Liver lesions can be visualized using contrast-enhanced multi-detector CT (CE-MDCT or CECT), but it is very difficult to localize these lesions for SBRT using cone beam CT (CBCT). It is often necessary to implant fiducial markers in the liver (an invasive procedure that carries risk of significant side effects), or expand PTV margins (increasing dose to normal tissue). Effort has been made at our institution to utilize IV contrast agents for better non-invasive lesion visualization during CBCT, but only very limited enhancement has been seen (Figs. 1 & 2). This failure is due in a large part to the pharmacokinetics of iodine contrast agents, which can have greatly varying hepatic concentrations over the course of a two-minute CBCT scan. This presentation will detail our investigation into the feasibility of CE-CBCT for liver lesions and the image quality effects of various imaging/injection parameters.

In order to optimize the use of IV contrast for CE-CBCT, we have developed a model to enable controlled studies of changes in image quality due to IV contrast pharmacokinetics. By performing multiple CBCT scans on phantoms containing different samples loaded with various amounts of iodine, we used published hepatic enhancement vs. time curves to reassemble 2D projection datasets where the object contrast mimics the time-varying nature of hepatic iodine concentration. In this way, the contrast injection and CBCT scan can be optimized to overcome the poor temporal resolution of CB scanning. For instance, this model has been applied to measure the reduction in signal-to-noise ratio (SNR) between CECT (Fig. 3) and CE-CBCT (Fig. 4), in which an ideal, static iodine concentration is replaced with a time-varying dynamic concentration, showing SNR reductions equating to an effective 20-40 HU decrease (Fig. 5). This model has also been applied to study the effects of iodine dose and scan timing, and deriving optimum timing for CE-CBCT imaging. With proper choice of the 2 minute CBCT scan window (Fig. 6), the SNR can be increased by a factor of two (Fig. 7). The results of this study will be used to implement CE-CBCT for non-invasive liver localization during SBRT. If lesions can be visualized with routine CBCT, it will become unnecessary to implant fiducial markers or expand PTV margins to account for poor differentiation of the lesion with respect to the surrounding normal tissue for accurate localization.

![Fig 1: CECT of a liver lesion (red arrow)](image1)
![Fig 2: CE-CBCT of the same patient](image2)
![Fig 3: MDCT image of 60 HU sample](image3)
![Fig 4: Dynamic CBCT with peak contrast of 60 HU. Iodine sample is denoted by red arrow.](image4)
![Fig 5: SNR degradation of 25%-75% from MDCT to realistic, dynamic CBCT.](image5)
![Fig 6: Hepatic enhancement curve for 175 mL iodine injection. Fast helical CT can image at peak contrast. CBCT hepatic enhancement depends strongly on timing.](image6)
![Fig 7: By optimizing scan timing, SNR of contrast samples can be improved by a factor of two.](image7)