New technology in radiotherapy

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Radiotherapy is a unique oncology field characterised by enormously fast technological progress both in imaging and treatment planning as well as in delivering planned doses of radiation. The aim of radiation therapy, however, still remains the same as at the beginning of this medical art – to destroy a tumour and spare healthy tissue. Nevertheless, despite technological development the cure rate of many cancers is still unsatisfactory and patients still suffer from side effects, even when undergoing currently available, sophisticated modern treatment methods. There have been continuous attempts to alter this situation and numerous efforts have been taken both in the field of imaging before treatment – to get better knowledge on the actual localisation of the tumour and its microscopic spread, as well as during treatment – for accurate set-up and tracking of both the tumour and the patient's anatomical changes. Development of advanced treatment planning systems allow us to prepare better, optimised virtual treatment plans, but we need to keep reminding ourselves that without careful verification of the treatment process even an excellent plan remains in the realms of fantasy. To close this gap efforts are being made to improve QA procedures and advanced imaging during treatment: the clinical value of Cone Beam Computed Tomography (CBCT), Megavoltage Computed Tomography (MVCT) and Magnetic Resonance (MRI)-guided radiotherapy are undergoing testing [1]. In tracking and dealing with the tumour and the organ at risk mobility is still a big challenge; new tools including robotic 4D real-time tumour tracking needs clinical validation [2]. Going further we face a challenge on how and when we should react to changes in the tumour and the patient during treatment and the real benefit of the so-called adaptive approach is still not clear. Under clinical validation there are tools and algorithms for advanced adaptive radiotherapy. Application of these algorithms is constrained by the computing power of computers used for calculations. Switching the data processing engine from a Central Processing Unit (CPU) to a Graphics Processing Unit (GPU) – similar to those used in computer games – will speed up the process of calculations, but not enough for advanced, fast on-line recalculation and adaptation of dose distribution [3]. Perhaps in the next era of quantum computing such calculations will be possible.

Unsatisfactory results of treatment lead us to look for new methods of delivering a high dose of radiation to the tumour while sparing the organs at risk. Methods of Stereotactic Body Radiation Therapy (SBRT) are of high interest, as they deliver a biologically high dose to the tumour, which should theoretically improve the outcome.

Different carriers of energy – protons or heavy ions – are in the future plans of many radiotherapy centres. Until now production of these particles has been very expensive and logistically difficult, but some new ideas like the Dielectric Wall Accelerator (DWA) [4] or laser-accelerated proton beams [5] seem to pave way for future solutions.

The hot topic of modern radiotherapy and nuclear medicine, often referred as to the "magic bullet" [6], the use of nanoparticles. The underlying idea is not new and has been known since the late 1960s. Nanoparticles are a "family" of carriers between 1 and 100 nm in size, which enables their easy incorporation into tumour cells and/or the vasculature. It is hoped that different forms of nanoparticles, like liposomes, dendrimers, quantum dots or carbon nanotubes, will allow for the passive transport of radionuclides to the tumour cells or active tumour targeting via molecular affinity [7].

Moreover, they could serve as multifunctional agents, for imaging and therapeutic purposes within the form of a single nanocarrier. Combination of these agents with cytostatics may potentially deliver new forms of chemoradiotherapy. Clinical validation of such an approach is awaited, but nanotechnology products are already in the pipelines of many manufacturers. Being modern radiation oncologists and having in our hands high-tech tools we have to remember that cancer is a biological condition and there is no progress possible in the radiotherapy of the

21st century without integration of technology with molecular biology and radiobiology. Henry Kaplan captured this in his great quote “If you want to treat Hodgkin’s disease, you must think like a Reed-Sternberg cell” [8] and every oncologist should keep this in mind. Available technology already provides tools for elegant, virtual dose-painting, but do we really know how and where to paint the dose?

Conflict of interest statement

The author declares no conflict of interest.

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