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Numerical simulation of tumor growth-reproduction of Gompertz model

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Introduction: Malignant tumors are difficult to observe in the growth process, and clarification of the phenomenon is desired. Gompertz model is said to apply to the growth of malignant tumors. Therefore, we aim to carry out numerical simulation of the growth process of malignancy and reproduce the model of Gompertz.

Method: Introduce particle model as a simulation method. A particle model is a numerical analysis method that uses cell clusters as particles with physical quantities and tracks the movement of particles. In the analysis procedure, first, a blood vessel network is placed in a three-dimensional area, and cancer cell group particles are randomly generated.

Calculation conditions: Blood vessels elongate and diverge according to the amount of attractant from undernourished cancer cells nearby. The amount of attractant was inversely proportional to the amount of nutrition. For nutrient transport between blood vessels and cells, the diffusion equation is used. Cancer cells with high nutrient concentration were actively divided and those with poor nutrition were dormant. We considered the killing by immune cells and the killing by internal pressure.

Results: Figure 1 shows the number of cancer cells grown over time, and Figure 2 shows the cancer status at the end of the calculation. In the early stage, proliferation is inhibited by the influence of immune cells. In the middle stage, some cancer cells that escaped from immune cells increased rapidly. In the late stage, the growth rate became slower because the malignant tumor became larger and the nutrient supply into the tumor worsened.

Conclusions: We performed numerical simulations from the onset of malignancy. It was confirmed that the number of cancer cells proliferated matched qualitatively to the Gompertz model.
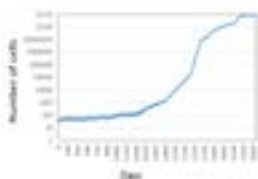

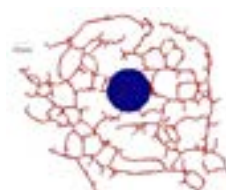Figure 1: The number of cancer cells grown over time

Figure 2: The cancer status at the end of the calculation

References:

1. Norton L (1988) A Gompertzian model of human breast cancer growth. Cancer Res 48: 7067-7071.
2. 2. Katsuya Nagayama, Hiroki Tomita and Ichiro Miura (2011) 3D Numerical Analysis of Blood vessel Network on Angiogenesis in Cancer Using a Particle Model. Theoreticaland and Applied Mechanics Japan, vol. 60 pp.353-357.

Biography

Katsuya Nagayama has his expertise in numerical simulation using particle model. The model was applied to express phenomena such as tumor growth, hair formation, skin turnover, alveolar bone regeneration and liver cell proliferation.

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