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Numerical Simulation of Phase Transfer during Cryosurgery for an Irregular Tumor Using Hybrid Approach

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Abstract : The infusion of nanofluids has dramatically enhanced the heat-carrying capacity of the fluids, applicable to many engineering and medical process where the temperature below freezing is required. Cryosurgery is an efficient therapy for the treatment of cancer, but sometimes the excessive cooling may harm the nearby healthy cells. Efforts are therefore done to develop a model which can cause to generate the low temperature as required. In the present study, a mathematical model is developed based on the bioheat transfer equation to simulate the heat transfer from the probe on a tumor (with irregular domain) using the hybrid technique consisting of element free Galerkin method with αα-family of approximation. The probe is loaded will nano-particles. The effects of different nanoparticles, namely Al_2O_3, Fe_3O_4, Au on the heat-producing rate, is obtained. It is observed that the temperature can be brought to (60°C)-(-30°C) at a faster freezing rate on the infusion of different nanoparticles. Besides increasing the freezing rate, the volume of the nanoparticle can also control the size and growth of ice crystals formed during the freezing process. The study is also made to find the time required to achieve the desired temperature. The problem is further extended for multi tumors of different shapes and sizes. The irregular shape of the frozen domain and the direction of ice growth are very sensitive issues, posing a challenge for simulation. The Meshfree method has been one of the accurate methods in such problems as a domain is naturally irregular. The discretization is done using the nodes only. MLS approximation is taken in order to generate the shape functions. Sufficiently accurate results are obtained.

Keywords : cryosurgery, EFGM, hybrid, nanoparticles
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