

Effectiveness of Therapy on Post-Extubation Dysphagia: Clinical and Electromyographic Findings

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ABSTRACT

INTRODUCTION: Patients who require prolonged endotracheal intubation (>48 hours) are at risk of dysphagia. Speech-language pathologists should perform swallowing exercises after extubation due to the high probability of developing aspiration pneumonia. There are no studies describing the use of swallowing techniques employed in post-extubation therapy aided by surface electromyography.

OBJECTIVES: To evaluate the effects of swallowing function therapy in extubated patients after prolonged orotracheal intubation by means of clinical and electromyographic evaluation.

METHODS: A total of 15 patients were enrolled in this study (average age 48.6 ± 16.5 years). The study was carried out in three phases: (1) Clinical and electromyographic evaluation using the Dysphagia Risk Assessment Protocol following dysphagia scores criteria, and the measurement of the suprahyoid muscles amplitude (μV) expressed by root mean square (RMS), respectively; (2) swallowing rehabilitation program; and (3) reevaluation of patients after therapy. The Wilcoxon paired test assuming a significance level of 5% was used for statistical analysis.

RESULTS: By means of the swallowing scale, it was verified that patients suffered from severe oropharyngeal dysphagia at the first evaluation (80%), but the rehabilitation therapy reduced clinical signs, persistent only in one patient (6.7%) post-therapy, thus, improving swallowing. Significant differences, pre- and post-therapy, for suprahyoid muscles during maximal voluntary isometric contractions of right ($P = .0067$) and left ($P = .0215$), saliva swallowing by right ($P = .0413$) and left ($P = .0151$), and liquid swallowing by right ($P = .0479$) and left ($P = .0215$) sides, were found, as shown by electromyography.

CONCLUSIONS: Swallowing exercises carried out by extubated patients after prolonged orotracheal intubation increased neuromuscular recruitment of suprahyoid muscles involved with swallowing and reduced dysphagia levels.

KEYWORDS: Deglutition, deglutition disorders, intubation, electromyography, rehabilitation

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Introduction

Patients hospitalized in critical condition and suffering from respiratory insufficiencies often require aid by means of mechanical ventilation, which then allows the lungs to be ventilated properly.¹ Mechanical pulmonary ventilation is used as a supportive measure for the treatment of several diseases, such as those derived from tracheal intubation.²

Orotracheal intubation, for life to be sustained, may lead to post-extubation swallowing dysfunction, delaying oral feeding.³ In particular, patients undergoing long period intubation, that is, ≥ 48 hours,⁴ pose a greater risk for dysphagia.⁵ Possible explanations include alterations of glottic anatomy,⁶ inactivity of laryngeal skeletal muscles, leading to atrophy,⁷ and decrease of alertness, owing to neuromuscular blocking or sedative agents,⁸ disturbing the security of swallowing process. Such events show a reported prevalence of 34% to 56%.⁹

Post-extubation dysphagia involves aspiration of food content into the upper respiratory tract, pneumonia, malnutrition, placing of feeding tubes, decrease in quality of life, increased time spent under health care, and higher mortality rates.¹⁰

Studies regarding rehabilitation of swallowing dysfunctions have been carried out by speech and language pathologists in post-extubation patients^{11,12} aimed at restoring physiological swallowing of patients by submitting them to mobility exercises of phono-articulatory organs and swallowing maneuvers. Both studies report overall improvement of swallowing due to the therapeutic techniques used, even though such techniques are not fully detailed by the authors. High variability in the number of therapy sessions and a very diverse number of techniques were used by the authors in one of the studies.¹¹ In another study, the Rodrigues et al¹² reported that the score systems that they used for evaluation of swallowing levels had not previously



been validated, which may not have ensured proper assessment of the true severity of dysphagia, and that therapeutic emphasis was given to indirect exercising (increasing oral control).

So far, research on muscular electric activity by surface electromyography (SEMG) in post-extubation therapy, has not been carried out. This technique has been used as an aid in differential diagnosis and monitoring of possible muscular disorders¹³ and contributed to the assessment of swallowing dysfunction. It also assists therapy techniques aimed at treating dysphagia as it can demonstrate the activity of suprahyoid muscles during swallowing exercises¹⁴ and also provide visual biofeedback to physicians and patients, which can be used to better understand muscle activity that takes place when exercising is carried out during therapy.^{15,16}

The hypothesis of this research is that rehabilitation exercises aimed at hyolaryngeal muscles may facilitate functional adaptation by means of strength training principles, resulting in improvement of muscle activity and recruitment in patients presented with oropharyngeal dysphagia following intubation, showing a meaningful impact on the swallowing physiology of patients, providing greater safety in oral feeding. Thus, the aim of this study was to evaluate the effects of swallowing function therapy in extubated patients after prolonged orotracheal intubation by means of clinical and electromyographic evaluation.

Methods

Ethical aspect

This study was approved by the Research Ethics Committee of the State University of Maringá, under protocol number CAAE – 18536013.0.0000.0104 and conducted according to ethical standards set forth in the Helsinki Declaration of 1975. All patients signed a free and informed consent form accepting to participate in the study.

Participants

Patients from an intensive care unit located in a public university hospital were selected to participate in the study, which took place in the period ranging from September 2015 to September 2016. Patients that met the following criteria were enrolled in the study: subjected to orotracheal intubation and mechanical ventilation for more than 48 hours; no tracheostomy; suffered from dysphagia after extubation; scored higher than 14 in the Glasgow Coma Scale¹⁷ and showed hemodynamic stability without the aid of vasoactive drugs. Also, only patients who did not need to be subjected to non-invasive support ventilation during evaluations and therapy exercises for 30 minutes, maintaining respiratory frequency lower or equal to 30 inspirations per minute, were included in the study. The following criteria were used for exclusion of patients from the study: surgical procedures involving head and neck, cervical and cranial traumas, lowered levels of consciousness, profound deafness and reintubation. Patients included in the study underwent therapy with specific exercises.

Data collection

The present study is a prospective interventional study, carried out in three different phases: (1) *Clinical and Electromyographic evaluation* of patients using the *Dysphagia Risk Evaluation Protocol (DREP)*¹⁸ and assessing their swallowing levels according to scales determined by the American Speech-Hearing Association (ASHA)—National Outcomes Measurement Systems (NOMS)¹⁹; (2) *Swallowing rehabilitation program*, performed in all patients of the study; and (3) *Reevaluation of patients after therapy*, assessing the same parameters prior to intervention.

Phase 1: the first evaluation of the patients was carried out in the period that took place 24 to 48 hours after extubation. *Clinical and Electromyographic evaluations* were carried out, simultaneously.

Clinical evaluation included the swallowing test using DREP, a validated protocol for characterizing clinical signs suggestive of laryngeal penetration or laryngotracheal aspiration and for determining the risk for bedside dysphagia, with a sensitivity of 70% and specificity of 88%. The instruments of cervical auscultation and pulse oximeter were used during the evaluations, according to the recommendation of the protocol. The evaluation procedures are composed of the swallowing test for 5 mL of water and 5 mL of pudding. Next, the swallowing levels were determined using the ASHA-NOMS scale (which varies from 1—least functional—to 7—normal functionality). The ASHA NOMS scale was selected for international validation. It is a multidimensional tool, organized to determine the type of diet the patient can ingest and the need for supervision that should be used in each case.

SEMG was performed using a four-channel Miotool (Miotec®) device. The channels were calibrated at 500 μ V with bandpass filters of 20 to 500 Hz, and notch filters of 60 Hz). An amplification factor of 2000 was used for the SEMG signals. The software used for SEMG data processing was Miotec® Miograph 2.0, which performs online acquisition, storage and processing of the signals.

The ground electrode was placed on the olecranon of the right arm to minimize interference from external noise.²⁰ The electromyographic activity of suprahyoid muscles (right and left) was assessed. The following tests were performed: (1) maximum voluntary isometric contraction of the suprahyoid muscles by pressing the tongue against the palate for three seconds with mouth ajar, (2) swallowing saliva (SS), (3) swallowing liquid (SL) (5 mL in a single swallow), and (4) swallowing pudding (SP) (5 mL in a single swallow—liquid bolus was prepared with 2.5 mL of water at room temperature plus 2.5 mL of liquid barium (Opti-Bar). Paste bolus was prepared with 3.6 g of ThickenUp Clear food thickener, 50 mL of water and 50 mL of liquid barium stirred until complete dissolution. The liquid bolus was classified as level 0 (thin liquid) and the pudding bolus as level 3 (moderately thick) according to the International Dysphagia Diet Standardization Initiative (IDDSI) classification.²¹ The electromyographic activity was expressed as root

Table 1. Demographic data and characterization of research subjects.

	BASIC DISEASE	AGE	GENDER	THS (DAYS)	TVM (DAYS)
1	PD	71	F	22	12
2	PD	20	F	20	2
3	LD	62	M	25	16
4	ID	19	M	17	3
5	PD	56	M	19	4
6	PABI	48	M	10	3
7	LD	56	M	21	5
8	PABI	57	M	25	6
9	PD	52	F	15	6
10	PABI	19	F	12	2
11	PD	66	M	17	6
12	LD	47	M	28	5
13	PD	55	F	21	2
14	LD	48	M	29	21
15	PD	55	M	18	9

Abbreviations: ID: infectious diseases; LD: liver diseases; PABI: poly-trauma with absence of brain injuries; PD: pulmonary disease; THS: time of hospital stay; TMV: time of mechanical ventilation.

mean square (RMS) of the amplitude (μV). Three swallows were performed, with an interval of 10 seconds between them, and the mean of three records was used for analysis.

Phase 2: patients were subjected to *Effortful Swallowing Exercises* and of the *Mendelsohn Maneuver*; the first set of exercises intensifies oral propulsion, while the second exercise improves elevation of the larynx during swallowing.²² Therapy was carried out for five consecutive days; on the first 2 days, patients were only subjected to *Effortful Swallowing* exercises and on the next 3 days they were subjected to practice of the *Mendelsohn Maneuver* and *Effortful Swallowing* exercises as well, with saliva being swallowed in every exercise. The exercising therapy consisted of three sets of 10 movements at a rate of one movement per second, with intervals of 10 seconds between sets; therapy was carried out in two sessions each day, with an interval of 2 hours between each session.

Phase 3: At the end of speech therapy sessions and on the same day, *Clinical and Electromyographic evaluations* were performed, following the same criteria described in phase 1.

Statistical analysis

For statistical analysis, stratified sampling using qualitative and quantitative discrete variables was used. In order to verify whether there would be any differences between the values obtained prior to and after therapy, descriptive analysis and Wilcoxon paired tests were used.²³ The level of significance used was 5%. All analyses were carried out using R[®] software.

Results

A total of 35 patients were assessed; 20 patients were excluded from the study, 11 of them male (55%). The reasons for exclusion were as follows: 2 (10%) subjected to surgical procedures involving head and neck areas, 4 (20%) cervical and/or cranial traumas, 12 (60%) with lowered levels of consciousness, 1 (5%) with profound deafness and could not follow the commands issued by the therapist, and 1 (5%) was re-intubated. Thus, a total of 15 remaining patients were enrolled in the study, their age being 48.6 ± 16.5 , 10 being male (66.7%). Demographic data and characterization of the patients are described in Table 1.

Table 2 shows the results obtained by *clinical evaluation* using the liquid and pudding consistencies and independent variables for dysphagia risk. Significant post therapy improvement (100%) was seen in variables cough, voice quality, choking, and extraoral loss for pudding and voice quality for liquid. Table 3 shows the characterization of swallowing levels before and after therapy had been carried out, according to ASHA-NOMS parameters. The results indicated that 12 patients (80%) out of those presented with severe oropharyngeal dysphagia, only one (6.7%) remained following therapy.

Table 4 shows the mean values for electrical activity (μV) pre- and post-therapy. Great variability and asymmetric distributions were observed for maximal voluntary isometric contractions of suprahyoid muscles and for pudding, pre- and post-therapy.

Results obtained by superficial SEMG assessing suprahyoid muscles pre- and post-therapy are shown in Table 5. The Wilcoxon test evidenced that therapy was effective, as maximal

Table 2. The results of the liquid and pudding test and the independent variables of the risk of dysphagia.

	LIQUID				PUDDING			
	PRE		POST		PRE		POST	
	N	%	N	%	N	%	N	%
Extraoral loss	6	40	1	6.7	7	46.6	0	–
Multiple swallows	12	80	6	40	13	86.7	7	46.7
Laryngeal elevation	15	100	3	30	15	100	1	6.7
Cervical auscultation	9	60	1	6.7	5	33.3	1	6.7
Voice quality	9	60	0	–	8	53.3	0	–
Cough	10	66.7	1	6.7	4	26.7	0	–
Choking	11	73.3	1	6.7	4	26.7	0	–
Nasal regurgitation	0	–	0	–	0	–	0	–
Residue in oral cavity	0	–	0	–	7	46.7	1	6.7

Table 3. Characterization of pre- and post-therapy swallowing levels (ASHA-NOMS).

ASHA	PRE		POST	
	N	%	N	%
1	1	6.7	0	0
2	1	6.7	0	0
3	8	53.3	0	0
4	4	26.6	1	6.7
5	1	6.7	0	0
6	0	0	6	40
7	0	0	8	53.3

ASHA-NOMS: American Speech—Hearing Association—National Outcomes Measurement Systems.

voluntary isometric contractions of suprahyoid muscles and saliva and liquid swallowing significantly improved after therapy.

Discussion

The association between dysphagia severity and time of orotracheal intubation observed in 60% of patients, pre-therapeutically, is well established by scientific literature.^{10,24} The mechanical impact of tubes inside oropharyngeal and laryngeal cavities may cause oropharyngeal dysphagia. Orotracheal intubation results in alterations of both chemoreceptors and mechanoreceptors present in pharynx and larynx mucosae.²⁵ These pathological changes can be aggravated with aging, such as body mass and mobility loss, compromising the ability of the upper respiratory tract to prevent aspiration.²⁶

The absence of coughing and the occurrence of choking during liquid intake following extubation, have been identified

in this study as possible risk factors for bronchoaspiration. The signs suggesting laryngeal penetration, seen in the literature, indicate laryngeal sensorial skills inhibition,²⁷ alterações associadas aos reflexos de deglutição ou transições faríngeas são esperadas como indutoras de aspiração traqueal.²⁶

The reduction of laryngeal excursion on the first assessment and its effect after therapy was observed in 30% and 6.7% of patients, for liquid and pudding, respectively. These findings corroborate the literature that shows motor changes caused by orotracheal intubation, such as muscular inactivity, sedation and laryngeal desensitization,²⁸ as a result of laryngeal mobility reduction.

The incidence of severe oropharyngeal dysphagia in this study was 80% in the pre therapy, and 6.7%, following therapy, as verified by ASHA-NOMS. The dysphagia seen, following extubation, might result in aspiration, thus, damaging the oral and pharyngeal phases of swallowing, and its early detection decreases the morbidity and mortality rates in intensive care patients.²⁹ A spontaneous recuperation of swallowing can occur in a 3-day post-extubation period, as found in the literature for 54% of the patients³⁰; however, in this research, improvement was detected after five consecutive days of therapy in 91.6% (11 patients out of 12 presented with severe dysphagia) and the exercises applied in the rehabilitation program helped patients to improve their swallowing function, by reducing the neuromuscular impairment caused by orotracheal intubation.

SEMG evaluations were responsible for the main findings of this study, as they evidenced significant differences when comparing maximal isometric voluntary contractions of suprahyoid muscles during saliva and liquid swallowing before and after therapy. Such differences can be attributed to increased neuromuscular recruitment of suprahyoid muscles, which prolonged larynx elevation and reduced residues in

Table 4. SEMG results of pre- and post-therapy clinical evaluations.

SEMG	PRE				POST			
	MEAN	SD	LOWER CI	UPPER CI	MEAN	SD	LOWER CI	UPPER CI
S1	42.29	33.43	23.78	60.81	68.90	52.48	39.84	97.96
S2	48.71	45.83	23.33	74.09	71.83	48.27	45.10	98.56
SS1	44.88	30.65	27.90	61.85	72.52	52.09	43.68	101.37
SS2	43.07	29.79	26.57	59.57	60.33	35.03	40.93	79.73
SL1	48.25	30.84	31.17	65.33	64.01	32.55	45.98	82.03
SL2	56.11	68.95	17.93	94.29	55.55	23.04	42.79	68.31
SP1	59.64	62.62	24.96	94.32	80.02	90.52	29.89	130.14
SP2	58.01	71.43	18.45	97.57	82.66	100.96	26.75	138.57

Lower CI: Inferior Confidence Interval (95%); Upper CI: Superior Confidence Interval (95%); S₁: right suprahyoid; S₂: left suprahyoid; SEMG: surface electromyography; SS₁: right suprahyoid saliva swallowing; SS₂: left suprahyoid saliva swallowing; SL₁: right suprahyoid liquid swallowing; SL₂: left suprahyoid liquid swallowing; SP₁: right suprahyoid pudding swallowing; SP₂: left suprahyoid pudding swallowing.

Table 5. Comparison between surface electromyography data in the pre- and post-therapy evaluation of swallowing in the suprahyoid muscles.

EMG	PRE	POST	P VALUE	SIGNIFICANT
S ₁	32.46	56.09	0.0067	*
S ₂	37.56	65.02	0.0215	*
SS ₁	29.48	53.10	0.0413	*
SS ₂	36.77	50.15	0.0151	*
SL ₁	39.90	70.35	0.0479	*
SL ₂	39.64	56.44	0.0215	*
SP ₁	33.95	49.52	0.1688	Ns
SP ₂	37.13	52.09	0.1514	Ns

S₁: right suprahyoid; S₂: left suprahyoid; SS₁: right suprahyoid saliva swallowing; SS₂: left suprahyoid saliva swallowing; SL₁: right suprahyoid liquid swallowing; SL₂: left suprahyoid liquid swallowing; SP₁: right suprahyoid pudding swallowing; SP₂: left suprahyoid pudding swallowing; *: significant; NS: no significant; EMG: electromyography.

pharyngeal recesses, reduced laryngeal penetrations and the multiple swallowing; all of these effects taking place due to the effectiveness of the exercising therapy employed in this study. Such findings corroborate with other studies, which describe the use of empirical and clinical data obtained by SEMG for assessment of swallowing.¹⁶ These data rely on a basic comprehension of the relation between electromyographic signals and movements that support swallowing. The movement of the hyoid bone and the biomechanical swallowing event are closely linked to the EMG signal, since the muscles responsible for the movement of the hyoid bone are very superficial and are located near the surface where the electrodes are placed. The movement of the hyoid bone is also one of the first biomechanical events that occurs during swallowing.¹⁶

Differences found for pudding deglutition (suprahyoid muscles), also evidenced in Table 5, can be linked to food consistency, as more muscle fibers must be recruited in order for swallowing to be performed. The viscosity has considerable effect up on deglutition, as a very viscous food bolus tends to be swallowed slower, suffering the effects of greater mechanical resistance, thus leading to increased activity of muscles responsible for swallowing,³¹ since duration, but not amplitude of activity of tongue and suprahyoid muscles becomes longer, as the consistency of foods increases.³²

Orotracheal intubation causes changes in swallowing, reduces the sensitivity of the laryngeal mucosa and weakens the tongue muscles, the effects of *Effects of Swallowing Exercises* and *Mendelsohn Maneuver* have led to an increase in muscle recruitment for specific functions,³³ improving the passage of the bolus to the esophagus and reducing the incidence of aspiration of food and liquid through the trachea.³⁴ The Mendelsohn maneuver involves the voluntary prolongation of the duration of laryngeal elevation during swallowing, effectively acting on the supra-hyoid muscles.³⁵

In swallowing therapy, the suprahyoid muscles must be highly active, so as to get fatigued.³⁶ Biomechanical changes, along with effortful swallowing exercises and their effects on the intake of food, leading to an increase of maximum oral pressure, reducing residues in the oral cavity, and improving the flow of bolus in a safer way, thus, diminishing the risk of food aspiration.³⁴

This study presented some shortcomings. All subjects studied were from the same institution, with a few patients intubated. The DREP protocol and the swallowing classification ASHA NOMS are validated and subjective instruments used in bedside assessment, routinely utilized in hospitals. Further studies using complementary objective evaluations such as swallowing videofluoroscopy and fiberoptic endoscopic evaluation are necessary, since these tools are important in the diagnosis of

dysphagia, so as to verify the effect of speech therapy intervention on other physiological aspects of swallowing.

Conclusion

Swallowing exercises carried out by extubated patients after prolonged orotracheal intubation increased neuromuscular recruitment of suprahyoid muscles involved with swallowing and reduced dysphagia levels. Such results suggest that surface SEMG is a useful technique in assessing biomechanical events relevant for swallowing.

Authors' Note

This work was conducted at the University Regional Hospital of Maringá, State University of Maringá, Maringá, Paraná, Brazil.

Author Contribution

AZGEG, GBF, SSY: participated in the study design, data collection, analysis and interpretation, writing of the manuscript and decision to submit it for publication. DFR participated in the statistical analysis and writing of the manuscript.

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