Special Lecture 1

Future Directions in Nuclear Medicine

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The past three decades have seen the emergence of nuclear medicine as a vigorous new medical discipline. Rarely in the history of medicine has there been a more successful wedding of clinical disciplines with the basic sciences. This remarkable union has given rise to a medical specialty that in the brief period of 30 years, has assumed a vital role in medical care. However, we are concerned today with future expectations. Since the basic ingredients of nuclear medicine are instruments and radiochemicals, the future is inextricably tied to developments in these fields and is dependent on an appropriate admixture of these ingredients.

Nuclear medicine instrumentation is constantly in a state of flux. Old instrumentation is continually being updated in an attempt to keep pace with new developments. Nevertheless, it is likely that today's scintillation camera, in an updated version, will continue to be the clinical workhorse for the foreseeable future. United States industry estimates that there will be 10,000 cameras in operation in the United States in 1985.

Emission tomography systems now in early production, because of cost and sophistication, will be found primarily in larger institutions. Single emission tomography has already demonstrated its capacity to localize neoplasms of the brain less than 1 cm in diameter that are frequently obscured in conventional images. Positron emission tomography systems hold forth the promise of unlocking secrets of cellular metabolism since they provide a means of imaging with nature's major elements—carbon, nitrogen, and oxygen. Use of these systems, however, will be limited to installations that have positron radionuclide production capabilities.

The interest in positron cameras has been an impetus to the development of self-shielded semi-automatic small cyclotrons. These machines can be coupled with automatic devices for radiopharmaceutical production. A number of companies worldwide and particularly in Japan, are actively engaged in the development of such machines. Intense effort can be expected in this field within the next few years. It is not very difficult to envisage a time when at least medical schools, medical research hospitals, and large regional institutions will have such instrumentation.

Computer systems will play an increasingly important role in clinical nuclear medicine. During the past few years, computerization has resulted in a quantum jump in noninvasive diagnosis, particularly in such areas as computed tomography and cardiovascular nuclear medicine. Dedicated

minicomputers will become standard in nuclear medicine departments. Furthermore, there will be a significant increase in dedicated microprocessor systems that can be plugged into existing camera systems to provide automated display and quality control, and as modules, to perform cardiac, renal, and lung assessments.

In the general area of radiochemical agents, there remain unresolved clinical needs. The substances now used for visualization of myocardial infarction are far from ideal. More effective agents are needed to assess regional blood flow in the myocardium and brain. Krypton-81m, with its 13-sec half-life, appears to be particularly promising for such applications. Better agents are also needed for tumor, abscess, and thrombus detection. Encouraging developments have been reported in the production of pure or monoclonal antibodies from human hybrid cells suggesting the possibility of specific tumor localization or even therapy with radiolabeled antibodies. In addition, the successful application of radiolabeled white cells to detect abscesses and infection, and the use of radiolabeled platelets to localize thromboses and the vegetations of bacterial endocarditis, are certain to play an important future role in the diagnostic process.

However, in the world of tomorrow, agents labeled with technetium-99m will continue to be used extensively. Compounds containing the short-lived cyclotron-produced positron emitting isotopes of C, O, N, and F are under intensive investigation in major research centers. Clinical application of these radionuclides will be determined by these ongoing investigations and the future availability of production facilities. The potential usefulness of these radioisotopes as physiologic or "true tracers" may usher in a new era in the understanding of human physiology and disease.

Radioimmunoassay will continue to grow, particularly for the study of infectious diseases, and pharmacology and toxicology. Areas that are insignificant at this time but can be expected to develop are cardiovascular and rheumatoid diseases. Before long, most assays will be performed on automated equipment, increasing speed and reducing costs. An annual growth rate of 12% is projected. In the United States it is estimated that 120 million tests will be performed in 1981. The future impact of enzyme immunoassay will be significant, though it will continue to be a smaller proportion of immunoassay testing than radioimmunoassay.

The future of nuclear medicine is also intimately concerned with challenges from the new imaging modalities. In some areas, nuclear medicine will continue with superiority, in others, it will give way to alternate technologies. In this regard, the primary approach to brain imaging has long since been usurped by transmission computed tomography (CT); but in other body areas, despite great expectations, transmission CT has been of limited value. This situation may change in the foreseeable future with the development of vastly improved body CT systems.

Ultrasound imaging, on the other hand, has proved to be a most useful complementary modality. It provides supplementary information, such as tumor differentiation and unique information with respect to pelvic disease and pregnancy. And of more current interest, is the new generation of ultrasound instrumentation—computerized systems, and the phased array real time echocardiography systems that may have a significant impact on cardiovascular nuclear medicine.

I see these competing modalities as the forerunners of a new era of noninvasive diagnosis. However, the concept of competing modalities is one that cannot survive in a world where economic constraints and cost containment are important determinants. I foresee the development of centers

of noninvasive diagnostic medicine where the various imaging modalities will be joined in the diagnostic process.

The future of nuclear medicine is bright regardless of its ultimate geographic configuration. It is clear that the medical community has recognized and accepted the contributions of nuclear medicine to patient care. The notable developments in cardiovascular nuclear medicine in the space of a few short years afford but a glimpse of what the future holds.