Second Workshop Radiotherapy & Mathematics

Title: Modelling of tumour hypoxia - the first step towards the Virtual Tumour

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Summary: The main problem in curing cancer resides in the different microenvironment in tumours than in normal tissues. All three components of tumour microenvironment, i.e. tumour vasculature, tumour oxygenation and tumour metabolism, contribute to the response of the tumour to a particular treatment. For radiation therapy in particular, tumour oxygenation is a very important factor that determines the biological effect of radiation. Tumour hypoxia, the lack of oxygen, is caused by a deficient vascular network and an increased interstitial pressure. Many studies have shown that poor tumour oxygenation is one of the main factors that determine the failure of radiation treatment. Therefore it is very important to account for the tumour hypoxia in the planning of the treatment in an attempt to identify the patients with poor oxygen supply to the tumours and to administer them tailored treatment strategies.

One alternative method to experimental work for characterizing quantitatively the tumour microenvironment is the theoretical simulation of the tissue based on measurable physical parameters. Thus, knowing the physical parameters of the tissue, one can use the equations that describe the fundamental physical processes in order to calculate theoretically the properties of the tissue microenvironment. In this respect, theoretical simulation of the tumour microenvironment is now the only available tool that may provide quantitative data for accurately describing tumour tissues. Thus, tissue oxygenation can be calculated starting from complex vascular arrangements and taking into consideration the oxygen diffusion into the tissue and its consumption at the cells. The results of the simulations could be used for modelling the tumour response to treatment or for investigating the efficiency of other measurements methods.

This presentation reviews important aspects that have been highlighted through the theoretical modelling of tissue oxygenation and in particular the relationship to vascular parameters. It also deals with the estimation of the efficiency of various measurement methods and the relationship between results obtained from different techniques. Particular attention has been given to resolution, averaging and other factors that may lead to systematic deviations of the measurement results. The role of the metabolic properties of the cells with decreased oxygenation was also taken into consideration for predictions of treatment outcome for full fractionated treatments. The findings stress the importance of incorporating hypoxia information into the biological modelling of tumour response for making clinical decisions. They also highlight the usefulness of theoretical simulation for evaluating the efficiency of strategies aimed to overcome the effects of tumour hypoxia.