# Defibrillation Electrode Position Study Using Current Density Imaging

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INTRODUCTION AND METHODS: The MRI technique Current Density Imaging (CDI) [1] was used to measure current density vectors in a pig in successive states of ventricular fibrillation (VF) and post-mortem (PM) for direct comparison of results. Typical Automatic External Defibrillation (AED) electrodes were placed in the two common clinical configurations: apex-anterior (AA) and apex-posterior (AP) as shown in fig. 1. Currents ranging from 58 mA to 140 mA were applied to the electrodes and the current vectors were measured throughout the whole body of the pig using a low frequency fast GRE CDI sequence. Both AA and AP electrode configurations were measured consecutively on the same 4 kg animal first for VF followed immediately by a repeat of the same measurements for PM (PM1) followed again by second PM acquisition (PM2). All of these datasets were acquired within 1.5 hours. Imaging parameters included 128 x 128 x 64 voxels with a size of 3.8 mm^3, TR of 10 ms and current pulses of 4.7 ms duration. Streamlines were computed for vector data to compare directions of current flow. The anatomical MRI data was used as a guide to perform segmentation of the heart and its ventricles. Statistics were performed on the current density magnitude data in the heart including cumulative distribution plots.
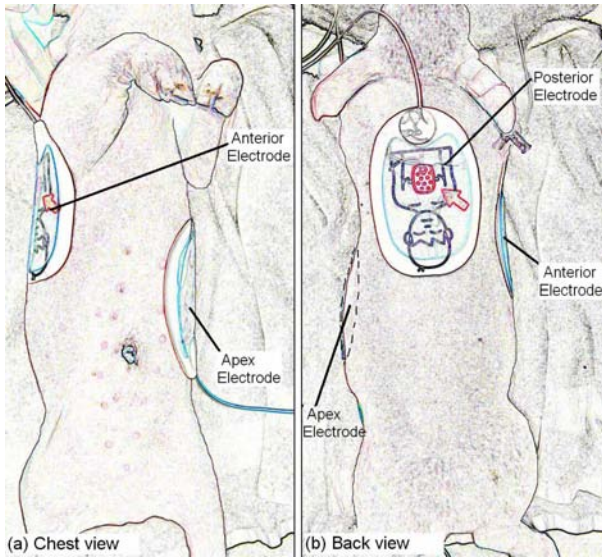

Fig. 1: Positions of AED electrodes on pig: (a) chest view showing AA configuration and (b) back view showing AP configuration.

RESULTS: Vector plots (blue arrows) and streamlines (red curves) are shown overlaying MRI isosurface data for VF AA and AP data in fig. 2. The streamlines shown in fig. 2 are all located inside the heart. A comparison of figs. 2(a) and (c) and figs. 2(b) and (d) clearly demonstrates that direction of current flow is highly dependent on electrode positioning even deep into the tissue i.e. inside the heart. One way to compare all of the data is to plot cumulative distributions of current density magnitude data in the heart as in fig. 3. In fig. 3, the red (solid) line is the cumulative distribution for AA data, the blue (dotted) line for AP and the blue (dash dot) line is AP scaled such that the 50th percentiles of the AA and AP data are matched. The slopes of the curves indicate variance in the data and curves positioned further to the right indicate higher current density values. The distributions show that more current reaches the heart for AP and there is a larger difference between AA and AP during VF compared with PM. The curves also show that distributions of current density magnitudes for AA and AP are similar after scaling. This work demonstrates that CDI can be used as an effective tool to measure electrode efficacy for different electrode configurations.

REFERENCES: [1] G. C. Scott et al. *IEEE Trans. Med. Imag,* **10**, No. 3, pp. 362-374, 1991.
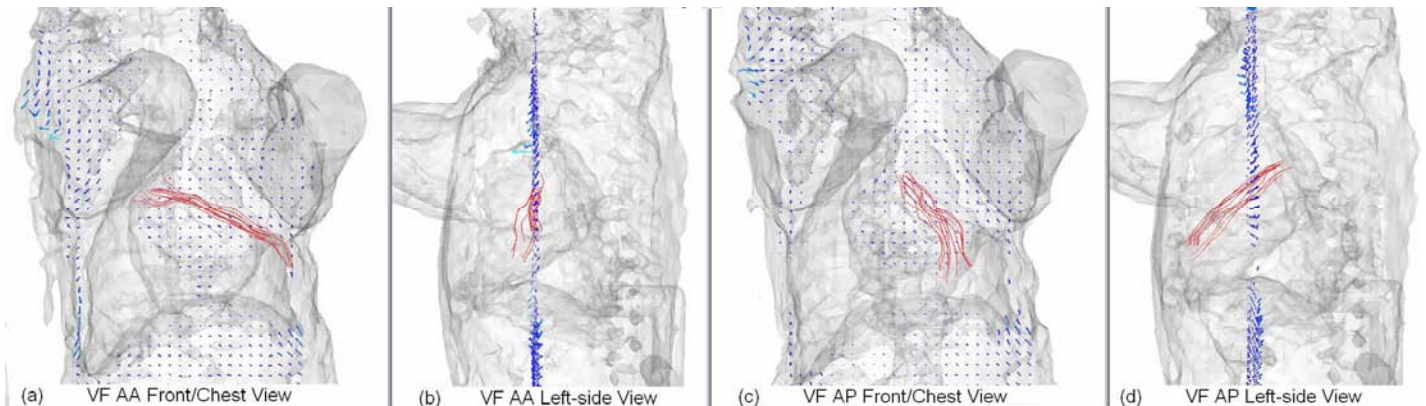
Fig. 2: Vector plots (blue arrows) in a plane and streamlines (red curves) through heart for (a) and (b) AA and for (c) and (d) AP electrode positions.
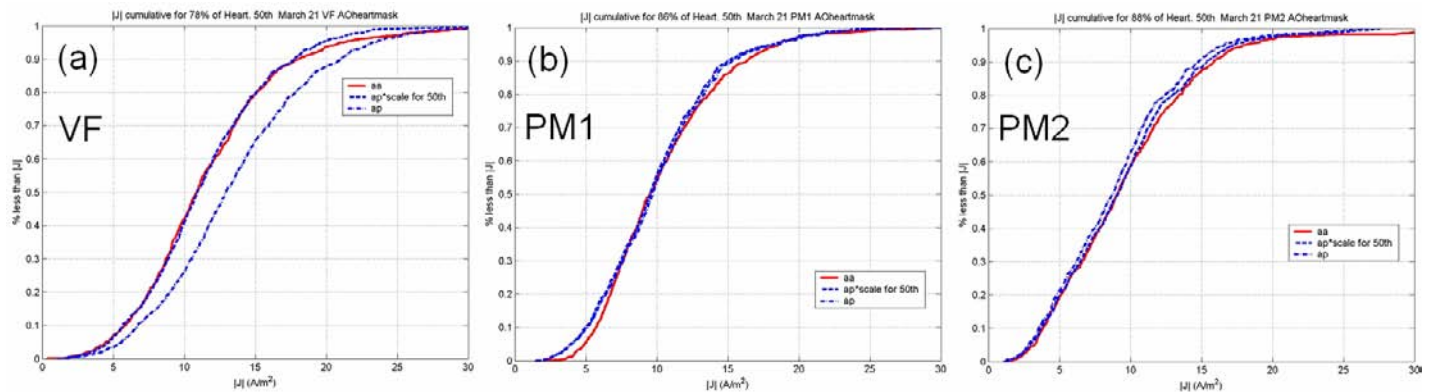
Fig. 3: Comparison of AA and AP cumulative distributions of current density magnitude in the heart for (a) VF, (b) PM1 and (c) PM2 (1/2 hour post-mortem).