Model of the Cardiac Defibrillation Induced By an Implantable Defibrillator in the Body

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Abstract

The use of cardiac rhythm management (CRM) devices is the first choice of therapy for the treatment of slow heart rate (bradycardia) and abnormal heart rate (tachycardia). A Pacemaker (PM) is a device implantable inside the body able to deliver low voltage electrical signals to the heart, to increase the cardiac pacing rate and relieve the symptoms of bradycardia. An Implantable Cardioverter Defibrillator (ICD) is a device implantable inside the body, able to deliver the same therapy of a pacemaker, while also inducing a high voltage cardiac defibrillation to correct cardiac arrhythmia. In Europe in 2013, PM implantations were about 530 per million inhabitants and ICD implantations were about 100 per million inhabitants. In Europe and America, numbers of implantations have been increasing in the last decades due to an increase in life expectancy and changes in dietary habits.

Despite the good results of CRM treatments achieved so far, manufacturers continuously research to improve the efficiency of their therapies, specifically to guarantee the efficacy of the therapy with the least invasiveness of the implant. For high-voltage defibrillation, the efficiency of the therapy is obtained by reducing the energy required to deliver the therapy. Low amounts of energy allow for smaller device dimensions, increasing the comfort for the patient and simplifying the implant procedure.

To this purpose, clinical studies are usually conducted to test new configurations of devices, commonly through animal and human testing, which represent expensive and complex experimental practices. Clinical simulation is an emerging testing alternative that aims to predict product performance and allows for reducing the burden of the animal testing. In the early feasibility testing of a new product, clinical simulation intends to select the most promising configurations for the animal testing that will be conducted at a later stage.

For clinical simulation, Microport Scientific Corporation, in collaboration with Synopsys Inc. using Simpleware™ software, has developed a model of a human torso, importable to COMSOL Multiphysics® and able to simulate cardiac defibrillation for different ICD configurations. CRM Devices can be imported in the model geometry and virtually implanted in the body, similar to the real clinical implantation. Electrical resistivity is defined for each organ of the body and an electrical voltage applied between the device electrodes, modeling the real therapy delivery. Finally, the model has been validated with

respect to the product configurations commonly used for cardiac defibrillation. In Microport, this model is currently used in the feasibility study of new CRM products.

Figures used in the abstract

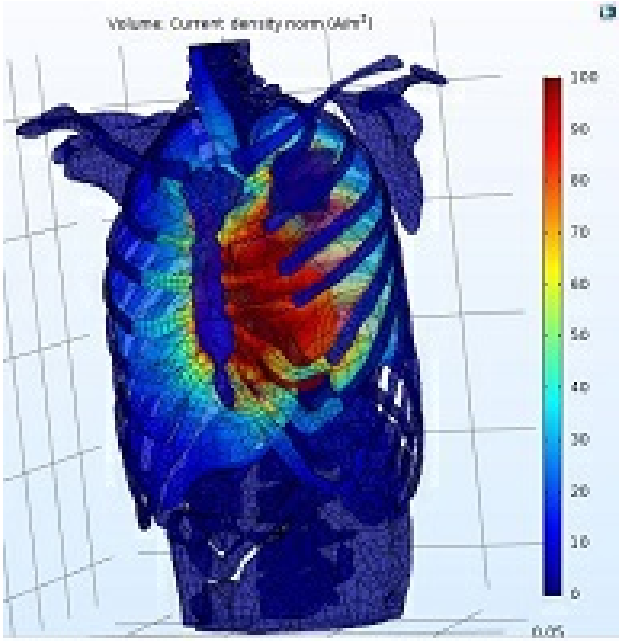

Figure 1: Current Density in the body induced by an Implantable Cardioverter Defibrillator.