Characterization of Electrode-Tissue Impedance, Reduction of Baseline Wander in eECG Recordings

Fachgebiet: Electronic Implants
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Over many decades, the electrocardiogram (ECG) has become an important diagnostic tool for diseases of the heart muscle or the heart's electrical conductivity system. Unfortunately, the main signals from the atria are much weaker (than the QRS) and are not easily recognizable. The esophageal ECG (eECG) plays an important role in long-term measurements. The position of the esophagus near the heart is a great advantage in recording the signals from the atria.

In the eECG, however, motion artefacts (called baseline wanders BLW) can be caused by swallowing or breathing, or even by the patient's heart contraction itself. Since the ECG has frequencies similar to the BLW, motion artefacts are not easy to filter out. For this reason, a new technique must be used to differentiate these signals.
An electrochemical model of the electrode-skin interface was developed by Webster. A similar model for the electrode-esophagus interface has to be worked out. An Electrical Impedance Spectroscopy (EIS) must be used to determine the different impedances of the interface. Since the various electrical sources are connected by different impedances, they should react differently on load variations.

Measurements and Results

In Vivo (Fig. 1): Several measurements were made at a pig's esophagus. Since the conditions changed during the measurements (movement of the catheter, gastric acid has surged up into the esophagus), only a part of the measurements were then used to build up a second order model.

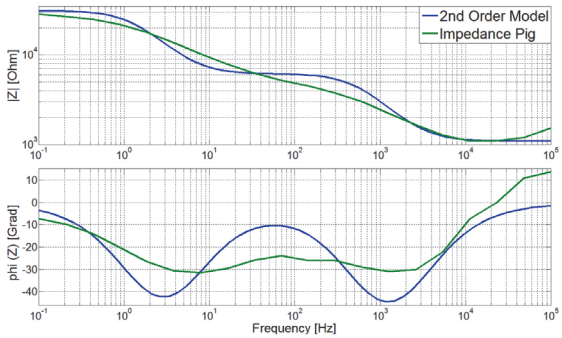

Fig. 1: Measured impedance of the pig's esophagus (green) compared with the second order model (blue).

In Vitro (Fig. 2): Measurements were obtained because measurements with a low frequency in the range of mHz (expected low pole frequency) are not possible to cover in an in vivo setup. Therefore we imitated the electrolyte (mucus/saliva) in vitro and measured in four different sodium chloride solutions (NaCl).

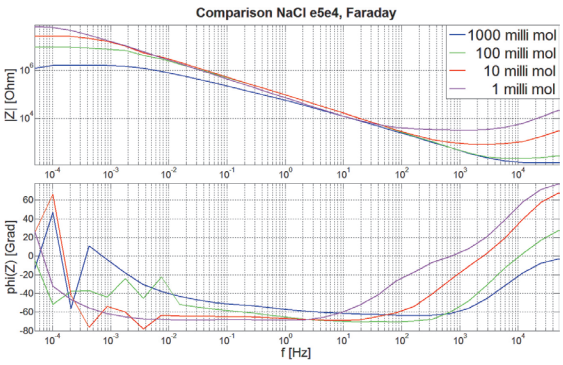

Fig. 2: EIS with several NaCl c(mmol). The impedances rise and cutoff f move to lower f as the NaCl decreases.

Discussion

The data which we collected from the pig's esophagus are not transferable one-on-one since the pig was under general anesthetic and the conditions were not stable during the measurements. Nevertheless, the in vivo measurement shows that the esophagus-electrode interface behaves like a model higher order than two.
The in vitro measurement explains how the system influenced by NaCl: The impedance falls and the possibility of electrochemical corrosion and disruptive breakdown of the electrode increases along with the increased NaCl concentration.
Since gastric acid (HCl) may rise up into the esophagus, measurements with HCl should be included to enhance the quality of the model of the esophagus-electrode interface.

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