Mathematical Modelling and Simulation of Inflammation as Immune Response - The Role of Hypoxia

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Abstract: Inflammation is a response of the immune system to disorders of the body caused for instance by infections. Modelling main processes involved in starting and stopping inflammation is leading to complex systems of differential equations describing flow, transport, diffusion, chemical reactions and interactions with mechanical structures, like vessel walls and tissue. Inflammation has an important impact on the perfusion and the supply with vital substances and the spread and the activities of immune cells.

The dynamics of inflammation and the availability of oxygen in blood and tissue are closely related. Oxygen is basic for the energy supply for cells, tissues and organs and affecting the activity of the immune system.

Depending on the specific situation, hypoxia may act pro-inflammatory. Cells may switch from aerobic to anaerobic energy production and generate by-products supporting inflammation. On the other hand, results of recent medical research indicate that hypoxia also may cause immune suppression, which my lead to a break down to the whole system. Modelling and simulation of relevant processes will help to analyse this situation.

In this lecture we present mathematical models and simulations of

- the formation of blockings of blood vessels, one of the causes of hypoxia
- the influence of hypoxia on the cellular respiration

We will discuss possible effects, which my lead to suppression of inflammation, and chal-lenges to future research in modelling, simulation and optimization.

The lecture is based on joint research with M. Neuss-Radu (Erlangen), G. Bocharov (Moscow), M. Thiel (Heidelberg), I. Yang (Heidelberg), V. Malieva (Heidelberg), integrated in the project "Scientific Computing for the Improved Diagnosis and Therapy of Sepsis", sponsored by Klaus Tschira Foundation and by BIOMS (Center for Modelling and Simulations in the Biosciences).

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