Review

Advances in the Approach for Analysis of regional blood flow

Qingyuan Shi[1], Xuelong Jin[2]

1. Academy of Medical Engineering and Translational Medicine, Tianjin University

2. Departmant of physiology and pathophysiology, Tianjin Medical University

Corresponding to Professor Xuelong Jin, Departmant of Physiology and Pathophysiology, Tianjin Medical University. Tianjin 300070, China.

E-mail: jinxl2003@163.com

Received: November 20, 2020; Accepted: November 26, 2020

Abstract

In recent years, the exploration of human brain function has been one of the research hotspots in the field of neuroscience. Anatomically, neurons and blood vessels go hand in hand, suggesting that cerebral blood flow can be used to reflect neurological function. Taking this as a starting point, this paper analyzes brain tissue blood flow from the perspectives of various CT imaging techniques and light imaging techniques and reviews the assessment of dementia based on regional blood flow.

Key words

PET, SPECT, CT perfusion cerebral blood flow imaging, Optical imaging technology, ICBF, Assessment of Dementia

Introduction

Blood flow to the brain is closely linked to metabolism in brain tissue, and measurements of blood flow to the brain can be used to assess functional changes in brain regions[1]. Continuous cerebral circulation and an adequate supply of oxygen are critical for maintaining the normal functionality of the brain [3]. Reduced cerebral blood flow (CBF) leads to a shortage of oxygen delivery and the accumulation of toxic metabolic wastes, causing irreversible brain injury[3]. At present, clinical imaging technology plays a great role in analyzing the hemodynamics and vascular changes of regional brain tissue.

In this paper, the progress of regional

blood flow analysis is reviewed from three perspectives: analyzing blood flow of brain tissue through various CT imaging techniques, analyzing blood flow of brain tissue through light imaging techniques, and evaluating dementia based on regional brain blood flow.

Analysis of tissue Blood Flow Using CT

Positron emission computed tomography (PET): it is a nuclear medicine technique used to image tissues based on the distinct ways in which normal and abnormal tissues metabolize positron-emitting radionuclides. Radionuclides are radioactive analogs of common physiological substrates such as sugars, amino acids, and free fatty acids that are used by the body.[15] It is a particularly powerful tool for quantifying the neurobiological links of cognition, mood and behavior. Initial PET studies of aging, psychiatric disorders and neurodegenerative disease have focused primarily on general physiological parameters such as cerebral blood flow and metabolism, and early neuroreceptor imaging studies relied on relatively non selective markers. Selective receptor radioligands now provide a previously inaccessible means to investigate the dynamic relationships among neurochemistry, aging and psychopathology in vivo. This approach has substantial advantages over peripheral (platelet and cerebrospinal fluid) markers, neuroendocrine challenge studies, animal models, and postmortem receptor binding measurements. [14].

Instrumentation and image processing have paved the way for an increase in functional imaging studies of neuropsychiatric disorders in the elderly.[14] Due to the capability to correct PET image data for the confounding effect of cerebral atrophy, PET permits relationships among age related brain changes and neurobiological disease mechanisms to be more accurately examined in the course of normal aging and in elderly patient populations.[14]

Lars Stegger et al. 's experimental study was performed in eight healthy volunteers sequentially on a prototype

PET/MRI and a stand-alone MR scanner with 128 × 128 and 192 × 192 matrix sizes. By comparing the gray matter value of cerebral blood flow, signal-to-noise ratio and contrast noise ratio, as well as the relative signal changes, it was found that blood flow maps showed good delineation of gray and white matter with no discernible artifacts. Furthermore, ASL brain imaging is feasible with a prototype hybrid PET/MRI scanner[6].

Single Photon emission conputed tomography (SPECT): SPECT is a device for performing tomography of organs by emitting γ rays of radionuclides. It uses either technetium or thallium, cardiac magnetic resonance imaging (cardiac MRI), andpositron emission tomography (PET).[15] In addition, SPECT can be performed using thallium-201 (Tl-201), a potassium analogue, or technetium-99 m labelled tracers. When Tl-201 is injected intravenously into a patient, it is taken up by the myocardial cells through regional perfusion, and Tl-201 is retained in the cell due to sodium/potassium ATPase pumps in the myocyte membrane. [15] SPECT imaging mainly included regional cerebral blood flow imaging, cerebral metabolism imaging and neuroreceptor imaging. SPECT is now an essential technique for certain studies such as cerebral blood flow imaging [13].

Computed tomography (CT) perfusion imaging is a technique used to measure cerebral blood flow, cerebral blood volume, and time-to-peak or mean transit time. The technique starts with the administration of a single, high-dose iodized contrast agent, and spiral CT imaging is then performed as the contrast medium passes through the blood vessels of the brain. CT perfusion cerebral blood flow imaging has significant advantages: it is fast and inexpensive and has been used effectively in intensive care for patients with neurological diseases [8].

Analysis of tissue Blood Flow Using Optical Imaging

There are many methods of optical imaging technology, including multi-photon imaging, diffusion optical imaging, living microscope imaging, two-photon phosphorescent lifetime

microscope, near-infrared fluorescence imaging and surface confocal imaging. The advantages of optical imaging are as follows: non-ionic low energy radiation; Continuous and real-time monitoring can be carried out; Highly sensitive; Noninvasive; Low prices; There are many different kinds of technologies. But the drawbacks of optical imaging are also apparent: limited penetration, from millimeters to centimeters, is currently used only in small animal models [16].

Single-wavelength laser speckle imaging can be combined with laser spot contrast analysis, thus using the same yuanshi laser spot image data, simultaneously obtaining artery-vein separation and blood flow imaging. This method is based on the relative temporal minimum reflectance analysis of laser speckle images. The simple and effective method of automatic vein separation that uses single wavelength coherent illumination can more accurately analyze the changes of cerebral blood flow in different brain tissue cavities [7].

Optical coherence Doppler tomography (ODT) is a promising neural technique for 3D imaging of cerebral blood flow networks, but quantitative CBFv imaging is still challenging [5].

Assessment of Dementia Based on Regional Cerebral Blood Flow

Regional cerebral blood flow imaging (ICBF) can be used as an important auxiliary technique for etiology assessment of dementia [10]. However, there are few characteristic changes in ICBF in early or preclinical disease. The study of Wolfram H. Knapp et al. concluded that for cognitive dysfunction patients with non-vascular causes, vascular activation did not enhance regional relative hypoperfusion, while neural activation of maze task would produce more obvious regional blood flow difference and enhance abnormal patterns of ICBF imaging [10].

Ohnishi T, Hoshi H et al used N-isopropyl-piodine-123-iodoamphetamine [(123I]IMP) in their study to perform brain SPECT in patients with progressive dementia and motor neuron disease. The study found that IMP SPECT showed decreased uptake in the bilateral frontal and temporal regions,

but not in the parietal and occipital regions. Thus, IMP SPECT has potential application value in the evaluation of progressive dementia with motor neuron disease [12].

Acknowledgment

We acknowledge the support of Ministry of Science and Technology of the People's Republic of China (No.2011DFA30550)

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