§9. Measurement Cardiac Magnetic Field

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Electrical current generated by the heart produces a weak magnetic field both within and outside the body. Electrocardiography (ECG) records the potential difference between two. The cardiac current also produce magnetic field, which is extremely weak (about 10pT), being one millionth as strong as the earth's magnetic. Thus, it has been very difficult to measure the cardiac magnetic field (magnetocardiogram: MCG). With development of SQUID (superconducting quantum interference), measurement of MCG became possible.

We measured MCG of normal subjects and patients with various cardiac diseases and the usefulness of MCG was tested. MCG has following advantages:

1. MCG can be recorded without touching the body. It is suitable for evaluation of the DC shift of the ST segment.
2. Pairs of dipoles with opposite direction and equal size show no potential difference, but produce a strong magnetic field. Accordingly, the MCG is useful for the detection of multiple dipoles.
3. The strength and location of a current dipole can be estimated by the analysis of isofield maps, aiding in the localization of sites of abnormal electrical activity in the heart.
4. The magnetic permeability of various human tissues is almost equal to that of a vacuum, so the influence of the tissues lying between the sensor and the current source can be neglected to some degree in magnetic measurements.
5. Magnetic flux is a vector quantity that has components in three dimensions.
6. Measurement of the magnetic field perpendicular to the anterior chest wall is a very sensitive method for detecting tangential currents.

Thus, the MCG is clinically useful for the diagnosis of right atrial and right ventricular overload, for localizing abnormalities of ventricular repolarization, and for the detection of multiple dipoles.[1,2] It is also expected to detect myocardial abonormalities due to radiation.

Although the MCG and ECG signals both arise from the same current source, the data that can be deduced from MCG and ECG are not exactly the same. The use of a combination of the ECG and MCG can enhance ability to locate cardiac sources.

References

1) Nakaya, Y., Magnetocardiography. Clin. Phys. Physiol. Meas. 1992; 13:191-229.

2) Nakaya, Y., Yukinaka, Y., Nomura, M., Kishi, F and Sito, K., Analysis of electromotive force by magneto-cardiogram. – Is the origin of initial QRS force (septal vector) of electro-cardiogram intraventricular septum? Proceedings of Biomag '96 , p. 232