ACTA OTORHINOLARYNGOLOGICA ITALICA 2023;43:20-25; doi: 10.14639/0392-100X-N2253

Head and neck

Olfactory function in laryngectomised patients: tracheo-oesophageal *versus* oesophageal speech

Funzione olfattiva nei pazienti laringectomizzati: voce tracheo-esofagea versus voce esofagea

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SUMMARY

Objective. This study aimed to evaluate olfactory function in patients rehabilitated with oesophageal (ES) voice or tracheo-oesophageal (TES) prosthesis to further verify whether there were differences in smell alterations depending on voice rehabilitation modality.

Methods. A total of 40 patients who had undergone total laryngectomy participated in the study. Speech rehabilitation was achieved through TES in 20 patients (Group A) or ES in 20 patients (Group B). Olfactory function was evaluated using the Sniffin' Sticks test.

Results. At olfactory evaluation, in Group A, 4/20 patients (20%) were anosmic, whereas 16/20 patients (80%) were hyposmic; in Group B, 11/20 patients (55%) were anosmic whereas 9/20 patients (45%) were hyposmic. A significant difference (p = 0.04) was found at global objective evaluation.

Conclusions. The study shows that the rehabilitation with TES contributes to maintaining a functioning, albeit limited, sense of smell.

KEY WORDS: total laryngectomy, oesophageal speech, voice prosthesis, Sniffin' Sticks test, smell dysfunction

RIASSUNTO

***Obiettivo**. Questo studio si propone di valutare la funzione olfattiva nei pazienti laringectomizzati totali riabilitati con voce esofagea (ES) e con protesi tracheo-esofagea (TES) per valutare se esistono differenze nell'alterazione dell'olfatto a seconda delle modalità di riabilitazione vocale.*

***Metodi**. Un totale di 40 pazienti sottoposti a laringectomia totale hanno partecipato allo studio. La riabilitazione del linguaggio è stata ottenuta attraverso TES (Gruppo A) in 20 pazienti o mediante ES in 20 pazienti (Gruppo B). La funzione olfattiva è stata valutata utilizzando lo Sniffin' Sticks test.*

***Risultati**. Alla valutazione della funzione olfattiva, nel Gruppo A, 4/20 pazienti (20%) erano anosmici mentre 16/20 pazienti (80%) erano iposmici; nel gruppo B, 11/20 pazienti (55%) erano anosmici mentre 9/20 pazienti (45%) erano iposmici. È stata riscontrata una differenza statisticamente significativa tra i due gruppi alla valutazione oggettiva globale con Sniffin' Sticks test (p = 0,04).*

***Conclusioni**. Lo studio mostra che la riabilitazione con protesi tracheo-esofagea contribuisce a mantenere una funzionalità, seppur limitata, dell'olfatto.*

PAROLE CHIAVE: *laringectomia totale, voce esofagea, protesi fonatoria, Sniffin' Sticks test, disfunzione dell'olfatto*

Introduction

In the last three decades, the incidence of laryngeal cancer has increased by 12%, with Europe recording the highest number of deaths [1]. The type of the treatment for laryngeal cancer depends on the stage of the disease at diagnosis and can benefit from different modalities, including transoral laser microsurgery, open partial horizontal laryngectomy, and (chemo)radiotherapy, with

Received: August 2, 2022
Accepted: December 23, 2022

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How to cite this article: Bianco MR, Pricoco GO, Azzolina A, et al. Olfactory function in laryngectomised patients: tracheo-oesophageal *versus* oesophageal speech. Acta Otorhinolaryngol Ital 2023;43:20-25. https://doi.org/10.14639/0392-100X-N2253

good oncological and functional outcomes [2-4]. In the last two decades, organ preservation strategies have increased; this can be attributed to improvements in preoperative staging and follow-up as a result of enhanced imaging techniques [5-7]. Organ preservation surgery is aimed at preventing the highly mutilating intervention of total laryngectomy (TL) and maintaining laryngeal function in light of oncological radicality.

TL has significant psychophysical and social consequences for the patient's quality of life [8,9]; this is attributed to the immediate loss of phonation, resulting from the removal of the larynx, and to alterations in respiratory and olfactory functions due to the permanent separation of the upper from the lower airways, which consequently results in a disconnection between the airways and the mouth and nose. Recovery of phonatory function can be achieved by an oesophageal speech (ES) or with a tracheo-oesophageal voice prosthesis (TES). In both methods of voice rehabilitation, an internal substitute sound source is placed in the pharyngoesophageal segment.

In recent years, functional recovery of phonation and pulmonary rehabilitation in patients undergoing TL [10] have received increasing attention [11]. However, the alteration in olfactory function is still underestimated.

Odours are perceived through the flow of air at the level of the olfactory cleft (orthonasal perception) and through odours derived from food (retronasal perception). Hypoanosmia following TL can be attributed either to a reduction in airflow at the level of the olfactory cleft or to the interruption of complex neurosensory feedback mechanisms following multiple damage to peripheral nerves related to the surgical procedure [12]; the former hypothesis is the most widely accepted [13].

Because the two methods of phonatory rehabilitation exploit a different mechanism for the passage of air to the upper and lower airways, they can affect the alteration of smells differently.

This study aims to evaluate olfactory function in patients rehabilitated with ES or TES, using the objective, Sniffin' Sticks test, methodology, in order to determine whether there are differences in the alterations of smell depending on the voice rehabilitation modality used.

Materials and methods

Patients

This multicentric study was conducted among patients who had undergone TL and who were recruited during follow-up visits over the period from June 2020 to May 2021 at (1) Otolaryngology Unit, Department of Health Science, University of Catanzaro, Italy; (2) the Otolaryngology Unit, Cannizzaro Hospital, Catania, Italy. The only inclusion criterion was completion of a speech rehabilitation course with ES or TES for at least 6 months. Smell rehabilitation patients, patients previously affected by alterations of smell, inflammatory or neoplastic sinonasal pathologies, patients who did not undergo voice rehabilitation or used electrolaryngeal speech, non-self-sufficient patients with disabilities of the upper limbs or with cognitive impairments, patients with loco-regional recurrence, and patients who refused to participate in the study were excluded.

The rehabilitation programme with ES was accomplished from the 15th through the 20th day after TL, as soon as the patient was able to eat orally, whereas rehabilitation with TES began the day after the insertion of the prosthesis and included specific training that consisted, initially, of training the emission of isolated vowels, gradually building up to the pronunciation of short sentences. The average time for administration of the programmed speech therapy within which the ES was learned was three months, whereas the time needed to learn TES was a few weeks. All the patients were instructed by speech language pathologists with extensive experience in the rehabilitation of laryngectomised patients.

Patients underwent endoscopic evaluation of the nasal cavities through optical fibre rhinoscopy to assess the absence of rhinosinus pathologies. Olfactory function was evaluated using the Sniffin' Sticks test (Burghardt®, Wedel, Germany) for smell threshold and odour discrimination tests. The Sniffin' Sticks test is a validated olfactory test that evaluates olfactory Threshold Discrimination and Identification (TDI) score by administering felt-tipped pens filled with odours to patients' nostrils [14]. For the olfactory threshold test, the threshold concentration at which the patient can identify n-butanol is established using a scale technique based on a forced choice of three alternatives. Among the pens presented, the patient must indicate the one they think contains the odorous substance. Odour discrimination ability is determined using 16 individual tests. Among the triplet presented, the patient must identify the marker that contains an odorous substance that differs from the other two. The odour identification test is conducted using 16 common odours. The patient must identify the smell by choosing the image or term that identifies it from the four variables presented. The numerical value obtained in the three tests is added to obtain the TDI score. TDI values ≥ 30.5 indicate normosmia, those from 16.6-30.5 hyposmia, and those ≤ 16.5 anosmia [15]. The test was performed in a large and airy room, and patients were asked not to eat at least 2 hours before the test. Patients were also asked not to use body perfumes on the day they were tested. All the pa-

tients had their eyes covered before beginning the smell threshold and odour discrimination tests.

Statistical analysis

Statistical analysis was performed using Med-Calc software Version 19.4 (Mariakerke, Belgium). Means and standard deviations were further calculated. Fisher's exact test was used to ascertain the differences between the demographic and clinicopathologic data of the two cohorts of patients. Mann Whitney test for independent samples was used to compare the results of the Sniffin' Sticks test between Group A and Group B. A p-value less than 0.05 was considered statistically significant.

Results

A total of 40 patients participated in the study; 8 (20%) were females, and 32 (80%) were males. The mean age at diagnosis was 65.72 ± 10.34 SD (range 46-85) years. According to the TNM classification, 16 (40%) patients were in stage III, and 24 (60%) in stage IV. Eight (20%) of the enrolled patients were subjected to TL alone, 20 (50%) to TL and neck dissection (ND), and 12 (30%) to TL, ND, and adjuvant chemo/radiotherapy. The mean time elapsed from TL was 57.86 ± 85.74 SD months. Speech rehabilitation was achieved through TES in 20 patients (Group A) and ES in 20 patients (Group B). A primary TES prosthesis positioning was performed in all patients. A Provox Vega prosthesis (ATOS Medical) was also placed in all patients. Group A comprised 14 males (70%) and 6 females (30%) with a mean age of 66.1 ± 9.60 SD years (range 46-81). Group B comprised 18 males (90%) and 2 females (10%) with a mean age of 65.41 years ± 10.90 SD (range 54-85). The mean time elapsed from TL was 46.2 ± 93.06 SD (range 6-324) months and 70.5 ± 75.54 SD (range 6-252) months in groups A and B, respectively, with no significant difference (p = 0.32). Table I shows the demographic and clinical data for the two groups of patients.

Evaluation of olfactory function

At olfactory evaluation, using the Sniffin' Sticks test, 15/40 (37.5%) were anosmic whereas 25/40 (62.5%) were hyposmic. In Group A, 4/20 patients (20%) were anosmic whereas 16/20 patients (80%) were hyposmic; in Group B, 11/20 patients (55%) were anosmic whereas 9/20 patients (45%) were hyposmic. Groups A and B were found to be significantly different at global olfactory evaluation (p = 0.04), highlighting that patients rehabilitated with TES have significantly better olfactory function than those rehabilitated with ES (Tab. II).

In Group A patients, the threshold result was 3.37 ± 4.49 SD whereas in Group B it was 1.41 ± 1.44 SD; discrimination in patients of Group A was 9.3 ± 3.30 SD whereas in Group B it was 7.75 ± 3.81 SD; identification in patients of Group A was 7.4 ± 2.41 SD and in Group B it was 6.66 ± 1.54 SD; TDI was 20.07 ± 6.75 SD and 15.83 ± 4.94 SD in Group

Table I. Demographic and clinical data of the Group A (TES) and Group B (ES).

	Group A (n = 20)	Group B (n = 20)	P-value
Age (years)			
< 60	6 (30%)	11(55%)	0.20
> 60	14 (70%)	9 (45%)	
Sex			
Male	14 (70%)	18 (90%)	0.23
Female	6 (30%)	2 (10%)	
Time since TL			
Mean ± SD (months)	46.2 ± 93.06	70.5 ± 75.54	0.32
Stage			
III	7 (35%)	9 (45%)	0.74
IV	13 (65%)	11 (55%)	
Neck dissection			
No	16 (80%)	18 (90%)	0.66
Yes	4 (20%)	2 (10%)	
Adjuvant treatment			
No	6 (30%)	12 (60%)	0.06
Yes	14 (70%)	8 (40%)	

TL: Total laryngectomy.

Table II. Objective olfactory test (Sniffin' Sticks test).

Sniffin' Sticks test	Hyposmia (values between 16.6 and 30.5)	Anosmia (values ≤ 16.5)	P-value
Group A	16 (80%)	4 (20%)	P = 0.04
Group B	9 (45%)	11 (55%)	

A and Group B, respectively (Fig. 1). The results of the Sniffin' Sticks test show a trend towards better outcomes with TES compared to ES, although the difference was not significant: threshold (p = 0.22); discrimination (p = 0.11); identification (p = 0.54); and TDI (p = 0.11) (Fig. 2).

Discussion

It is known that TL, performed for advanced stage laryngeal carcinomas or subglottic carcinomas, or as a salvage surgery for relapsing carcinomas, is associated with loss of laryngeal and nasal physiological functions.

Odorous substances reach the olfactory epithelium through the nasal airflow, where the olfactory neurons pick them up. The interruption of nasal airflow results in a lack of perception of odorous substances by the olfactory epithelium [16], causing hypo-anosmic conditions in laryngectomised patients. Odours are perceived through the passage of air at the level of the olfactory cleft (orthonasal perception) but also from odours in food (retronasal perception).

Over the years, several methods have been used to rehabilitate the sense of smell. Rehabilitation manoeuvers, such as the Nasal Airflow-Inducing Maneuver (NAIM), described by Hilgers et al. are currently being used. This manoeuver creates a negative pressure in the oral cavity and oropharynx to induce orthonasal airflow [17].

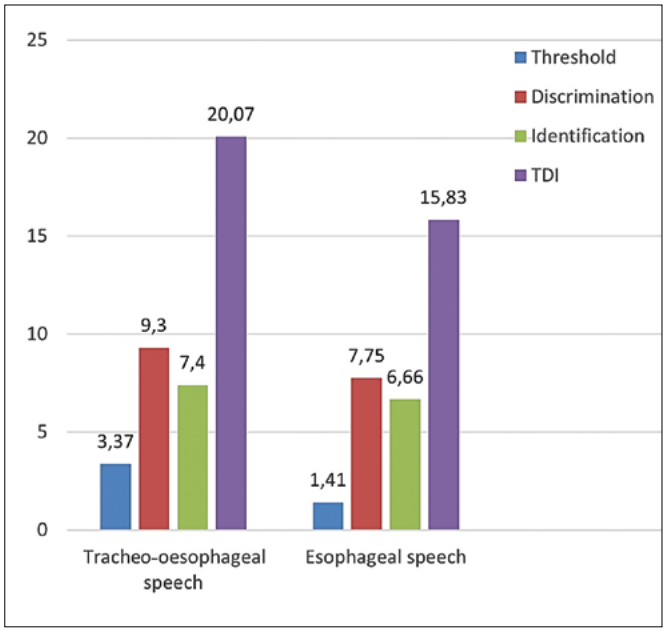

Figure 1. Results of Sniffin' Sticks test.

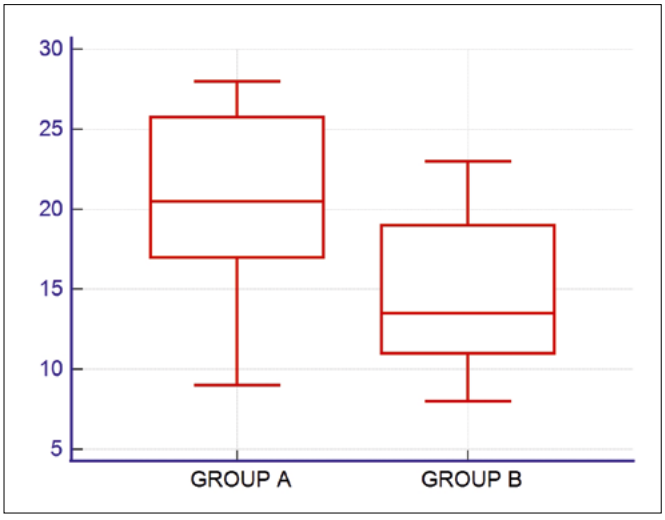

Figure 2. Comparation of TDI results (Mann Whitney test for Indipendent samples).

Another technique is that of the larynx bypass, described by Schwartz et al. [18], which is a device consisting of a flexible tube that connects the tracheostoma to the mouth, restoring orthonasal airflow. This method, although effective, is rarely used at present due to the poor handling of the device [19].

In our study, none of the patients had undergone olfaction rehabilitation prior to evaluation. Altogether, 37.5% of patients were anosmic and 62.5% were hyposmic.

To date, there are few studies on olfactory functionality with objective methodology, such as the Sniffin'Sticks test. Riva et al. [20] noted hyposmia in all 50 laryngectomised patients enrolled in their study. Kesimli et al. [21] noted severe hyposmia and anosmia in 60 and 40% of cases, respectively, in 15 patients who had undergone total laryngectomy.

Haxel et al. [22] reported 72% anosmic, 16% hyposmic and 12% normo-osmic patients. However, in these studies, the modality of phonatory rehabilitation was not considered.

To the best of our knowledge, this study is the first to evalu-

ate olfactory function in laryngectomised patients in relation to the modality of speech rehabilitation.
Patients rehabilitated with TES showed a lesser loss of smell than patients rehabilitated with ES. The smaller alteration in olfactory functionality in patients rehabilitated with TES can be explained by the different pathway of airflow in the vocal tract. Schutte et al. [23] evaluated pressure and airflow parameters at the level of the sound source, the voice prosthesis, and the trachea in patients rehabilitated with ES and TES. In this study, it was found that the airflow expelled during the sound production in TES voice was considerably greater (131 ml/s) than in ES phonation (82 ml/s). Ng [24] obtained a similar result: airflow in TES speakers was considerably greater (134.15 ml/s) than in ES patients (70.5 ml/s). These results correlated with the different anatomical/physiological situations in the two groups of patients. In TES phonation, air is supplied directly from the tank of the lungs, while in ES phonation, the volume of the air tank depends on the patient's ability to aspirate and retain air in the oesophagus and stomach.
These results could explain why patients with TES may have a greater chance of perceiving odorous substances in a retronasal way, because a greater quantity of air at higher pressure arrives compared to patients with ES. Thus, the cells of the olfactory epithelium could be subjected to greater stimulation, which would allow them to reduce the degenerative phenomena of the neuroepithelium [12].
Loss of laryngeal and nasal functions negatively affect the quality of life of these patients [10,25]. Over the years, specialists have placed much effort into rehabilitating patients for speech, breathing and smell, which are important functions when ensuring an adequate level of psycho-physical well-being [10,11,13,18,19,26].
These results suggest that phonatory rehabilitation of total laryngectomised patients with TES improves quality of life not only because of good speech recovery, but also due to the partial maintenance of olfactory function.
This study is limited in that the number of patients recruited was small. These results need to be confirmed by additional studies with larger numbers of patients.

Conclusions

The present study shows that the rehabilitation of the laryngectomised patients with TES not only contributes to better quality of voice production, but also to maintaining functionality, albeit limited, of the sense of smell. It would, therefore, be useful to increase use of protocols for evaluation and rehabilitation of olfactory function by qualified personnel in these patients as quickly as possible after surgery.

Acknowledgements
We thank Mr. Taraso Luca, speech therapist, for his support in evaluation of patient's olfactory function.

Conflict of interest statement
The authors declare no conflict of interest.

Funding
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author contributions
MRB: study design, revision of the manuscript, final approval, final agreement; GOP: data collection and interpretation of data, drafting of the manuscript; AA: acquisition of data; GDD: acquisition of data; VS: study design of the manuscrip; EA: conception and design, interpretation of data, revising manuscript.

Ethical consideration
The study was approved by Ethics Committee Area Centro Regione Calabria -6/6/22-.
All the patients were informed of the purpose of the study before they gave written informed consent. This study was conducted ethically, with all study procedures being performed in accordance with the requirements of the World Medical Association's Declaration of Helsinki.
Demographic and clinical data were collected.

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