

Development of a Whole Body Atlas for Radiation Therapy Planning and Treatment Optimization

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The main objective of radiation therapy is to obtain the highest possible probability of tumor cure while minimizing adverse reactions in healthy tissues. A crucial step in the treatment process is to determine the location and extent of the primary tumor and its loco regional lymphatic spread in relation to adjacent radiosensitive anatomical structures and organs at risk. These volumes must also be accurately delineated with respect to external anatomic reference points, preferably on surrounding bony structures. At the same time, it is essential to have the best possible physical and radiobiological knowledge about the radiation responsiveness of the target tissues and organs at risk in order to achieve a more accurate optimization of the treatment outcome.

A computerized whole body Atlas has therefore been developed to serve as a dynamic database, with systematically integrated knowledge, comprising all necessary physical and radiobiological information about common target volumes and normal tissues. The Atlas also contains a database of segmented organs and a lymph node topography, which was based on the Visible Human dataset, to form standard reference geometry of organ systems. The reference knowledgebase and the standard organ dataset can be utilized for Atlas-based image processing and analysis in radiation therapy planning and for biological optimization of the treatment outcome. Atlas-based segmentation procedures were utilized to transform the reference organ dataset of the Atlas into the geometry of individual patients. The anatomic organs and target volumes of the database can be converted by elastic transformation into those of the individual patient for final treatment planning. Furthermore, a database of reference treatment plans was started by implementing state-of-the-art biologically based radiation therapy planning techniques such as conformal, intensity modulated, and radiobiologically optimized treatment planning.

The computerized Atlas can be viewed as a central framework that contains different forms of optimal treatment plans linked to all the essential information needed in treatment planning, which can be adapted to a given patient, in order to speed up treatment plan convergence. The Atlas also offers a platform to synthesize the results of imaging studies through its advanced geometric transformation and segmentation procedures. The whole body Atlas is anticipated to become a physical and biological knowledgebase that can facilitate, speed up and increase the accuracy in radiation therapy planning and treatment optimization.