ELECTRONIC DEVICE CORRECTS FOR MOTION IN GAMMA CAMERA IMAGES

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Previous efforts to remove motion artifacts from gamma camera images have required access to a computer, mechanical linkage to the patient, or a high counting rate. An instrument which does not have these limitations has been built and tested.

The device operates by using the Anger camera's x- and y-coordinate signals to hold the cathode-ray tube display stationary regardless of any motion of the source in front of the crystal. As the counting rate is decreased to zero, the device automatically ceases to stabilize the image and it appears as normal. The instrument is straightforward to operate. No external counting rate dependent adjustments are required.

Preliminary phantom studies have shown that the instrument effectively tracks and corrects for motion. Corrected views of a moving phantom appear almost identical to normal views of a stationary phantom. The instrument has been evaluated in two medical centers, and both have found it useful for sharpening liver scintigrams.

Efforts to remove motion artifacts from liver scintigraphs have been numerous and well documented. Hoffer, et al (*1*) have described an analog circuit which uses the Anger camera's x- and y-coordinate signals to determine the centroid position of the liver. Changes in centroid position due to respiration can then be corrected, and the cathode ray tube display is held stationary. This approach has several important advantages. It is easily interfaced to the camera through rear panel jacks provided by the manufacturer. It requires neither a computer nor a mechanical connection to the patient. Finally, it corrects in real time and a corrected image takes no longer to obtain than a normal scintigraph.

While Hoffer's approach to the problem was felt to be excellent, his use of a sample and hold at the input caused the instrument to require a high counting rate ($\gtrsim$250,000 cpm) for a good correction. Also, the device requires manual adjustment of external controls to work properly at varying counting rates. Our objective was to develop an instrument which incorporated the advantages of Hoffer's device, was able to effectively correct breathing motion at the lower counting rates often found in nuclear medicine laboratories, and did not require counting-rate dependent adjustments. These objectives had to be accomplished while keeping the statistical variation in the output signal insignificant.

We have developed an instrument which contains these features. A good correction for motion of breathing frequency is obtained at rates half the counting rate that Hoffer's device requires. At higher counting rates, motion as fast as 1 cycle/sec can be corrected. Moreover, the instrument automatically operates at maximum efficiency for a given counting rate. If the counting rate is too low for correction, the image is not altered and appears identical to a "normal" or uncorrected image.

MATERIALS AND METHODS

The instrument operates by taking the average over about 1,000 counts of the x- and y-coordinate signals from the Anger camera. Figure 1 shows a block diagram of the circuit for one coordinate. The coordinate signal is gated into the circuit by means of an analog switch. Unlike the sample and hold used by Hoffer, the switch does not randomly alter the width of the incoming pulses. Eliminating this factor allows the instrument to operate at half the counting rate required by Hoffer's device.

The pulses which pass through the gate are aver-

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aged across Capacitor C, and this average is subtracted from the coordinate signal in the difference amplifier to give a corrected position signal whose average is zero. The center of the image will then be held in the center of the screen to within plus or minus the statistical fluctuations of the correction signal. The feedback loop insures that the average position calculated by the integrator is taken over a fixed number of counts (1,000 in our case) instead of a fixed amount of time, as in Hoffer's case. The statistical fluctuation of the x and y averages, for an object of diameter D, is $\pm$ D/2(1,000)$^{1/2}$ or about $\pm$0.20 cm for a 12 cm liver. As this fluctuation is independent of counting rate, no counting rate dependent settings must be made as is the case in Hoffer's circuit. The device is inexpensive; the circuit components cost about $200.

The frequency of motion which the device can correct for is a function of counting rate and is related to the time required to average over 1,000 counts. A general expression for these variables is: maximum frequency = counting rate/($2\pi \times$ 1,000), where maximum frequency is in cycles per minute and counting rate is in counts per minute. As can be seen from the equation, the ability to correct faster motion is directly proportional to counting rate. Actual data taken with the device are shown in Fig. 2.

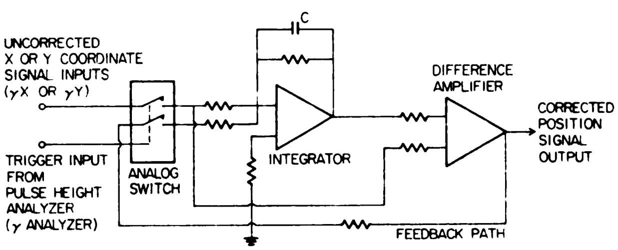

FIG. 1. Simplified circuit diagram of instrument.

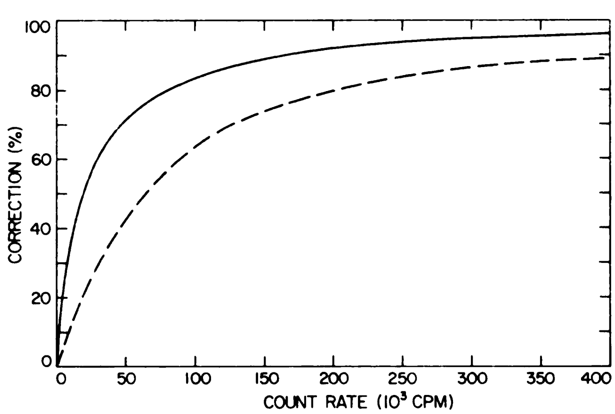

FIG. 2. Graph shows percent correction of 5-cm movement as function of counting rate. Solid line represents motion of 20 cycles/min. Broken line represents motion of 60 cycles/min.

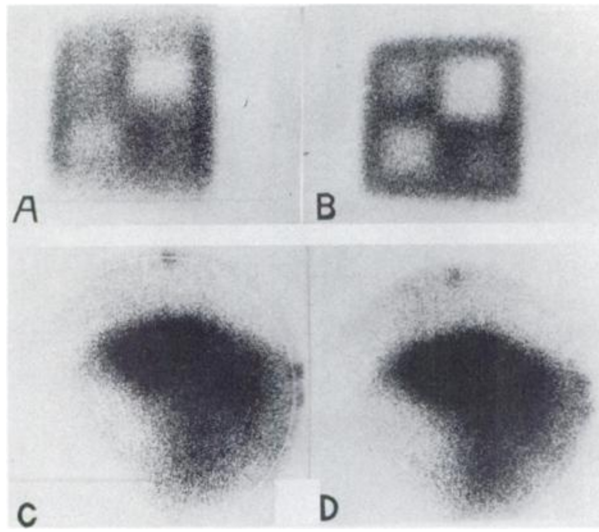

FIG. 3. A and B are 250,000 count views of phantom moving 5 cm at 12 cycles/min. A is without correction; B is corrected. C and D are 250,000 count scintigrams without (C) and with (D) correction.

RESULTS AND DISCUSSION

Studies of the effectiveness of the instrument using a 16.5-cm^2 phantom revealed striking differences between normal and corrected views (Fig. 3A). Corrected images of a moving phantom were almost indistinguishable from normal views of a stationary phantom. From this evidence it was concluded that given an adequate counting rate, this instrument was capable of tracking and correcting for virtually all nonplastic motion the liver might make. Clinical tests conducted at the Cancer Foundation of Santa Barbara and the Veterans Administration Hospital in San Francisco show a noticeable sharpening of liver scintigraphs (Fig. 3B).

ACKNOWLEDGMENT

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REFERENCE

1. HOFFER PB, OPPENHEIM BE, STERLING ML, et al: A simple device for reducing motion artifacts in gamma camera images. *Radiology* 103: 199–200, 1972