Purpose: To study the image effects of the time-wise dynamic aspect of intravenous contrast agents to enable contrast-enhanced cone-beam CT (CE-CBCT) localization of liver lesions for stereotactic body radiation therapy (SBRT).

Methods: A model was developed to study dynamic IV contrast agents using static phantoms and to derive optimum parameters for CE-CBCT imaging. Ten samples containing iodine at 0-5 mg/mL were prepared in cylindrical tubes, corresponding roughly to 0-100 HU as measured by 120 kV helical CT imaging. Each sample was imaged separately in a tissue-equivalent phantom, yielding ten datasets (roughly 650 projections each) corresponding to these static CBCT images. To reconstruct images of dynamic contrast concentrations, the CBCT 2D projections were re-assembled to match the expected amount of contrast at different points in time. This model was applied to published hepatic contrast enhancement curves, and optimum imaging and contrast injection parameters were derived.

Results: A signal-to-noise ratio (SNR) decrease of 25%-75% in dynamic CE-CBCT images from ideal CT of samples with a 20-100 HU difference from water was observed in the un-optimized scans. This demonstrates the difficulty of CE-CBCT, and was noticed even in geometries that minimize or eliminate x-ray scatter, detector glare, and motion. Using our model, we found parameters for iodine injection, CBCT scanning, and injection/scanning timing which optimize contrast enhancement, and a 100% SNR increase with respect to the un-optimized scans was achieved.

Conclusions: The effect of IV contrast is severely degraded in CBCT, and optimization of image and timing parameters is crucial for improved CE-CBCT imaging for target localization. CBCT has very low temporal resolution, and the pharmacokinetics of IV contrast must be carefully considered in order to apply this technique to localize liver lesions for SBRT. This model will be used to establish the feasibility of CE-CBCT for routine localization of liver lesions.