

AIRWAY DISEASE

# Evaluation of a method for assessing pulmonary function in laryngectomees

## *Valutazione di un metodo per studiare la funzione polmonare nei pazienti sottoposti a laringectomia totale*

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### SUMMARY

In total laryngectomies the impairment of pulmonary function reflects the sum of pre- and post-operative ventilatory changes. Objective information on the respiratory condition in laryngectomees, as assessed in the pulmonary function laboratory is somewhat limited, perhaps because of difficulties related to methodology. The aim of our study was to evaluate the reproducibility of a method employed to assess the pulmonary function in laryngectomized patients. The experimental extra-tracheal device was set up with a silicone adapter through a cardboard tube to the skin around the tracheostoma. Pulmonary function tests included measurements of forced vital capacity, force expiratory volume at 1 second and Tiffeneau index in 3 consecutive evaluations, in 11 patients who underwent total laryngectomy. The control group comprised 11 patients, not laryngectomized, evaluated by conventional spirometry. Those responsible for evaluating were asked to report possible technical failures and to demonstrate the reproducibility of the curves resulting from the tests. The use of the silicone adapter and skin adhesive provided a complete, airtight seal of the system, in all cases. The presence of the tracheo-oesophageal prosthesis did not negatively affect the test results. All patients attributed a maximum value, both for comfort and acceptance, of the device. The values are comparable in both groups, thus indicating the accuracy of the proposed methodology. All examinations were reproducible. After total laryngectomy, pulmonary function testing, with an extra-tracheal device, is not only reliable but also easy to perform in a routine out-patient setting. The methodology did not present air leaks and was, therefore, well accepted by all patients tested.

**KEY WORDS:** Total laryngectomy • Respiratory function tests • Spirometry • Tracheotomy • Laryngeal neoplasms • Respiration

### RIASSUNTO

*Le alterazioni della funzionalità polmonare osservate nei pazienti sottoposti a laringectomia totale dipendono dalle modificazioni della ventilazione polmonare dovute all'intervento chirurgico. I dati oggettivi che si possono ottenere da una valutazione ambulatoriale dei pazienti laringectomizzati sono limitati dalle difficoltà della metodica stessa. Lo scopo del nostro studio è stato quello di valutare la riproducibilità di un metodo utilizzato per studiare la funzionalità respiratoria nei pazienti laringectomizzati. Per tale motivo è stato allestito un sistema sperimentale extratracheale costituito da un tubo di cartone connesso ad un adattatore in silicone per la cute circostante il tracheostoma. Durante i test di funzionalità respiratoria sono state registrate la capacità vitale, il volume espiratorio forzato ad 1 secondo e l'indice di Tiffeneau, in 3 valutazioni consecutive di 11 pazienti sottoposti ad intervento di laringectomia totale. Il gruppo di controllo, costituito da 11 pazienti non laringectomizzati, è stato studiato con spirometria convenzionale. All'esecutore dell'esame è stato richiesto di segnalare le possibili cause tecniche di insuccesso e dimostrare la riproducibilità delle curve degli esami eseguiti. L'uso degli adattatori peristomiali in silicone e degli adesivi cutanei ha evitato qualsiasi possibilità di dispersione del flusso aereo. La presenza di un'eventuale protesi fonatoria tracheo-esofagea non ha modificato negativamente i risultati dell'esame. Tutti i pazienti hanno accettato il sistema senza problemi con giudizio positivo in termini di comfort. I valori registrati erano sovrapponibili in entrambi i gruppi, confermando l'accuratezza della metodica in esame. In conclusione, grazie al sistema di ventilazione extratracheale messo a punto, le prove di funzionalità polmonare offrono risultati affidabili, sono facilmente eseguibili nella normale routine ambulatoriale e ben tollerate dalla totalità dei pazienti.*

**PAROLE CHIAVE:** Laringectomia totale • Test di funzionalità respiratoria • Spirometria • Tracheotomia • Tumori laringei • Respirazione

Acta Otorhinolaryngol Ital 2011;31:243-247

## Introduction

Many patients with head and neck cancer have a history of smoking and the pulmonary complications frequently lead to postoperative death. Spirometric pulmonary function tests are rarely performed in patients submitted to laryngectomy due to technical problems<sup>1</sup>. Many of these patients also suffer from chronic obstructive lung disease<sup>2</sup>. Pulmonary airway obstruction was found in 81% of laryngectomized patients<sup>3</sup>.

In the post-laryngectomy state, the impairment of pulmonary function reflects the sum of ventilatory changes, mostly caused by pre-laryngectomy smoking habits and other negative effects, as well as changes due to non-physiological post-laryngectomy airway conditions. As breathing through the tracheostoma, after total laryngectomy, bypasses the natural air-conditioning function of the upper respiratory tract, a reduced filtering of solid air-borne particles and aerosols and inhalation of unhumidified and unheated air occurs. Compared with breathing through the upper airways, tracheostoma reduces, aerodynamically, the airflow resistance during inspiration and expiration, which may have a negative effect on peripheral lung ventilation (alveolar collapse) by shifting the equal-pressure-point<sup>4,7</sup>. There are various disadvantages, for the respiratory system, in post-laryngectomy status, regardless of possible tumour disease-related symptoms. One of the most important prognostic factors regarding the survival of laryngectomized patients is the progressive deterioration of pulmonary function<sup>5,8</sup>. Objective information on the respiratory condition in laryngectomees, as assessed in the pulmonary function laboratory, is somewhat limited<sup>2,5,9-11</sup>.

The influence of the removal of the larynx itself and the consequent decrease in dead space ventilation can only be assessed, when pre- and post-operative spirometric values are available. Data on this topic are controversial<sup>12-14</sup>. A reliable estimate of pulmonary function is mandatory in laryngectomized patients in order to avoid complications in surgical interventions to assess the effects of therapy and even for preventive purposes<sup>15</sup>.

Traditionally, the assessment of pulmonary function, in these patients, has been performed by means of a cuffed trachea cannula connected to a pulmonary-function analyzer<sup>5,12,16</sup>. However, the use of a cannula is troublesome for several reasons. First of all, its insertion is often an unpleasant experience for the patient, and leads to uncomfortable coughing, sometimes lasting for several minutes<sup>15</sup>. Furthermore, the use of a cuffed cannula is considered a negative influence on the results of forced expiration and inspiration tests due to a decrease in the actual diameter of the trachea. Trachea masks, manually placed over the stoma, have also been used for this reason but sometimes allow air leaks<sup>2</sup>. Extra-tracheal devices have been reported to be used by some Authors in order to avoid such problems<sup>9-11</sup>.

A standardized, simple and inexpensive method for the assessment of pulmonary function, in laryngectomized patients, would be very useful, but it is necessary to evaluate this method in order to determine its accuracy. The aim of this study was to evaluate the reproducibility of a method developed to assess pulmonary function in laryngectomized patients.

## Material and methods

Overall, 11 patients (9 male, 2 female), underwent total laryngectomy in the Head and Neck Surgery of Ana Costa Hospital and Santa Casa da Misericórdia de Santos, Brazil. The median age was 66.5 years (ranging from 45 to 84). All patients were informed about the aims of the study and all volunteered to take part in the study. Exclusion criterion was presentation of any respiratory infection during the 2 weeks preceding the study. The Guilherme Alvaro Hospital Institutional Review Board approved this study (Registration no. 025/09).

Laryngectomees were asked to complete a questionnaire to obtain their clinical history. Details were requested concerning previous and current data referring to lung diseases, allergies, other diseases related to pulmonary function, previous smoking and drinking habits, date of laryngectomy and voice rehabilitation modality and the Medical Research Council Dyspnoea Index was applied<sup>17</sup>. Both height and weight of patients were measured before the test.

The experimental extra-tracheal device was set up with the Regular Provox Adhesive base plate (Provox®, Atos Medical, Hörby, Sweden) and the adapter with an inner diameter of 2.5 cm and a circumferential 2.5 cm elastic flange to connect the mouthpiece of the spirometer through a cardboard tube to the skin around the tracheostoma. The length of the cardboard was the minimum necessary to connect it to the mouth-piece of the spirometer in order to avoid the dead space increase (4.5 cm) (Fig. 1). When the stoma was connected to the tubing of the spirometer, via



Fig. 1. Experimental extratracheal device.



Fig. 2. Experimental extratracheal device connected to the patient.

the adapter, movements of the participants, as, for example, in forced respiratory manoeuvres, could still be tolerated, maintaining a complete airway seal (Fig. 2). After pulmonary function testing the adhesive was removed and the skin was examined for irritation or allergic reactions. The patients were asked to rate comfort and acceptance of the device, and adverse skin reactions were also evaluated.

After the adjustment of the silicone adapter and insertion of a filtre into the tubing system, participants were assessed by means of spirometric measurements (KOKO D201017 - PDS Instrumentation) (Fig. 3). Pulmonary function tests included standard measurements of forced vital capacity (FVC), force expiratory volume at 1 second ( $FEV_1$ ) and Tiffeneau index ( $FEV_1/FVC$ ).

After the correct calibration of the equipment, each participant underwent three consecutive evaluations according to the international protocols and techniques, previously validated in the literature<sup>18</sup>. Test results were displayed on a monitor, stored on hard drive, and data were thereafter listed in Tables and presented as Graphs (flow-volume loops and pressure-flow Graphs). All tests were performed by a pneumologist specialized in spirometry. The test results were independently evaluated by two pneumologists, with expertise in spirometry, that did not participate in the study. The 11 tests related to the group of laryngectomized patients (Group I) were evaluated together with 11 tests from patients, not laryngectomized (Group II), performed by conventional spirometry. It was decided to use a control group of patients, not laryngectomized, in order to assess the reproducibility and accuracy of the method used for laryngectomees. The 22 tests were mixed and those evaluating were not told which group belonged to each exam. They were asked to diagnose the exams, report possible technical failures, in each of the tests, and to check the reproducibility of the curves from the tests.

The tests were separated again later and the percentage of



Fig. 3. The experimental extratracheal device connected to the spirometer.

possible technical errors, in the exams and reproducibility, were assessed for each group of tests.

## Results

The mean interval between laryngectomy and pulmonary function test was 74.3 months and ranged from 6 months to 124 months. Prior to laryngectomy, 6 participants (54%) had been cigarette smokers and 9 (82%) had been alcohol drinkers. Three participants did not report previous smoking and 2 prior alcohol drinking (Table I).

Eight patients (73%) were rehabilitated with a tracheo-oesophageal prosthesis (Provox<sup>®</sup>, Atos Medical, Hörby, Sweden) and 3 (27%) with oesophageal voice.

Six participants (54%) had a Dyspnoea Index (MRC) of 0, three (28%) of 1, one (9%) of 2 and one (9%) of 3.

After the assessment had been made in each group, a comparison was made. In Group I, 7 patients had their exams diagnosed as normal and in the control group 8 tests were normal. In both groups, there were 3 patients with obstructive ventilatory disturbances, only one participant from Group I presented a restrictive ventilatory disorder, this patient had diaphragmatic paralysis before the examination (Table I).

The use of the adapter caused no problems in any of the 11 participants. It could easily be attached to the stoma and the lung function analyzer in all patients. The use of the silicone adapter and skin adhesive provided a complete, air-tight seal of the system throughout pulmonary function testing, in all cases. The tests usually lasted for 15 minutes. The silicone adapter was also well sealed with its very flexible flanges in those cases where the skin surface of the peristomal area was uneven because of scar formation or uneven anatomical morphology. The presence of tracheo-oesophageal prosthesis (Provox<sup>®</sup>, Atos Medical, Hörby, Sweden) did not affect the test results in any way. No subject showed signs of discomfort at any

**Table I.** Comparative results Group I × Group II.

	Group I	Group II
Age (media)	64	48
Tobacco (+)	5	6
Normal (n)	7	8
OVD (n)	3	3
RVD (n)	1*	0

OVD: Obstructive ventilatory disorder; RVD: Restrictive ventilatory disorder;  
\* Patient with diaphragmatic paralysis.

time during the procedure. No adverse skin reactions were observed after use of the skin adhesive. All patients expressed a maximum value for comfort and acceptance of the device.

The pneumologists who evaluated independently the tests found low levels of technical failure in examinations. Only one exam was rejected in the Group I, thus indicating the accuracy of the methodology proposed.

## Discussion

Relatively little attention has been paid to assessment of pulmonary function in patients who have undergone total laryngectomy, in the literature. One of the reasons for this lack of information could be the present difficulties in performing standard lung function tests in those patients<sup>15</sup>. However, there are numerous studies reporting that a large percentage of laryngectomees have obstructed the airways and many of these might benefit from medical treatment<sup>3 5 8</sup>.

Due to the probability of dying from a second cancer, lung diseases are the second leading cause of mortality in laryngectomized patients, which suggests the need to perform spirometry periodically<sup>8</sup>.

The lack of performing studies on pulmonary function in laryngectomized patients is not so much because of the absence of indication, but the lack of technical means to carry out the tests<sup>8</sup>. Some authors describe the use of cuffed cannulas<sup>5 12</sup> or trachea masks placed manually over the stoma to connect the patient to the lung function analyzer<sup>2 11</sup>. However, the introduction of a trachea cannula is often uncomfortable for the patient and the seal of the trachea mask generally present air leaks.

The presence of indwelling voice prosthesis with a wide diameter, i.e. the Provox<sup>®</sup> valve, does not seem to negatively affect the test results<sup>7</sup>. It is thought to be crucial not to reduce the diameter of the tracheal lumen during measurements (e.g., with cuffed cannulas) in order to obtain more representative data<sup>3</sup>, a fact that has also been emphasized in other studies<sup>2 7</sup>. Some studies describe the use of extra-tracheal devices, constructed with a plastic tube and a latex balloon cuff to obtain an airtight seal to avoid such problems<sup>9</sup>.

In all cases in our study, an air-tight seal was maintained throughout the entire procedure, including also those cases in which forced expiration manoeuvres were associated with involuntary tilting movements of the thorax and neck or pulsed, high-pressure loadings during coughing. No adverse skin reaction was observed after use of the skin adhesive.

Besides the convenience of an extra-tracheal device, data in some studies show unequivocally that the values of lung volumes and functions, determined with the use of extra-tracheal devices, are more reliable<sup>15</sup>.

The findings presented herewith are in agreement with those reported in the study performed by Hess et al.<sup>3</sup> indicating the need to re-evaluate the role of pulmonary function screening within follow-up of post-laryngectomy patients, and, particularly, in view of the availability, accuracy and easy use of pulmonary function screening equipment.

## Conclusions

The pneumologists who independently evaluated the tests found low levels of technical failure in the examinations. They concluded that all examinations except one were reproducible.

## Acknowledgements

Authors thank MZ Medical, São Paulo, Brazil, for providing the Regular Provox Adhesive base plates.

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Received: January 20, 2011 - Accepted: April 3, 2011