Accurate conductivity model of the human abdomen for electrogastrography

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ABSTRACT: *Electrogastrography is a non-invasive method for obtaining information of electrical activity of the stomach. Due to non-invasiveness, it may be useful tool in routine diagnostic use, but because the nature of electrical activity of the stomach is not completely clear, it is not in everyday use. Electrical modeling may solve some unexplained questions. We present an electrical conductivity model, which takes into consideration the inhomogeneities of human body and anatomical shape of the stomach. Two three-dimensional models have been made, one based on the anatomical data of Visible Human, and other on CT images of a healthy subject. These models enable a more detailed analysis of the reflection of the effect of electrical activity of the stomach to the abdominal surface.*

1. INTRODUCTION

The normal electric activity of the stomach is a periodical signal which controls the mechanical muscular action of the stomach wall. In this sense, stomach works like the heart, electric signal controlling mechanical action. However, the signal is very slow and weak compared to the heart's activity. The recording of the electrical activity of the stomach can be done in various ways, invasively or non-invasively. Non-invasive methods are usually called electrogastrography (EGG). EGG has been for a long time a promising method of obtaining information of electrical activity of the stomach [1]. However, due to the lack of information of the relationship between the mechanical and electrical action of the stomach, it has not been in routine clinical use.

This work is an attempt to construct as accurate volume conductor model as possible with the goal of getting more information of the electrical nature of stomach's activity. It is known that various diseases e.g. motion sickness and medical drugs affect on the activity of the stomach[2], and this model can also be an effective tool in understanding these effects[3].

2. METHODS

The volume conductor model is constructed from a set of anatomical tomography images, which show major tissues and organs. The tissue segmentation is based on IARD method, which was originally developed for brain tissue segmentation[4]. This method can be applied in the segmentation of the thorax[5]. Because heart was possible to segment, it was obvious that stomach could be segmented as well and thus an electric model of the thorax including the stomach could be created. After the tissues are segmented, resistivity values for different tissues can be given to the model. The computation of the electric field inside the volume conductor is based on finite difference method (FDM) [6,7].

The two models presented here take into account all major anatomical inhomogeneities. One model is created with Visible Human Man (VHM)[5] anatomical data and another one is done with CT images of a healthy subject. Reason for this is that although VHM data is easy to segment and all organs and tissues are clearly visible, the images are taken from a cadaver and therefore the anatomy may differ from a living person. Other reason for this is that from a living subject, the EGG signal can be recorded and therefore applied in this model taking into account the real electrode placement and other information of the subject.

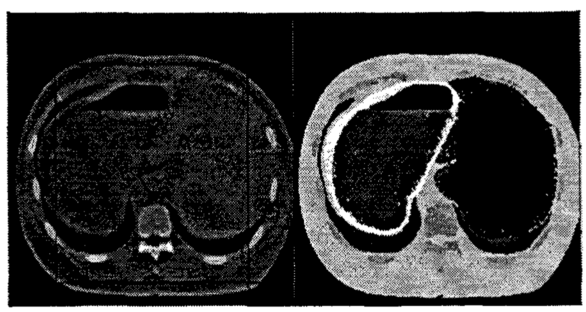

Figure 1. A screenshot from the segmentation program. One of the original CT slices on the left and the corresponding segmented slice on the right. Tissues which have been segmented in this picture are stomach wall, liver, bones and lungs.

For CT imaging, the stomach of the subject was filled with water and a section of the trunk on stomach level was scanned. The model is made from image set which contains 69 slices.

Once the three-dimensional conductivity model is constructed it can be used in different simulation studies. A specific header data format has been declared which allows easy modification in selected source configurations and simulation setup. For example resistivity values of the modeled tissues can be modified at this stage without altering the actual geometry of the model.

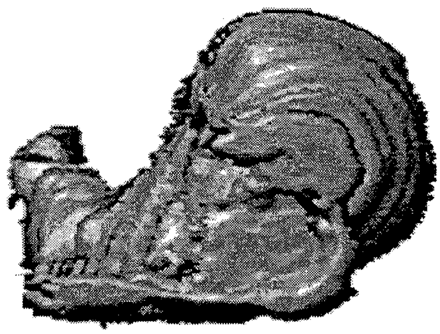

Figure 2. A 3-D representation of human stomach, reproduced from the segmented data.

3. DISCUSSION

Uniform, homogenous models have been used for the trunk in modeling of stomach's activity, but these are not anatomically very accurate[3,8]. Another problem in modeling is how the shape of the stomach is implemented in model. These two approximations are avoided when the model is created from actual anatomical human data, e.g. CT or MR images. Also, the inhomogeneities of the thorax can be taken into consideration more easily. Typically these are other organs, bones and other tissues, e.g. fat.

Thus, by using real anatomical data and finite difference methods in modeling of the electrical activity, we are closer to the reality than using simple mathematical approximations. However, when the anatomical shape and electrical properties of tissues e.g. resistivity are implemented in the model, the key problem is to model the actual source.

This kind of conductivity model gives a possibility to solve both forward and inverse problems in bioelectromagnetism and different source models can be applied in it. Already similar models have been used in brain and heart research e.g. for calculation of the measurement sensitivity of impedance cardiography or ECG[7,9]. This is one of the first anatomically realistic models used in electrogastrography research, and may help in understanding the relationship between mechanical and electrical activity, electrical nature of the stomach. The model could be used in e.g. simulating various diseases and finding an optimal placement of measuring electrodes.

4. CONCLUSION

Using an accurate conductivity model in electrogastrography studies may increase the understanding of this electrical activity in different states of the stomach that offer this non-invasive research method more credibility in routine use.

5. REFERENCES

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