Diffusion-Weighted PROPELLER MRI for Tissue Selective Intra-Procedural Positioning of Percutaneous Biopsy Needles within Rabbit VX2 Liver Tumors

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INTRODUCTION

Percutaneous needle biopsy currently serves as a conclusive diagnostic procedure for liver lesion characterization. MRI can be used for intra-procedural guidance during percutaneous liver-directed interventions (1). Optimal targeting of viable tumor tissues is critical during biopsy procedures. Viable tissue is required for accurate histological confirmation of malignancy. Sampling errors may result when using conventional anatomic and/or contrast-enhanced images for intra-procedural guidance. These sampling errors may lead to insufficient material for diagnosis and require additional tissue sampling. Diffusion-weighted MRI (DWI) is a promising method for in vivo differentiation between viable tumor tissues and tumor necrosis (based upon differences in tissue water mobility) (2,3). TSE-based DW-PROPELLER techniques (4) should be less sensitive to susceptibility-induced field inhomo-geneities near interventional devices. In this study, we tested the hypothesis that intra-procedural DW-PROPELLER imaging can be used to selectively position biopsy needles within either viable or necrotic regions in VX2 rabbit liver tumors.

METHODS

MR-Guided Percutaneous Procedures

All percutaneous procedures and imaging experiments were performed with VX2 rabbits (N=6) positioned within a 1.5T clinical scanner (Siemens Espree) using a four-channel head coil. T2W-PROPELLER images were acquired at contiguous axial slice positions covering the entire liver volume. Next, baseline DW-PROPELLER images were acquired at the same slice positions: FOV = 200x200 mm², TR/TE = 3000/77ms, matrix = 192x192. TH=3.0 mm, ETL = 21, blade # = 60, BW = 798 Hz/pixel, b-value = 0, 534 and 866 s/mm². After baseline imaging, an MR-compatible 22 gauge aspiration biopsy needle (E-Z-EM Inc.,NY,USA) was inserted percutaneously into the selected rabbit liver tumor. Next, serial T2W and DW-PROPELLER (b-value = 534 s/mm²) imaging was performed with needle position iteratively adjusted between measurements to target either viable, necrotic, or intermediate border tissue regions. At final needle position, for each selected tissue type, DW-PROPELLER images at all b-values were acquired. For comparison purposes, we acquired a set of single-shot DW-EPI images. Prior to biopsy procedures we also acquired contrast enhanced (CE)-TIW-GRE images. At final needle location, a solution with 40-120µm spherical polystyrene particles (PVA) was injected through the needle hub to allow confirmation of needle tip position at necrosis.

RESULTS

In Fig.1-3, DW-PROPELLER images clearly depicted intra-tumoral tissue heterogeneity, particularly for those larger VX2 tumors consisting of viable peripheral regions surrounding a central necrotic core. The MRI compatible needles were clearly visualized in each DW image as signal voids along the needle track. At a total of 23 needle positions within 15 VX2 tumors, mean ADC values within the ROIs encompassing the needle tip was selected. Each of these ROIs was transferred to the corresponding baseline DW-PROPELLER image series (without needle in place) and the ADC values within these ROIs were calculated. Mean ADC within the ROI encompassing the needle tip was compared to the corresponding quantitative necrotic tissue estimate (H&E histopathology). For these measurements, the Pearson’s correlation coefficient was calculated with p < 0.05 considered statistically significant.

CONCLUSIONS

We have demonstrated the feasibility of using DW-PROPELLER MRI to guide biopsy needle placement to selectively target viable tissues within VX2 rabbit liver tumors. DW-PROPELLER is a promising method to optimize placement of percutaneous devices during interventional procedures. Future translational studies should evaluate the use of the DW-PROPELLER techniques for functional targeting during MR-guided percutaneous procedures in liver cancer patients.

References: