

# Diagnosis of Ovarian Masses with Multi-Parametric Magnetic Resonance Methods: Preliminary Results

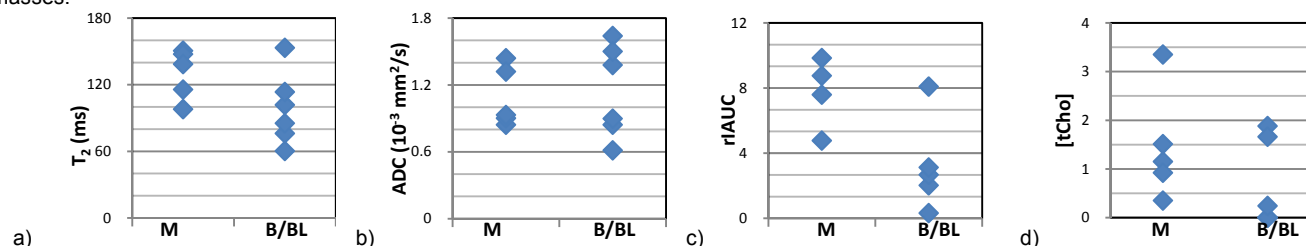
J. S. Carter<sup>1</sup>, N. Lakkadi<sup>2</sup>, J. E. Kuehn-Hajder<sup>3</sup>, I. V. Iltis<sup>2</sup>, L. S. Downs, Jr.<sup>4</sup>, and P. J. Bolan<sup>2</sup>

<sup>1</sup>Obstetrics, Gynecology, and Women's Health, University of Minnesota, Minneapolis, Minnesota, United States, <sup>2</sup>Radiology/CMRR, University of Minnesota, Minneapolis, MN, United States, <sup>3</sup>Radiology, University of Minnesota, Minneapolis, MN, United States, <sup>4</sup>Obstetrics, Gynecology, and Women's Health, University of Minnesota, Minneapolis, MN, United States

**Introduction:** The prognosis for newly diagnosed ovarian cancer depends largely on the stage at diagnosis. Early stage disease has a 90% 5-year survival rate, compared to a 30-40% 5-year survival rate at advanced stage (1). Unfortunately, most women are diagnosed at advanced stages because of the lack of effective screening tools and infrequency of symptoms at early stage. Several screening strategies have been assessed using combinations of risk factors, patient symptoms, serum biomarkers, and diagnostic imaging (US, CT, MRI), but none of these strategies have shown to be effective as a cost-effective screening program (2). The goal of this study is to demonstrate the potential of several quantitative MR-based metrics for use as biomarkers to differentiate between malignant and benign ovarian masses. If successful, the findings from this study would be used to further develop the technique(s) and assess its accuracy as a screening biomarker.

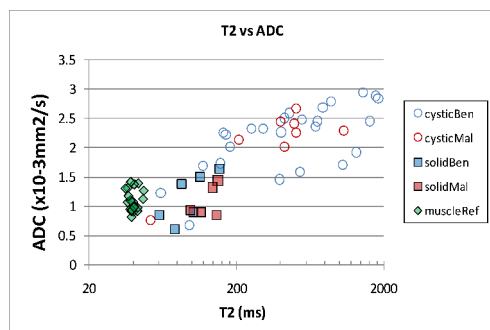
**Materials and Methods:** Twenty-four subjects with an ovarian mass were evaluated with quantitative MR scanning prior to surgical resection and histologic verification. Subjects were scanned on a 3T MR scanner (Siemens, Erlangen, Germany) using body matrix array coils. The imaging protocol consisted of conventional T<sub>1</sub>- and T<sub>2</sub>-weighted anatomical images followed by quantitative methods. Quantitative T<sub>2</sub> mapping was performed using a Carr-Purcell spin-echo sequence (7 slices, TE = 13-314 ms in 24 steps) and offline non-linear fitting to a mono-exponential decay function. ADC maps were acquired using a spin-echo EPI sequence (b=0, 50, 250, 500, 1000 s/mm<sup>2</sup>). Dynamic contrast-enhanced images were acquired (TR/TE = 3.5/1.2 ms, 8.4 s) with a bolus of Gd-DTPA (0.1 mmol/kg, 3 mL/s, 20 mL saline), and analyzed by comparing the initial area under the curve (IAUC) normalized by a muscle reference. Single-voxel spectroscopy was obtained using the point resolved spectroscopy (PRESS) localization technique with TE averaging (TE=50-200ms in 64-256 steps) to reduce artifacts. Voxels were placed in the largest solid portion of the masses whenever possible. Quantification of total choline-containing compounds (tCho) was performed using T<sub>2</sub>-corrected water as an internal reference (3). All metrics were compared to pathologic findings using t-tests for distinguishing between malignant and non-malignant (benign and borderline) lesions.

**Results:** Final pathology resulted in 6 malignant, 2 borderline, and 16 benign masses. One subject with a malignant mass could not complete the scan and was excluded. Four masses were solid (1 malignant, 3 benign), 7 were mixed solid and cystic (4 malignant, 3 borderline/benign), and 12 were predominantly cystic without measurable solid components larger than the cystic septa (12 borderline/benign). This analysis focused on masses with solid, measurable regions, which included 5 malignant, 1 borderline, and 5 benign masses. These results are summarized in Fig. 1. Grouping borderline with benign masses, the relative IAUC was higher in malignancies after one outlier (Brenner tumor) was removed (p=0.033), T<sub>2</sub> values revealed a trend of longer values in the malignant masses, and neither ADC nor tCho quantitative concentrations were different. Spectroscopy identified tCho peaks in 100% of the malignant masses and 50% of the nonmalignant masses, resulting in a 73% accuracy to distinguish malignant versus benign ovarian masses.



**Figure 1.** Differences in a) T<sub>2</sub>, b) ADC, c) relative IAUC, and d) [tCho] between malignant (M) and non-malignant (B/BL) masses.

**Figure 2.** Comparison of T<sub>2</sub> versus ADC in reference tissue (muscle) and in solid and cystic regions of the masses. Note the large range of T<sub>2</sub> values.



**Conclusions and Discussion:** This study shows that multiple, quantitative MR-based measurements for the diagnosis of ovarian masses are feasible and highly reproducible, as assessed by the muscle reference in Figure 2. IAUC is a significant predictor of malignancy and is expected given the increased vascularity of malignant masses. T<sub>2</sub> values tended to be longer in malignancies, but with overlap in the non-malignant group. ADC was not a predictor, and had a bimodal distribution in solid components. Malignancy was associated with detectability of tCho but not with elevated tCho concentrations. This suggests that MRS measurements are easier in malignancies, perhaps due to size differences. Study limitations included small population size and manual ROI measurements. Future work will include a larger population, histogram-based analyses, and advanced DCE analyses.

**References:** 1) Munkarah A et al. Curr Opin Obstet Gynecol 2007;19(1):22. 2) Iyer VR et al. AJR 2010;194:311. 3) Bolan PJ et al. ISMRM 2011. **Acknowledgements:** NIH P41 RR08079, NIH T32 CA132715, UMN AHC Seed Grant, and the Randy Shaver Foundation.