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Neuroimaging in Psychiatry: An Update

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Neuroimaging in Psychiatry: An Update

INTRODUCTION

Psychiatrists have tried for generations to understand the causes of mental disorders. In the last third of the 20th century, technological advances in the biological, medical, and psychological sciences have allowed for more direct and sophisticated study of the brain than was previously conceivable.

This paper addresses the state of neuroimaging in psychiatry. Current imaging methods are described, followed by a discussion of imaging applications in clinical practice. A comprehensive review of neuroimaging research findings in psychiatry is beyond the scope of this paper. However, the major findings in schizophrenia are reviewed in order to illustrate the potential these methods have for advancing psychiatric knowledge.

IMAGING METHODS

All modern neuroimaging methods are based upon the ability of a detector to measure high-energy photons coming from the brain. The data obtained by the detector is processed using computer algorithms that construct 2- or 3-dimensional images of the brain for visual interpretation or that allow for quantitative data analysis. Brain imaging methods include structural and functional imaging techniques. In a structural scan, a static image of brain anatomy is generated without providing any direct information about current physiologic function. A functional study provides information about cerebral blood flow, cerebral metabolism, or receptor populations in the brain.

COMPUTED TOMOGRAPHY

In computed tomography (CT) scanning, a collimated beam of x-rays produced by a rotating assembly passes through the brain of the subject. The x-rays are differentially attenuated based on the radiodensity of the tissue, with bone the most radiopaque (ie, appearing white on film or screen) and air the least radiopaque. The attenuated beam is recorded by a detector (ie, a scintillation crystal); a computer algorithm reconstructs the data into a series of 2-dimensional images. The spatial resolution of this technique is high (1 to 2 mm), and

excellent images of the skull, ventricles, and sulci can be obtained.

CT scanning has several limitations. Because the radiodensities of gray matter and white matter differ by only a small margin, gray matter/white matter resolution is only fair, and the ability of CT scanning to discriminate small or deep brain structures is limited. The contents of the posterior fossa (ie, brainstem, cerebellum) are particularly difficult to visualize because of the thick bone surrounding that region of the brain. Finally, only transverse sectioning of the brain is possible with CT scanning.

MAGNETIC RESONANCE IMAGING

Magnetic resonance imaging (MRI) exploits the phenomenon of nuclear magnetic resonance. Atoms with an odd number of protons have paramagnetic properties. These protons, when placed in a static magnetic field, will align and spin, or resonate, in relationship to the axis of the field. When the proton is exposed to a brief radiofrequency pulse oriented transverse to the axis of the field, it absorbs energy, causing a change in the proton's orientation. Termination of the pulse results in realignment within the static magnetic field, a process known as T_1 relaxation, or longitudinal relaxation. The accompanying release of energy, or realization, produces a detectable signal. An additional signal can be detected immediately after the radiofrequency pulse before realignment occurs. The rapid decay of this signal is known as T_2 relaxation, spin-spin relaxation, or transverse relaxation.

Hydrogen nuclei in water molecules are the chief source of MRI signals in biological tissues. Differential relaxation rates in different tissues are used to distinguish structures of the brain. MRI provides far better soft tissue resolution than CT, and gray matter/white matter differentiation is outstanding. The cerebellum, brainstem, and deep subcortical structures may be clearly visualized. Images can be generated in the transverse, coronal, and sagittal planes. Precise volumetric analysis of small brain structures and regions is possible. (In contrast, quantitative measurement, or morphometric, capabilities of CT are principally limited to cerebral ventricular volume and ventricular brain ratio.)

Depending on the clinical or research application, various pulse and detection algorithms and image