High Temporal Resolution Finite Element Simulations of the Aorta for Thoracic Impedance Cardiography

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Impedance cardiography (ICG) is a simple and cheap method to acquire hemodynamic parameters non-invasively but this technology is not considered to be reliable. The task of this work was to analyze where the electrical current paths run and which tissue contributes significantly to the ICG measurement result employing finite element computer simulations.

For this purpose, a model of the human thorax has been built based on the Visible Human dataset. It is composed of static volumes of the Visible Human dataset and new dynamic volumes: aorta, heart, vena cava, carotid vessels, rib cage and lung. The static volumes comprise the tissues fat, muscle and abdominal organs. Simple geometries have been used to rebuild dynamic structures to obtain a reasonable calculation time. The aorta has been divided into 23 segments so that a propagating pulse wave can be simulated. To change the diameter of each segment, flow data derived from a project in which the arterial system has been rebuild using silicone representing an arterial model has been used to calculate each diameter and its temporal behaviour. For current injection, standard ring electrode positions have been chosen.

103 points in time during one heartbeat have been simulated using a low frequency electroquasistatic solver. In addition, the absolute value of the thoracic impedance has been calculated. The scaled simulated ICG signal shows a good correlation ($r = 0.75$) with a measured ICG wave, which means that the aorta can be considered as major contributor to the ICG signal. In addition, the global minimum could be assigned to the closure of the aortic valve by comparing the curve to the temporal behaviour of the aortic pressure.