Novel approaches to performance assessment of heat and moisture exchangers for pulmonary protection and rehabilitation in laryngectomized patients

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Chapter 7

Incidence of severe tracheobronchitis and pneumonia in laryngectomized patients: a retrospective clinical study and a European-wide survey among head and neck surgeons

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ABSTRACT

Background: Laryngectomized patients, lacking conditioning of the breathing air in the upper respiratory tract, have reported considerable pulmonary complaints. It is assumed that these patients also run a higher risk of developing severe respiratory infections. Unfortunately, there is little scientific information available about the occurrence of respiratory infections and related health costs in these patients with and without the use of an HME. Therefore, the occurrence of respiratory infections in laryngectomized patients was investigated in the Netherlands Cancer Institute and by means of a survey among head and neck oncology surgeons throughout Europe.

Methods: The number of tracheobronchitis and/or pneumonia events was retrospectively scored between 1973-2013 in medical records of 89 laryngectomized patients treated in our Institute. To assess expert experiences and opinions regarding these pulmonary problems, a study specific survey was developed. The survey was send by email to head and neck surgeons from 10 different countries.

Results: In the medical record study, an average of 0.129 respiratory infections per patient/year was found in non-HME users and 0.092 in HME users. In the survey (response rate HN surgeons 20%; countries 90%) 0.285 episodes per patient/year in non-HME users was statistically higher than the 0.066 episodes per patient/year in HME users. The average mortality in the HME user group per entire career of each physican was estimated on 0.0045, and for the non-HME user group this was 0.0152.

Conclusions: There is a tendency that the number of tracheobronchitis and pneumonia episodes in non-HME users is higher than in HME users.
INTRODUCTION

During total laryngectomy (TLE) the entire larynx is removed, resulting in a permanent disconnection of the upper and lower airways. The tracheal epithelium becomes directly exposed to the relatively cold and dry ambient air entering the trachestoma. This results in dehydration of mucus (altered mucus viscosity) and a reduction of ciliary activity causing impaired mucociliary clearance.\textsuperscript{1-3} Also, tracheal epithelium damage has been found, such as loss of ciliated cells, goblet cell hyperplasia, excessive mucus production and metaplasia in laryngectomized patients.\textsuperscript{4} Consequently, the majority of patients with a trachestoma have pulmonary complaints such as frequent coughing and forced expectoration of mucus, which leads to psychosocial problems affecting quality of life (QoL).\textsuperscript{5,6} Patients with impaired mucociliary clearance are also more susceptible to recurrent infections and chronic airway inflammation.\textsuperscript{2,7} These postlaryngectomy pulmonary infections (tracheobronchitis or pneumonia) are more frequent in wintertime and the accompanying tracheal crusting often requires antibiotic treatment or even hospitalization. However, precise numbers on occurrence of pulmonary infections among laryngectomized patients are not known.

Prevention and treatment of pulmonary problems play a major role in the rehabilitation of laryngectomized patients.\textsuperscript{8} Presently, pulmonary rehabilitation after laryngectomy is best achieved by means of heat and moisture exchangers (HMEs) applied in an airight seal covering the trachestoma. An HME has three physical properties: heat and moisture exchanging capacity, adding resistance to the airflow and filtering out airborne particles.\textsuperscript{9} There is compelling evidence from basic physiological research and from prospective randomized clinical trials that HMEs for laryngectomized patients do have a positive effect on pulmonary climate and respiration, significantly lowering frequency of coughing and mucus production, and a substantially reducing tracheal dryness. Moreover, these studies have shown that psychosocial functioning and quality of life are improved with use of HMEs.\textsuperscript{6,10,11,12-14} Because of all the evidence that HMEs have such positive effects on pulmonary/patient functioning, these medical devices are an integral part of TLE rehabilitation in many European countries, but unfortunately there are still other EU countries where this is not the case, often due to reimbursement issues.
Pulmonary infections, i.e. tracheobronchitis, pneumonia, often grouped under the denominator lower airway tract infections, have an important impact on quality of life (QoL) of laryngectomized patients but also on medical costs. There is little scientific information available on the actual pulmonary infection rates and on possible related mortality and whether there are differences in these rates between non-HME users and HME users. Therefore, the present study was initiated. First, data on pulmonary infections was retrospectively assessed from the patient medical records, both for non-HME and HME users. However, during this exploration, it became apparent that there is a large documentation bias regarding pulmonary infections in the early years of the cohort. This was reason to subsequently develop a European-wide survey to assess expert opinion and experience regarding these disease entities amongst head and neck surgeons, in order to gain better insight in the magnitude/occurrence of these pulmonary problems in laryngectomized patients.

**METHODS**

1) *Retrospective patient file study*

The number of tracheobronchitis and/or pneumonia (pulmonary infectious) events, antibiotic treatment and hospital admissions was investigated retrospectively from data from 89 medical records of laryngectomized patients from the Netherlands Cancer Institute (NKI-AVL) hospital (tertiary comprehensive cancer institute) in Amsterdam, The Netherlands. The patient database from a previous study about the use of voice prosthesis in laryngectomized patients and the institutes’ cancer registration database were used for patient selection. Inclusion criterion was a follow-up for at least 5 years with medical record documentation and no other recurrent or new malignancy during this follow-up period. All selected patients were extracted in order of date of surgery, patients with a TLE between 1973 and 2004 and were divided in two groups; one group HME users (N = 51 patients) and one group non-HME users (N = 38 patients). Non-HME users were mostly treated before 1990, as HMEs were not yet available in the Netherlands. Physical functional mobility/impairment or duration of HME use were not taken into account. Pre-existent (prior
to TLE) secondary lung diseases were scored for all patients. Patient characteristics are shown in Table 1.

**Table 1.** Patient characteristics of the retrospective clinical study in the Netherlands Cancer Institute of 89 patients.

<table>
<thead>
<tr>
<th></th>
<th>No HME (N=38)</th>
<th>HME (N=51)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Date total laryngectomy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>1983</td>
<td>1995</td>
</tr>
<tr>
<td><strong>Indication Surgery</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary</td>
<td>24 (63%)</td>
<td>20 (39%)</td>
</tr>
<tr>
<td>Salvage</td>
<td>14 (37%)</td>
<td>31 (61%)</td>
</tr>
<tr>
<td><strong>Radiotherapy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>no RT</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>Post-operative (C) RT</td>
<td>(0) 11</td>
<td>(0) 19</td>
</tr>
<tr>
<td>Pre-operative (C) RT</td>
<td>(0) 14</td>
<td>(2) 31</td>
</tr>
<tr>
<td><strong>Follow-up (years)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>11.88</td>
<td>10.11</td>
</tr>
<tr>
<td>Range</td>
<td>2.8-25.3</td>
<td>5.1-19.3</td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>67</td>
<td>63</td>
</tr>
<tr>
<td>Range</td>
<td>47-96</td>
<td>37-90</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>35</td>
<td>45</td>
</tr>
<tr>
<td>Female</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td><strong>Pre-existent lung disease % (patients)</strong></td>
<td>7 (18 %)</td>
<td>13 (25 %)</td>
</tr>
</tbody>
</table>

* The mediastinum was never included in the radiation field; the most caudal border of the radiation field was the clavicle; the tracheostoma was included in all cases of post-operative radiotherapy. HME: Heat and Moisture Exchanger; RT: radiotherapy; C: chemotherapy

Retrospective scoring of medical records was performed by two observers and scoring period started 3 months after total laryngectomy and ended in case of death, start of HME use (in case of prior non HME use) or recurrent disease/ second malignancy (range scoring period 1973-2013). During the study period various HME
types were in use (e.g. Stomvent, FreeVent, and Provox), and these were not further specified in the analysis.

2) **Online survey**

**Participants**

Invitations for participation in the online survey were sent by email to head and neck (oncology) (HN) surgeons from 10 different countries: Belgium, Norway, Denmark, Sweden, Finland, Germany, Luxembourg, Poland, Spain, and the Netherlands. (Figure 1)

![Flow chart of electronic survey invitations and respondents](image)

**Figure 1.** Flow chart of electronic survey invitations and respondents
Procedures

The email with the link to the online survey was sent on June 25, 2013, and a reminder was sent 4 weeks later (July 31, 2013). The email included an introductory letter and a link to the online survey. The survey was in English.

Online survey

A structured study-specific survey was developed with 16 questions assessing sociodemographic aspects and experience of the health professionals, common practice for postlaryngectomy patients in their own practice, hospital or for patients at home in the respondents’ country. Furthermore, the survey included questions regarding the estimation of the number of (seasonal) tracheobronchitis and/or pneumonia cases (pulmonary infections) – and related mortality per year in the respondents’ practice. Subsequently respondents were asked to provide a hypothetical estimation of the probability of (seasonal) tracheobronchitis and/or pneumonia cases per year in their clinic. The questionnaire is provided in Appendix 1. Questions could only be answered in consecutive order, without the knowledge of content of the next question. To be able to go to the next question, the former had to be answered.

Statistical analysis

The data of the surveys were transferred to SPSS 21.0 (SPSS, Chicago, IL). All collected continuous data was tested formally on normality. Descriptive statistics were used to analyze the data. Baseline differences between HME and non-HME user groups were assessed with paired t-test with a confidence interval of 95%.

RESULTS

1) Retrospective patient file study

In the 38 non-HME users an average of 0.129 pulmonary infections (tracheobronchitis and pneumonia together) per patient/year was documented. For the 51 HME users this average was 0.092 per patient/year. The difference between non-HME users and HME users was not statistically significant (p-value = 0.33). The number of antibiotic
treatments reported in the non-HME user cohort was 2.58 per year (6.8 %) and for the HME users this was 4.0 (7.8 %) per year (p-value = 0.70). Hospital admittance for a pulmonary infection was one per year for the non HME group and 0.5 in the HME group (p-value = 0.12) (Table 2).

In the non-HME group, there were 7 patients with pre-existent (prior to the TLE) lung disease (chronic obstructive pulmonary disease (COPD) and asthma) and in the HME group there were 13 patients with these conditions. For patients with lung disease, the occurrence of pulmonary infections was 0.321 per patient/year in the non-HME group and 0.177 per patient/year in the HME group (p-value = 0.43).

Table 2. Incidence of pulmonary infections, antibiotic treatment and hospital admission from the retrospective medical record data of 89 patients with and without HME in the NKI-AVL.

<table>
<thead>
<tr>
<th></th>
<th>No HME (N=38)</th>
<th>HME (N =51)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonary infections per year (patient/year)</td>
<td>4.9 (0.129)</td>
<td>4.7 (0.092)</td>
</tr>
<tr>
<td>Antibiotic treatment per year % (patient/year)</td>
<td>6.8 % (0.07)</td>
<td>7.8% (0.08)</td>
</tr>
<tr>
<td>Hospital admission per year (patient/year)</td>
<td>1 (0.03)</td>
<td>0.5 (0.01)</td>
</tr>
</tbody>
</table>

2) Survey

Participants

From the 373 email requests, 74 surveys from 9 different countries were filled in online, a response rate regarding HN surgeons of 20%, and regarding countries of 90%. However, data entry was not always finalized. Surveys were excluded when >20% data were missing, rendering 43 surveys valid for complete analysis (see Figure 1). Missing data occurred mostly after the question if the physician used HMEs (question 3), or after the first question regarding the estimations of upper airway infections (question 14), see appendix 1. After this exclusion still all 9 countries were represented: there were 5 respondents from Denmark, 1 from Norway, 1 from Sweden, 8 from Finland, 2 from Spain, 5 from Belgium, 11 from Germany, 5 from Poland and 5 from the Netherlands. The average working experience with laryngectomized patients was 17.9 years (SD 8.3). Thirty-nine out of 43 (91%) of the HN surgeons prescribed HMEs to their patients, whereas the remaining 4 (9%) did
not prescribe HMEs. The average working experience with HMEs was 11 years (SD 5.7). The estimated total number of laryngectomized patients per respondent (in his/her practice) was 208 (for all respondents total of 8960 patients, range 5-400), from this 208, an average of 28 patients (13.5%) did not use HMEs.

The physicians were asked to reflect on the usual pulmonary care for laryngectomy patients, both in hospital and at home. Both in the hospital and at home, mostly HMEs were used (84%), followed by stoma covers and suction. Less used were external humidifiers or intra-tracheal application of a saline solution. See Table 3 for all applications.

**Table 3.** Common clinical care for laryngectomized patients in the hospital and at home (multiple answers possible).

<table>
<thead>
<tr>
<th></th>
<th>Hospital</th>
<th>At home</th>
</tr>
</thead>
<tbody>
<tr>
<td>HME</td>
<td>36</td>
<td>35</td>
</tr>
<tr>
<td>Stoma covers</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td>Suction</td>
<td>21</td>
<td>12</td>
</tr>
<tr>
<td>External humidifier</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>Saline</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Inhalation</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>I don’t know</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**Table 4.** Routine diagnostics and follow-up for tracheobronchitis or pneumonia (multiple answers possible).

<table>
<thead>
<tr>
<th></th>
<th>Diagnostics</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain X-ray</td>
<td>33</td>
<td>13</td>
</tr>
<tr>
<td>CT-scan</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Sputum culture</td>
<td>19</td>
<td>3</td>
</tr>
<tr>
<td>bronchoscopy</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>endoscopy</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>No follow-up</td>
<td>-</td>
<td>18</td>
</tr>
<tr>
<td>Auscultation</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Flexible tracheoscopy</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>I don’t know</td>
<td>-</td>
<td>2</td>
</tr>
</tbody>
</table>
Table 5. Routine treatment for tracheobronchitis or pneumonia (multiple answers possible).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antibiotics Oral</td>
<td>22</td>
</tr>
<tr>
<td>Antibiotics intravenous</td>
<td>25</td>
</tr>
<tr>
<td>Sodium Carbonate instillation</td>
<td>6</td>
</tr>
<tr>
<td>Physiotherapy</td>
<td>8</td>
</tr>
<tr>
<td>Respiratory therapy inhalation</td>
<td>10</td>
</tr>
<tr>
<td>Bronchoscopic cleaning</td>
<td>1</td>
</tr>
<tr>
<td>I don’t know</td>
<td>2</td>
</tr>
</tbody>
</table>

(Seasonal) tracheobronchitis or pneumonia

On average, for the HME user group the estimated annual number of tracheobronchitis and/or pneumonia episodes was 4.92, and divided by the average number of patients per practice, this means an annual probability of 0.066 per practice. For the non-HME user group these Figures are 6.97 for the annual number of pulmonary infectious episodes and 0.285 for the annual probability per practice (p=0.047) (See Table 6). The average number of estimated outpatient consultations, and average number of estimated hospital admissions and the average percentage of prescription of antibiotics are also shown in Table 6 or both groups. The differences between the HME users and non-HME users were statistically not significant (p=0.517, p=0.604 and p=0.963 respectively). The average days of hospital admission was 4.2 (SD 2.8) for the indication tracheobronchitis and/or pneumonia.
Table 6. Pulmonary infections, treatment and mortality rate in HME users and non-HME users.

<table>
<thead>
<tr>
<th></th>
<th>HME users</th>
<th>Non-HME users</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean episodes of (seasonal) trachea-</td>
<td>4.92</td>
<td>6.79</td>
<td>0.047#</td>
</tr>
<tr>
<td>bronchitis or pneumonia cases per</td>
<td>(0.066)*</td>
<td>(0.285)</td>
<td></td>
</tr>
<tr>
<td>year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean of outpatient consultations for</td>
<td>7.1</td>
<td>8.2</td>
<td>0.517</td>
</tr>
<tr>
<td>(seasonal) trachea-bronchitis or</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pneumonia per year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean of hospital admissions for</td>
<td>4.5</td>
<td>4.9</td>
<td>0.604</td>
</tr>
<tr>
<td>(seasonal) trachea-bronchitis or</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pneumonia per year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean percentage of prescription of</td>
<td>35%</td>
<td>40%</td>
<td></td>
</tr>
<tr>
<td>antibiotics for (seasonal) trachea-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bronchitis or pneumonia per year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypothesis that (seasonal) trachea-</td>
<td>10%</td>
<td>23.5%</td>
<td></td>
</tr>
<tr>
<td>bronchitis or pneumonia occurs in</td>
<td>(7-13%)</td>
<td>(15-32%)</td>
<td></td>
</tr>
<tr>
<td>10% of the HME users with a range of</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-13% per year, what is the estimation for non-HME users?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean mortality in relation to (season</td>
<td>3.7</td>
<td>4.1</td>
<td>0.097</td>
</tr>
<tr>
<td>al) trachea-bronchitis or pneumonia</td>
<td>(0.0045)**</td>
<td>(0.0152)</td>
<td></td>
</tr>
<tr>
<td>over the entire professional experience</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*(probability per year: divided by mean laryngectomized patients per practice: 98.95, from which 74.48 HME users, 24.47 non-HME users)

**(probability per year: divided by mean laryngectomized patients per practice: 98.95, from which 74.48 HME users, 24.47 non-HME users, and divided by mean years of experience: 11)

# significant at p<0.05

The most widely applied diagnostics for pulmonary infection was a plain X-ray (77%) and sputum culture (44%). For follow-up, this was an X-ray in 30%, in 42% no follow-up was reported. The most reported treatment for pulmonary infection was oral/intravenous antibiotics (see Table 4 and 5 for all applications).

Providing the information that recent research has shown that pulmonary infections occur in 10% of the HME users with a range of 7-13% per year, the HN surgeons were asked to give an estimation about this incidence for non-HME users. This resulted in an average of 23.5% (min 14.7% - max 31.8%) (Table 6).
Incidence of pulmonary infections in laryngectomized patients

Mortality in relation to (seasonal) tracheobronchitis or pneumonia

The average mortality in the HME user group was estimated on 3.7 cases, and for the non-HME user group 4.1 cases, divided by the average total patients per practice and experience per physician, this means an annual probability for HME users of 0.0045 and for non-HME users 0.0152 (p=0.097, see Table 6).

DISCUSSION

The major finding in this study was that the number of pulmonary infections (tracheobronchitis and pneumonia episodes together) in non-HME users was higher compared to HME users. This corresponds with the higher percentage of prescription of antibiotics for pulmonary infections per year for non-HME users compared to HME users in both the data from the retrospective patient files and the European survey. For the number of hospital admissions for pulmonary infections per year, the medical records study also showed a higher rate for non-HME users, but the European survey showed little difference between HME and non-HME users. The difference in the average mortality related to pulmonary infections between the two groups, with a probability of 0.0045 per year for the HME group versus 0.0152 for the non-HME group was borderline significant (p=0.097).

The pulmonary infection incidence rates for both non-HME users and HME users from our medical records data (0.129 and 0.092 patient/year respectively) and from our survey (0.285 and 0.066 patient/year) are considerably higher compared to the incidence reported in non-laryngectomized/healthy adults of comparable age. The incidence of lower respiratory tract infections in healthy adults aged 65-74 years in primary care was reported 0.042 person/ years\(^1\) and in another prospective study monitoring adults visiting a general practitioner for an acute lower respiratory tract infection during one year had showed an overall incidence of 0.044 adults/year.\(^2\) In our medical records study, patients with pre-existent lung disease (before TLE) not unexpectedly showed a higher occurrence of pulmonary infections than patients without known lung disease (non-HME users: 0.321 patient/year and HME users: 0.177 patient/year).

In a prospective study, Jones et al investigated the HME effect on pulmonary function in laryngectomized patients, and predefined chest infection (pulmonary
infection) rate was scored in 25 HME users (0; range 0-1.0) and 25 non-HME users (1; range 0.3-1.8) during follow-up period of six months. The infection rate in non-HME users was found to be significantly higher than in the HME users, in accordance with our results. However, the overall incidence of scored pulmonary infections was much lower compared with the incidence of pulmonary infections in the present study for both groups (non-HME and HME users). The follow-up period of 6 months in the study of Jones et al might have been too short to monitor the incidence of lower respiratory tract infections and this could have led to an underestimation of the number of chest infections. The relatively small number of patients in each group (25) might have influenced the outcome as well.

In another prospective study about scoring episodes of infections and bacterial colonization in lower airways in non-hospitalized patients with long-term/ chronic tracheostomy (> 6 months) and breathing without an HME, an incidence of 30 episodes of pulmonary was reported in 39 patients over a follow-up period of 1 year (0.77 patient/year). This incidence is much higher (> 3 times) than the incidence of infections in non-HME users from our medical record study and the European survey. This could be due to the chronic presence of cannulas in tracheotomized patients, but it is also possible that we still have underestimated the number of pulmonary infections in laryngectomized patients, as no routine sputum culture was performed for this indication.

Antibiotic treatment during the follow-up of a year for the 30 infectious episodes in the study about tracheotomized patients mentioned above was given in 46% of the patients. In our survey the percentages of antibiotic prescription was 35% in the HME users and 40% in non-HME users and this corresponded with the difference between the incidences of pulmonary infections in these two groups. This suggests that in European clinical practice the treatment for pulmonary infection diagnosis is antibiotic treatment, as we assumed in the introduction and this should be taken into account in the cost-effectiveness assessment of HMEs. In the present retrospective medical record study we found documentation of tracheobronchitis without reporting antibiotic treatment. This is possibly due to under-documentation, and, as already mentioned, this was one of the reasons to perform a European survey.
Little is known about the mortality related to pulmonary infection in laryngectomized patients with or without the use of an HME. This mortality is difficult to assess and is probably very low. In the prospective study on pulmonary infections and bacterial airway colonization in 39 tracheotomized patients (already mentioned above), there was one patient who died with signs of pneumonia two years after the end of the sample collection. In a population-based study among patients with oral cavity or oropharyngeal cancer, a mortality of 20.3% non-cancer-related deaths was found between 2004-2007. Suicide, cardiovascular diseases, and pneumonia accounted for more than half (51.4%) of these deaths. Pneumonia was in 10.1% cause of death in patients with oral or oropharyngeal cancer in the 1980s and this decreased to 5.3% over the subsequent years. However, in oropharyngeal cancer patients development of pneumonia is mostly based on aspiration and in laryngectomized patients this is hardly possible (only in case of leakage through or around a voice prosthesis, if present). In our survey, the mortality rate related to pulmonary infections is lower (less than 5%) than in the oropharyngeal/oral cavity patients, so pulmonary infections do not seem to be increase mortality rates in laryngectomized patients.

In the present study there are some limitations regarding the data from the medical records, as the study design was retrospective and because there are currently few laryngectomized patients in our institute not using an HME. The median year of treatment (total laryngectomy) was 1983 for the non-HME users and 1995 for the HME users. However, as surgery was performed in a similar way and the respiratory shortcut (tracheostoma situation) is therefore the same in all scored patients and the patients groups were quite similar, also with respect to voice prosthesis use, introduced in 1980 and applied in 95% of the patients. The main limitation of the retrospective study was a documentation bias. Especially, in the early years many of the pulmonary infectious episodes and treatments were not documented well. Furthermore, many infectious episodes are managed by the general practitioner and are not reported in the medical record of the hospital.

Another arguable limitation of the survey might be the relatively low response rate of 20%. However, for a European survey in which 9 out of 10 (90%) approached countries were represented by the respondents is the term European well-founded and the outcome data still can be considered valuable. The low completion rate of
the survey suggests that it was apparently difficult to fill in the estimations of the number of treated patients, and the number of infectious episodes. Most of the “drop-outs” (N=31, Figure 1) occurred at these specific questions (Appendix 1: nr.14-20) in the survey. It might be that the drop out respondents at this point realized themselves that their working experience with laryngectomized patients was too limited to answer these questions properly. The respondents who have completed the questionnaire appear to have a substantial working experience (on average 17.9 years) with an average of 208 laryngectomized patients per practice, which underlines that the results represent “expert opinions” on the subject. Moreover, there has been little methodological research around influences on response rates in online surveys, and the opinions regarding what response rate can be considered sufficient vary.\(^{22}\) Response rate generally affects representativeness, for which we believe this is covered in our survey.

Finally, for both the medical records study and the survey case, its obvious that the design of the studies do not deliver the highest level of evidence.\(^{23}\) However, these studies give an insight into probable trends, and therewith can lead to further research.

The results of this study underline that it is important for laryngectomized patients to use an HME in order to decrease the incidence of tracheobronchitis and/ or pneumonia. It is worth noting that in Europe different types of HMEs are available and a recent comparison study has measured high heterogeneity in humidity performances between these devices. Differences in humidity performance might influence the incidence of pulmonary infections and clinical complaints, however breathing with any HME device is better than open stoma breathing.\(^{24}\)

In conclusion, there is a tendency that the incidence of severe tracheobronchitis and/ or pneumonia (pulmonary infectious) episodes in non-HME users is higher than in HME users, which has an impact on medical costs, quality of life and possibly survival.

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APPENDIX 1

Questionnaire on severe (wintertime/crusting) trachea-bronchitis and pneumonia in laryngectomized patients in relation to the use of HMEs

General questions:

1. What is your profession:
   - □ Head &Neck (oncology) surgeon
   - □ Medical oncologist
   - □ Radiation Therapist
   - □ Oncology Nurse/nurse practitioner
   - □ Speech Language Pathologist (SLP)
   - □ Other, namely: _____________________________

2. In which country do you work?
   _______________________

3. Do you prescribe Heat and Moisture Exchangers (HMEs; artificial nose) to your laryngectomized patients?
   - □ Yes
   - □ No

4. For how many years have you been working with laryngectomized patients?
   __ years

5. For how many years have you been working with HMEs?
   __ years

6. What is the estimated total number of laryngectomized patients in your practice?
   □ ....

7. Could you estimate from these patients the total number who do NOT use HMEs?
   □ ....
8. To what percentage of your patients do you prescribe HMEs today?
   - percentage of long-term laryngectomees ..%
   - percentage in the immediate postoperative period ..%

*Routine treatment of upper airway infections (tracheitis/pneumonia/bronchitis)*

9. In your hospital, what is “usual care/most common care” for postlaryngectomy patients?
   - HME
   - Stoma covers
   - Suction
   - External Humidifier
   - Saline
   - I don’t know
   - Other, namely: _____________________________

10. In your practice, what is “usual care/most common care” for postlaryngectomy patients at home?
    - HME
    - Stoma covers
    - Suction
    - External Humidifier
    - Saline
    - I don’t know
    - Other, namely: _____________________________

11. What is the routine diagnostic procedure for (seasonal) tracheobronchitis/pneumonia at your facility? (more answers possible)
    - Plain X-ray
    - CT scan
    - Sputum culture
    - I don’t know
    - Other, namely: _____________________________
12. What is the routine treatment for (seasonal) tracheobronchitis/pneumonia at your facility? (more answers possible)
- Antibiotics oral: _____________
- Antibiotics intravenous: _____________
- Sodium Bicarbonate instillation
- Physiotherapist
- Respiratory therapist
- I don’t know
- Other, namely: _____________________________

13. What is the routine follow-up procedure for (seasonal) tracheobronchitis/pneumonia at your facility? (more answers possible)
- Plain X-ray
- CT scan
- Sputum culture
- I don’t know
- Other, namely:_____________________________

Questions regarding upper airway infections (tracheitis/pneumonia/bronchitis)

14. In your practice, How many times/episodes you diagnose a patient with (seasonal) tracheobronchitis/pneumonia per year?
- in the HME user group: ..
- in the non HME user group: ..

15. In your practice, How many outpatient consultations you have for (seasonal) tracheobronchitis/pneumonia per year?
- in the HME user group: ..
- in the non HME user group: ..

16. In your practice, How many hospital admissions you have for (seasonal) tracheobronchitis/pneumonia per year?
- in the HME user group: ..
- in the non HME user group: ..
17. In your practice, in what percentage you prescribe antibiotics for patients with (seasonal) tracheobronchitis/pneumonia per year?
   - in the HME user group: ..% 
   - in the non HME user group: ..% 

18. If a patient has to be admitted for (seasonal) tracheobronchitis/pneumonia, how many days is the admission in your hospital on average?
   - ... days 

19. Recent research has shown that (seasonal) tracheobronchitis/pneumonia occurs in 10% of the HME-users with a range of 7-13% per year. Based on this knowledge, how would you estimate this chance with range for NON-HME-users?
   - chance for NON HME users: ..
   - minimum: ..
   - maximum: .. 

20. In your entire professional carrier with laryngecomtized patients, how many patients did you ever encounter who died in relation to (seasonal) tracheobronchitis/pneumonia?
   - in the HME user group: ..
   - in the non HME user group: ..
Incidence of pulmonary infections in laryngectomized patients

REFERENCE LIST


