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Digital portal imaging in Cobalt-60 radiation therapy

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Introduction:

Prior to the introduction of on-board kilovoltage X-ray imaging, portal imaging (that is, radiographic imaging with the megavoltage (MV) treatment beam) was the most effective way to verify the patient's position for external beam radiation therapy. Portal imaging began with film based detectors and evolved to digital detectors known commonly as electronic portal imaging detectors (EPIDs). While the use of EPID based portal imaging has diminished somewhat in modern radiotherapy delivered on kV imaging equipped linear accelerators, MV portal imaging continues to play an important role since it directly relates the treatment beam geometry to the patient bony anatomy.

Cobalt-60 (Co-60) therapy machines (which are still in widespread use in many parts of the world, due to their simplicity, reliability and relatively low cost) are generally not equipped for digital portal imaging. In this work, we show that the Co 60 unit's large source size and high energy are not insurmountable obstacles to effective digital portal imaging. An amorphous silicon EPID whose output is sharpened and histogram-equalized, produces Co 60 digital portal images that clearly show the necessary bony anatomy in the pelvic, thoracic and cranial regions. These results suggest a simple EPID-based workflow for treatment verification that is compatible with conventional x-ray simulation for treatment planning.

Methods:

The experimental setup comprised of a Theratron 780C cobalt-60 irradiator (BEST Theratronics, Kanata, ON) equipped with amorphous silicon EPIDs mounted on a free-standing cart. The EPID was either a XRD1640 panel (Perkin Elmer Optoelectronics, Fremont, CA) or an aSi500 unit (Varian Medical Systems Palo Alto, CA). The phantoms to be imaged were mounted on a 3-axis computer controlled positioning stage. The phantom and the panel were positioned at various source to axis/source to detector distances to investigate effects of imaging geometry. Specifically, SAD/SDD was set at 80/100, 80/120, 100/125 and 100/140 (dimensions in cm). The frame integration time for EPID acquisition was 133ms for the XRD1640 experiments (100ms for aSi500 runs) and 4 frames were averaged for each image.

The phantoms imaged were the anthropomorphic CIRS 801-P pelvis (CIRS, Norfolk, VA) and SBU-4 (Kyoto Scientific Specimens). These phantoms are designed to be representative of natural human anatomy.

Raw images from the EPID required post-processing to yield viewable images of acceptable quality. Image processing was done using in-house software written in MATLAB (Mathworks, Natick, MA). Global contrast adjustments (window and level) were found to be important, but not always sufficient, for extracting useful images from the raw EPID data. Additional techniques, such as iterative deconvolution and contrast-limited adaptive histogram equalization (CLAHE) were used to enhance images. For comparison, some images were also taken on a Varian 6MV linear accelerator with a built-in aSi500 panel.

Results:

Qualitatively, it was found that the post-processed Co-60 images were comparable to the ones obtained with the 6MV portal imager and that they are sufficient to identify bony anatomy. Deconvolution sharpening increased image quality as determined by measured point spread functions. CLAHE processing improved local contrast, thus overcoming the two main disadvantages one would expect of imaging using the Co 60 source.

Conclusions:

These results suggest that portal imaging in the treatment beam of a cobalt 60 unit, using modern amorphous silicon EPIDs, is possible and potentially useful. With some post-processing to enhance sharpness and contrast, the image quality achievable with the Co-60 system approaches that of a 6 MV linear accelerator's portal imager, and is adequate to identify key parts of the bony anatomy relative to the treatment beam.

It is not necessary to have a fully integrated, gantry-mounted EPID system to achieve some of the benefits of portal imaging. An independent EPID mounted on a mobile stand would be sufficient to produce portal images and double-exposure fields like those shown here. The only electrical interface required between the EPID and the Co-60 unit would be a source-out synchronization pulse.

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