Effect of Cerebrospinal Fluid on the Sensitivity Distribution of EEG and MEG

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Abstract: The relative merits of the EEG and the MEG may be compared by comparing their half-sensitivity volumes (HSV), i.e. ability to concentrate their measurement sensitivity on a limited region of the source area. It has been previously shown that in a spherical three-cell head model the EEG is more capable in concentrating its measurement sensitivity than the MEG. In this study we examined what is the effect of the cerebrospinal fluid (CSF) to the HSV. We found that the CSF, because of its better conductivity, increases HSV of the EEG. Despite of that, the EEG is still more capable in localizing its measurement sensitivity than the MEG.

INTRODUCTION

Since David Cohen made the first measurement of the magnetic field induced by the electric currents of the brain [1] it has been believed that because the skull is transparent to the magnetic field, the MEG should be more capable in concentrating its measurement sensitivity in a small region of the brain than the EEG. It was also believed that the MEG should measure something different from the brain's electric activity than the EEG. Our theoretical calculations [2] have shown that neither of these assumptions are true. We have used a three-shell spherical head model and a concept of half-sensitivity volume (HSV) to investigate the spatial resolution of EEG and MEG for superficial sources. We found that the half-sensitivity volumes of both the two-electrode and three-electrode EEG are smaller than that of the planar gradiometer MEG. Only the micro-SQUID MEG device is capable of recording the brain's electric activity with a slightly smaller HSV than the EEG.

Our earlier model did not include the layer of cerebrospinal fluid (CSF) between the skull and brain. In this paper, we study the effect of CSF on HSVs.

METHODS

To investigate the EEG and MEG detectors' ability to concentrate their measurement sensitivity we used the concept half-sensitivity volume. The HSV is the volume of the source region, in which the detector's sensitivity is more than one half of its maximum value in the source region [2]. If a source is homogeneously distributed, the smaller the HSV is, the smaller is the region from which the detector's signal originates.

We used a spherical model of human head to calculate the sensitivity distributions. It included four concentric spheres bounding the regions of the brain, CSF, skull, and scalp. The resistivities of the brain and scalp regions were 222 Ω-cm, that of the skull was 17,600 Ω-cm, and that of CSF was 65 Ω-cm. The scalp, skull and CSF had radii of 9.2 cm, 8.5 cm, and 8.0 cm, respectively. The calculations were made with different thicknesses of CSF layer, thus, the radius of the brain was changed accordingly.

RESULTS

Figure 1 presents the effect of the depth of the cortex on HSV of MEG and EEG. The HSV is given as function of detector separation for planar gradiometer, two-electrode lead, and three-electrode lead. The depth of the cortex has the strongest effect on the HSV of electric leads due to the low resistivity of CSF. HSV of planar gradiometer is affected only due to increased measurement distance.

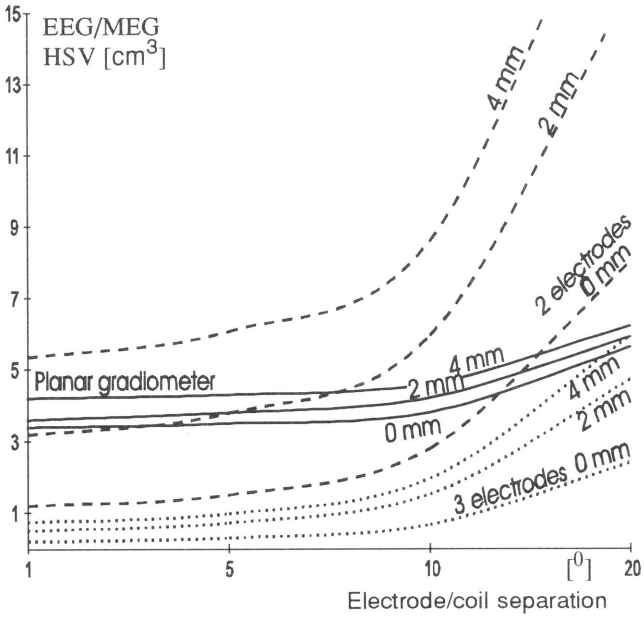

Figure 1: The effect of the distance of the cortex from the skull on the HSVs of electric and magnetic leads. The results are calculated for 0, 2 and 4 mm thickness of CSF layer.

DISCUSSION

The depth of the cortex - or in other words - the thickness of CSF layer increases the HSV of EEG. Despite that, however, EEG is still competitive method if small electrode distances are used.

REFERENCES

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