

Study of the Scanning Technique

(1) The Positioning of the Body and the Detector

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For obtaining better scintigrams in scintiscanning, we conducted a few basic and clinical experiments and found interesting results which are reported in this paper.

I) Basic Experiment: we used linear phantoms and compared the information of the upper and lower detectors with the separate sets of information by using these detectors separately.

i) For an organ of more than 5 cm in thickness, it is much better to utilize the addition of the upper and the lower detectors.

ii) A better vertical resolution can be obtained by crossing the focuses of the upper and lower detectors rather than by the isosensitive scan which matches the focuses of these two detectors.

iii) For an organ near the surface, better results can be obtained if a collimator of a longer focal distance is used.

II) Clinical Experiments: we studied the positioning of the body and the detectors for scintiscanning of the brain, liver and pancreas.

i) Brain: The addition method enables to

determine the lesion in two direction on the positive side, and has the merit of shortening the scan time. A lesion in the peripheral parts of the base of the brain can be better scanned by Towne's projection of the skull which places the detector with an angle of 30° to 40° to the axis of the body in face-up position.

ii) Liver: the liver is a large organ and therefore it is difficult to place the whole liver within the effective range of resolution in the vertical direction of the collimator by means of a single detector. For this reason, it is necessary to use the addition method of the upper and the lower detector, or to conduct scanning in four directions.

iii) Pancreas: although we obtained a good pancreas scintigrams by the addition method, sometimes the images of the liver and the pancreas overlapped in the scintigrams. In such a case, we may sometimes separate the images of the liver and the pancreas by making the posture of the patient in a semi-sitting position ($20^\circ \sim 40^\circ$) and positioning the detector vertically to the axis of the body.

A Simple Method of Image Restoration for Scintigraphy

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Mathematically speaking, observed image is the convolution of the true radioisotope distribution and the point spread function of the collimator used. In our previous report the point spread function was approximated by the 21×21 matrix and the convolution integral equation was expressed as the simultaneous algebraic equation which were solved by the iterative approximation method. One of the disadvantage of this method is the con-

siderable time necessary for the computation.

The point spread function could be approximately described by a two-dimensional Gaussian function. Convolution integral equation with Gaussian kernel could be solved by using the exponential of the generalized Laplacian.

To investigate the practical effectiveness of this new image restoration method (differential operator method), a preliminary experiment was conducted using digital scan data of

a point source and a paper thyroid phantom obtained by using a rectilinear scanner with a honey-comb collimator.

The computation for the image restoration was performed by an IBM-7090 electronic computer.

The second-order moments were calculated from a central part of the smoothed and normalized resolving power array that consisted of a circular domain with a radius of 15 elemental images.

The result suggests that the resolving power array is almost axially symmetrical.

To visualize the effectiveness of the present method, the width at the half-maximum of the transverse profile curve of the resolving power array through the center was compared before and after the image restoration. The first approximation of the differential operator method resulted in sufficient sharpening of the point spread function and yielded a slight narrower half-maximum width than did the third iteration of the iterative approximation method.

Moreover, the former needed a much shorter

computation time (about 2 minutes) than did the latter (about 30 minutes).

As the next step, the digital scan data of the thyroid phantom was used. It may be concluded that the blurred image of the phantom seemed to be focused more sharply by the differential operator method than by the iterative approximation method.

The present method, however, yielded more mottleness than did the iterative approximation method, suggesting that the former is more sensitive to the statistical fluctuation included in the original data than does the latter.

Although further investigation would be necessary to determine the choice of these two mathematical focussing method, it can be concluded that the newly proposed method of image restoration is less time-consuming, and might be applicable to the on-line real time data-processing.

Moreover, one may be able to build an analog computing-circuit based on the similar mathematical principle in any radioisotope imaging system themselves.

Operational Count Rate Meters and Their Application to Scinti-Scan

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The operational count rate meter is proposed which has a more suitable response for a particular purpose of measurement. The characteristics of the rate meter are specified by the step response $F(t)$, the impulse response $f(t)$, and the frequency response $W(\omega)$, and there are following relations between them:

$$f(t) = \frac{d}{dt} F(t)$$

$$W(\omega) = \int_0^\infty f(t) e^{-j\omega t} dt$$

The relative standard deviation of the output is given by

$$\sigma = \frac{1}{\sqrt{nT}}$$

where n is the count rate and T is the "equivalent time constant" given by the following

equation:

$$T = 1 / \int_0^\infty [f(t)]^2 dt = 2\pi / \int_{-\infty}^{+\infty} |W(\omega)|^2 d\omega$$

A simple circuit using two CR pairs is proposed, and the formulas for its performance are given. It can be used with desired response of over-, critical-, or under-damping. A critical-damped or a slightly under-damped rate meter provides the more quick response for a sudden change in radiation intensity than the conventional rate meters.

For a band-limited input signal, the under-damped rate meter can enhance the fast varying component of the signal. The application to radio-isotope imaging is proposed to improve the blur in the image. The experiment based on electronic simulation shows that the spatial resolution can be improved by a factor of about 1.8 without appreciable image distortion.