Instrumentation

Production of Dynamic Persistence Displays Using a Computer

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We investigated the image quality of dynamic gamma-camera studies using sequential summation of data to give differing types of persistence display. Comparative results of two techniques are illustrated and applications are discussed.

The rate of change of radioactive distribution can provide useful information regarding the function of organs and blood flow in the human body (*1*). Introduction of the Anger type (gamma) camera has made it possible to examine relative rates of change over areas of the body. The recording of the information can be accomplished either by photographic integration over short time periods or by digital storage of sequential images.

The quantification of radionuclide images has been discussed by Brown et al. (*2*). In particular, Knowles (*3*) discusses applications and processing of "dynamic" images using a computer. These techniques have been applied to such organs as the liver (*4*), brain (*5*), heart (*6*), and kidneys (*7,8*).

An image of satisfactory quality depends upon the acquisition of sufficient counts. The limiting factors of radiation dose to the patient, counting rate capabilities of gamma cameras, and analogue-to-digital conversion times for computer interfacing reduce the number of counts that can be recorded within small time periods. These limitations have the effect of poor visualization of rapid changes in distribution.

We present two simple methods by which the appearance of dynamic images can be altered by introducing "persistence" to the images displayed. The methods introduce higher counts per frame without reducing the rate of change of frames. The implications of temporal and spatial resolution of the processed images are discussed.

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Methods

Protocols were generated on a Dyanne (Link Systems Limited, High Wycombe, England) data processor utilizing standard commands that should be available on comparable equipment. The protocols can be generated within a few minutes and saved for future use as a primary command.

(a) **Persistence display:**
This method of display sequentially sums the current image with the previous and subsequent images. The new image that is formed is written into a new studyfile.
i.e.:
i^{th} image of new studyfile $=\{(i-1)+i+(i+1)\}^{th}$ images in acquired data file, with the restrictions that $1<i<$ number of frames in study.

(b) **Accumulation display:**
This command progressively sums the images in the acquired data; each addition forms the subsequent image in a new studyfile.
i.e:
i^{th} image of new studyfile $\Sigma^{n}(i)$ images in acquired data file, where n is the number of frames in the acquired data file.

Results

Multiformatted images of the vascular, concentration, and drainage phases in a renal study of a patient who was undergoing routine investigation are shown. The patient was injected with 185 MBq (5 mCi) of Tc-99m DTPA. The initial 30 frames and subsequent 60 frames were recorded using acquisition times of 1 and 30 sec, respectively. The images were recorded from a Dyanne data processor from signals acquired using a General Electric Maxi-camera 400T gamma camera.

Comparable images of a) original data, b) persistence,

and c) accumulation displays are shown. All images were recorded using the same display levels and mode of presentation (Fig. 1).

Discussion

The visual appearance of a cinematic display depends upon several parameters. These include the number of counts and the number of pixels forming an image, the time duration of each frame relative to the changing activity, and the distribution of counts within an image.

The number of counts being recorded at any one time is chiefly limited by the amount of radioactivity that can be administered to a patient and the counting rate capabilities of the gamma camera. The counting rate capabilities of various instruments can vary from 30,000 to 200,000 counts/sec, (*3*) but typically, most studies have counting rates no greater than 10,000 counts/sec. At the time of dynamic data acquisition, the decision has to be made regarding the matrix size to be used and the time to be spent accumulating data in each frame. This decision consequently determines spatial and temporal resolutions. It also assumes a knowledge of the change of spatial and temporal distribution before data are collected.

A typical matrix size for dynamic acquisition is 64 × 64; the resulting spatial resolution is within the capabilities of most gamma cameras in use today. Vascular changes of radioactive distribution within the major blood vessels necessitate that rates of acquisition for each frame may be of the order of 1 sec. Consequently, if the distribution of radioactivity was approximately uniform, the number of counts within each pixel would average about 2 counts, wth a poor statistical image resulting. In practice, however, the counts are initially confined to a relatively small number of pixels, which give a better quality picture. This situation is not maintained; inevitably the distribution of counts becomes more diffuse. Thus, in a dynamic display, the statistical significance of counts within each image varies with time.

Temporal smoothing of data has been performed by using a digital filter (*9*), and by performing weighted averaging of each corresponding pixel in temporally adjacent

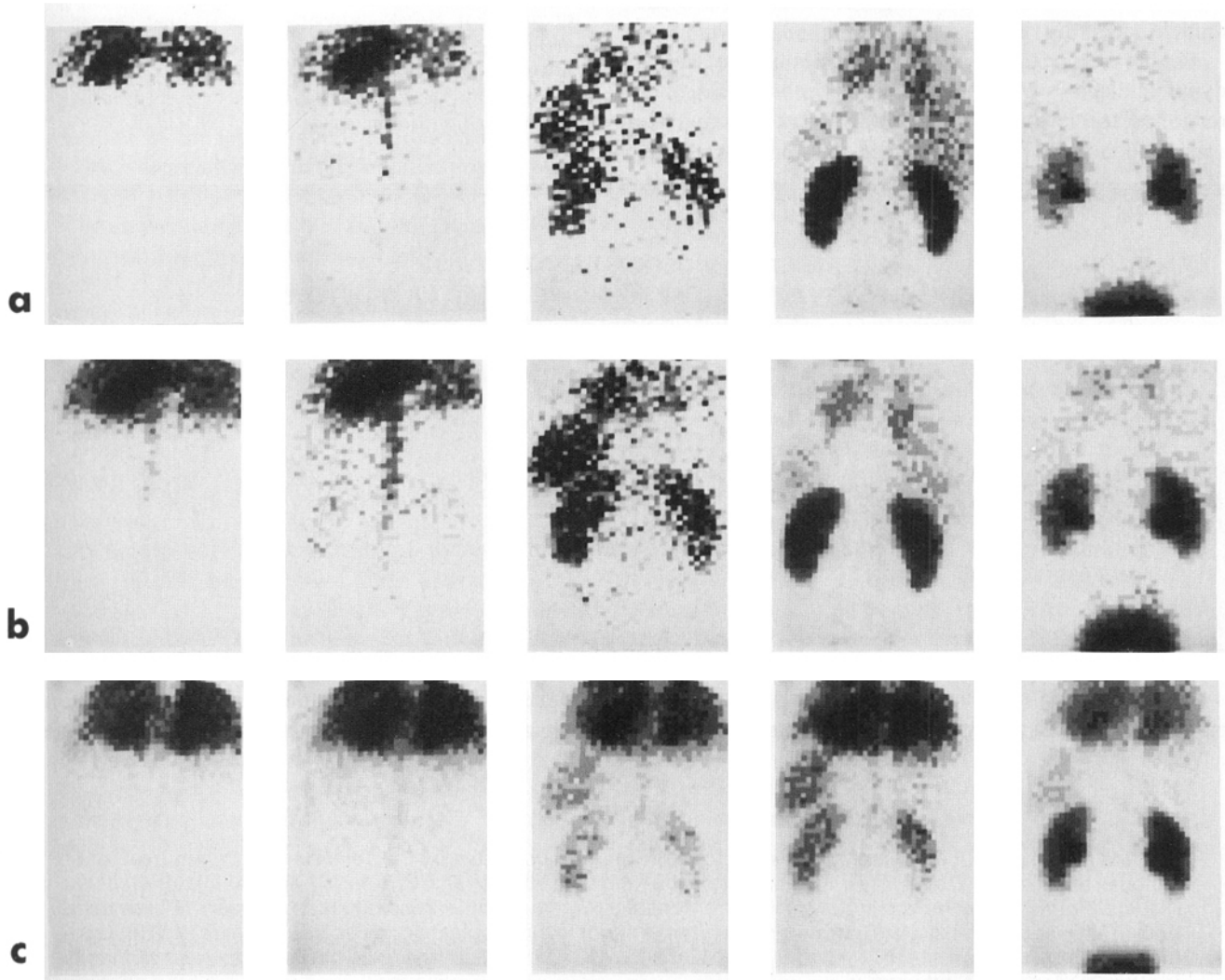

FIG. 1. Radioactive distribution in renal study at 8-, 10-, 16-, 180-, and 1,770-sec postinjection of Tc-99m DTPA, using (a) original data, (b) persistence, and (c) accumulation modes of display.

images, as discussed by Knowles (*3*).

The persistence display we present is similar in concept to the latter method, but we have simplified the technique by effectively applying unity weighting values and summation, without obtaining the mean value. We do this to achieve a compromise between increased frame time and rapid rate of frame change. The temporal resolution of the modified data is not significantly altered, provided that the initial image acquisition time and frame rate is comparable to actual changes in radioactive distribution. The second method we present—an accumulation or growth display—is introduced to reduce the effect of statistical fluctuations dominating the display levels of later images in the dynamic display. This method of processing images changes the temporal resolution of the system.

The results of these two methods demonstrate the relative quality of images. In the case of the persistence display, examination of time-activity curves has shown no appreciable change in temporal resolution. However, while the accumulation display produces images of statistically superior quality, the temporal information of the data is essentially modified.

The persistence display is, therefore, applicable to most dynamic displays while the second method appears to be restricted to viewing the appearance of radioactivity in an organ relative to its vascular supply. Further investigations are proceeding to assess the possible applications of both methods. We, however, believe that further improvements can be made in cinematic displays by adopting a method bounded by the techniques discussed.

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