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CONFORMAL THERAPY: POTENTIAL GAINS AND PITFALLS

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Conformal therapy opens a new era in radiotherapy with precise delivery of high radiation doses to tumours in such a way that the radiation isodose curves just conform the often irregular shaped tumours. A three-dimensional treatment planning system and modern linear accelerators with multi-leaf collimators now allow much more individualized treatment techniques in order to deliver a higher radiation dose to the tumour while sparing the surrounding normal tissues. The potential gain of conformal therapy is therefore to increase local tumour control and to reduce dramatically the normal tissue volume which receives a high radiation dose, hereby reducing the percentage of late normal tissue complications.
There are, however, many pitfalls of this approach and these must be prevented before a real therapeutic gain can be expected. For example underestimating the tumour extension with CT and MRI results in too narrow margins for the irradiated area. Errors can easily be introduced in the complicated 3-dimensional dose calculation, in the transfer of data from treatment planning to simulator and to linear accelerator. However, new developments such as digitized reconstructed radiographs, in vivo dosimetry, on-line portal imaging, are now available to continue control of this complicated treatment approach. The therapeutic gain of treatment with this new approach is now investigated in many sites such as head and neck and lung tumours in soft tissue malignancies and prostatic cancer.

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RESULTS OF A RANDOMISED TRIAL IN PELVIC MALIGNANCY, QUALITY ASSURANCE AND REDUCTION OF MORBIDITY.

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The trial was designed to establish whether a simple conformal technique, in patients undergoing pelvic radiotherapy at conventional dose levels, could produce a detectable reduction in acute toxicity. Acute toxicity scores, determined by self-assessment questionnaires, were recorded before, during and for three months after radiotherapy. Two hundred patients have been entered, analysis is on-going and results will be presented. Data currently available shows an average reduction of 54% in the volume of rectum receiving 90% or more of the prescribed dose in conformal plans. Further analyses aim to establish correlation between peak toxicity scores and volume of normal tissue raised to different dose levels.
A quality assurance protocol using serial portal images was an integral part of the trial. The results will be presented and discussed in relation to planning margins required for conformal techniques

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POSSIBILITIES AND LIMITATIONS OF NON-HOMOGENEOUS DOSE DISTRIBUTIONS

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Optimization using a biological objective functions which maximize the probability of achieving tumor control without severe complications, P_+, have been performed for a number of different clinically relevant target volumes.
With external beam radiotherapy the target volume in many situations includes one or more concave sections. Such situations are common when treating for example breast, larynx, and cervix tumors. To obtain suitable dose distributions for concave target volumes, using the traditional treatment modalities with uniform or wedged beams, usually requires a large number of beam portals or arcs. Using large numbers of beam portals is time consuming, complex and may therefor result in an increased risk for mistakes. Because of this, treatment planning has traditionally been performed using dose distributions with a lower number of beams, resulting generally in convex isodose surfaces around the target volume. Treatments using convex shaped dose distributions on concave target volumes will always result in unnecessary irradiation of normal tissues or even organs at risk close to the target volume. However, if the fluence distribution of the radiation fields are allowed to vary, it is straight forward to obtain concave isodoses also with a low number of beam portals.
Optimization of dose plans, for a cervix cancer with involved regional lymph nodes, has been performed using both traditional treatment using homogeneous and wedged beams and using non-homogeneous beams. The results show that the use of non-homogeneous fluence profiles may increase the probability of complication free tumor control significantly. When using non-uniform beams a high precision in beam patient alignment is more important than with conventional treatment techniques. Another limitation is the treatment machines which rarely have the possibility to deliver non-homogeneous beam profiles dynamically. Since the required number of beam portals is low the use of compensators is also feasible.

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HEAVY CHARGED PARTICLES : A POSSIBILITY FOR PRESISE DELIVERY OF A HIGH RADIATION DOSE

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Heavy charged particle radiotherapy offers a unique possibility for precise radiation dose delivery. The physical parameters of charged particles offer attractive attributes for radiotherapy. These include sharp distal falloff at the end of the particle track, sharp lateral beam edges, and advantageous ratio of dose at depth relative to the entrance region and variable penetration up to a depth of 30 cm in tissue. The use of 3-D treatment planning, including techniques for image transfer from MRI to CT, facilitates highly advantageous conformal therapy. Each beam is individually shaped to the target volume and appropriate tissue compensation is utilized to account for tissue inhomogeneities and conform the stopping edge of the charged particle beam to the distal edge of the target volume.
Dynamic conformal charged particle therapy can be accomplished using a 2-D raster scanning technique, combined with variable depth penetration, either by varying the accelerator energy or introducing a variable absorber in the beam path. A combination of scanned beams results in a high level of conformation of dose to the desired target volume. Charged particles may also be used to treat target volumes encircling critical structures such as the spinal cord through appropriate shaping and joining of beams.
These techniques result in a higher ratio of dose in tumor relative to normal tissues, higher local and regional tumor control rates and improved survival for many difficult to treat tumors.
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