The YEAR BOOK of

Nuclear Medicine

1979

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Introduction

Major developments of this and the preceding year have occurred on many fronts.

In the area of radiopharmaceuticals, three major advances include the growing use of (1) ^{99m}Tc-tagged hepatobiliary agents, (2) in vivo red blood cell tagging for cardiovascular studies and (3) platelet and white blood cell tagging techniques for diagnosing and localizing arterial thrombi or ulcerations.

During this time our "hardware" colleagues have not been sleeping. At the "front end" of the detector systems there are promising new collimator designs. We are now able to record, simultaneously, cardiac images at two different angles, then change to a different collimator that has seven pinholes and can provide us with a tomographic display of the heart. Therefore, do not be too quick to discard your old cameras; they may just need a collimator "face lift." In the wings, new breeds of cameras are being designed and tested. These include the new breed of tomographic units and others that are specially designed to optimize low-, medium- or high-energy photon imaging. For those of you who covet positron emitters, but are not near a medical cyclotron, the gallium-68 – germanium-68 generator may be a viable alternative.

The growth of nuclear cardiology is even more impressive, as it extends into the smaller community hospitals. In larger hospitals, satellite facilities are springing up to take care of this new growth as well as to bring these valuable procedures to the bedside of seriously ill patients who cannot be moved.

In education there is increasing growth as new programs in both nuclear radiology and nuclear medicine continue to be approved.

The future for our field looks bright as it continues to provide new knowledge and patient service.

I continue to invite the readers of this volume to make suggestions and, if necessary, criticisms of this work in order to maximize its usefulness.

JAMES L. QUINN, III, M.D.

Radiation Physics and Instrumentation

Nuclear Medicine Begins with a Boa Constrictor that defecated in London in 1815, according to Marshall Brucer[1] (Tucson, Ariz.). William Prout, who had isolated the first pure sample of urea from patients with gout a year before, witnessed the event and found a sample of the feces of the snake to be almost pure uric acid, on the basis of "proportional number" or atomic weight comparisons. Crookes discovered thallium in 1861, and subsequently J. J. Thomson made a long series of measurements to estimate the weights of "particles of matter." Becquerel discovered roentgen rays in 1896 and the Curies announced the discovery of polonium in 1898. In 1900, Crookes prepared a solution of uranium and a ferric salt that was intensely radioactive. By 1934 at least 40 radionuclides had been reported. William H. Sullivan attempted to organize the rapidly changing nuclear data into an immediately visible form in a chart of nuclides.

Robley Evans publicized physicobiologic information about Hevesy's indicator-dilution studies in animals, with the use of radioactive tags, in 1936 and Compton and Means set up a committee to study the feasibility of this idea. In 1943, Samuel Seidlin, a New York endocrinologist, achieved the destruction of hyperactive metastases of thyroid carcinoma with radioiodine. Paul Aebersold of the Atomic Energy Commission promoted the use of the radionuclides available from work on atomic weapons. In a very practical sense, nuclear medicine could not have advanced far without a radiopharmaceutical industry.

► [The Lost Dutchman Mine has been found and is now located on Via Celeste in Tucson, Arizona. Please check the original article. – Eds.] ◄

Nuclear Medicine: New Techniques in Diagnosis are reviewed by M. V. Merrick[2] (Edinburgh). The clinical value

(1) J. Nucl. Med. 19:581–598, June, 1978.
(2) J. R. Coll. Surg. Edinb. 22:224–238, May, 1977.

of the isotope liver scan depends to a large extent on the pathologic process under study. The role of ultrasound in studying liver disease remains somewhat controversial. There is considerable disagreement as to whether secondary lesions appear as high-reflective or as silent areas. Computed axial tomographic (CAT) scanning can also detect liver metastases; some appear radiolucent and some relatively radiodense. A number of radiopharmaceuticals are available for studying hepatocellular function; rose bengal, as an example, is used in the differentiation of atresia from other forms of jaundice. Isotope scanning of the pancreas has been in clinical use for a number of years. Selenomethionine is also taken up by the placenta, representing a significant fetal hazard, and is contraindicated during pregnancy. The principal value of the pancreatic scan is to distinguish the diffuse defect of chronic or relapsing pancreatitis from the localized defect of carcinoma. Normal scans are rare in patients with symptomatic carcinoma.

Isotopes, principally orthoiodohippurate, have long been used to study renal function. The most familiar nuclear medicine technique is three-probe renography. Use of the gamma camera requires much larger doses of radioactivity than does three-probe renography. The use of technetium-labeled diethylenetriamine pentaacetic acid provides higher count rates for a given radiation dose. A number of agents that bind to the renal cortex are available. Isotopes are of considerable value in assessing the kidney after trauma. Proper use of isotopes is essential in the management of renal transplants. In the skeleton, the CAT scanner permits the detection of small cortical endosteal erosions. The bone scan is not a picture of the amount of calcium present at a given site, but an indication of where turnover is occurring. Bone scanning is of limited value in following the progress of disease. Scanning is particularly useful in patients without evidence of dissemination and where doubt about dissemination exists.

It is now possible to visualize the adrenals with the use of a number of substituted cholesterol analogues. Many agents have been investigated for specific concentration in malignant tissues. Gallium is taken up by most involved nodes in Hodgkin's disease. It is likely that the CAT scanner will be much more reliable in staging of Hodgkin's disease. In other forms of malignant disease, CAT scanning is undoubtedly more accurate than any available radionuclide technique.

► [His heart is in the Highlands, and so is his head. – Eds.] ◄

Improvement of Scintigrams by Computer Processing is discussed by Stephen M. Pizer and Andrew E. Todd-Pokropek[3] (Univ. of North Carolina). Computer processing can improve the quality of scintigrams in several ways. It can increase the accuracy with which the image approximates the activity distribution by reversing degradation and can selectively enhance normal or abnormal structures of interest. It can optimize use of the display system presenting the image. The need to correct distortion in both intensity and space can be avoided by attention to calibration and to the setup of the imaging device used and by use of the sliding energy window technique. Nonuniformity correction should not be done with a flood field, especially in quantitative studies. Rather, any needed correction should use the sensitivity matrix. Statistical fluctuations and degradation of resolution are commonly corrected with linear-stationary techniques, but nonstationary techniques often appear to be more successful at the expense of increased processing time. Nine-point binomial smoothing and variable-shape averaging are used for pure smoothing. Unsharp masking, Metz or Wiener filtering and biregional sharpening are used for both sharpening and smoothing.

High-quality display devices are necessary to obtain any benefits from degradation correction. Use of the display should be matched to the processing done. Contrast enhancement, as by histogram equalization, is often helpful. Most scintigram processing is done with computers with about 32K 16-bit words. Floating-point hardware is often useful. Processing time tends to be negligible compared with time for user specification of the processing to be done, so the quality of command languages should be of concern. Observer studies with phantoms have shown processing to improve detectability of lesions when a single display is used for both processed and unprocessed images, but not when unprocessed images on standard analog displays are compared with processed images on common computer displays.

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(3) Semin. Nucl. Med. 8:125 – 146, April, 1978.

There remains considerable question as to whether processing increases lesion detectability to any clinically significant extent, but processing is clearly useful as a part of more complex protocols, such as those involving quantitation, edge detection or image subtraction. Processing also aids in the localization of certain anomalies known to be present, as in thyroid and parathyroid studies.

► [A difficult subject is presented here in a clear and understandable fashion. – Eds.] ◄

Measurement of Performance of the Gamma Camera Oscilloscope Display is reported by P. F. Sharp and J. R. Mallard[4] (Aberdeen, Scotland). Ideally, the gamma camera oscilloscope display would show all detected gamma photons. However, photographic film is a nonlinear recording medium, and the gamma camera itself does not always give the correct spatial position of each detected gamma photon because of differences in photomultiplier tube sensitivity.

A computer simulation of the display was produced and evaluated in an attempt to assess the best possible performance of this type of display system. The simulation was made on a graphic display interfaced with a computer. The display consisted of a square matrix of 1024×1024 points. The simulated test-pattern represented a uniform background distribution of radionuclide on which was superimposed a circular disk of increased activity 2 cm in diameter. The ratio of background to target area on the simulated image was 256:1. The target was imaged so as to have a rectangular count density profile. Simulated display records were produced for backgrounds ranging from those containing a total of 12,500–200,000 counts over the whole displayed area. The method of constant stimuli was used to measure five observers' responses to the display records. Two thousand observations were recorded.

Increasing the total of counts in the background decreased the detection contrast. Although the shape of the curve describing the relationship between detection contrast and the number of background counts was that predicted by statistical theories, the corresponding value of the statistical index was much higher than expected. This suggests that the statistical theories are based on a rather oversimplified ap-

(4) Br. J. Radiol. 50:822–824, November, 1977.

proach and that there is a need for a more accurate model if the interaction between display and observer is to be described in purely mathematical terms.

► [One of these days, we may have a standard of reference for each of the camera's components. We can then use these in formulating our vitally needed instrument "quality control" programs. – Eds.] ◄

Comparison of the Anger Tomographic Scanner and the 15-in. Scintillation Camera for Gallium Imaging. The Anger tomographic multiplane scanner is a relatively new gamma-imaging device that provides three-dimensional information. Its tomographic capabilities offer several theoretical advantages, including delineation of deep structures and more precise localization of both normal and diseased structures. Mary F. Hauser and Alexander Gottschalk[5] (Yale Univ.) evaluated the relative merits of the tomoscanner and the 15-in. scintillation camera with multiple windows. The latter provides as good ^{67}Ga images as any commonly used device.

Fifty-one subjects were given ^{67}Ga-citrate intravenously in doses based on clinical indications: 6 mCi for infection and 10 mCi for tumor. Patients were routinely imaged initially at 48 hours. Most patients were examined with the Searle LFOV with Microdot and a medium-energy parallel-hole collimator. With the tomoscanner, a medium-resolution collimator was used.

The tomoscanner was more often preferred than the camera in the 18 normal subjects, but the difference in preference by 2 experienced interpreters was not significant. The preference for the tomoscanner for the 33 abnormal subjects was significant. In all, the tomoscanner was favored in 25 cases and the camera in 6; in 20 instances, the two methods were considered equivalent. The overall preference for the tomoscanner was significant.

The tomoscanner is most helpful in examination of the abdomen and thorax. Identification of deep structures is definitely superior to that with the camera. The ability to localize in the anteroposterior direction is very useful in postsurgical patients, in whom recent incisions can be confusing (Fig 1). Problems with colonic gallium and the superposition of two lesions are reduced with tomography.

(5) J. Nucl. Med. 19:1074–1077, September, 1978.