Institut für Physiologie Prof. Dr. K. Mottaghy
Uniklinik Pauwelsstr. 30, D- 52074 Aachen

Czech Technical University in Prague

Faculty of Biomedical Engineering

Institut für Physiologie
RWTH Aachen University, Germany
Prof. Dr. K. Mottaghy

Pauwelsstr. 30
52074 Aachen

Tel.: +49241 80 89170Fax:
+49241 80 82434

Email: mottaghy@ RWTH-Aachen.de
kmottaghy@ukaachen.de

To whom it may concern

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Ref.: Review of the Dissertation Thesis:
Effect of ventilation parameters on mechanical Power delivery to the lungs

Submitted by: Ing. Šimon Walzel, Faculty of Biomedical Engineering

Topicality of the dissertation topic:

Mechanical ventilation (MV) is not only a therapeutic method for several medical indications as e.g. during surgical procedures, but also a high effective tool to treat ventilatory insufficiency or failure including severe lung disease such as acute respiratory distress syndrome (ARDS). However, due to its some non-physiological principles, MV is associated with a number of serious adverse effects. Despite the fact that enormous attention is paid to minimizing these adverse effects, the problem has not been resolved. One parameter that has recently been associated with the severity of lung damage during MV is the mechanical energy that is transferred to the lungs with each controlled breath. The dissertation deals with the study of the assessment, calculation, and clinical effects of energy transferred to the lungs during MV. The distinction between airway and tissue resistance in the delivery of mechanical energy has obvious physiological background and clinical significance. The topic is timely and fits well with ongoing efforts to establish more reliable criteria for lung-protective ventilation.

Fulfillment of the objectives of the dissertation thesis:

The objectives for the presented dissertation were defined as: (i) construction of a

physical lung model including tissue viscoelasticity, (ii) separation of tissue from airway resistance, (iii) evaluation of simplified power equations, and (iv) pilot clinical validation. These goals are reasonably selected. The objectives are achieved and systematically documented.

The methods and procedures of the solution:

The experimental design is sound and goes beyond mere computer simulations. Maxwell's tissue modeling element is reasonable and adequate. However, it should be borne in mind that the rheology of lung tissue and its viscoelasticity can also be represented by more complex models e.g. according to Kelvin–Voigt, Zener, fractional, or poroelastic. For the future investigations on this important and interesting subject are these alternatives to be considered which are not yet fully explored in the thesis, but they may change the interpretation of mechanical energy delivery. In fact, modeling of the respiratory system is more complex and involves nonlinearity, hysteresis, regional inhomogeneity, and multi-compartment behavior.

Results of the dissertation and specific contributions of its author:

The results demonstrate that tissue and airway resistance affect energy delivery in different ways. This finding is novel and relevant. However, when assessing the general validity of the conclusions, it should be noted that they are based on a single rheological model.

Relevance for the practice and development of the field of study Biomedical and Clinical Technology:

The results highlight the limitations of simplified equations commonly used at the patient's bedside. Relying on mechanical energy equations as a guide for lung protection strategies therefore remains problematic, and further studies as mentioned above, are needed in this area. The documented influence of airway flow resistance and viscoelastic resistance of the lung tissue on measured ventilation signals is also important for practice, as in certain cases it is not possible to distinguish between these resistances from the measured data as uncovered and documented in the thesis.
For the assessment of the adverse effects of MV, it is essential to know where and how mechanical energy is dissipated in the respiratory system.

Formal arrangement of the dissertation thesis and its language level:

The dissertation is well written, and concisely illustrated with clear figures and tables.
The quality of the language is high, and the argumentation is logically developed.

Comments and final evaluation of the dissertation thesis:

(i) A wider discussion of alternative rheological models would improve the interpretation of results. How might additional mechanical properties of lung tissue influence the delivery of mechanical energy and, more generally, the application of lung-protective ventilation?
(ii) The combination of engineering methodology with physiological relevance and is interdisciplinary character are strong points of this work.

Conclusion:

This dissertation is an original and valuable contribution to the field of biomedical engineering. Therefore, despite the mentioned limitations, I recommend it for defense, and I support strongly awarding the Ph.D. degree.

Prof. Dr. K. Mottaghy