《特別講演》

Future Prospects of PET, SPECT and MRS for the Clinical Investigation of Heart Metabolism and Neurotransmission

André SYROTA

Professor, Service Hospitalier Fédéric Joliot, 4 Ploce du Céneral Leclerc, F-91406 Orsay, France

Positron Emission Tomography (PET) and Nuclear Magnetic Resonance Spectroscopy (MRS) can be compared because both techniques are now able to provide quantitative information on regional tissue function in man. Recent developments in SPECT suggest that this technique could also be useful for the clinical investigation of myocardial metabolism and neurotransmission.

PET and MRS are based on the use of isotopes of the basic biological elements (Carbon, Oxygen, Nitrogen, Hydrogen, Phosphorus) combined with a detection system for the accurate measurement of their distirbution within an organ. Positron-emitting isotopes, ^{11}C, ^{13}N, ^{15}O have very short half-lives. As a consequence, high amounts of radioactivity can be injected and the specific radioactivity of the synthetized labeled compounds is very high. This explains the high sensitivity of PET.

However there are no gamma ray emitting isotopes of hydrogen and phosphorus but these elements, (^{1}H and ^{31}P) naturally present in molecules, have a spin 1/2 and can be detected by NMR spectroscopy. Phosphorylated compounds such as ATP, phosphocreatine and inorganic phosphate can thus be easily detected. Carbon 13, a stable isotope of carbon can also be detected by NMR either in natural abundance (1.1%) or after injection of a molecule specifically labeled with ^{13}C, e.g. ^{13}Cl-glucose.

Nuclear magnetic resonance spectroscopy has been used for many years for the study of metabolism in isolated perfused organs or in vivo in small animals. Applications to human studies are more recent mainly for technological reasons and, in particular, because they require large, powerful and very homogeneous magnets which are difficult and expensive to build. PET provides unique information on myocardial viability by combining ^{18}F-FDG and a flow marker. It also allows investigation of the parasympathetic and sympathetic innervation of the heart with the use of new pre- and postsynaptic ligands. SPECT and ^{123}I-MIBG seem very promissing for the investigation of the adrenergic function in congestive heart failure, in cardiomyopathies and in the denervated transplanted heart.

Direct characterization of receptors for neurotransmitters seems impossible with MRS because of its sensitivity but changes in phosphorylated compounds and intracellular pH can now be monitored in humans. PET detects only 511 keV gamma rays and cannot give information on the identity and structure of the molecule and this molecular information is a unique advantage of MRS. Metabolites can be easily detected and followed over time with MRS; metabolic pathways (glycogene synthesis, glycolysis, tricarboxylic acid cycle) can thus be studied in vivo in normal conditions and in coronary disease. However, spatial resolution achieved with MRS is very low compared to that achieved with PET and MRS in comparable situations.