Correlation of fat signal from Dixon imaging with 18F-FDG accumulation using an integrated PET/MR system

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Introduction

The combination of PET and MR can increase the diagnostic value of both modalities by providing supplementary information. PET measures the spatial distribution of an appropriate tracer while MR offers a huge variety of soft tissue contrasts, like T_1, T_2, diffusion, and water and fat. For the latter, Dixon imaging has been developed yielding excellent fat suppression and also clinically useful information about the fat distribution and its content in specific tissues [1]. Current literature shows [2] that there generally is limited ^{18}F- Deoxyglucose (FDG) uptake [3] in tissue with high fat content. Therefore, the information about the fat content might be very useful in PET image interpretation. Integrated PET/MR platforms, now becoming available, enable the combination of anatomical information and information about the fat content from the Dixon images with the functional information stemming from the ^{18}F-FDG-PET due to the intrinsic registration of PET and MR data. In this patient study, we demonstrate a correlation between fat void regions and FDG uptake. This information may serve for partial volume correction in PET reconstruction and permits further characterization of disease.

Methods

5 patients with indications for diagnosing and staging of breast and head/neck cancer underwent a protocol containing high-resolution whole-body Dixon imaging and ^{18}F-FDG-PET on a Philips Ingenuity TF PET/MR scanner. For Dixon imaging, a multi-station, dual-echo, 3D gradient-echo, breath-hold (17.4s per station) acquisition was performed in axial orientation ($TR/TE_1/TE_2$ = 3.2/1.1/2.0ms, α=10°, FOV(RL/FH/AP)=450/356/150mm³, voxel size 1.6×1.6×3mm³) using body coil reception. Based on the data, water/fat separation was performed [4]. For the PET acquisition, a total dose of 5.9+/-0.7 MBq/kg FDG was injected intravenously 60 minutes prior to acquisition. The emission data were acquired for 2 minutes per bed position, using 7 to 8 bed positions per patient depending on the patient height. For PET reconstruction, the data were corrected for decay, random events, dead time, and scatter; the attenuation correction was based on a segmented MR image [5].

Results and Discussion

Figure 1 shows a coronal cross-section of the MR Dixon water and fat images along with the corresponding PET images and the overlays, visually showing a high negative correlation of FDG-avid areas in the PET image with areas with high fat content according to the Dixon fat image. This holds for the subcutaneous as well as the visceral fat. This finding is confirmed by a scattergram showing the abundance of the different PET / fat intensity combinations: areas with high PET intensities (the left upper peak in the scattergram) have typically a low fat intensity, i.e. stem from tissues with low fat content, and areas with high fat content (the broad peak on the right hand side) have a low PET signal intensity. The population of the area between those two peaks might be due to the partial volume effect.

Figure 2 again reveals the high correspondence between the non-FDG-avid areas in the PET with the high-intensity areas in the Dixon fat image; using the high contrast of the fat images for superior anatomical reference, e.g. lymph nodes can easily be localized in the FDG image, and the high spatial resolution of the Dixon images could even be used to correct for the partial volume effect of the PET in the lymph node, giving potentially a more reliable estimate of the true activity within the lymph node. Note also the coarse depiction of the epi/pericardial fat in the Dixon fat image, which is hardly affected by motion artifacts despite the fact that the Dixon images were acquired without cardiac gating, again allowing for rather accurate anatomical referencing of the PET image.

An exception of the rule of negative correlation of FDG uptake and fat contents is bone marrow, as is exemplified by the FDG uptake in the spine in Fig. 1; however the reason for FDG uptake in bone marrow is still under debate and might be e.g. due to prior chemotherapy. It is also known [2] that brown fat accumulates FDG to some extent; however in adults brown fat is usually only present in the neck area, where one might thus need to expect different fat content / FDG uptake patterns.

These general findings are in line with the current understanding of metabolism of fat cells; deviations from that pattern are indicative for specific diseases.

Conclusion

The combination of Dixon imaging, in particular Dixon fat images, with ^{18}F-FDG-PET images, yields useful insights for diagnosing and staging in oncology and liver disease, and beyond that also into different aspects of the metabolism of fat cells. This information may further be used for corrections of the PET activity (e.g. partial volume correction) to obtain a more accurate estimation of PET activity in fat void regions such as isolated tumors, metastasis and lymph nodes.

References

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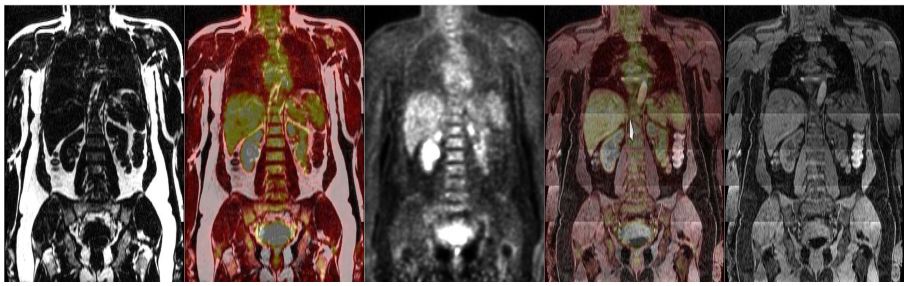

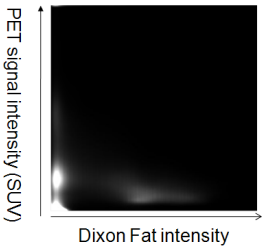

Fig. 1: PET and Dixon MR. Selected slice from 3D data (L→R) original and as overlay: fat, fat+PET, PET, water+PET, water only Right: scattergram of the PET intensity (SUV) versus the Dixon Fat signal intensity, showing a strong negative correlation between the two.

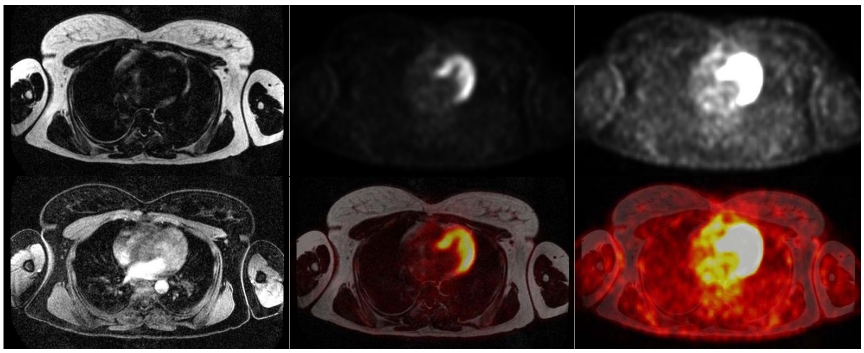

Fig. 2: PET and Dixon MR.axial images of a patient showing (top row, from left): Dixon fat image, PET with level/window settings for viewing the myocardium, PET with level/window settings for viewing soft tissue, (bottom row:) Dixon water image, overlay of the PET images above over the Dixon fat image. Note the depiction of the axillary lymph node on the right (patients left) side on the MR images and the corresponding PET structure.