Will linac gantry-mounted CBCT replace CT simulation?

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Introduction

Introduction of Image Guided Radiotherapy (IGRT) systems into clinical practice is rapidly becoming standard in radiotherapy centers. Since it now involves multimodalities upstream for planning as well as linac gantry-mounted imaging downstream for treatment verification, IGRT cannot be performed efficiently without readjustment of the radiotherapy workflow, especially with respect to the role of CT-simulation [1].

Material and Methods

In this work we have tested the feasibility of using the image sets of PET-CT diagnostic studies as reference for CBCT registration and patient marking. Our method involves five steps: (1) The diagnostic PET-CT images received from all our referring services are imported into our virtual simulation workstation (AcQPlan from Philips) and registered. (2) The GTV is delineated using both modalities images, the treatment isocenter calculated as the center of this GTV and orthogonal AP/LAT DRR's generated. (3) The CT images, the isocenter and the DRR's are exported into the linac image acquisition workstation as reference for simulation. (4) Fluoroscopic images of the patient lying on the treatment couch are taken with our linac X-Ray gantry mounted system (XVI from Elekta). Patient is approximately repositioned using the shifts obtained from registration with the DRR's. (5) A CBCT acquisition is taken with the patient in this position and the images registered to the reference PET-CT. The residual positioning errors are corrected by couch translations and the patient marked on the new position. Provided that CBCT can reliably be registered with PET-CT and provides images of sufficient quality for dosimetry planning, our method eliminates the need for a pure CT-simulation step. In the present work we however still performed subsequently a CT-simulation which allowed us to analyze the accuracy of our method.

Results

Up to the time of writing (July 7th 2008) we have tested our method for 5 patients with clearly visible lung tumors. All image registrations have been done manually using the standard software provided by the manufacturers. Average repositioning based on fluoroscopy was 0.9 cm and dropped down to 0.4 cm when CBCT was performed. However difference between isocenter positions based on CBCT and CT-simulation was 0.7 cm. Subsequent CBCT taken during treatment have shown this difference to be of the same magnitude than systematic repositioning shifts and can be attributed to the different respiratory artefacts between CBCT and SV as well as to the difficulty of setting up the patient into the right position.

Conclusion

Use of PET-CT and CBCT images as an alternative for standard CT-simulation looks like a promising method which would simplify the IGRT workflow. It will require however the development of special software capable of correcting the difference in position between diagnostic CT and treatment CBCT [2] as well as mapping their Hounsfield numbers. Once available the method will be cost effective since it avoids extra scans and replaces expensive sophisticated lasers systems for simulation.

References

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