15th International Symposium on Computer Methods in Biomechanics and Biomedical Engineering
and
3rd Conference on Imaging and Visualization
CMBBE 2018
P. R. Fernandes and J. M. Tavares (Editors)

Abstract ID-52

VALIDATION MEASUREMENTS AND COMPUTER SIMULATIONS OF THE NEWBORN'S BRAIN COOLING PROCESS

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Keywords: brain cooling process, cool cap, hipothermic therapy, Pennes bioheat equation, inverse analysis, validation measurements

Summary: The purpose of this work is to present the computational and experimental analysis of the neonate's brain cooling process. The brain cooling can be nowadays considered as a hypothermic therapy which allows to reduce significantly or even fully eliminate negative results of the hypoxic-ischaemic encephalopathy (HIE) which is still a relatively frequent problem encountered during childbirths (2 cases for every 1000 births).
The fully 3-D real geometrical model of the newborn's body is built using Mimics software and the Design Modeler and utilizing available MRI and CT scans. The developed model is based on the Pennes bioheat equation which allows one to determine temperature field within all neonate's tissues. The blood perfusion rate, metabolic heat generation rate as well as arterial and venous blood temperature are all dependent on the tissue temperature. In order to determine proper values of the model parameters an attempt to experimental measurements and inverse analysis, based on the standard least-square method, is also carried out. Those measurements include experiments with the own thermal mannequin, specially designed stand to register the heat rate within a cooling cap and the thermographic camera. Obtained model parameters were also compared to the data obtained from neonatologists and medical literature.
To implement the whole model, the Ansys Fluent with its User Defined Function capability was used. Tuned model was then applied to simulate the neonates' brain cooling process with a good accuracy and to determine of the proper time of the therapy individual for a patient. Obtained results are also compared to real hypothermic therapy. In this way the new protocol of the therapy and particularly its rewarming phase can be established in the safe way.