Mechanics in solid tumour growth

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Abstract

This talk will focus on the multiphase and the mechanical aspects of solid tumour growth from the avascular to the vascular phase. In fact, tumour cells usually live in a environment formed by other host cells, extra-cellular matrix and extra-cellular liquid. Cells duplicate, reorganise and deform while binding to each other thanks to adhesion molecules exerting forces of measurable strength. Some examples are then described, specifically focusing on contact inhibition of growth, nutrient limited avascular growth, interaction with the environment and vascular growth. In particular a mechanical model of solid tumour growth which takes adhesion mechanisms into account is described. The extracellular matrix is treated as an elastic compressible material, while, in order to define the relationship between stress and strain for the cellular constituents, the deformation gradient is decomposed in a multiplicative way distinguishing the contributions due to growth, to plastic rearrangement and to elastic deformation. On the basis of experimental results at a cellular level, it is proposed that at a macroscopic level there exists a yield condition separating the elastic and viscoplastic regimes. Previously proposed models are obtained as limit cases, e.g. fluid-like models are obtained in the limit of fast cell reorganisation and negligible yield stress. A test case is studied in detail showing how tumour growth can be influenced by stress, how and where it can generate plastic reorganisation of the cells and how it can lead to capsule formation and compression of the surrounding tissue.