5th International Conference on Computational and Mathematical Biomedical Engineering – CMBE2017
10–12 April 2017, United States
P. Nithiarasu and A.M. Robertson (Eds.)

COMPUTATIONAL ORGAN CRYOPRESERVATION

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Keywords: *cooling protocols, cryopreservation, rewarming, thermal stresses, optimized cooling*

1 BACKGROUND AND MOTIVATION

Despite the recent success in the normothermic preservation, hypothermic preservation is still considered as the best preservation method. Based on the “Q10 law” for cell metabolic rate variation with temperature, reducing the organ average temperature from +37°C to +4°C reduces the metabolic rate approximately by 95 percent [1]. As a result of reducing the cell metabolic rate, oxygen and glucose consumption and carbon dioxide production are decreased as well. Current effort in the cryopreservation community is to continue the cooling process to a deep freezing level to minimize the metabolic rate for an extended period of time, and then rewarm and implant the organ. That is, the objective is to cool and to rewarm the organ as fast as possible to minimize the metabolic decay, while keeping local thermal and hydrodynamic stresses during these protocols below certain levels to avoid permanent damage to the organ. Extensive experimental research has been performed in this area for the past half a century, but only a few numerical studies have been performed due to the complexity of such multi-disciplinary three-dimensional unsteady simulations [2-5].

The Organ Procurement and Transplantation Network’s (OPTN) policy prioritizes the organ allocation to the most critically ill matched patients. As part of this policy, OPTN defines five concentric geographical zones in the USA for organ allocation. In many cases, the donor and the recipient of the compatible organ are at vastly different geographic locations. Currently, the time limit for an explanted organ to remain viable for transplantation is too short for transportation to distant locations. An optimal cooling and rewarming protocol is a key in extending the current preservation time, thereby making transplant organs available to a large number of potential recipients.

2 TOPICS OF THE MINI-SYMPOSIUM

Due to its intrinsic multi-disciplinarity (interplay between fluid mechanics, heat transfer, phase change, thermoelasticity, electric and magnetic fields, chemistry, inherent unsteadiness, etc.), adequate mathematical modeling for the analysis of cooling and rewarming three-dimensional realistic human organs or parts of the organs and details of numerical algorithms with convincing computational results are sought that address topics such as:

- Fluid-solid unsteady interaction during perfusion with a cold/warm fluid
- Perfusion cooling of organs including several branching levels of vasculature
- Phase change latent heat release/absorption in unsteady processes in inhomogeneous organ tissue
- Unsteady thermoelasticity of non-isotropic organ tissues during perfusion and phase change
- Unsteady thermal runaway problem when applying EM fields during cooling and warming

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