Oxygenation in Cervical Cancer and Normal Uterine Cervix assessed using BOLD MRI at 3 Tesla: Initial Experiences

R. R. Hallac[1], Y. Ding[1], Q. Yuan[1], R. W. McColl[1], J. Lea[2], R. D. Sims[1], P. T. Weatherall[1], and R. P. Mason[1]
[1]Radiology, UT Southwestern Medical Center at Dallas, Dallas, TX, United States, [2]Ob-Gyn Oncology, UT Southwestern Medical Center at Dallas, Dallas, TX

INTRODUCTION

Prognosis is particularly poor for cervical cancer patients who present with large hypoxic tumors. While tumor size can be assessed non-invasively, invasive electrodes have been required to measure oxygenation. A noninvasive assessment would be particularly attractive to patients and physicians and potentially allow the design of personalized medicine regimes (1). BOLD (Blood Oxygen Level Dependant) contrast MRI is a non-invasive technique sensitive to tumor vascular oxygenation (2) that we have tested to assess cervical cancer in this study. Deoxyhemoglobin causes T_2* shortening and the signal change accompanying an oxygen breathing challenge can indicate vascular oxygen dynamics. This process has been shown to relate to elimination of hypoxic fractions in rat breast tumors (3). We seek to evaluate whether BOLD response to hyperoxic gas challenge has prognostic value for these patients.

METHODS

A 3 T Phillips Achieva MR scanner and a multichannel phased-array surface coil were used to evaluate normal volunteers and patients with locally advanced cervical cancer following IRB approved consent. Dynamic T_2*-weighted MRI and T_2* maps were acquired using a multi echo sequence, while subjects breathed air for 2 mins followed by oxygen (15 l/min) and in some cases return to air. In addition first-pass perfusion MR images were used to investigate tumor vascularity.

RESULTS AND DISCUSSION

BOLD MRI provided good data quality both for patients (n=5) and normal volunteers (n=4). Baseline T_2*-weighted signal intensity was stable, but increased to variable extents (3 to 20% ΔSI) in tumors upon O_2 breathing. Anecdotally, the smallest ΔSI corresponded with a patient having progressive disease. Normal cervix showed a large change (average 10% ΔSI), but muscle (a control tissue for comparison) showed minimal response (Figure 1). T_2* maps indicated a decrease in R_2* values after breathing oxygen $\Delta R_2^* = 7.14 s^{-1}$ in cervical tumor, $4.23 \pm 3.2 s^{-1}$ in cervical tissue, $1.21 \pm 0.83 s^{-1}$ in uterine tissue, and $-1.93 \pm 4.18 s^{-1}$ in muscle (Figure 2).

CONCLUSION

This preliminary study demonstrates BOLD MRI is feasible for non-invasively examining oxygenation changes in cervical cancer in response to hyperoxic gas breathing. Additional patients are currently being evaluated and followed clinically to assess prognostic value of the observations. A noninvasive imaging technique to assess tumor hypoxia could help in selecting optimized treatment regimens without subjecting patients to additional interventions.

Acknowledgment: Investigations supported by the Mary Kay Ash Foundation

References 1) *Int. J. Radiat. Biol.* 2006;82:699; 2) *Curr Med Imaging Rev* 2005;1:229; 3) *Magn. Reson. Med*. 2009;62:357

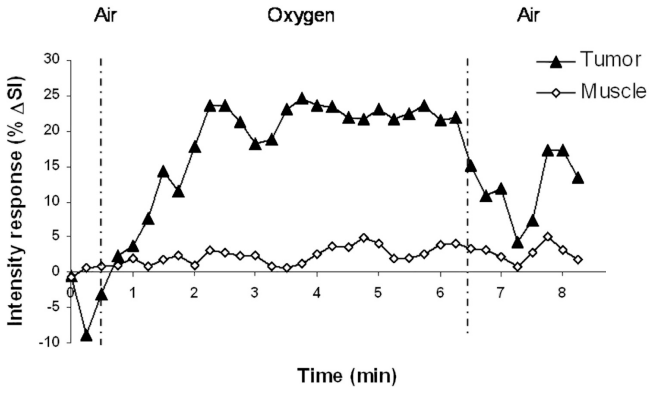

Figure 1 BOLD kinetics in cervical tumor and muscle. Relative signal intensity (SI) of tumor responded to patient breathing 100% O_2, whereas muscle showed minimal response.

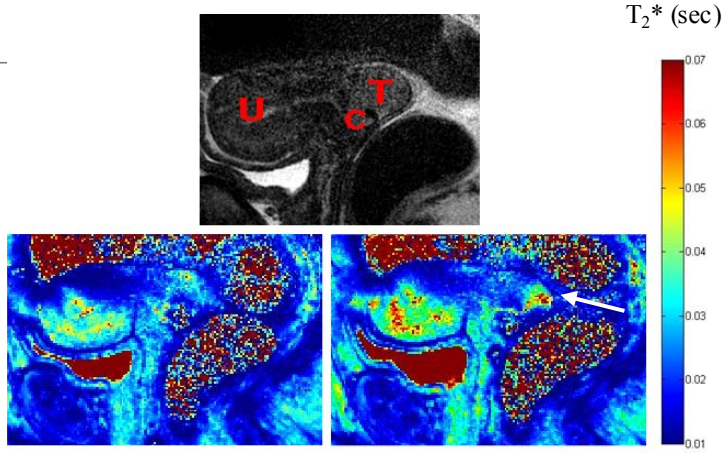

Figure. 2 Anatomical image (top) shows the uterus (U), cervix (C) and tumor (T). Bottom: T_2* maps in patient while breathing air (left) and oxygen (right). Distinct changes in T_2* values with oxygen are seen for different organs- notably the tumor indicated by white arrow.