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ACC.13
62nd Annual Scientific Session & Expo
TCT@ACC-i2

E1832
JACC March 12, 2013
Volume 61, Issue 10

TCT@ACC-i2: Invasive and Interventional Cardiology

MYOCARDIAL ABLATION AND DECELLULARIZATION BY IRREVERSIBLE ELECTROPORATION: A NOVEL NON-THERMAL NON-PHARMACOLOGICAL BIOPHYSICAL APPROACH

Poster Contributions
Poster Sessions, Expo North
Sunday, March 10, 2013, 3:45 p.m.-4:30 p.m.

Session Title: Preclinical and Translational Research
Abstract Category: 52. TCT@ACC-i2: Translation and Pre-clinical Research
Presentation Number: 2111-244

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Background: Irreversible electroporation (IRE) is an emerging cell ablation modality based on the biophysical phenomenon of electroporation. It can induce significant ablation of biological tissues with minimal heat generation and no damage to extra cellular components. We aimed to test the hypothesis that IRE can be used as a non-thermal ablation modality for heart decellularization.

Methods: We used finite element simulation models to determine optimal IRE protocols. Safety and efficacy of in-vivo IRE were evaluated with two needle electrodes in an open thoracotomy rodent model, comparing six different protocols. Degree of ablation was determined by histologic analysis at day 7. This experiment was followed by an in vivo experiment (N=24) which compared myocardial damage of three IRE intensities (500V, 250V and 50V) with that of a rodent model of myocardial infarction (MI). Animals were followed for 28 days. Echocardiographic evaluation was performed at days 0, 7 and 28. The extent of myocardial damage was determined by histologic analysis at 28 days.

Results: Computer simulation showed that 10 direct currents of 100 microsecond pulses at a frequency of 1 Hz do not induce a significant increase in temperature. In vivo IRE induced myocardial cell death within seconds, without significant arrhythmias or heart failure. Histologic analysis showed that an IRE protocol of 500V induced a 60% reduction in myocardial thickness at day 7. Echocardiographic analysis at 7 and 28 days showed significant deterioration of ejection fraction and fractional shortening in the 500V and MI groups compared with 250V and 50V groups ($P<0.05$).Histologic analysis at 28 days showed that the percentage of scarred myocardium was 36%±18%, 11%±10%, 8%±6% and 3%±4% in the MI, 500V, 250V and 50V groups, respectively.

Conclusion: Our study describes for the first time an irreversible electroporation protocol that selectively ablates cellular components in the beating heart with no thermal damage. This modality can be used as a novel clinical tool for myocardial tissue ablation to treat arrhythmias and obstructive hypertrophy, as well as to generate natural scaffolds for myocardial tissue engineering.