Invited Lecture 2

"Recent Advances and Future Developments in Nuclear Cardiology"

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The specialty of nuclear cardiology has grown from a curiosity to a major clinical service in the past 10 years. In most laboratories, cardiac studies are second only to bone scanning in total numbers performed. Of the three major types of studies performed: ^{99m}Tc-PPO_4 infarct imaging, thallium-201 myocardial imaging, and gated blood pool ventricular function studies; the latter are, in my opinion, of the greatest current clinical utility. The addition of exercise to thallium imaging and ventricular function studies provides information regarding pathophysiology that is essentially unobtainable by other means.

In considering the future developments in nuclear cardiology, we shall begin by briefly reviewing the current status and then the expected new technology.

Myocardial Imaging

Thallium-201 imaging, using standard scintillation cameras, is clearly established as being useful when the correct patient subgroups are studied. However, the sensitivity and specificity are only about 85–90% when detection of patients are considered and much less when lesion detection per se is considered. Limited angle tomography with the seven-pinhole collimator and/or the rotating slant-hole collimator appears to improve the sensitivity of lesion detection significantly (5-10%), but at the expense of specificity which decreases a like amount. This can be predicted from the imaging physics which clearly show that poor Z-axis resolution and error propagation are inherent limitations of limited angle tomography. In spite of this limitation, the low cost and ability to run on widely available nuclear computer systems are positive factors.

True computer reconstructed emission tomography requires wide angle sampling. Several systems are now being developed, the General Electric 400-T being the one I am most well acquainted with. Detailed studies with phantoms simulating clinical thallium imaging demonstrate clearly improved spatial resolution and image contrast, compared to planar or limited angle techniques. Initial studies in patients confirm that the technique can be used for thallium imaging. In spite of the theoretical improvements with wide angle tomography, many problems remain: attenuation corrections are very difficult to make; detector resolution is less than optimum, due to medium resolution collimation (required by the relatively low photon yield) and the distance between the detector and image object (FWHM for a line source exceeds 1.5 cm under normal imaging conditions). Meaningful solutions of this problem will, in my opinion, require radiopharmaceutical agents which provide a

greater photon flux than thallium-201. With improved radiopharmaceuticals and wide angle tomography, nuclear techniques will approach or match the accuracy of contrast coronary arteriography. Positron tomography is not discussed here and is presented by Dr. Phelps.

Ventricular Function Imaging

ECG synchronized first transit studies and blood pool studies using current camera computer systems are excellent in the clinical information portrayed. What these techniques lack in spatial resolution is amply compensated for by the ability to obtain multiple studies under a variety of physiologic conditions. Studies measuring ventricular function during bicycle exercise handgrip exercise, cold pressure tests, and many pharmacologic interventions are just beginning. The limitations here are not technologic but conceptual, in that ventricular function responses in health and disease are not clearly understood. As an example, the simple view that failure to increase the left ventricular ejection fraction during exercise is specific for coronary artery disease, is clearly wrong and occurs in many other types of cardiac diseases and possibly some normals. These limitations in data interpretation must be clearly understood before these tests are used to detect various forms of heart disease. Nonetheless, simple measurement of the resting ejection fraction is one of the single most useful tools in clinical cardiology, with immense diagnostic and prognostic information. In 1980, I believe this test is second only to bone scanning in providing clinically relevant information.

While positron and single photon tomography techniques can and will be applied to ventricular function testing with improved resolution of abnormalities, they are less crucial here than with myocardial imaging.