Proton-decoupled 31P MRSI Detects Liver Regeneration Stimulated by Embolization

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Introduction

Proton-decoupled ^{31}P spectroscopic imaging MRSI has demonstrated metabolic changes in the regenerating liver following major partial hepatectomy (PH) for cancer treatment (1). In patients with liver abnormalities due to prior chemotherapy or other factors, regeneration after PH can be problematic. Pre-surgical chemoembolization of the tumor-bearing lobe not only treats tumor, but stimulates regeneration in the untreated, non-cancerous lobe. Thus, the patient is given a “head-start” on regeneration prior to the actual resection of the tumor-bearing lobe. The present study followed the course of ^{31}P metabolic changes before and after embolization using three-dimensional (3D) ^{31}P spectroscopic imaging.

Materials and Methods

6 patients with liver metastases from colorectal cancer were studied under IRB guidelines. All patients were studied at baseline and 48 hours following either right (N = 5) or left (N=1) portal vein embolization with polyvinyl alcohol. One patient was studied on 3 subsequent occasions 20 days after embolization, 6 days after 2/3 PH and 22 days after PH. All studies were performed on a 1.5 Tesla Signa scanner (rev. 5x) equipped with a proton decoupler (G.E., Milwaukee, WI). Following whole-liver imaging using the body coil, a dual-tuned 1H/31P antenna (IGG Medical Advances, Milwaukee, WI) was placed adjacent to the non-cancerous lobe of the liver and T2-weighted FSE images were acquired. The water signal was shimmed using a fast gradient-echo algorithm. The ^{31}P flip angle power was determined using a triphenylphosphite standard, with a fully relaxed FID acquired for quantitation. ^{1}H-decoupled 31P CSI (2) with a hard-pulse, phase-encode, acquire scheme was performed with the following parameters: matrix 8x8x8, FOV = 24, 28 or 32 cm, TR = 1s, averages = 4, points = 1024, SW = 8000 Hz, flip angle = ~45°, scan time = 34 minutes. Waltz 4 decoupling was applied during data acquisition with low level CW power in the remainder of the TR interval. NMR data were processed using SAGE/IDL (GE, Milwaukee WI, RSI, Boulder, CO) and peak areas fit using MRUI-AMARES (3). Metabolite quantitation was performed as described previously (4) with saturation correction based on published liver T1 values (5). Metabolite levels relative to the standard were reported as normalized units (n.u.) and metabolite ratios were also calculated from raw peak areas.

Results

The metabolite which changed most consistently after embolization was phosphoethanolamine (PE) which increased in 5/6 patients (Fig 1a). However, in this limited number of patients, the difference in the mean baseline vs. mean followup metabolite levels was not statistically significant for any single metabolite. The mean ratio of PE/NTP did increase significantly (mean % increase = 82.5 ±78.1%, $p = 0.04$) (Fig. 1b). Figure 2 includes the results of 5 separate proton-decoupled ^{31}P MRS studies in one subject over the time course of embolization and subsequent major hepatectomy and recovery. Compared to the baseline, there is an increase in PE at 48 hours after embo. followed by recovery at 20 days and then a striking increase in PE measured 6 days after PH, with subsequent recovery (not complete) at 22 days. Quantitative analysis demonstrates significantly elevated PE, and reduced GPE, GPC and NTP at 6 days after PH in agreement with previous results (1).

Conclusions

This study demonstrates that with proton-decoupling, changes in relative amounts of phosphorus metabolites are detectable in regenerating liver stimulated by embolization of the opposite lobe. These changes are more subtle than those observed in the regenerating liver after major hepatectomy. However, they indicate that 31P MRSI may aid in monitoring interventions which stimulate liver regeneration.

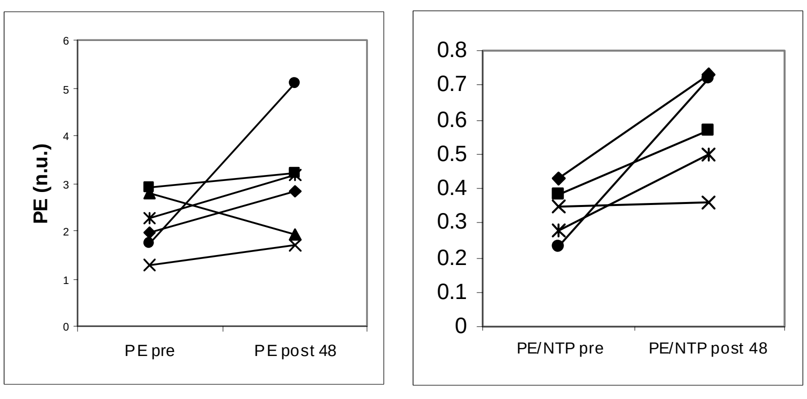

Figure 1. (A) normalized PE levels at baseline and 48 hours after embo in the non-cancerous lobe. (B) PE/NTP at baseline and 48 hours after embo.

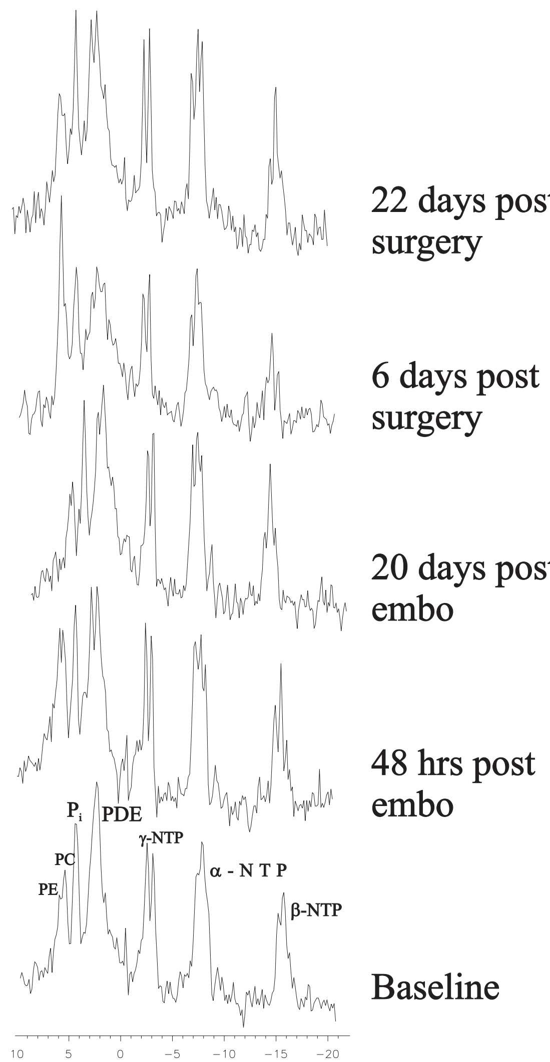

Figure 2 (Right). Proton-decoupled ^{31}P MRSI data acquired from a single patient at 5 time points during the course of embolization and subsequent partial hepatectomy.

References

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