Neuro MRI Symposium l: Advanced Neuroimaging

SY01-1

Structural Changes in Top Athlete Brain

Osamu Abe

Radiology, The University of Tokyo, Tokyo, Japan

There are a wide variety of factors to regulate the contrast of magnetic resonance imaging (MRI), such as T1 and T2 relaxation time, proton density, perfusion and diffusion, temperature, and other factors. In daily clinical practices, we pick up abnormal lesions and make qualitative diagnoses based on combinations of something-weighted image contrasts. Although it is very effective to visually diagnose lesions that produce distinct contrast different from surrounding normal tissues such as cerebral infarction and tumor, MRI contains not only fine contrast differences but also a lot of valuable quantitative information which cannot be evaluated only by visual inspection, which include global and regional brain structure and function. Voxel-wise statistical analysis of the brain is a sophisticated method that has been remarkably developed for over 20 years. The use of voxel-based approach has an advantage in searching for abnormalities throughout the entire brain both in an exploratory or hypothesis-driven fashion, compared with manually drawn region of interest approach, which is insensitive to differences elsewhere in the brain. Recently, we have completed data collection of top athlete brain before and after the official games, including structural, diffusional, and resting-state functional MRI. However, due to limited time in the symposium, we will give preliminary voxel-based and surface-based morphometric results on top athletes' brain before and after the games as well as body weight control in this talk.

Keywords : Brain, Magnetic resonance imaging, Top athlete, Voxel-based morphometry, Surface-based morphometry

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Neuroimaging of Multiple Sclerosis: Disease Activity and Progression

In-Young Choi

[1]Neurology, University of Kansas Medical Center, Kansas City, KS, United States, [2]Molecular & Integrative Physiology, University of Kansas Medical Center, Kansas City, KS, United States, [3]Hoglund Brain Imaging Center, University of Kansas Medical Center, Kansas City, KS, United States

Multiple sclerosis (MS) is the most common immune-mediated disease of the central nervous system (CNS), affecting over 2.3 million people worldwide. The disease courses of MS vary significantly among patients, and anti-inflammatory drugs are effective for patients with relapsing-remitting multiple sclerosis (RRMS) in the initial inflammatory phase. Subsequently, a significant portion of the patients converts to progressive forms of MS (secondary progressive MS, SPMS) and eventually become unresponsive to anti-inflammatory drugs as their neurological decline continues [1]. This could be explained by a diminishing role of inflammatory processes and/or the increasing contribution of alternative processes such as oxidative stress during the disease progression.

Glutathione (GSH) is a critical antioxidant and quantitatively the most important in the cerebral antioxidant defense system [2]. The impaired cerebral antioxidant system and increased oxidative stress lead to mitochondrical damage, lesion formation, and decreases in brain GSH levels [3]. We have demonstrated lower brain GSH levels in patients with secondary progressive MS compared to healthy controls using multiple quantum filtered chemical shift imaging (CSI) of GSH [4]. Our extended study showed that GSH deficits were evident in the degenerative phases of MS (primary progressive MS (PPMS) and SPMS) compared with the inflammatory phase of MS (relapsing remitting MS, RRMS) and healthy controls [5]. Over three years of longitudinal follow up of patients with SPMS showed a greater reduction in brain GSH levels in patients who are clinically worsening while patients with stable clinical conditions showed no change in brain GSH based on a blinded clinical appraisal of a neurologist [6]. Brain GSH levels were also correlated with patients' Expanded Disability Severity Scale (EDSS), fatigue, and depression.

Our studies suggest that GSH is a promising mechanism-based biomarker for pathologic shifts occurring during MS disease progression from the inflammatory phase to the degenerative phase. Unlike static imaging biomarkers such as brain atrophy, which is a measure of accumulated neurodegeneration and rather irreversible upon a reversal of the disease process, GSH provides a dynamic measure of an ongoing process of oxidative stress that likely contributes to neurodegeneration. Dynamic biomarkers such as GSH are also conducive to longitudinal studies, especially those involving treatments targeting the pathologic processes linked to the measure [7].

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Keywords : Multiple Sclerosis, Human Brain, Glutathione, MRS, Oxidative Stress

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4D-Flow MRI for Brain Aneurysm

Yoshiyuki Watanabe

Radiology, Osaka University, Suita, Osaka, Japan

Hemodynamics in brain aneurysms is believed to play an important role to initiate growth and rupture of aneursym. Phase contrast magnetic resonance imaging (PC-MRI) and computational fluid dynamics (CFD) are two major methods to evaluate intracranial flow. PC-MRI is accomplished using methods that resolve single-directional flow in two spatial dimensions (2D) of an individual slice. More recently, three-dimensional (3D) spatial encoding combined with velocity-encoded phase contrast MRI (here termed 4D flow MRI) has drawn increased attention. 4D-flow MRI offers the ability to measure and to visualize the temporal change of complex blood flow patterns within an acquired 3D volume. CFD is a branch of fluid mechanics that uses numerical methods and algorithms to solve and analyze problems that involve fluid flows. Computers are used to perform the calculations required to simulate the interaction of liquids and gases with surfaces defined by boundary conditions.

In this talk, I will present the comparison of 4D-Flow MRI and CFD to evaluate intracranial brain aneurysm and to develop a new physically consistent data assimilation method based on feedback control for patient-specific blood flow analysis.

Next, we evaluate the intra-aneurysmal flow pattern using 4D-flow MRI and show the result of our research to elucidate in vivo analysis of the flow dynamics of ACOM aneurysms from both A1 arteries using 4D-Flow and digital subtraction angiography (DSA).

Based on recent research, an overview is provided over the potential this new imaging technique has in different parts of the intracranial arteries, mainly for aneurysm evaluation.

Keywords : Brain aneurysm, Phase-contrast mri, 4D-flow MRI