

論文の内容の要旨  
Abstract of Dissertation

Simultaneous measurement of cardiac action potential and intracellular calcium with an accurate registration method

(高精度画像レジストレーション手法を用いる  
心筋細胞膜活動電位と細胞内カルシウムイオンの同時計測).

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Abstract

Recently it was suggested that “Calcium sinkhole” would have important role in generation of arrhythmia phenomena. But this phenomenon is very difficult to be measured, so the precise mechanism of calcium sinkhole is still unclear. In order to analyze this phenomenon optical mapping with accurate simultaneous measurement of membrane potential and intracellular calcium, with high spatial resolution is needed in order to visualize this phenomenon.

In order to study various mechanisms of arrhythmia, optical mapping system is a powerful method. There are many reports about optical mapping system that deal with dual measurement of membrane potential and intracellular calcium, however actual registration method had not been established. In order to analyze shock induced wave propagation of action potential and intracellular calcium, it was developed dual mapping system using a new image registration method, consisting of camera calibration, corresponding point-based registration using laser and mutual information as a registration method for alignment respective optical fluorescence images.

Optical System configuration consists of 2 high speed CMOS digital as well as a customized LED ring light that was used as excitation light source. The fluorescence from the stained heart was collected through an optical configuration system that separates membrane potential and intracellular calcium signals using a specific dichroic mirror and optical filters

Evaluation of the registration of experimental data set in the Langendorff perfused rabbit heart, reveals that the accuracy of the registration obtained was  $RMSE=1.38\pm 0.70$  pixel on Experimental data set 1 and  $RMSE=0.76\pm 0.38$  pixel on Experimental data set 2, on the alignment process of the images. Then was measured point electrical shock induced virtual electrode phenomenon using this system in rabbit heart specimen.

The experimental protocol consist of two stimulating electrodes, S1 (pacing) and S2 (monophasic cathode shock stimulation) at S1-S2 coupling interval (150~290 ms) with intervals of every 10ms. The line connecting S1 and S2 sites was parallel to the epicardial fiber orientation. After 4 S1 stimulations, a S2 was applied with a stimulus strength ranging from -20v to -30V. The pulse duration was 10 ms.

Initial experiment results using rabbit hearts reveals that action potential wave propagation and intracellular calcium wave started at the same time simultaneously from Virtual Anode area induced by shock stimulation. Results indicate that  $Ca_i^{2+}$  wave didn't started before  $V_m$  wave. Of course this experiment was performed in more simple and basic condition than the previous research that electrical shock applied during complex ventricular tachycardia condition.