Passive conductance of ECG and other biopotentials

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Aims: Our aim was to show that the propagation of the endogenous biopotential may be treated as the passage of electromagnetic wave through the physical medium and explained using a well-known theory for dispersive media. We also aimed at supporting theoretical predictions for such quantities as the wave velocity by direct measurement.

Methods: We derived the formula for the propagation of endogenous electromagnetic waves directly from Maxwell's laws and a formula for the refractive index widely used in optics. We hypothesized, that the wave propagates through the passive tissue involving all physical mechanisms for material polarization: ionic and non-ionic. In consequence, known data on bioimpedance spectra measurements may be used to estimate the properties of a unipolar ECG wave. Finally, we designed a simple experiment to confirm if the passage of unipolar potential obeys the derived rule.

Results: We were able to confirm by direct measurement that unipolar ECG potential propagation may be described using the formula we obtained. The result remains at an approximation level since we did not decompose the body into individual tissues and the low-frequency part of the bioimpedance spectrum, relevant to ECG frequencies, is poorly documented. We have also discussed the coherence of the unipolar ECG: a unique property well known in laser optics. Due to its coherence, the ECG signal, unlike any other biopotential, can be measured between virtually any two points on the body at a large distance from the source.

Conclusions: We conclude that our results allow to integrate the theory of bioimpedance with the theory of biopotential measurement. This brings an improved interpretation of various biopotential measurements. If a clear relation between passive conductance and the properties of the electromagnetic spectrum is further confirmed, it will unify the description of electrical phenomena within the body with the physical theories.