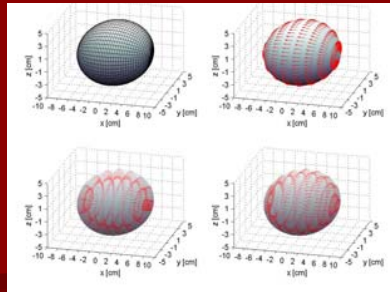


Modeling Gastrointestinal Electrical Activity in the Vanderbilt GIST Laboratory

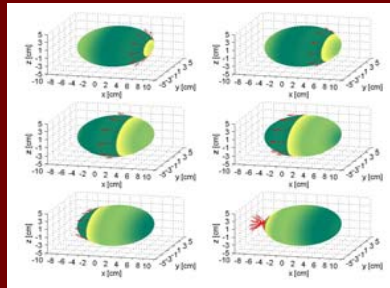
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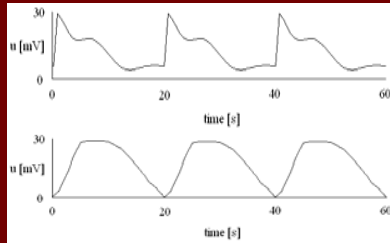
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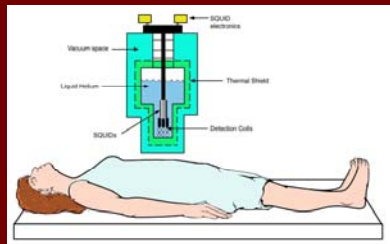
1. Electric dipoles propagating on ellipsoidal surfaces



2. Gastric activation front propagating on an ellipsoidal surface



3. Simulated waveforms of gastric electrical activity



4. Experimental setup for the MGG

Introduction

The purpose of the Gastrointestinal SQUID Technology (GIST) laboratory is to investigate gastrointestinal (GI) diseases non-invasively using Superconducting QUantum Interference Device (SQUID) technology. Our lab is equipped with a Tristan 637i SQUID biomagnetometer (Fig. 5) located in a magnetically silent shielded room (Fig. 6), which also contains a patient bed that can be automatically raised or lowered using a pneumatic pump system (Fig 7). The experimental setup of the magnetogastrogram (MGG) is shown in Fig. 4.

GEA ellipsoidal modeling

The goal of this project is to investigate GEA in an idealized geometry similar to that of the stomach, where the electrical physiology of this organ can be investigated within the framework of an analytic mathematical model involving the concept of the electric current dipole. In the context of the quasistatic approximation to Maxwell's equations, such a dipole represents the approximation of a current with spatial extent by a unique current dipole vector. Fig. 1 shows simulations of current dipoles propagating along the idealized stomach with various orientations with respect to its surface. Fig. 2 shows an electric potential activation front propagating along the stomach with a frequency of 3 cpm; current dipoles are shown in red at the edge of the front, slowly advancing toward the pylorus. In Fig. 3, simulated GEA waveforms are presented.



5. SQUID magnetometer in the Vanderbilt GIST Lab



6. GIST lab shielded room



7. GIST patient bed with pneumatic pump system

FEM/BEM imaging of the GI tract

The goal of this second project is to study GI physiology using a realistic FEM/BEM model based on data available from the Visible Human Project. A 3D visualization of the torso and GI system reconstructed from these data is shown in Fig. 8. Similar views are presented from different angles in Fig. 9, where the position of the stomach within the torso is emphasized.

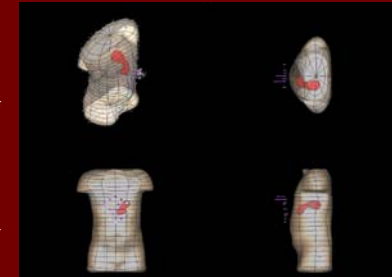
Fig. 10 shows two-dimensional maps that associate frequency intervals of the MGG AR spectrum with specific anatomic locations on the surface of the human abdomen. The gastric signal is strongest, as shown on frequency map no. 4, which is associated with the 3-4 cpm frequency range. In Fig. 11, the anatomic model from Figs. 8-9 is used to simulate duodenal electrical activity (DEA) as well as the electric and magnetic fields that are produced above the human body by DEA. The current dipoles producing these fields are shown in Fig. 11 as green arrows propagating along the GI tract. Electric and magnetic field vector arrows are shown above the abdomen at locations corresponding to SQUID magnetometer sensor positions.

References

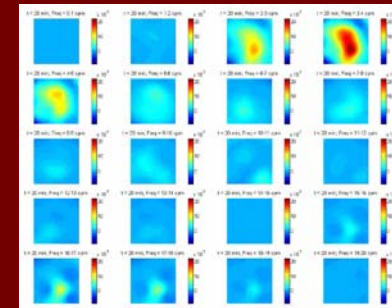
- [1] A Irimia, LA Bradshaw (2005) Ellipsoidal forward modeling of gastric electrical activity *Phys Med Biol* to be submitted
- [2] ML Buist *et al.* (2003) Modeling GI electrical activity *Digestive Diseases Week* Orlando FL USA



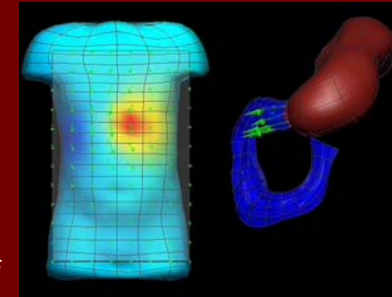
8. Anatomic model for GI modeling [2]



9. Imaging of the stomach and torso



10. 2D frequency maps of GEA



11. Duodenal electrical activity imaging