Study of the Electrical Conductivity of Tissues

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The literature about conductive properties of biological tissues is very controversial and large value differences are being found. The challenge faced in present thesis was to master the measurement of impedance of biological tissues within the electrical impedance tomography frequency range. Moreover,in this work, we propose a possible surrogate for in-vivo animal experiments based on the use of ventilated excised pig lungs placed into a saline tank.

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Materials and Methods

The impedance measurements were performed by an impedance spectroscope HF2 from Zurich Instruments (Zürich, Switzerland). Based on analytical and numerical analysis, we developed a dedicated measurement probe. The measurement head of the probe was composed of a linear horizontal Wenner electrode array with four gold-covered stainless-steel electrodes. The measurement set-up was calibrated using saline solutions of various known molarity. The tissue samples, from pigs, were acquired at a local slaughterhouse. The fresh samples were examined between 1 and 14 hours after death. The imaging of the lung's ventilation using the 32 active-electrode EIT system «Pioneer Set» from Swisstom (Landquart, Switzerland) was realized within a saline water tank. The lungs were kept open, even under water, by closing the upper part of the tank with a tight cover, which in some extend mimic the physiology of the thorax. In this way, the lungs can be kept open and ventilated with pressures in the physiological range.

Results

From the analytical and numerical analysis the minimal sample size, which satisfies the infinity assumption, is given by minimal width 16a, height 5a and spacing between the sample's border and the nearest electrode 8a, where a is the inter-electrode spacing. For liver, heart and lungs the specific impedance results are found in the same value range as the one reported in the literature. Nevertheless, we observed differences of 2% between the references and the measurements for the liver two hours after death. In the second part of this work, we were able to ventilate excised lungs within a saline water tank. The lungs exhibited the expected hysteresis curve in the impedance versus pressure plot, reported in Fig. 2.

Discussion

In this work, we developed a robust and well documented method to measure the specific impedance of biological sample; the results correspond to the findings of similar studies. The differences could be explained by 1) the sample water content, 2) the sample freshness (time degradation of the tissue after death), 3) the room temperature and 4) the localization of the measurement spot. The developed experimental set-up for ventilating excised pig lung shown promising results. A similar set-up could potentially be used as a surrogate for in-vivo animal studies or for the pre-clinical testing of EIT instruments.

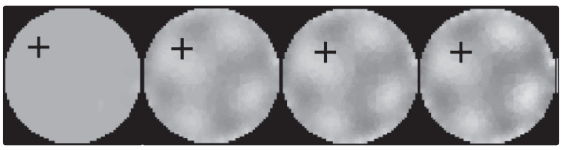

Fig. 1: EIT images of pig lungs placed into the EIT test tank filled with a saline solution with 9 g/l NaCl. Pressures in the trachea (a) 0 cmH2O, (b) 34 cmH2O, (c) 43 cmH2Oand (d) 144 cmH2O. The cross is the test pixel.

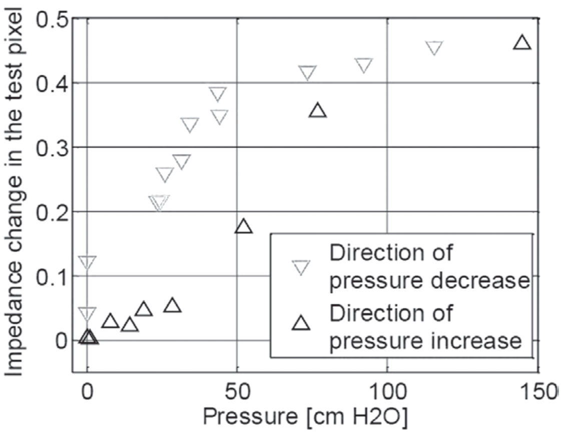

Fig. 2: Impedance change of the pig lungs placed into the EIT tank filled with a saline solution in function of the air pressure at the trachea. The impedance was taken from the pixel marked by the cross on Fig. 1.