Verification of Lung and Kidney Shielding in Total Body Irradiation using an EPID with Extended Image Detection Unit


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Introduction
Total body irradiations (TBI) for conditioning patients with leukemia prior to bone marrow transplantation (BMT) require time consuming verification of shielding block positions as well as dosimetric control. Short treatment times contribute to reproducibility and patient comfort and increase the accelerator capacity. To reduce setup time conventional port films were replaced by a prototype of an Electronic Portal Imaging Device (EPID) with Extended Image Detection Unit (IDU) suitable for our TBI technique.

Methods and Material
A Varian Clinac 2300C/D is used for conventional therapy and for TBI. The machine is equipped with a standard PortalVision system. For TBI the patient is treated in a second treatment room at a distance of 510 cm above the focus of a vertical beam. Each fraction is given with ap (patient prone) and pa (patient supine) beams. Individually shaped shielding blocks for lungs and also for kidneys (if preexposed by radio immuno therapy) are positioned on a lucite tray under the tabletop of the TBI treatment couch. The standard IDU of the PortalVision EPID consists of 256×256 liquid filled ion chambers and covers a sensitive area of 32.5×32.5 cm². In order to achieve a sufficiently large sensitive area for our TBI setup an Extended Image Detection Unit (IDU XL) was constructed by Varian. The IDU XL is composed by arranging four standard IDUs to a square resulting in an overall size of 65×65 cm² with an absolute spatial resolution of 1.27 mm. To avoid death space in the complete image, the IDUs are mounted with overlapping edges. Build up plates are optimized for treatments with 6MV photons. The XL detector is covered by a completely closed housing mounted on linear guiding rails at the ceiling. The detector can be moved out of the beam area to allow easy patient setup as well as to reduce exposure of electronic parts. The vertical distance from the tabletop can be adjusted. For clinical use we selected a fixed distance of 90 cm resulting in a covered area of 56×56 cm² and a spatial resolution of 1.10 mm referred to the position of the patient. Thus the region of the lungs together with that of the kidneys are shown in a single image. As a fully integrated part of the VARiS Vision network the PortalVision XL shares one central database with all other Visual VARiS applications installed in our department. This software package provides tools for image processing (e.g. contrast enhancement) and analysis (e.g. image matching) as well as import filters for digitized simulator films or digitally reconstructed radiographs (DRR).

Results
The mechanical support of the PortalVision XL detector system is easy to handle and allows fast and precise positioning. As the user interface for image acquisition and processing is identical to the standard PortalVision system no special training is required to operate the PortalVision XL. In
contrast to conventional port films the image acquisition time of about 2 seconds is negligible in the TBI procedure. The overall time for a TBI session could therefore be reduced by about 30% to less than half an hour. Depending on the selected acquisition mode the patient dose varies typically between 0.8 and 5 mGy for one image, i.e. the exposure of the patient for verification purposes can be significantly reduced up to one order of magnitude. These extremely low doses for image acquisition justify a simple procedure of positioning the shielding blocks: the evaluation of an image with roughly positioned blocks yields the needed shifts to get the planned positions.

The quality of the PortalVision XL images corresponds to that of conventional treatment portal images from the standard PortalVision and is suitable for verification of lung and kidney shielding blocks in TBI. The kidneys themselves can not be detected in portal images, neither acquired on film nor with EPID. The verification is therefore done by comparing the kidney block positions in portal images with segmented kidneys in imported DRRs in relation to vertebrals and external radioopaque markers (fig. 1 and 2).

Unlike conventional port films the PortalVision XL allows to monitor the patient’s positioning and block shielding during the whole TBI treatment. The image processing and analysis tools of the standard PortalVision software can be applied to the PortalVision XL images as well. Thus quantitative evaluation of setup errors is carried out faster and more precise as compared to conventional port films.

**Discussion and Conclusion**

The PortalVision system with extended IDU meets the clinical requirements with respect to the application in TBI treatments and replaces conventional port films. Moreover, the ionization chambers of the IDU may offer the possibility of transmission dosimetry, which makes this EPID a very promising device for in vivo dosimetric measurements.