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Molecular Imaging in Clinical Investigation of Central Nervous System Diseases

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Molecular imaging is an emerging technology used both in basic neurosciences and clinical practice that greatly enhances our understanding of the pathophysiology and treatmentin central nervous system (CNS) diseases. It is a novel multidisciplinary technique that can be defined as real-time visualization, in vivo characterization and qualification of biological processes at the molecular and cellular level. It involves both the imaging modalities and the corresponding imaging agents. Among all of the molecular imaging modalities, positron emission tomography (PET) and single photonemission computed tomography (SPECT) have occupieda particular position that visualize and measure the physiological processes using high-affinity and high-specificity molecular radioactive tracers as imaging probes in intact living brain. Nowadays, amount of excellent and comprehensive literatures indicated that molecular imaging in neuroscience have provided tremendous insights into disturbed human brain function, particularly on its clinical application in Alzheimer's disease (AD) andParkinson's disease (PD) as major CNS disorders.

The human brain is the most complex organ which acts as the center of the nervous system. The cerebral cortex, the largest and most important part of the brain, consists of about 15~33 billion neurons, which account for 10% of the total numbers of whole brain cells, the rest are called glial cells. The human brain is very vulnerable to neurodegenerative (ND) disorders, such asAlzheimer's disease (AD), Parkinson's disease (PD) and multiple sclerosis (MS). It is also susceptible to psychiatric conditions, such as schizophrenia and depression. Although the neural mechanisms behind theses brain dysfunctions are under extensive investigation at the tissue level and more features have been identified, how these cells interact with one another and the detailed molecular or subcellular processes are not well understood.

Recently, noninvasive neuroimaging techniques such as magnetic resonance imaging (MRI), positron emission tomography (PET) and single positron emission tomography (SPECT) have made it possible to identify the fundamental biological processes of the neurological diseases in a noninvasive manner. The advent of molecular imaging has enabled researchers and clinicians to better understanding the molecular basis of the diseases. Generally speaking, molecular imaging is a rapidly growing technique aiming at elucidatedthe sophisticatedbiological processes and specific pathways at the cellular and molecular levels in human and other living systems. Molecular neuroimaging of the brain will be of great importance for clinical applications.

Technologies in molecular imaging have developed from a standalone modality to multi-modality method. Multi-modality imaging fuses two or more imaging modalities into a hybrid system emerging as a crucial means to provide more precise details than single only imaging modality. For brain imaging, the representative molecular imaging modalities are including the MRI, X-ray computed tomography (CT), PET and SPECT. The strength of multi-modality molecular imaging lies in combing the morphologic and functional processes, paving the way to further insight into molecular pathology of human diseases.

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