Extended Abstract Insight Medical Publishing 2020
Vol.4 No.2

Commentary to Quantitative PET/MRI Evaluation and Application in Neurology

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Introduction:
With the high spatial resolution of magnetic resonance imaging (MRI) particularly for the soft tissue such as in brain and non-ion radiation involved, the integrative positron emission tomography (PET)/ MRI system is expected to provide almost equivalent image quality compared with PET alone or PET/CT system, and simultaneous MRI information that is not conventionally available [1]. PET-MRI opens new horizons in multi-parametric neuroimaging for clinical research that allows simultaneous imaging of multiple parametric changes such as blood flow and metabolism at the same time. While MRI could provide superior structural information, applying MRI anatomical priors to reduce the PET partial volume effect could be achieved to improve spatial resolution of PET images for clinical and research usages.

Objectives: Further applications in brain tumors and cancer response monitoring have reported complementary and valid information that this relatively new modality could achieve based on newly developed techniques. Newer and better MRI-based attenuation correction (AC) such as zero TE (ZTE) for more bone-related tissue signal detection and faster reconstruction compared to UTE/Dixon has been reported [3-6]. Advanced MRI-based motion correction for PET image reconstruction, newer PET time of flight reconstruction and incorporation with compressed sensing techniques have offered attractive superior temporal and spatial resolutions for disease diagnosis and prevention [7-9]. We briefly review the applications of PET/MRI in neurology with two examples in Alzheimer's disease and brain tumor cases in this commentary.

Results: Numerous imaging studies in Alzheimer's disease (AD) have been performed to study characteristic brain alterations including brain atrophy with earlier involvement of medial temporal lobe [10], brain hypo- perfusion in the posterior cingulate and parietal regions [11], reduced functional and structural connectivity in the default mode network (DMN) based on MRI findings [12] and hypo-metabolism based on PET imaging findings [13]. A regional coupling between metabolism of glucose (via PET kinetic analysis) and cerebral blood flow (CBF) had been reported with reductions post-caffeine compared to precaffeine conditions in controls [14], and in demented patients [15] based on separate scans. An evaluation of the real-time coupling of these two key imaging parameters with simultaneous acquisitions had not been performed before. For example, FDG metabolism had been found to increase twice as the energy brain activation needs (i.e., larger change in metabolism than change in CBF), and at a later time the unmetabolited fraction of the tracer was cleared off so that the tissue concentration of the tracer could reflect the metabolic rate [16,17]. Neurovascular coupling between neurochemistry (e.g., dopamine receptor occupancy) and hemodynamic change (e.g., cerebral blood volume) using simultaneous PET/fMRI acquisitions had been reported recently with similar temporal profile and dose response in non-human primates

Conclusions: he article by Zhou [2] had evaluated the most up-to-date PET/MRI scanner performance with multiple functional and structural metrics together with application demonstrations. Voxel-wise analyses in the template space also showed the majority of brain voxels (>95%) with significant correlations ($r>0.54$, $P<0.05$) between PET/MRI with Dixon MR-based AC method and PET/CT based on SUVR (standard uptake value ratio, a quantitative metric of normalized PET tracer dosage uptake) choosing cerebellum as the reference region (Figure 1A). A tight coupling between PET/MRI PET image and PET/CT PET image with a slope of fitting close to 1 in the middle temporal gyrus (MTG) was demonstrated in (Figure 1B). Furthermore, the global mean difference based on SUVR between PET/MRI and PET/CT was small using Dixon MR-based AC and PET/CT (difference=4%), And our findings agree with currently accepted notion that the MRI-based AC could achieve comparable imaging quality to standard-CT AC, with ≤ 5% differences between the PET/MRI and PET/CT PET images. The integrated PET/ MRI images showed comparable image quality to stand-alone imaging modality (both MRI and PET) with the gains of simultaneous multiparametric acquisitions, reduced scan time and potential patient discomfort. Furthermore, tight correlation between blood flow and metabolism was found in several brain gray matter regions including the temporal lobe in patients.