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Original Article
Artigo Original

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The applicability of high resolution manometry in total laryngectomy

Aplicabilidade da manometria de alta resolução na laringectomia total

Keywords

Total Laryngectomy
Esophageal Voice
High Resolution Manometry
Laryngectomy
Rehabilitation

ABSTRACT

Purpose: This study aims to measure the pressure of the pharynx and the pharyngoesophageal segment (PES) at rest and during phonation in total laryngectomized patients, with different levels of voice production. **Methods:** four total laryngectomized individuals participated in the study, All patients underwent High Resolution Manometry (MAR) at rest and during phonation. After this process, a descriptive analysis of the results was performed. **Results:** we observed that during rest the patients had PES pressure below normal and this data may be related to changes in the muscular connections at the level of the upper esophageal sphincter (UES) especially the interruption of the cricopharyngeal plexus. During phonation, two patients presented higher UES pressure values during phonation, when compared to the values found at rest, suggesting that introduction of air into the esophagus is followed by pharyngoesophageal contraction and that during phonation the patients with good esophageal speech may develop more pressure in this region. **Conclusion:** Studies with a greater number of participants may help define, for example, subjects who may benefit from procedures such as cricopharyngeal myotomy or other medical conduct in order to facilitate the acquisition of esophageal voice in these patients.

Descritores

Laringectomia Total
Voz Esofágica
Manometria de Alta resolução
Laringectomia
Reabilitação

RESUMO

Objetivo: medir a pressão da faringe e do segmento faringo-esofágico (SFE), no repouso e durante a sua vibração (na produção de voz esofágica) em pacientes laringectomizados totais com diferentes níveis de produção de voz. **Método:** participaram do estudo quatro indivíduos laringectomizados totais, todos submetidos à Manometria de Alta Resolução (MAR) no repouso e durante a fonação. Após esse processo, foi realizada uma análise descritiva dos resultados. **Resultados:** em nosso estudo, observamos que, durante o repouso, os pacientes apresentaram pressão do esfíncter esofágico superior (EES) abaixo da normalidade, e este dado pode estar relacionado a alterações das conexões musculares, ao nível do EES, especialmente, a interrupção do plexo cricofaríngeo. Durante a fonação, dois pacientes apresentaram maiores valores de pressão do EES, em todas as fonações, quando comparado com os valores encontrados no repouso, sugerindo que a introdução de ar no esôfago é seguida de contração faringo-esofágica e que, durante a fonação, os pacientes bons falantes esofágicos, podem desenvolver maior pressão nesta região. **Conclusão:** estudos com maior número de participantes podem ajudar a definir, por exemplo, sujeitos que poderão se beneficiar de procedimentos como a miotomia do cricofaríngeo ou outra conduta médica, a fim de facilitar a aquisição de voz esofágica nesses pacientes.

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INTRODUCTION

Cancer is one of the most serious diseases that affect the larynx. One of the treatments for curing laryngeal cancer in the main rehabilitation centers for patients undergoing head and neck surgery is total laryngectomy.

In some cases, the impact of the disease can be devastating for the patient, leading to difficulty in speech and swallowing. The speech of the patient will have to develop a sound source different from the vocal folds. The new sound source for these patients is the vibration of the Pharyngo-Esophageal Segment (PES). The authors hypothesize that the excessive pressure in the PES, or the exaggerated reduction of that same pressure, can make this process difficult. The treatment for laryngeal cancer depends on the clinical stage, the extent and location of the tumor (supraglottic, glottic, and subglottic).

The use of surgically-implanted speech prostheses is an international trend towards the rehabilitation of these patients, and it is considered the gold standard for communication. The esophageal voice is the most common method of communication in Brazil for social and economic reasons.

The production of esophageal voice uses the esophagus as a temporary reservoir of air, expelling and working it into the upper cavities of resonance and articulation, that is, the esophageal voice is the one in which the air supply passes from the external environment to the position of the esophagus, stored at the level corresponding to the cervical vertebrae numbers 5, 6 and 7, below the pharyngoesophageal segment. The sound of the esophageal voice is hoarse and low in frequency[1].

After a total laryngectomy, esophageal contractions by swallowing are altered with a decrease in the amplitude of the contraction and an increase in the number of non-peristaltic contractions. It is almost unknown what happens with the intra-esophageal pressure at the moment when the voice is produced.

High-Resolution Manometry (HRM) is a new method for clinical practice and applicability in the study of intra-esophageal pressure in patients that underwent laryngectomy.

HRM is a variant of the conventional manometry, in which multiple pressure sensors are organized in the catheter. Thus, the analysis program is capable of creating a map using color-coded isobaric contours or showing conventional plots in real-time. It consists of 36 circumferential sensors spaced by one centimeter[2].

The pressure measurement of the PES and the entire esophagus allows a better understanding of what occurs in the post-laryngectomy region and its impact on phonation. This fact is reflected in greater clinical and research applicability.

METHODS

This prospective study had four patients from the Voice and Head and Neck Rehabilitation Clinic of *Escola Paulista de Medicina-Universidade Federal de São Paulo* (EPM-UNIFESP) of both genders, without age restriction, three of whom underwent total laryngectomy and one of them had a total laryngectomy associated with partial pharyngectomy. All of them were submitted to radiotherapy and chemotherapy as an additional treatment showing changes in the scapular girdle, such as pain, stiffness, edema, and limited movement due to neck dissection (three patients with Selective Neck Dissection (SND) and one patient with Modified Radical Neck Dissection (MRND)). A speech therapist evaluated the four patients with laryngectomy and was classified as good esophageal voice speakers, according to the Wepman scale (1953). The patients were at different levels of the Wepman scale (IV-II). All patients underwent HRM (ManoScam 360 – High-Resolution Manometry model A100), performed at the outpatient clinic of the Department of Surgery at EPM-UNIFESP to obtain the values of the pharyngoesophageal segment at the time of attempting to produce an esophageal voice.

All patients underwent HRM after fasting for 8 hours. The protocol included a solid catheter with 36 circumferential sensors spaced at 1 cm (Given Imaging, Los Angeles, CA, USA). After topical anesthesia of the nostril with xylocaine, the catheter was introduced nasally until reading the proximal esophagus, the Upper Esophageal Sphincter (UES), the Lower Esophageal Sphincter (LES) and the entire pharynx. The catheter was fixed and, after 20 seconds to measure basal pressures, 10 swallows of 5 mL of water were administered at 30-second intervals, with the individuals in the left lateral position, according to the protocol used by the outpatient clinic of the Gastroenterology Discipline of EPM-UNIFESP. During the evaluation of the pressure during the sustained emission and in the chained speech, patients were asked to emit a sustained vowel "a" from the count of "1 to 5" and "pa ta ka", according to available literature, with interval of at least 30 seconds between speech modes. The patients were instructed to use their usual intensity and frequency of speech (Figure 1, Figure 2, Figure 3, Figure 4).

The normal values considered in this project were derived from the ManoView software of the Chicago group, and it was the average basal pressure of the UES (obtained in the landmark), between 34-104 mmHg;

The results obtained in this study were analyzed descriptively.

- The following variables were measured:
- From the UES:
- Basal pressure: measured at the beginning of the examination with the patient at rest, at the midpoint, calculated by the mean pressure of 20 seconds, in mmHg.
- From the pharynx:
- Peak pharyngeal pressure: measured from the point of highest pressure;
- Peak pharyngeal pressure time: the relationship between the maximum pressure and rise time;
- Pharynx rise time: from the beginning of the contraction to the maximum pressure;
- Duration of pharyngeal contraction: measured in milliseconds;
- Pharynx recovery time: from maximum pressure to the end of the contraction.
- Wepman Scale (1953)

- This scale has three variables: level, type of production and speech skills.
- Level 1: automatic speech production and normal speech skills;
- Level 2: continuous voluntary speech production and speech skills - phrases;
- Level 3: voluntary speech production and speech skills - words;
- Level 4: voluntary speech production and speech skills - monosyllabic;
- Level 5: voluntary speech production (sometimes) and speech skills - absence of words;
- Level 6: production of involuntary speech and speech skills - absence of words;
- Level 7: no speech production and speech skills - no sound production.

A speech therapist performed this classification at the Voice and Head and Neck Rehabilitation outpatient clinic at EPM-UNIFESP, evaluating the communication capacity of patients with esophageal voice, using the Wepman Scale (1953). An average of six months was the esophageal voice training time of the patients.

The Ethics and Research Committee of Escola Paulista de Medicina - Federal University of São Paulo study approved this study under number 0904/2017, and all participants signed an informed consent form to participate in this study.

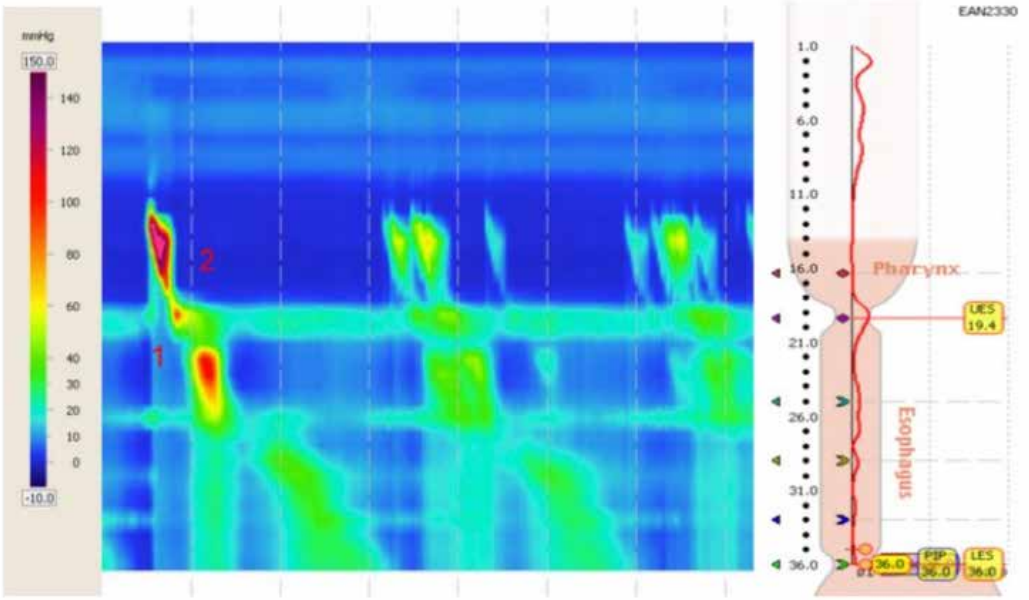

Figure 1: Manometric evaluation of the Upper Esophageal Sphincter (UES). (1) duration of relaxation. (2) duration pharyngeal contraction

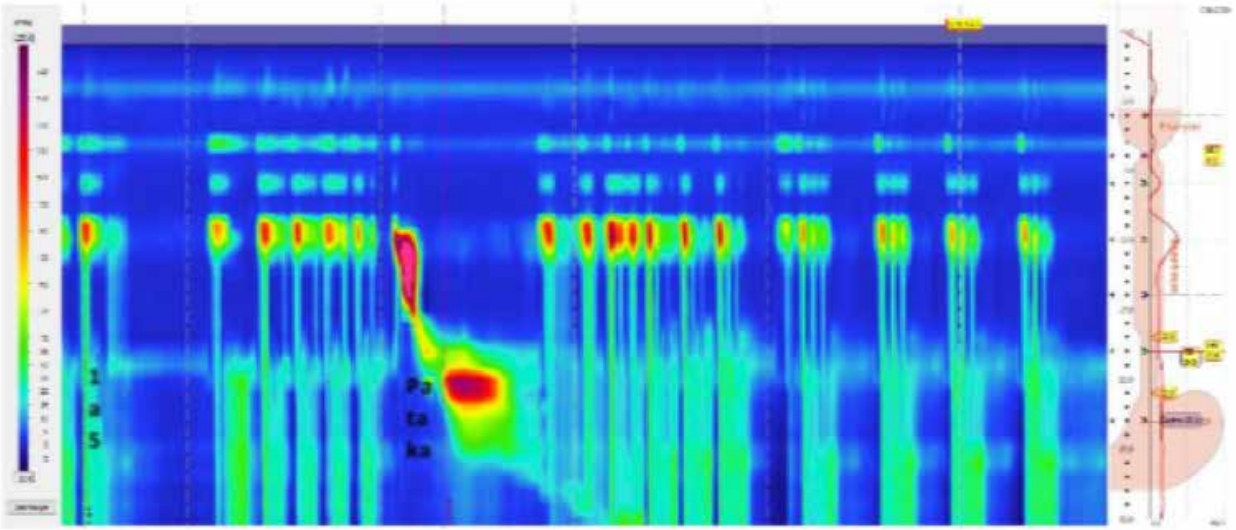

Figure 2: Manometric evaluation of the Upper Esophageal Sphincter (UES) during speech

RESULTS

The mean basal pressure of the UES at rest was altered in all patients. We found that the four patients had low UES pressure at rest. The pressure varied from 7.2 mmHg - Wepman IV to 15.5 mmHg - Wepman II, indicating a hypotonicity of the UES (Table 1).

During the phonation of the sustained vowel "a", the UES pressure ranged from 9.7 to 20 mmHg; during the phonation of "1 to 5", the pressure of the UES ranged from 9.8 to 21 mmHg and during the phonation of "pa ta ka", the pressure of the UES ranged from 9.5 to 14.8 mmHg in the patients (Table 1).

After 10 swallows, the average peak pressure of the pharynx varied from 10.4 to 19.8 mmHg; the peak pressure of the pharynx above the UES ranged from 64.1 to 114.4 mmHg; the time of peak pharyngeal pressure varied from 150 to 300.6 mmHg/s; the time of the rise of the pharynx varied from 301 to 424 ms; the duration of pharyngeal contraction ranged from 568 to 823 ms, and the time to recover the pharynx ranged from 234 to 522 ms, among patients. These parameters do not have pre-defined normal values, as the studies have different methodologies and different equipment. Thus, there is no consensus (Table 2).

Table 1: Pressure of the Upper Esophageal Sphincter (UES) during phonation and at rest

	DURING PHONATION			AT REST	
Patients	UES pressure (mmHg) during phonation - vowel/a	UES pressure (mmHg) during phonation - "1 to 5"	UES pressure (mmHg) during phonation - "pa ta ka"	Basal Pressure UES (mmHg)	Normality (mmHg)
1 (WEPMAN LEVEL IV)	9.7	15.9	14.8	7.2	34-104
2 (WEPMAN LEVEL III)	15.5	11.0	11.4	11.3	34-104
3 (WEPMAN LEVEL II)	20.0	9.8	9.5	11.9	34-104
4 (WEPMAN LEVEL II)	16.6	2.0	14.3	13.5	34-104

Table 2: Manometric variables of the pharynx after 10 swallows of 5 mL of water*

Patients	Mean peak pressure (mmHg)	Peak pressure (mmHg)	Peak time (mmHg/s)	Rise time (ms)	Contraction duration (ms)	Recovery time (ms)
1 (WEPMAN LEVEL IV)	14.5	64.1	150.8	334.0	568.0	234.0
2 (WEPMAN LEVEL III)	12.5	79.4	157.5	424.0	592.0	234.0
3 (WEPMAN LEVEL II)	10.4	84.0	247.3	301.0	823.0	522.0
4 (WEPMAN LEVEL II)	19.8	114.4	300.6	343.0	716.0	373.0

***Peak pressure:** the measure of the greatest pressure point. Peak time: the relationship between the maximum pressure and rise time. Rise time: from the start of the contraction to the maximum pressure. Recovery time: from the maximum pressure to the end of the contraction.

DISCUSSION

Understanding the mechanisms that act on the esophageal voice is fundamental due to the low rate of patients who can develop this means of communication after total laryngectomy. This study had four patients with total laryngectomy and considered good esophageal voice speakers, according to the scale of Wepman Scale, (1953). They had the pressure of the pharyngoesophageal segment evaluated through the HRM.

The voice quality and speech effort in patients with laryngectomy rehabilitated with esophageal voice are widely different. The tone of the pharyngoesophageal segment and the quality of the new sound source are based on the dynamics of adaptation and vibration of the pharyngeal mucosa[3], varying according to the individual characteristics of this population[4].

head and neck regions are constantly affected by radiotherapy. Acute or chronic changes can occur such as telangiectasis and damage to connective tissue like fibrosis, trismus, edema, and necrosis of soft tissues[5].

In this study, all patients underwent radiotherapy as an additional treatment, what can damage the esophageal voice(6).

Functionally, the UES is recognized manometrically as a high-pressure zone, 3-4 cm long, which separates the atmospheric pressure in the pharynx from the subatmospheric pressure in the cervical esophagus[7]. After a total laryngectomy, the fibers of the CricoPharyngeal Muscle (CPM) are brought together due to the suture, changing the size and length of the UES, which may explain the occurrence of changes in this region. The impairment of the UES function can also occur due to the section of vagal branches, reducing the tone of the CPM and causing uncoordinated contractions of the constrictor muscle[8].

During rest, total laryngectomy patients show reduced UES pressure when compared to healthy individuals[9]. Another study evaluated six total laryngectomy patients without dysphagia and six control patients, all of them underwent HRM. A decrease in UES pressure was seen in total laryngectomy patients, and the low pressure was due to possible changes in muscle connections at the UES level, especially cricopharyngeal interruption[10].

In this study, we found that the four patients had low UES pressure at rest (I: 7.2 mmHg; II: 11.3 mmHg; III: 11.9 mmHg; IV: 13.5 mmHg), when compared to the expected normal values (34-104 mmHg) in which the low pressure may be related to possible changes in muscle connections at the UES level, especially the interruption of the cricopharyngeal plexus, however, the low UES pressure does not seem to be a major factor for the development of the esophageal voice.

During the evaluation of the pressure of the UES in the phonation, we asked the patients to emit the vowel/a/and the "pa ta ka" and, count from 1 to 5. During the sustained vowel phonation "a", the pressure of the UES ranged from 9.7 to 20 mmHg; during the phonation of "1 to 5", the pressure of the UES ranged from 9.8 to 21 mmHg and, and during the phonation of "pa ta ka", the pressure of the UES ranged from 9.5 to 14.8 mmHg among patients. Patients I and IV showed higher pressure in the UES during phonation when compared to pressure at rest. Patients II and III showed higher pressure values only when emitting the vowel "a". For the production of the esophageal voice, the sphincter needs to remain contracted to contain the air. However, our patients showed decreased UES tonus, according to the results of UES pressure obtained during the measurement at rest. On the other hand, the peak pressure of the pharynx was higher in all patients than the pressure values of the UES during rest and phonation. After swallowing water, the pharyngoesophageal region contracts. The introduction of air into the esophagus is also followed by contraction of the pharyngoesophageal region, suggesting that, during phonation, good esophageal speaking patients may develop greater pressure in this region, at the time of esophageal production. We also observed that the duration of pharyngeal contraction was longer in the best esophageal speakers (level II), which may be related to the presence of the cricopharyngeal bar, defined as a muscular prominence11 or as a mucous mass in the posterior pharyngeal wall[12].

Many of the failures in the acquisition of esophageal voice by patients with laryngectomy are due to the existence of abnormalities in the cricopharyngeal region inherent to the reconstruction and a possible variation in tonus. The PES must have sufficient resistance to the passage of air to generate a sound. However, this resistance cannot be enough to generate an excessively tense sound or prevent its production. The literature shows the relationship between the degree of very high PES tone and the impossibility of acquiring esophageal voice. Some studies have concluded that a moderate or low tone is favorable for this acquisition[13]. In other studies, these anatomical factors influence the acquisition of esophageal speech[8,14,15]. However, these studies did not have accurate equipment as HRM.

total laryngectomy patients who experience spasm in the PES and/or changes in tonus may undergo preventive or curative treatments such as cricopharyngeal myotomy and application of botulinum toxin. Despite being invasive procedures, they allow muscle relaxation, preventing the occurrence of spasms or hypertonicity in the PES. The literature records studies on the action of cricopharyngeal and botulinum toxin myotomy in total laryngectomy patients. However, especially in this case, most studies were performed in patients rehabilitated with the tracheal-esophageal voice, who showed vocal improvement after treatment. Regarding myotomy, some authors have observed that there is a decrease in the peak of pharyngeal pressure and a decrease in spasms and hypertonicity in total laryngectomy patients[16,17,18,19]. In our study, none of the patients underwent these procedures.

We need a greater understanding to diagnose and characterize the difficulties of the production of esophageal voice, allowing when possible, specific medical interventions to facilitate communication in these patients. The use of HRM to measure the pressure of the PES can assist us in this understanding, defining a medical and speech therapy conduct and benefit the rehabilitation of these patients.

CONCLUSION

Our study observed that during rest, all patients had UES pressure below normal. During phonation tasks, there was pressure variation.

We have studied a limited number of patients and used parameters, whose normal values are still controversial, as the studies show different methodologies and different equipment, thus there is no consensus. No statistical analysis of the data was performed due to the low number of patients.

The use of HRM to measure pressure in the PES can give us a better understanding of the physiology of phonation. Thus, unnecessary procedures can be avoided and therapeutic approaches with better prognosis can be selected. Additional studies can further characterize the pressure of the PES of patients with laryngectomy and identify aspects susceptible to the dysfunction of this structure, which is closely related to the production of esophageal voice in these patients.

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Authors' contributions

TLS did the bibliographic survey, statistical study, and wrote the present work. FAMH helped to elaborate on the method, performed the high-resolution manometry exams, and corrected the written work. RRR helped to elaborate on the method, guided and supervised the final writing of the paper.