

Defibrillation Current Density Imaging in a Live Pig
Invited Lecture, World Congress on Medical Physics and Engineering,
Seoul Korea, August 2006

M. L. G. Joy⁺, T.P. DeMonte⁺, D. Wang⁺, A.W. Ma⁺, A. I. Nachman⁺, D. Jorgenson*
⁺ IBBME, University of Toronto Canada,
^{*}Phillips Medical Systems – Seattle, USA

The goal of this work was to use current density imaging to determine the effect of defibrillation electrode placement on the distribution of current in the heart of a small (4.0-4.6kg) anesthetized pig. Three pediatric defibrillation electrodes were placed; over the apex of the heart, over the outside of the front right leg and over the upper back. Current was applied in two ways: AA) between the first and second electrode or AP) between the first and third. Current Density images were made for each of three states: IV) regular cardiac rhythm, VF) ventricular fibrillation, PM) after euthanization.

A Fast GRE current density imaging sequence was used. For the IV state this was synchronized with the natural heart beat using a pulse oximeter. Data was gathered during diastole. For the other states data was gathered continuously. The width of the 60mA current pulses was 4.7 ms and the Voxel size was 3.8 x 3.8 x 3.8 mm for all experiments with 64 slices covering the whole body.

Each 3D CDI image required data acquisition in three physical orientations of the pig. In the IV state each acquisition took about 12-15 minutes including the time required to reorient the pig. In the VF and PM states the acquisition time was 5 min. Thus total imaging time for a complete VF or PM study was 5 min x 3 orthogonal positions x 2 electrode configurations = 30 min. Currents up to 140 mA were used.

The data was processed by standard CDI algorithms to produce a three dimensional current density vector at each pixel whose neighboring pixels had a magnitude SNR greater than 3 in every orientation. These current densities were processed statistically over segmented regions of interest in the heart. For the PM state they were also used to compute the relative conductivity using the CDII formula.

The current distribution was clearly different for the different electrode positions. The average current density, for the same applied current, was higher for the AP orientation. However, when normalized to the same average current density, the histograms of the current over the heart in AA and AP were strikingly similar.