Mathematical model of breast cancer based on mechanical and biological properties of tissues developed for computer-aided personalized neoadjuvant therapy

Hanna Piotrzkowska-Wróblewska [13], IPPT, Polish Academy of Sciences
Czesław I. Bajer, IPPT, Polish Academy of Sciences
Bartłomiej Dyniewicz, IPPT, Polish Academy of Sciences
Mateusz Jacek Bajkowski, Warsaw University of Technology

Abstract: The paper presents a mathematical and numerical model of a breast cancer and proposes its use in predicting the growth rate of tumor and his response to applied neoadjuvant treatment. The following physical and biological properties of cancer tissue were taken into account in the mathematical model: V_T - concentration of cancer cells in the tumor, V_E - stiffness of the tumor and surrounding tissues (shear wave elastography), degree of tissue vascularization V_K - expressed as a percentage of the area of the tumor section occupied by blood vessels, p - percentage of cancer cells in during division (proliferation coefficient Ki-67) and the vector v, containing components of the apparent velocity of the movement of the field of active cancer cells. The model takes into account the relationships between all the variables mentioned above. The parameters values were the values obtained on the basis of the results of histopathological examinations of breast tumors (V_T and p) and ultrasound assessment (V_K vascularization - color Doppler, V_E stiffness - shear wave elastography).

Two stage of tumor evolution were considered. The first phase - longer - concerned the period of growth and the second one - shorter - included the time of treatment. It was assumed that time of growth of tumor lasting 36 months. This phase may to be shorter or longer, depending on the characteristics of the cancer The assumed treatment period of time was 20 weeks. However, the duration of therapy depends on the frequency of administration and the type of drug.

A computer program, was utilized to simulate the process of tumor development and phase of treatment based on clinical data. Numerical simulations of monitored variables derived from clinical data, have been presented. The proposed mathematical and numerical model can be applied to prediction the effects of treatment after particular phases of chemotherapy individually for every patient.

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[13] Speaker: hpiotrzk@ippt.pan.pl