Method for the Study of Pulmonary Function in Laryngectomized Patients

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Abstract: Objectives: To develop an instrumental method that allows the mouthpiece of the pneumograph to be fitted to the tracheostoma of laryngectomized patients in order to carry out a pulmonary function study (spirometry) as reliably as possible. Material and methods: We studied a sample of 33 laryngectomized patients, all of whom were males aged between 47 and 77 years old. A Sibelmed® Datospir 92 computerized spirometer was used for the spirometric assessment. This dry spirometry equipment uses a Fleisch pneumotachometer to record flows and volumes. A stoma-spirometer adapter was created out of a cardboard tube, an adhesive and a silicone disc. Results: All of the patients tolerated the stoma-spirometer adapter. Neither air leaks nor increase in the air flow resistance were recorded. Conclusions: A simple and effective instrumental method has been developed allowing spirometry on laryngectomized patients to be performed efficiently. We consider that the facts studied may enable us to add new resources to the more effective understanding of the respiratory handicap in laryngectomized patients.

Key words: Spirometry. Total laryngectomy. Lung function.

INTRODUCTION

The loss of upper respiratory tract function due to a total laryngectomy has various unfavorable effects on the rest of the respiratory tract. In fact, laryngectomized patients present a greater pulmonary function affection than what would be predicted for a population of subjects with a larynx.

The majority of laryngectomized patients have been heavy smokers. For many, lung damage accumulated over years of exposure to tobacco smoke has worsened their chances of survival in the immediate post-operative stages as well as in the medium to long term, thus increasing the likelihood of their developing a second primary lung tumor.

The risk of primary (synchronous or metachronic) or metastatic lung tumors appearing in the laryngectomized population has obliged us to carry out periodical radiological (simple radiography or CT) check-ups, with the aim of diagnosing the feared lung cancer as early as possible. Nevertheless, the progressive deterioration of lung function that laryngectomized patients suffer from is the most important prognostic factor of survival in those who overcome the risk of a second tumor.

Saying this, the study of pulmonary function (spirometry) should be borne in mind as a complementary examination in the follow-up of our laryngectomized patients.
Carrying out spirometry on laryngectomized subjects is not free from technical difficulties, which on many occasions cause the tests to be abandoned. This abandonment cannot be justified because of the extremely high morbidity and mortality that these patients are exposed to, given the alteration in their pulmonary function owing to their double condition as ex-heavy smokers and the vulnerability caused by the absence of the upper respiratory tract.

The aim of this study is to demonstrate an instrumental method that allows us to perform spirometry on laryngectomized patients, overcomes various technical difficulties and obtains reliable and objective results of the pulmonary function in these patients.

MATERIAL AND METHODS

We studied a sample of 33 laryngectomized patients; of whom all were men aged between 47 and 77 years old. An average of 58.48 months (range; 3-240 months) had elapsed since the surgery. A total of 13 patients (39%) received complementary treatment with external radiotherapy between the fourth and eighth week following the total laryngectomy, as opposed to a total of 20 patients (61%) for whom it was unnecessary.

The participants in the study were informed of its purpose and freely agreed to their inclusion. The following were defined as criteria for exclusion from the study: having suffered a respiratory tract infection during the previous two weeks, previous COPD or lung cancer. Two patients were excluded before carrying out the spirometry, one for having had a bout of flu 5 days before the test and the other for having had surgical intervention for lung cancer four months previously.

Material used

The main aim of the study was to devise a method that would enable us to adapt the pneumograph to the patient’s stoma in the most reliable way possible.

A Sibelmed® Datospir 92 computerized spirometer was used for the spirometric assessment. This dry spirometry equipment uses a Fleish pneumotachometer to record flows and volumes. The records are digitized using an A/D U9 converter card with 12 bits of resolution and high speed conversion. Expiration and inspiration volume and flows based on time are recorded as well as the variations in volume throughout 70%-75% of the FTV. This is very useful for its slight variability, the fact that it is simple to do and its efficient determination of the state of both the peripheral (<2 mm) and the central (>2 mm) respiratory tracts.

A system was created, using clinical material designed for other purposes, which would allow the spirometer terminal to be fitted to the hole of the tracheostoma. This system consists of a cardboard tube (7.3 cm in length and 2.4 cm in diameter) which is assembled at the end of the pneumograph and from here to the stoma in a manner that ensures there is no leak of air between the adapter and the stoma. In order to do this, we used a circular adhesive (Inhealth® Adhesive Tape Disc) with a hollow interior that connects to a silicone disc (Inhealth® tracheostoma valve housing, Large) on the side that is to be stuck to the peristomal skin. The other side of the disc has a raised edge around the internal hole that allows it to be firmly attached to the cardboard tube and thus to the pneumograph (Figure 1). In this way a stable adapter has been created without leaks and without any need for significant modification of the resistance of the passage of air from the tracheostoma to the pneumograph (Figure 2).

Spirometry

Spirometry was done on the patients during orthostatism, calculating the following parameters:

- Tidal volume (TV): measures the lung volume of inspiration and expiration during 30s of quiet breathing.
- Maximum voluntary ventilation (MVV and Resp./min.)
- This is the maximum volume of air that can be breathed in a minute. However, as maximum hyperventilation proves exhausting, it is limited to 15 seconds and the value obtained is multiplied by 4. Its interest lies in the close relationship that it has with the sensation of dyspnea.
- Forced expiration volume (FEV): This is the volume of air expired in the first second with a forced expiration after a deep inspiration. It is also named maximum expiration volume in the first second (MEVS). Similarly, expiration volumes can be determined in the first half second and at the initial two or three seconds of the forced expiration, respectively. The FEV/TV reflects the velocity of the passage of air during the first second of the expiration especially throughout 70%-75% of the FTV. This is very useful for its slight variability, the fact that it is simple to do and its efficient determination of the state of both the peripheral (<2 mm) and the central (>2 mm) respiratory tracts.
- Tiffenau Index: This is an index (volume of expired air based on time) which reflects the fraction of the vital capacty expelled during the first second of a forced expiration preceded by a forced inspiration. The determination of the Tiffenau Index is usually expressed as a percentage, which is very useful in daily clinical practice as it allows us to easily differentiate ventilation/breathing disorders of obstructive and restrictive origins.
- Forced vital capacity (FVC): Measures the maximum volume that can be expired after a maximum inspiration.

All the patients did the different spirometric tests three times and the best value obtained from the 3 attempts was recorded.
RESULTS

The following spirometric variables were studied: tidal volume (TV); maximum voluntary ventilation (MVV); maximum respiratory frequency per minute (resp./min); forced vital capacity (FVC); forced expiration volume in the first second (FEV₁) and Tiffenau Index (FEV₁/FVC). The descriptive results of the study are summarized in Table 1. The variability that could be imagined for the different spirometric variables was also studied for the following factors: post-surgical radiotherapy, patient’s age and amount of time elapsed since surgery. Analysis of the variance was done (ANOVA of a factor), without obtaining any statistically significant result (P > .05) for any of the spirometric variables studied.

The material used to adapt the pneumograph to the patient’s tracheostoma obtained excellent results. There were no skin problems caused by the adhesive used to permeate the skin in any of the patients. No peristomal leaks were recorded during the forced expirations. Tolerance of the procedure was 100%.

DISCUSSION

Eighty-one percent of the laryngectomized patients presented an obstructive pattern in the spirometry, since the absence of the upper respiratory tract (URT) function conditions the lower respiratory tract. In laryngectomized patients, the spirometry revealed an increase in RV (residual volume) and FRC (functional residual capacity) and a decrease in FEV₁% (forced expiration volume in the first second), demonstrating obstructive spirometric changes. A considerable decrease (relating to the control population) of the following values was revealed: TLC (total lung capacity), FEV₁%, TC (tidal volume), MEF (maximum expiratory flow), AEF50 (average expiratory flow at 50%) and AEF25 (average expiratory flow at 25%), which means in practice that there is a greater obstructive component than in non-laryngectomized patients of the same age. Some authors show that neither the time elapsed since surgery nor radiotherapy determine a worsened pulmonary function, but the age of the patients does have considerable influence, although we could not find statistically significant differences in the variables studied (radiotherapy, age, time elapsed since the surgery).

We believe that it is important to evaluate the pulmonary function of laryngectomized patients, since the morbidity-mortality associated with lung function in these patients is not negligible. There are also authors who show the benefits of using “active” spirometry (forced inspiration) as a preventative method and a way of handling the atelectasis, which patients who have undergone major head and neck surgery suffer from in the post-surgical period.

Nevertheless, the lack of initiative in undertaking pulmonary function studies in laryngectomized patients is not so much due to the fact that there are no indications for it as to the lack of adequate technical procedures that enable it to be carried out. There are no commercialized materials currently available to adapt the mouthpiece of the pneumograph to the tracheostoma and although some authors attach the spirometer terminal directly to the cannula of the tracheostoma, we believe that this procedure is not methodologically correct, since the diameter of the cannula is always less than that of the trachea, considerably increasing the resistance to the passage of air flow.

The purpose of this work is to find an instrumental method that will allow spirometry on laryngectomized patients to be performed in the most reliable way possible. Using perishable material designed for other purposes, we have devised a cheap and hygienic (using material that is used only once) procedure, which does not remove resistance to the passage of inspired or expired air, which prevents air leaks (which occur with some masks) and which is free from adverse effects for the patient.

CONCLUSIONS

A total laryngectomy is an extra handicap added to the already poor pulmonary function (obstructive pattern) characteristic of these patients, who in the majority of cases have a history of serious tobacco use.

After the possibility of suffering a second tumor, the affectation of pulmonary function is the second major cause

### Table 1. Descriptive Values of the Spirometric Parameters Obtained

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Average</th>
<th>Standard Deviation</th>
<th>Inferior Limit</th>
<th>Superior Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV</td>
<td>1.89</td>
<td>0.11</td>
<td>1.75</td>
<td>2.03</td>
</tr>
<tr>
<td>MVV</td>
<td>57.94</td>
<td>3.40</td>
<td>54.38</td>
<td>61.50</td>
</tr>
<tr>
<td>Resp./min.</td>
<td>29.90</td>
<td>7.26</td>
<td>24.71</td>
<td>35.10</td>
</tr>
<tr>
<td>FVC</td>
<td>2.95</td>
<td>0.32</td>
<td>2.70</td>
<td>3.20</td>
</tr>
<tr>
<td>FEV₁</td>
<td>2.44</td>
<td>0.26</td>
<td>2.30</td>
<td>2.60</td>
</tr>
<tr>
<td>FEV₁/FVC</td>
<td>84.41</td>
<td>6.32</td>
<td>78.57</td>
<td>90.26</td>
</tr>
</tbody>
</table>
of morbidity and mortality in laryngectomized patients, which means that we must perform periodic monitoring using spirometry periodically.

The problem stems from the fact that spirometry-tracheostoma adapters are not currently manufactured. We have created a simple, cheap and easy to use method that consists of adapting the pneumograph terminal of the spirometer to the tracheostoma of the patient, without modifying the resistance of the air flow, with no evidence of peristomal leaks and without any adverse effects on peristomal skin.

REFERENCES