Hepatic Extraction Fraction from HIDA SPECT for Assessment of Liver Response to Radiation therapy

Radiation-induced liver toxicity is a limiting factor for intensification of radiation therapy (RT) for intrahepatic cancers. $^{99m}$Tc-labeled immindodiacetic acid (IDA) SPECT is an established imaging modality to assess hepatocellular function. In this study, we investigated HIDA SPECT for estimating hepatic function, and evaluated the quantitative metric of hepatic extraction fraction (HEF) for prediction of dose response after RT.

**HIDA SPECT.** Eleven patients with unresectable intrahepatic cancers were treated by 3D fractioned conformal RT with a dose range of 30-65 Gy. SPECT/CT was acquired before RT, after receiving 45%-60% of the planned doses, and 1 month after the completion of RT. Dynamic SPECT data were acquisition started at the time of injection of 5-15mCi $^{99m}$Tc-membrofenin and lasted up to 60 minutes. Twenty-seven dynamic volumes of SPECTs (Matrix: $128\times128\times142$; FOV:$500\times500\times355$ mm$^3$) were reconstructed using the filtered backprojection method with the 15-sec temporal resolution for the first 8 phases, 30-sec for the next 6 phases, and 1–10 min for the remaining 13 phases.

**Hepatic extraction fraction.** The impulse response function of a liver voxel was determined by deconvolution of the liver dynamic activity curve with respect to the input function from aorta. Then, an exponential curve was fit to the impulse response function between 7 and 30 minutes, and was extrapolated to zero time point. HEF was estimated as the ratio of the extrapolated activity at zero time to the maximum activity of the impulse response function (1).

**Hepatic Function Dose-Response.** By co-registering the CT from SPECT/CT to the treatment planning CT, 3D dose distributions were mapped onto the HEF images (Figure 1). After excluding gross tumor volume and large vessels, the liver tissue voxels were divided into volumes of interests (VOIs) based upon accumulated biologically-corrected doses to the end of RT. The averaged values of the HEF and dose in each VOI were computed. Then, we evaluated the dose-response function of HEF in the liver tissue.

Figure 2 shows the dose-response function of HEF 1 month after RT compared to pre RT in one patient. The averaged dose-response function of HEF from the 11 patients 1 month after RT is shown in Figure 3, where the changes in the HEF significantly correlate with doses. In addition, we noted that significant difference of individual liver sensitivity to radiation.

Our preliminary tests suggest that the HEF has the potential to characterize radiation-induced hepatic dysfunction, thus impacting on assessing and predicting radiation toxicity in the liver.

References: