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Evaluation of the therapeutical potential of heavy ion therapy in patients with locally advanced prostate cancer

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The use of carbon ions in patients with locally advanced prostate cancer (PC) is very well constituted. This study was dedicated to the investigation of the feasibility of carbon ion therapy on the basis of physical dose distributions.

One of the aims of this work was to determine optimal beam directions for carbon ion radiation therapy (RT) in PC patients. Using the novel technique of an active beam delivery system we defined a class solution for the PC carbon ion therapy. As two opposed horizontal fields were found to be the best combination for carbon ion RT, a gantry does not add further improvement of the dose distribution for this indication in the majority of the patients.

Our investigations show, that carbon ion therapy delivers very homogeneous dose distributions. The 95% and 90% target coverage for the gross tumor volume (GTV) and the clinical target volume are extremely high with about 99%. The maximum dose to the rectum using two opposed horizontal carbon ion beams alone was 71.8 Gy in average. The clinically relevant maximum dose to the rectum ($Dr_{\max(V-1ml)}$) was less than 68 Gy.

It is the first analysis, which investigates the role of inner organ motion in carbon ion therapy in PC patients. We found, that the $Dr_{\max(V-1ml)}$ was increased by 6.6 Gy in average as a result of inner organ motion. This result has substantial clinical impact for the dose prescription.

In the frame of this work also the plan combinations of photon-IMRT (intensity modulated RT) and a carbon ion boost were analyzed with respect to inner organ motion. Our results show slightly but significantly better stability of the dosimetric parameters, if the combined method was used. The $Dr_{\max(V-1ml)}$ was increased by 4.7 Gy to 70.8 Gy in average, but further analysis of the volume of the rectum receiving more than 68 Gy shows an increase by less than 4 ml.

This study could show that safe dose escalation, excellent target coverage and decreased rectal toxicity are major characteristics of irradiation with heavy charged particles. The high precision and sharp dose fall-off requires special consideration of the patients fixation and inner organ motion. Therefore, a new approach to the RT of prostate cancer patients was designed to translate dosimetric advantages of heavy charged particles into clinical advantages.

The combination of photon-IMRT and a carbon ion boost to the GTV is a rational solution in order to introduce heavy ion RT for the treatment of prostate cancer patients. On the basis of the presented investigations a clinical phase I/II study combining photon IMRT with a carbon ion boost has been designed and submitted for approval. This allows further investigations to confirm the results of our treatment planning study in the clinical practice.