Real-time Quantitative Monitoring of Percutaneous MRI-guided Cryoablation of Renal Cancer

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Purpose: The safety and effectiveness of percutaneous image-guided ablations can be improved if the procedure could be assessed quantitatively and in real time. Using MRI's ability to depict both the tumor and the iceball during cryoablations, we developed a novel computerized tool that utilizes fast automatic segmentation methods to compute ablation metrics and tested its accuracy in MRI guided cryoablations of renal cancer.

Methods: Under an IRB-approved protocol, intraprocedural 3T HASTE images from 14 kidney tumor cryoablation procedures in 14 patients (11male; mean age=62; mean tumor size=3.5cm, range:1.6-5.7cm) were retrospectively applied to our computerized monitoring tool. First, the tumor was manually segmented (mean time=2min) using images obtained just before freezing. The software automatically segmented (mean time=1min) the probes[1,2] (range:2-5); two cases required manual correction due to segmentation error. After rigid registration[3] (mean time=5s) of these images to the images obtained at the end of the freezing cycle (iceball at maximum size), automatic segmentation of the iceball using graph cuts-prior method[2,4] was performed (mean time=25s). By comparing iceball volume to tumor volume, % tumor coverage (%TC) and Dice similarity coefficient (DSC) were computed for each case. These computer generated ablation metrics were then compared to metrics calculated from manual segmentation of the tumor and the ablation zone in 24 hr MR images of same cases as gold standard. Pearson correlation coefficient was used to analyze accuracy of the computerized tool.

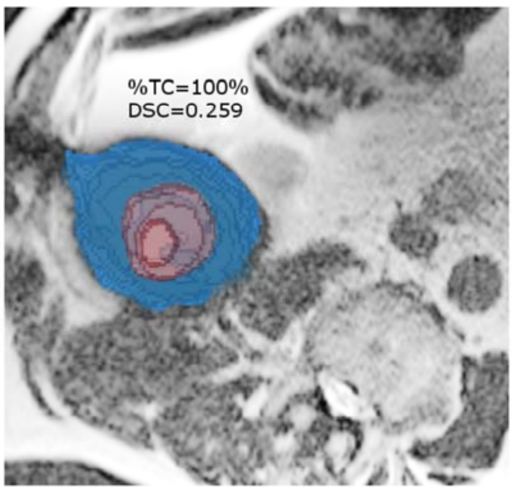

Fig. 1 Computer generated iceball (blue) and tumor (red)

Results: %TC was 100% in all cases both with the computerized tool and 24hr manual analysis except in one case. This had 76% computer generated %TC from misregistration of tumor and iceball volume due to intraprocedural displacement of the kidney by hydrodissection. Mean DSCs for computer generated and 24 hr analyses were 0.17 (range:0.01-0.31) and 0.18 (range:0.01-0.42) respectively (r=0.81). The mean computer generated iceball volume and 24hr manual ablation zone volume were 78mL and 99mL respectively (r=0.77). In 12 cases with follow-up (mean=8months, range:5-12), cancers were ablated completely. Fig. 1 shows the tumor mass (red) after registration of the baseline scan, and the automatically segmented 3D iceball (blue).

Conclusion: Although our data are preliminary and retrospective, they suggest that a novel computerized tool can be used to provide accurate real time quantitative assessment of key ablation metrics intraprocedurally. A prospective trial is planned. Computerized tool can be used to provide ablationists real time quantitative information regarding how much the tumor is being treated and how much peritumoral tissue is being ablated; this novel tool could potentially increase the safety and effectiveness of percutaneous ablations in the kidney and other organs.

References: **1.** Liu X, Tuncali K, Wells WM III, Zientara GP. Automaic probe artifact detection in MRI-guided cryoablation. Proc. SPIE Med Imag Conf 2013, 86712E. **2.** Liu X, Tuncali K, Wells WM III, Zientara GP. Automatic 3D probe localization and iceball segmentation for MRI-guided kidney cryoablation. Proc. 21st Ann Mtg ISMRM 2013, 1821. **3.** Fedorov A, Beichel R, Kalpathy-Cramer J, et al. 3D Slicer as an image computing platform for the quantitative imaging network. Magn Reson Imaging 2012; 30(9):1323-41. **4.** Liu X, Tuncali K, Wells WM III, Morrison P, Zientara GP. Fully automatic 3D segmentation of iceball for image-guided cryoablation. Proc. IEEE Conf Engrg Med Bio 2012; 2327-30. The work was supported by NIH grants R01-CA152282 and P41RR019703.