

MSc assignment

Title: Understanding and optimization of Heat and Moist exchangers for laryngectomized patients

Research team

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Introduction

Heat and Moist exchanger (HME) is an important medical device for pulmonary rehabilitation after total laryngectomy. It actually stores and releases heat and water during breathing. So far, the most modern HMEs are able to restore a major part of the lost upper respiratory tract air conditioning capacity, but there is still a gap towards the normal physiological level. Adding more HME material would be the simplest way to increase performance. However anatomic and cosmetic restrictions limit its size. Just adding more material will lead to increase of airflow resistance, which in turn will lead to poorer patient compliance. The challenge is to further increase water exchange capacity without undue increase of airflow resistance. Present core material and form and size (height and diameter) are based on empirical experience. In order to achieve a further increase in performance of the HME a better understanding is required of the way an HME functions during breathing.

Background

The active part of an HME (the core) consists of a substrate (currently often a foam) covered with a hygroscopic salt. The hygroscopic salt continuously binds a relatively thick layer of water in humid conditions. The high heat capacity of this water, combined with the heat capacity of the substrate provides the heat sink for the thermal and evaporative / condensation energy exchange which makes the heat and moisture exchange possible.

The dynamic behavior of an HME is poorly understood, both the thermodynamics and the aerodynamics. Evaporation of water requires a large amount of energy, which is released upon condensation. During evaporation the material may cool so far that it freezes (and evaporation will be hampered), and upon condensation the device will heat up, so that further condensation is not possible. Clever design of the device might optimize the heat exchange. This is supported by the performance of an HME, which included an additional hydrophobic filter. Unexpectedly this filter which was only meant to filter dust and bacteria turned out to increase HME performance. This filter probably acted as a heat exchanger, raising the overall temperature of the HME and therefore its performance: supposedly the freezing phenomenon was decreased. Aerodynamically some patients have complained about an unacceptable resistance of the high performance HMEs during prolonged use which seems to be associated with the observation that too much water collects causing dripping of. However, airflow resistance of HME's has only been measured for dry HME's. Measuring airflow resistance under breathing conditions has never been done.

Research questions

This MSc assignment aims to address one or more of the following research questions:

1. Can we formulate a (qualitative) theory of dynamic function of an HME?
2. How can one optimize the dimensions of the current core material?
3. Are there alternative core materials for HME?

For more information about the assignment please contact:

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