Feasibility of dual pharmacokinetic modeling using Gd-DTPA/MRI and ^{18}F-FDG/PET

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INTRODUCTION

MRI-PET bimodal imaging is already a reality in fundamental and clinical research. Reaching the full potential of such dual imaging approaches for broader clinical acceptance may be through new methodologies that take advantages of one modality to compensate for the limitations of the other. The arterial input function (AIF) is commonly used for several types of MRI and PET pharmacokinetic analyses, but measurement of the AIF remains a challenge for both modalities. The most commonly used MRI contrast agent, Gd-DTPA, and PET radiotracer, ^{18}F-FDG, both are subjected to extravasation and excretion, and ^{18}F-FDG can be further internalized into cells. The aim of our study was to evaluate the correspondence between the AIF derived from MRI and PET, and to determine whether the AIF obtained by one modality can be converted into the AIF for the other modality. Such a conversion would be particularly useful for pharmacokinetic modeling of data acquired with both imaging modalities.

METHODS

Fisher rats (n = 7) were scanned in a µPET scanner during an intravenous co-injection of ^{18}F-FDG and Gd-DTPA to evaluate the correspondence between the two AIFs. Blood samples were collected manually at several time points and the blood concentration of ^{18}F-FDG and Gd-DTPA was determined with a gamma counter and by induced coupled plasma mass spectroscopy, respectively. These AIF curves were fitted with a 4-parameter bi-exponential model [Tofts *et al*. MRM 17, 357-367 (1991)] after normalization to the AIF maximum value. The parameters represent a fast and a slow decay, each with independent amplitude. To compare ^{18}F-FDG and Gd-DTPA AIF curves, a Student's *t*-test was performed to compare each fitting parameter and the area under the curve (AUC). The relationship between the injected dose normalized by the weight of the rat and the maximum value of the AIF was then investigated. We report the myocardial metabolic rates of glucose (MMRGlc) in the rats using both ^{18}F-FDG AIF and an AIF converted from the Gd-DTPA AIF.

RESULTS

Fig. 1a shows the Gd-DTPA and ^{18}F-FDG normalized AIF. The two curves are not identical; the fast decay parameters are similar while the slow decay and amplitude parameters were statistically different ($p<0.05$). Phosphorylated ^{18}F-FDG accumulates in cells and is known to return more slowly to the vasculature. We noted that the ratios between the MRI and PET AIF parameters were similar in all rats. Using these ratios, Fig. 1b shows that it was possible to convert the Gd-DTPA AIF into a ^{18}F-FDG AIF, and *vice versa*. Indeed, there was no statistical difference between experimental curves and converted curves. In other words, a Gd-DTPA AIF can accurately predict the ^{18}F-FDG AIF. Furthermore, a linear relationship was found between normalized injection dose and the maximum value of the AIF for both modalities. Therefore, no blood sample would be required for the conversion from Gd-DTPA to ^{18}F-FDG AIF, and *vice versa*. Fig. 2 shows (a) AUC values for experimental Gd-DTPA AIF and the corresponding AIF converted from the ^{18}F-FDG AIF renormalized using the injected dose, and (b) AUC values for experimental ^{18}F-FDG AIF and the corresponding AIF converted from the Gd-DTPA AIF renormalized using the injected dose. No significant statistical difference was found between AUC values for experimental and converted curves. This was also true for MMRGlc values.

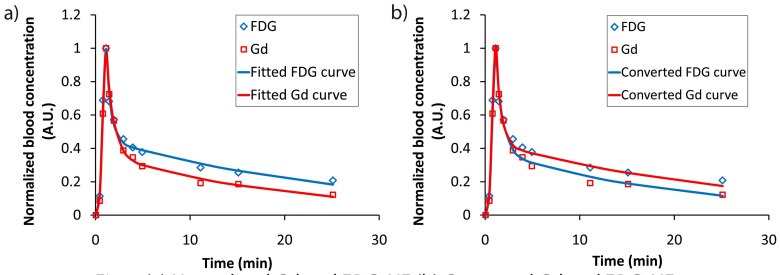

Fig. 1 (a) Normalized Gd and FDG AIF (b) Converted Gd and FDG AIF

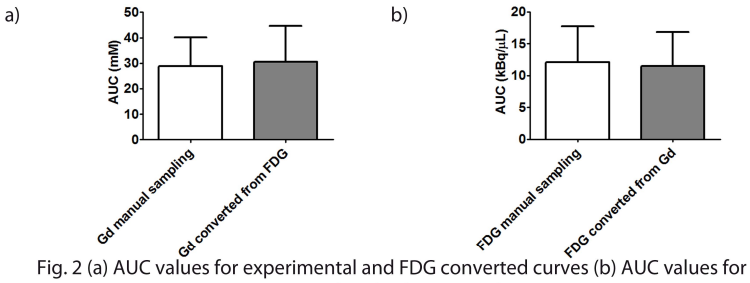

Fig. 2 (a) AUC values for experimental and FDG converted curves (b) AUC values for experimental and Gd converted curves

CONCLUSION

It is possible to convert the Gd-DTPA AIF obtained by manual blood sampling into a ^{18}F-FDG AIF, and *vice versa*. The ^{18}F-FDG AIF derived from the Gd-DTPA AIF can be used for PET pharmacokinetic modeling. This conversion and the relation between the injected dose and the maximal value of the AIF shown here suggest that it would be possible to perform dual kinetic modeling, using the reference region in MRI or an imaged-derived AIF in PET, without requiring calibration with blood samples.