from level 3 (moderate dysphagia) to level 4 (discrete/moderate dysphagia), with both motor and sensory stimuli. These findings agree with a study[14] that found an improvement in the classification of dysphagia severity in patients with different etiologies, including cases of head and neck cancer that underwent NMES therapy with vitalStim and presented mild/moderate oropharyngeal dysphagia.

The results of the penetration and aspiration evaluation showed an improvement in honey consistency with sensory stimulation (level 7 to level 4), eliminating aspiration, and motor (level 7 to level 6). However, there was worsening in the motor stimulus (level 1 to level 2) for the pudding consistency. When compared to the literature[15], using functional electrical stimulation (maximal level of tolerance), another study also found reduction of penetration and aspiration, and it is important to consider that the group of patients studied by the authors had nasopharyngeal carcinoma. In another study[7], there was improvement in the PAS scale, using neuromuscular electrical stimulation (motor level) combined with conventional exercises. Other authors[8] observed an improvement in the PAS scale for the group that received conventional exercises, without NMES.

A possible explanation for worsening deglutition with pudding consistency during motor stimulus application may be the possible reduction of hyolaryngeal elevation during deglutition, described by some authors in a study conducted with healthy adults[16]. On the other hand, the improvement of the results obtained with the sensorial stimulation can be attributed to the increase of the sensorial input, resulting in an improvement in the motor responses involved in the deglutition process.

Regarding the scale of waste, for the consistencies of pudding and honey, it was verified decrease of residues in the root of the tongue with sensorial stimuli (level 3 for level 0) and motor stimuli (level 3 for level 0), while, for honey consistency, there was an increase in residues in the posterior wall of the pharynx with motor stimulus (level 1 to level 3), demonstrating a possible positive impact in the oral phase of deglutition with the applied stimuli, however with pharyngeal function impairment with motor stimulation. Differently from this study, in the literature[15], benefits were found in the pharyngeal phase of swallowing, characterized by reduction of stasis in pyriform sinuses, taking into account that the authors mention that functional electrical stimulation can increase the movement speed of the hyoid bone and reduce stasis in pyriform sinuses. The non-agreement of the findings of the present study with the cited study[15] can be justified by the methodological differences, especially regarding the different modalities of electrical stimulation applied and the location of the cancer presented by the patients.

For the oral and pharyngeal transit time, there was no difference between the different levels of stimulation in the different consistencies. However, one study showed a value of $p=0.056$, in the comparison of TTO pre- and post-electrical stimulation in post-treatment patients of nasopharyngeal cancer, being assumed that statistical significance would be achieved with the increase in the number of study participants[15]. The other publications addressing NMES in cancer cases did not investigate oral or pharyngeal transit time.

In the present case, an increase in the speed of contraction of the muscles used during the swallowing process was expected, with an improvement in oral and pharyngeal transit time, but this may not have occurred due to the possible muscular fibrosis developed after radiotherapy treatment. In addition, only the immediate effect of NMES on swallowing function, which may not have been sufficient to improve muscle contraction, was verified, and further studies are needed to verify the effect of NMES application in an intervention process.

No studies were found that applied the sensory stimulus in individuals with dysphagia after head and neck cancer, making it impossible to compare the results, and the findings of the clinical case presented confirmed the hypothesis that the NMES, during the deglutition function, modifies the signs of oropharyngeal dysphagia due to horizontal partial laryngectomy and radio chemotherapy.

Despite the draw of the order of presentation of the stimuli, the final sequence was zero amplitude, sensory level and motor level, which could be promote an electrical stimulus effect, benefiting the action or the reverse occurs, that is, an adaptation to the stimulus. However, it is believed that the order of the stimuli used (without stimulus, sensory stimulus, motor stimulus) did not generate a cumulative effect, because, during the isolated sensory stimulation, only the cutaneous afferents (sensorial receptors in the skin) are already being stimulated by the surface electrodes. During the stimulation motor level, the intensity of the stimulation is increased to activate both the cutaneous afferents and the motor nerves for a muscle contraction[17]. In addition, a deglutition sequence, irrespective of any electrical stimulus in a healthy individual, or even with oropharyngeal dysphagia, may favor the latter by repeated swallowing. However, such findings were not observed in the study, demonstrating that NMES influences the physiological responses of deglutition, depending on the level of stimulation applied (sensory or motor).

As a limitation of the present study, it is important to mention that due to technical problems that occurred during the recording of the videofluoroscopy examination of swallowing, it was not

possible to analyze the oral transit time with sensory stimulus specifically for the pudding consistency and the oral transit time and pharyngeal with zero amplitude for honey consistency. In addition, the NMES was not applied in a therapeutic approach because the patient did not return to the educational institution for speech and language rehabilitation because they lived in a distant location.

Despite the limitations presented, the study suggests that NMES may be effective when used as a coadjuvant in the treatment of oropharyngeal dysphagia in patients who have undergone laryngeal cancer treatment. However, it is important to emphasize the need for new studies, for a better understanding of the use of this technique. Finally, it is expected that this study may contribute to the understanding of the immediate effect of NMES on the deglutition function in patients after the treatment of laryngeal cancer and the development of future research.

FINAL COMMENTS

The application of NMES at sensory and motor level reduced the degree of dysphagia in the patient of this study, with greater benefits of the sensory level in relation to the motor, regarding the presence of penetration and residues.

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Authors contributions

DRC participated in the project creation, data collection and interpretation, and the article writing; MMASA participated in the data analysis, as evaluator; CMFR participated in the patient selection and in the revision of the final version of the article; PSSS participated in the patient selection and in the revision of the final version of the article; GBF participated in the project creation, data interpretation and article writing, as evaluator.