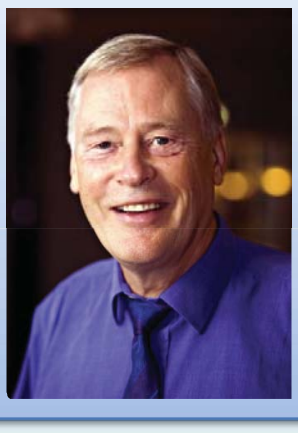
Plenary Speaker



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Talk title: Recent Developments in Photon and Light Ion Therapy

Background. The fast development of energy, intensity and radiation quality modulated radiation therapy (IMRT and QMRT) during the last two decades using photon and electron beams has resulted in a considerable improvement of radiation therapy, particularly when combined with radiobiologically based treatment optimization techniques. This development and the recent development of advanced tumor diagnostics based on PET-CT imaging of the tumor clonogen density opens the field for new powerful radiobiologically based treatment optimization methods. The ultimate step is to use the unique radiobiological and dose distributional advantages of light ion beams for truly optimized bioeffect planning where the integral 3-dimensional dose delivery and tumor cell survival can be monitored by PET-CT imaging and corrected by adaptive therapy optimization methods.

Purpose. The main purpose of this presentation is, to discuss the principal areas of development of therapy optimization considering the whole therapy chain from tumor diagnostics and patient fixation through therapy planning and treatment optimization to the repeated treatment setups and dose delivery on a patient that hopefully has a shrinking tumor and often may loose weight. Finally, it is the integral dose delivery and the biological effect distribution that matters so the shaping of the optimal incident beams is a truly complex inverse problem which is hard to solve by such a simplistic concept as a planning target volume.

Methods. The above introduction indicates that Biologically Optimized Adaptive Radiation Therapy (BioArt) is really the ultimate way to perform high precision radiation therapy using checkpoints of the integral dose delivery and the tumor response, and based on this information, performing compensating corrections of the dose delivery. By using biologically optimized scanned high energy photon or ion beams it is possible to measure in vivo the 3-dimensional (3D) dose delivery using the same PET-CT camera that was used for diagnosing the tumor spread. This method thus opens up the door for truly 3D biologically optimized adaptive radiation therapy where the measured dose delivery to the true target tissues can be used to fine adjust the incoming beams so that possible errors in the integral therapy process are eliminated towards the end of the treatment. Interestingly enough practically all major error sources can be corrected for in this way such as organ motions, treatment planning errors, patient setup errors, and dose delivery problems due to gantry, multileaf or scanning beam errors. When it is possible to quantify surviving tumor clonogens after the first week or two of therapy, this information can be used to also account for uncertainties in biological response data and really cover all clinical uncertainties at the same time as more accurate dose response data can be derived. The response of the PET-CT camera is related to the truly delivered integral dose with correct temporal averaging, thus if only small errors are seen, it is sufficient to adjust the last few treatment fractions. Thus, when using PET-CT tumor response monitoring, it is even possible to account for the uncertainty in biological response of the patient and to do real time in vivo predictive assay to perform truly biologically optimized radiation therapy.

Results. Several examples of radiobiologically optimized dose delivery are presented and examples of the above mentioned new treatment techniques are illustrated for a number of clinically relevant targets. The unique properties of light ion therapy in this context are also presented in more detail.

Conclusions. Using the recently available biologically based treatment optimization algorithms it is possible to improve the treatment outcome for advanced tumors by as much 10 – 40%. The adaptive radiotherapy process based both on 3D tumor cell survival and dose delivery monitoring has the potential of percent accuracy in tumor response and dose delivery, not least with 3D geometric Bragg peak scanning and intensity modulated ion beam dose delivery. There is no doubt that the future of radiation therapy is very promising and gradually more and more patients may not even need advanced surgery but instead could be cured by photon and electron IMRT and ultimately biologically optimized light ion therapy, where the high LET-RBE Bragg peak is solely placed in the gross tumor volume.

Biography

Dr. Anders Brahme is Professor of Medical Radiation Physics at the Department of Oncology-Pathology, Karolinska Institutet, and Department of Medical Radiation Physics, Stockholm University and Hospital Physicist at Karolinska University Hospital since 1988. He got his Master of Science degree in electrical engineering at the Royal Institute of Technology in 1969 and his Ph.D. thesis on the application of the Microtron accelerator for radiation therapy was presented 1975 at Stockholm University. Since then he has been active in the development of radiation dosimetry, quality assurance and radiation therapy equipment and techniques for most types of radiation from electrons and photons to neutrons, protons and light and heavy ions. He initiated the development of inverse radiation therapy planning and intensity modulated radiotherapy using scanning beams and dynamic multileaf collimator systems. During the last two decades he has been mainly active in the field of radiotherapy optimization using light ions and accurate radiobiological models describing the response of tumors and normal tissues. By such techniques he has been able to maximize the expectation value of the complication free tumor cure under consideration of intensity modulation, dose fractionation, radiation modality selection, the number of beam portals and their angles of incidence as well as uncertainties in geometrical and biological response parameters.

Anders Brahme