Making Artificial Ventilation Safer with EIT

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Patients need to be artificially ventilated for different reasons. For example, due to injury, illness or during anesthesia. Even with today's modern ventilation devices many patients die during or even due to artificial ventilation.

If the pressure is too high, the lung tissue becomes overdistended and damaged. If the pressure is too low, a lung section may collapse. Therefore, ventilating with the wrong pressure may lead to lung damage or even to death. Hence, it would be helpful if we could visualize the lungs during ventilation to optimize ventilation parameters.

With computed tomography (CT), we can create cross-sectional images of the thorax. However, CT works with ionizing radiation, which may cause cancer. For a continuous monitoring of ventilated patients we need another method. Electrical impedance tomography (EIT) also delivers cross-sectional images. The resolution is lower than the one of CT, but it is still possible to detect problems during ventilation.

How does EIT work? We place electrodes around the thorax on the skin. Then we inject very small, non-harmful alternating currents into the body. We measure the resulting voltages on the skin. Then we use different electrodes for current injection and measure many voltages again. Using these voltage and current values, we can calculate a cross-sectional image.

Due to the expected large clinical and business potential, the start-up Swisstom was created in Landquart. One founder of Swisstom is an engineer, the other one a medical doctor. The common interests of BFH and Swisstom led to a CTI project. Main research partner was BFH's Institute for Human Centered Engineering (HuCE). Partners were also HSR and Carleton University.

At BFH, my colleague, Jörn Justiz, and I led this project. We developed, for example, a sophisticated test system. A robotic arm places a high-impedance object into a tank, which is filled with saline solution and equipped with electrodes. Now we are able to determine the position of the object within the tank based on the cross-sectional image and compare it to the actual position. In this way, we can systematically characterize and validate EIT systems. We published in reputable journals such as Physiological Measurement and the IEEE Transactions on Medical Imaging. Swisstom has successfully introduced products into the market and is currently selling them.

One of the two main research assistants is now head of the innovation group of a local company. The other assistant was hired by Swisstom immediately after finishing his master's project. So, our application-oriented education is beneficial to everyone: it is good for students, who can work on exciting and relevant projects already during their studies, which helps them to get good jobs after graduating. And it is good for Swiss companies, who can get to know students early and can then hire well-trained graduates.

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Real-time EIT monitoring during mechanical ventilation with an easy-to-use sensor belt (picture source: swisstom.ch)