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Short-scan CT paired with beam tailoring minimizes patient dose in radiosensitive tissues.

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Introduction: While computed tomography (CT) is a well-established noninvasive primary diagnostic imaging modality, ionizing radiation limits its clinical use. Tailoring the x-ray beam to focus on a region-of-interest (e.g. the heart) has been recently shown to reduce patient dose while maintaining image quality inside the ROI. Short-scanning (reconstructing images from $180^\circ + \text{fan angle}$) is also known to reduce patient dose but using these two approaches in combination for additional dose savings has not been explored. We utilize patient-derived segmentations to assess dose savings from scanning the heart with different dose savings approaches.

Methods: Patient-derived phantoms were generated based on labeling of contrast-enhanced chest CT angiograms (CTA) for a cohort of 6 patients ($N = 3$ females) with BMIs ranging from 21-35. For each phantom, a fan-beam acquisition was simulated with a conventional bowtie or tailored (CardiAcquire) filter. Image reconstruction was performed using a fan-beam reconstruction for 360 degree dataset as well as short-scan data using Parker weighting. For short-scanning, dose deposition depends on the views acquired and was calculated throughout the range of gantry positions. Deposited dose was quantified by calculating cumulative dose at three regions of the chest (right lung, sternum, and spinal cord) and was normalized to conventional scanning (full-scans with bowtie filtering).

Results: Short scanning reduced dose relative to full-scans by $61.3 \pm 5.7\%$ in the right lung, $86.6 \pm 3.4\%$ in the sternum, and $72.0 \pm 7.4\%$ in the spinal cord. CardiAcquire further increased the dose reduction to $96.5 \pm 1.2\%$ in the right lung, $94.2 \pm 5.0\%$ in the sternum, and $96.9 \pm 0.9\%$ in the spinal cord. The minimum dose for each region was localized to different, but consistent gantry positions: 167° for right lung, 83° for sternum, and 237° for spinal cord.

Conclusions: Beam tailoring and short scanning can be combined to achieve significant dose savings to tissues of interest. Furthermore, the gantry position which minimized dose for a region of tissue was consistent across our cohort which suggests increased clinical translatability.

Figure 1: Dose deposition in selected tissues (sternum, spinal cord, right lung) normalized to the dose from a conventional full-scan with bowtie as a function of gantry position. Red lines represent dose with a bowtie filtered short-scan per patient. Blue lines represent dose with a CardiAcquire short-scan per patient. The black dotted line represents the average full-scan dose across all patients using CardiAcquire. The blue dotted lines represent the range of gantry positions where dose measurements fell within 5% of the minimum dose for CardiAcquire short-scans.