# PANCREAS SCANNING WITH $^{75}$Se-SELENOMETHIONINE AND $^{198}$Au USING DIGITAL-DATA-PROCESSING TECHNIQUES

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Radioisotope scanning of the pancreas using $^{75}$Se-selenomethionine as a tracer presently gives poor results principally because of pronounced hepatic affinity of this compound. As a result, the usual scan documents do not let one distinctly visualize the entire organ because the upper regions are buried in the liver image. Because we believe that the expedients generally used to dissociate the two images (*1,2*) are often ineffective, we have developed a new electronic subtraction technique using information provided by an Anger scintillation camera.

## PRINCIPLE OF METHOD

The subtraction technique consists of the administration of a second isotope with an elective hepatic tropism in addition to $^{75}$Se. The energy difference between the two isotopes must be great enough to allow efficient separation using standard electronic equipment. $^{198}$Au meets this requirement. However, it should be noted that only the 270-kev photoelectric peak of $^{75}$Se is used for counting although it is situated in the Compton region of the $^{198}$Au spectrum.* In addition the selenium spectrum contains a peak at 400 kev where approximately 10% of the decay events are emitted. This peak is extremely close to that of $^{198}$Au at 408 kev.† These incompatibilities could partially degrade a perfect separation, but it is possible to minimize their effects as will be shown later.

The data are stored in an electronic matrix representing the spatial distribution of information successively acquired from the two isotopes with subsequent electronic subtraction.

## METHOD AND INSTRUMENTATION

Electronic subtraction is accomplished with a Pho/Gamma scintillation camera (Nuclear-Chicago) coupled to a data-storage and processing system (Intertechnique) made up of the following modules:

1. A dual analog-to-digital converter (ADC) for coding digitally the x- and y-amplitudes furnished by the camera. These amplitudes represent the spatial coordinates of a scintillation event in the camera detector caused by a radioactive event of selected energy in the examined organ.

2. A data-storage unit in which digital information can be classified and stored in a 4,096-channel ferrite-core memory. The ADC selects a memory channel whose location represents the coded values of x and y. Thus a given radioisotope can be stored in the memory according to its position in space and—with the aid of the single-channel pulse-height analyzer in the camera electronics—according to its energy. The memory contents can be displayed on a built-in oscilloscope while data are being accumulated. In this way the contents of any particular channel can be determined at any time during the examination while the channel number defines the spatial coordinates of the stored events.

3. A volumetric display unit which generates a wide variety of presentations of the memory contents on its own built-in oscilloscope. It can present projected images of the explored organ and can display perspective views (profile amplification) so that zones of high uptake appear as peaks, and zones of low uptake appear as valleys; the height of the peaks is proportional to isotope concentration. In addition, sectional views in the x–y plane can be presented with the curve traced on the oscilloscope screen representing isotope concentration along the selected "slice" of the organ. For the projected or perspective images, one can vary two analog controls to erase zones containing either more than or less than a given number of counts, thus accentuating

* At 270 kev approximately 15% of the counts collected are due to $^{198}$Au Comptons.

† At 408 kev approximately 15% of the counts collected are due to $^{75}$Se (*3*).

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zones of low or high isotope concentration. The joint action of both controls lets the user delineate isocount zones. It is possible at any time to expand the image and to photograph the image at the termination of the exploration.

4. Data-processing unit. This device can record memory contents on magnetic tape. Subsequently it can subtract memory contents accumulated during a given interval from those accumulated during another interval using preselected coefficients while maintaining spatial relationship between channels. It can record a series of seven successive images stored during a single exploration, letting the user choose the one most suitable for diagnosis after the measurement is terminated. This feature is a great aid for observing transient phenomena.

After the usual preparation the subject receives 250 $\mu$c $^{75}$Se-selenomethionine injected intravenously.

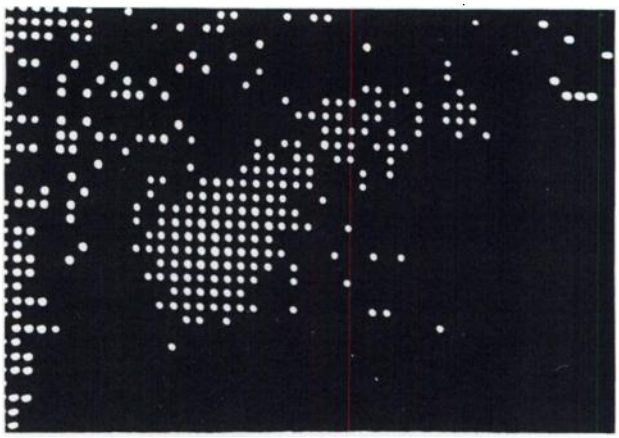
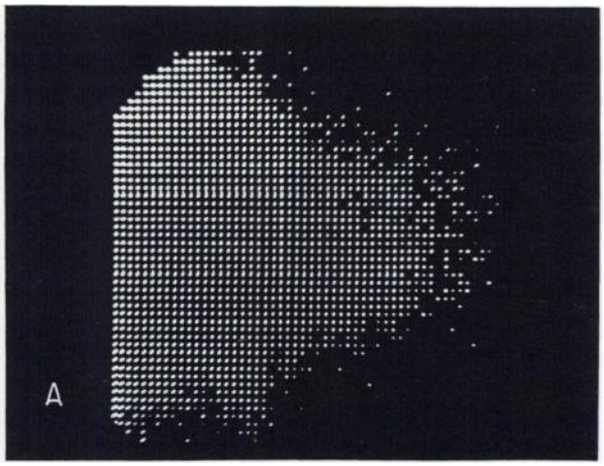


**FIG. 2.** Enlarged results of algebraic subtraction of two images in Fig. 1. Only pancreas remains.



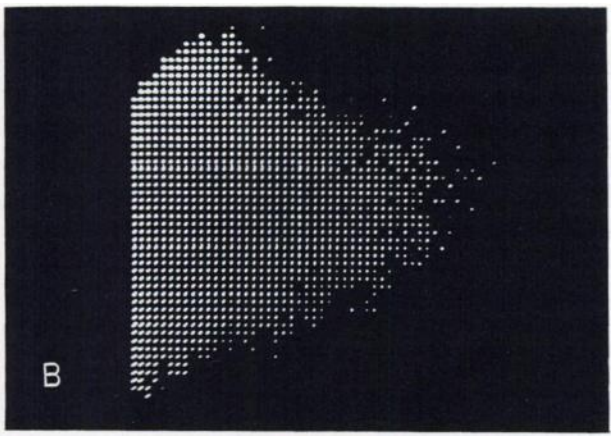




**FIG. 1.** Electronic subtraction technique for scanning pancreas. A shows left part of image obtained after injecting $^{75}$Se-selenomethionine with pancreas protruding slightly from lower edge of liver. After injecting $^{198}$Au, discrete liver image in B results.

One-half hour later he is placed under the detector. The camera spectrometer is calibrated on the 270-kev peak of $^{75}$Se using a 50-kev window. It appears preferable to begin the examination using selenium only so that no distortion occurs from the $^{198}$Au Compton contribution. Detector pulses are stored positively and counting is stopped when the image on the volumetric display unit has sufficient density. Then 250 $\mu$c of $^{198}$Au are injected intravenously. The spectrometer is now adjusted to count on the 408-kev peak, and information is stored negatively. During the second count the hepatic image progressively disappears and counting is terminated as soon as the pancreas is clearly separated from the liver. A Polaroid photograph can now be taken of the pancreatic image, producing a permanent recording for further diagnosis.

A less empirical method also exists. After storing the data from the $^{75}$Se peak, one chooses a point on the right lobe of the hepatic image in a zone where no pancreatic tissue is present. Using the controls provided on the volumetric display, one can identify the chosen point numerically by displacing intensified horizontal and vertical axes on the screen until they intersect over the point. This precise reference allows the user to locate the same point on the screen of the data-storage module. The vertical displacement of the point on this screen is proportional to the activity at the chosen point. The displacement and channel number are recorded for future reference, and the memory contents are transferred to magnetic tape, emptying the memory.

The spectrometer is now fixed over the 408-kev peak, the $^{198}$Au injected, and information is again stored negatively until the contents in the channel

representing the point chosen above are equal to its previous contents. The $^{75}Se$ information now on tape is reinjected into the memory, the contents being the algebraic sum of the selenium and gold images. In principle, the resulting image is that of the pancreas only. However, the pancreas image is not always complete because during the storage of gold data the 15% 400-kev selenium peak contributes additional unwanted information. This phenomenon makes it necessary for one to use a third method which, while more time consuming, has the great advantage of giving excellent results. It involves the positive storage and transfer to tape of information obtained from $^{75}Se$ and the subsequent and identical negative processing of data acquired from the gold. The $^{75}Se$ image is played back to the memory, and the gold information is then algebraically added to the memory contents using a coefficient of attenuation when playing back from the tape to the memory. While using the coefficient, the gold image is repeatedly added algebraically to the $^{75}Se$ information until a clear pancreatic image is obtained. In this way, compensation is made for the $^{75}Se$ contribution to the gold peak. The rapidity of the method described allows each one to be repeated several times during the course of an examination and to record numerous series of "information blocks" on tape which can be processed later at the user's convenience. The analog controls on the volumetric display are most useful for accentuating anomalies in the image of the pancreas.

## RESULTS AND COMMENTS

The electronic subtraction technique is most useful for the construction of images of the isolated pancreas. In Fig. 1A one can see the left part of the image obtained after injecting $^{75}Se$-selenomethionine. The head of the pancreas protrudes slightly from the lower edge of the liver, but most of the body is covered by the hepatic image. After the injection of $^{198}Au$, the discrete liver image is obtained (Fig. 1B). Figure 2 shows the enlarged results of the algebraic sum of the two images: only the pancreas remains. Therefore our method described is different from that reported by E. Kaplan, *et al* (*4,5*) who used a rectilinear scanner producing black and white or color documents to perform direct subtraction with a dual-channel spectrometer. His technique has the advantage of generating a full-size scan document while our method requires photographic enlargement. But its rapidity lets us store and display many images until the best one is produced. The optimum image is chosen with the aid of the two permanent display oscilloscopes.

We have noticed that the postinjection time interval for maximum selenomethionine uptake varies widely from patient to patient from ½ to 1 hr. One is forced to proceed blindly when using conventional apparatus; thus there is a risk that the most favorable moment for making an exploration will pass unnoticed. Our instrumentation lets us make several subtractions starting ½ hr after the first injection, giving us the best chances to build an optimized image.

It should be noted that in addition to the hepatic concentration of $^{75}Se$, intestinal elimination can distort the isolated pancreatic image in the same manner: nothing prohibits the use of a third isotope with an intestinal tropism for performing an additional subtraction. For this reason we presently tend to reduce our doses so that the activity absorbed does not restrict the possible administration of a third radioelement.

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