Dosimetric Predictors for Volumetric Liver Deformation and Change in Liver Function after SBRT for Hepatocellular Carcinoma: An in-vivo Assessment Based on Longitudinal Magnetic Resonance Imaging

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AIM & INTRODUCTION

To determine which dosimetric parameters are most associated with volumetric liver changes on magnetic resonance imaging (MRI) and changes in liver function as assessed by Albumin-Bilirubin (ALBI) score, for patients treated with stereotactic body radiation therapy (SBRT) for hepatocellular carcinoma (HCC). Identifying dosimetric parameters associated with worsening liver function and volumetric liver changes can allow for SBRT planning strategies aimed at reducing this risk.

METHODS

- Patients treated with SBRT for HCC with pre- and post-treatment MRI using Gd-EOB-DTPA contrast and minimum 6 months imaging follow-up were included.
- Whole liver and lobar liver volumes were contoured on pre- and post-SBRT MRI scans using Couinaud classification as right lobe (RL), left lobe (LL), and caudate lobe (CL).
- ALBI scores were tabulated from SBRT start and up to 2 years post-treatment. Dosimetric data from the SBRT CT scan were overlaid with pre-treatment MRI using contour-based deformable registration.
- Linear regression was used to assess the association between volumetric changes and dosimetric parameters as well as the change in ALBI scores. T-tests were used for associations between categorical and numerical variables.

RESULTS

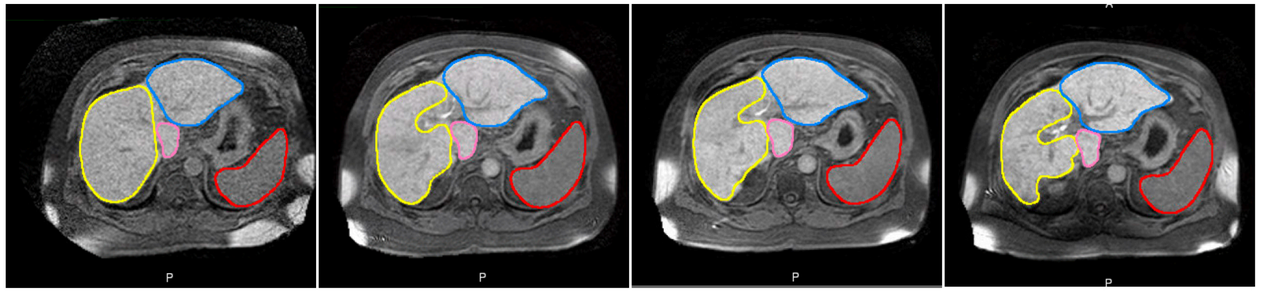

Figure 1. Contrast-enhanced liver MRIs with segmented liver lobes pre- and post SBRT representing the volumetric change for patient B shown in Figure 2.

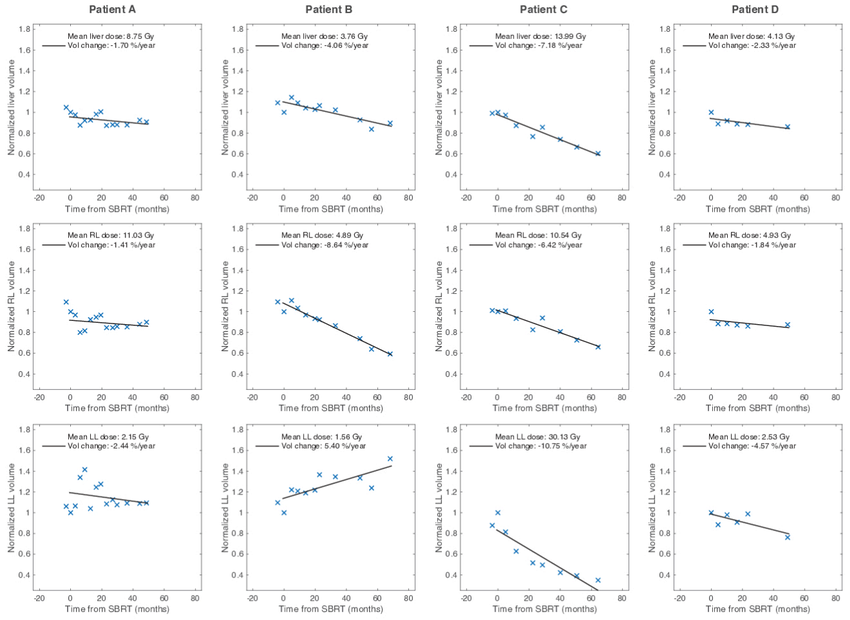

Figure 2. Linear regression analysis showing the change in liver and right or left lobe volume over time.

Table 1. Linear regression showing the association between volumetric change and dosimetric parameters.

Dosimetric predictor	Reg. coeff	p-value	R^2
Liver vol change (%/year)			
Mean dose	-0.79 /Gy	0.065	0.065
$V5_{Gy}$	-0.26 /%	0.15	0.040
$V10_{Gy}$	-0.18 /%	0.10	0.052
$V15_{Gy}$	-0.30 /%	**0.047**	0.075
$V20_{Gy}$	-0.41 /%	**0.044**	0.077
$V30_{Gy}$	-0.20 /%	0.077	0.060
Right lobe vol change (%/year)			
Dosimetric predictor	Reg. coeff	p-value	R^2
Mean dose	-0.91 /Gy	**0.022**	0.098
$V5_{Gy}$	-0.32 /%	0.10	0.051
$V10_{Gy}$	-0.21 /%	0.061	0.067
$V15_{Gy}$	-0.34 /%	**0.013**	0.11
$V20_{Gy}$	-0.44 /%	**0.008**	0.13
$V30_{Gy}$	-0.21 /%	**0.017**	0.11
Left lobe vol change (%/year)			
Dosimetric predictor	Reg. coeff	p-value	R^2
Mean dose	-1.39 /Gy	**<0.001**	0.31
$V5_{Gy}$	-0.47 /%	**0.003**	0.16
$V10_{Gy}$	-0.34 /%	**<0.001**	0.25
$V15_{Gy}$	-0.48 /%	**<0.001**	0.32
$V20_{Gy}$	-0.60 /%	**<0.001**	0.33
$V30_{Gy}$	-0.28 /%	**<0.001**	0.31
Caudate lobe vol change (%/year)			
Dosimetric predictor	Reg. coeff	p-value	R^2
Mean dose	-0.84 /Gy	**0.033**	0.086
$V5_{Gy}$	-0.16 /%	0.37	0.016
$V10_{Gy}$	-0.13 /%	0.19	0.034
$V15_{Gy}$	-0.21 /%	0.12	0.047
$V20_{Gy}$	-0.33 /%	**0.037**	0.083
$V30_{Gy}$	-0.15 /%	**0.023**	0.097

RESULTS

53 patients were included with 37.9 months median follow-up. In total, 362 MRI scans were used to assess liver volumes pre- and post-SBRT, median 6 per patient. Baseline median liver, RL, LL and CL volumes were 1454cm^3, 1017cm^3, 407cm^3 and 32cm^3, respectively. Median change in liver, RL, LL and CL volume post-SBRT was -7.2%/year, -7.7%/year, -2.8%/year and -8.3%/year, respectively, with LL increasing for some patients. Mean dose and volume receiving 20 Gy ($V20_{Gy}$) were the strongest predictors of volumetric change (Table 1). Worse baseline ALBI grade was associated with steeper liver volume decrease (p=0.031), whereas rate of worsening ALBI score post-SBRT was associated with mean dose to liver (0.044/month/10 Gy, p=0.017), LL (0.023/month/10 Gy, p=0.038), CL (0.021/month/10 Gy, p=0.015) but not RL (0.017/month/10 Gy, p=0.22). Patients with improving vs. worsening post-SBRT ALBI scores received mean liver doses of 6.9 Gy vs. 10.3 Gy (p=0.003).

CONCLUSIONS

Significant volumetric changes were seen post-SBRT, which correlated with mean dose and $V20_{Gy}$ to the liver and lobes. Most patients (75%) had RL tumors and sparing the LL allowed for some compensatory hypertrophy. Dosimetric parameters were also strongly associated with worsening liver function post-SBRT.

CONTACT INFORMATION

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