Differences in two-compartment model parameters of gluteal and deep pelvic muscles

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TARGET AUDIENCE: 1) Medical physicists developing quantitative DCEMRI techniques.

PURPOSE: Dynamic contrast-enhanced MRI (DCEMRI) is increasingly used as a tool to assess cancer therapies. Quantitative methods are important and allow absolute measurement of kinetic parameters, such as K^{trans}, which can be used to assess response to therapy. Deriving the arterial input function (AIF) is crucial in determining the correct K^{trans}, and in some of the methods for pharmacokinetic modeling it is derived from reference tissues, typically muscle. [1] It is usually assumed that skeletal muscle is characterized by common K^{trans} and v_e values, and published values are used accordingly, including values measured in calf muscles. [2] Here, we demonstrate that the deep pelvic muscles differ significantly in their values of K^{trans} and v_e from the gluteal muscle and that thus skeletal muscles should be characterized individually.

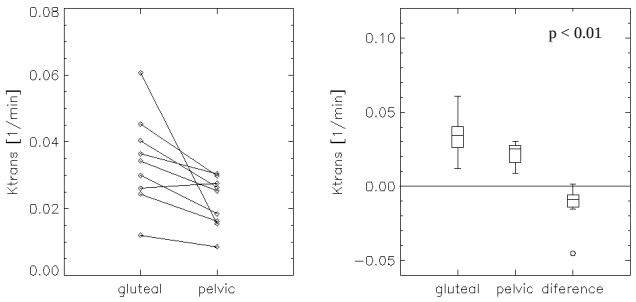

Figure 1: (LEFT) The values of K^{trans} in gluteal and deep pelvic muscles are shown. The lines connect the measurements in the same patient. (RIGHT) The boxplots show the distributions of K^{trans} values in gluteal and deep pelvic muscles, and the distribution of their paired differences. The p value is < 0.01.

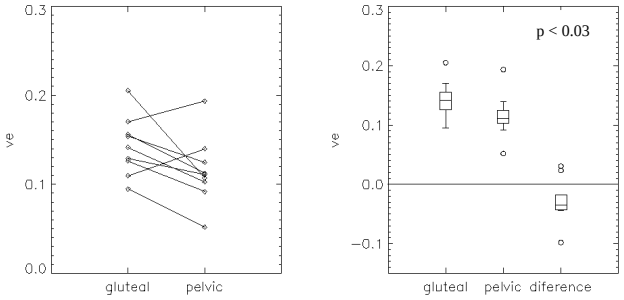

Figure 2: The same information as in Figure 1 is given for v_e. The p value is < 0.03.

METHODS: Male patients with castrate resistant prostate cancer were accrued, after informed consent was obtained, to an IRB-approved and HIPAA-compliant clinical trial of a new anti-angiogenic compound (XL184). Nine DCEMRI scans have been performed in four patients, and the K^{trans} and v_e of the gluteal and deep pelvic muscles (psoas or obterator externus) were determined. To this end, a T1-weghted DCEMRI sequence was acquired, with 2 x 2 x 5 mm^3 voxels, TR/TE of 7.5/2.85 ms, flip angle of 10 degrees, and 10 s temporal resolution. Standard dose of 0.1 mmol/kg of gadodiamide (Omniscan, GE, Waukeesha, WI) was injected in under 10 s. Concentration of the contrast agent in the muscle was determined using the reference tissue method. [3] From the concentration time curves, K^{trans} and v_e were determined by two-compartment modeling [4], using the population AIF. [5] The values of K^{trans} and v_e in the gluteal and deep pelvic muscles were compared using the non-parametric Wilcoxon signed-rank test.

RESULTS: We found a statistically significant decrease in the values of K^{trans} (by 31% on average, range +6% to -75%, $p < 0.01$) and v_e (by 19% on average, range +28% to -49%, $p < 0.03$) in deep pelvic muscles, compared to the gluteal muscle. Figures 1 and 2 illustrate the values and the differences in the values of K^{trans} and v_e. The average values for gluteal and pelvic muscles, respectively, were 0.034 ± 0.014 and 0.022 ± 0.008 for K^{trans}, and 0.14 ± 0.03 and 0.11 ± 0.04 for v_e.

DISCUSSION AND CONCLUSION: In this work, the population AIF was used, and therefore the variations in the AIF due to e.g., varying cardiac output, were not accounted for. This may cause small inaccuracies in the absolute measurement of K^{trans} and v_e values. However, the goal of this work was not to provide accurate measurement of kinetic parameters, but to demonstrate significant differences between the gluteal and deep pelvic muscles. For this purpose, our method of looking at paired differences is adequate, as variations in the AIF are likely to bias both muscles' parameters in the same direction.

The gluteal muscle is often used as the reference tissue to derive the AIF in quantitative DCEMRI experiments. But, sometimes it is not available in sufficient cross-section, or is compromised with excessive fatty infiltration and a different muscle is used. Our results indicate that the gluteal muscle and deep pelvic muscles need to be separately characterized, and care has to be taken as to which one is used as the reference tissue. Failure to do this may result in undue variations in K^{trans} values measured in the tumor.

[1] Kovar et al., JMRI 1998, 8(5):1126-34.
[2] Faranesh et al., MRM 2006, 55(5):1114-23.
[3] Medved et al., JMRI 2004, 20(1):122-8.
[4] Tofts et al., JMRI 1999, 10(3):223-32.
[5] Parker et al., MRM 2006, 56(5):993-1000.