Improved Display of SPECT Data

TO THE EDITOR: We read with interest both the editorial by Dr Keyes (*1*) and the paper of Wallis and Miller (*2*) on improved display of SPECT data in the August issue of *The Journal of Nuclear Medicine.* We very much agree with the comments that "shaded surface rendering" has limited application in functional imaging, whereas volume rendering offers appeal in certain "hot spot" applications. It is therefore disappointing to see the emphasis that manufacturers expend on developing so called "3D" displays when better reconstruction techniques (such as iterative methods) would be more useful. Dr Keyes points out the importance of motion as one aspect of these displays which enhances depth perception. There are other factors involved in cine displays that further improve perception which were not explicitly considered: the effects due to visual integration and enhanced edge detection.

We feel that Wallis and Miller may have understated the improvement that their technique offers by only considering noise and constant on *static* images: had they extended their analyses to an ROC evaluation of the rotating cine display we suspect that the benefits of their method would probably be even more effectively demonstrated. In addition, there is another class of cine display, that which uses composites of different parameters in one display, which was not mentioned in the editorial. These displays (which often incorporate shaded surface rendering) combine different modalities, or different functional parameters from a single modality, into a single display and are finding increasing utility in nuclear medicine.

Several years ago we studied the influence of cine displays on perception in the context of nuclear medicine data (*3*). Visual perception experiments were designed to study the effect of cine display on perceived noise. ROC experiments were performed to assess the detection of objects (circles, squares, triangles) of low contrast (−5%, −10%) in a noisy (Poisson) background using our standard nuclear medicine computers (PDPII/Gamma-II, Digital Equipment Corp., Maynard, MA) and displays (VS Vol, Digital Equipment Corp.). The background count levels were chosen to approximate the count density over the liver in a single view of a SPECT liver/spleen acquisition. Observers rated, whether an object was present or not, on a scale of 1–5. In the first experiment a stationary object was placed in a cine display; in the second, the object was allowed to move, constrained to the horizontal plane (as for a SPECT display). These data were compared with "static" images of equivalent count level. The false-negative ratios for detection of a "cold" 5% object (mean of 2 observers, 100 studies (50 true-positive, 50 true-negative) in each series examined) were: 4% for a moving object, 22% for a stationary object in a cine display, and 36% for a single frame static display.

The increased perception of the stationary defects in a cine display over a single frame of the same count density suggested that the cine display alone takes advantage of visual integration effects by a linear filtering (*4*) of the random fluctuations due to noise. This might appear a surprising result: the visual system might be expected to "lose" an object when presented with a lot of rapidly changing information. The noise fluctuation in these examples was ±35% compared with the contrast of the defect (−5%). The critical duration for visual summation (*6*), that is, the time duration of a flash of light beyond which adding time ceases to have any effect in temporally distinguishing successive flashes, varies under different conditions but is generally in the range 20–100 msec. Below critical duration, Bloch's law shows a linear relationship between duration time and summation (*7*). In the cine display, we used a frame time of 60 msec, so we could be reasonably certain that we were approaching the "saturation" limit. The comparison of the two cine modes, containing moving or stationary defects, shows the further important role that motion plays in these displays, probably due to edge enhancement. It has been demonstrated in psychophysical experiments that the contrast sensitivity of the visual system shifts to higher frequencies when observing an object in motion (*5*). We did not investigate the "kinetic depth effect" of the cine display.

We also attempted to measure the relative information content of the static compared with the cine displays. The results showed that a single frame of 6–8 times the count level of the cine was required to perform at the same perception level. A further study of 20 static versus SPECT liver/spleen scan acquisitions on randomly selected subjects were reviewed by one of our experienced nuclear medicine physicians. His subjective opinion was that he "lost nothing" by viewing in the cine mode; he was surprised to see rib impressions in the lateral projection in *every* one of the cine displays, which is not the norm in conventional static display. While this is an anecdotal observation, it nevertheless illustrates that extra information can be presented that is not apparent in alternative displays of the same data. Other groups have likewise reported favorable findings using rotating SPECT displays (*8*).

While we recognize the limitations of "shaded surface rendering," these images can still be helpful, especially when used to convey multiple parameters. In certain cases, shaded-surface rendering serves as an useful anatomical reference for further information. An example is in myocardial perfusion investigations where conventional count density profiles can be mapped (using color) on to the shaded-surface (intensity) image of the left ventricle to demonstrate relative regional perfusion (*9*). When viewed as a rotating cine, the integrated information greatly aids localization. The shaded surface in this example can be a reference from a blood-pool scan, a normal myocardial perfusion scan, computed tomography, or magnetic resonance imaging data, not necessarily from the subject being examined. Similar techniques have found application for combined modality displays (PET/NMRI, etc). Color can convey additional information to that displayed by simply using intensity and motion.

In summary, cine displays appear to increase detectability for a number of reasons in addition to those suggested by Dr. Keyes: noise is suppressed due to visual summation (a low-

pass operation) and perception is improved further by edge enhancement (a high-pass operation). It is possible to present even more information by combining cine displays with color and intensity to represent different parameters, and hence extra information. Techniques such as those of Wallis and Miller should be welcomed because they continue to enhance the information conveyed, as well as exploiting the intrinsic ability of the human visual system. However, we feel that incorporating the effects of motion in their assessment of the technique would further substantiate the benefits of the method.

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Iodine-125-MIBG Therapy for Neuroblastoma

TO THE EDITOR: It is with great interest that we have read of the use of [^{125}I]MIBG for the treatment of neuroblastoma published in the preliminary report of Sisson et al. (*1*) in the September issue of the *Journal*. We are pleased to see that the therapeutic application of this agent is being studied elsewhere and in general we support this article.

We would, however, draw the Editor's attention to the fact that the MIBG group at The Netherlands Cancer Institute has used [^{125}I]MIBG to treat neuroblastoma since 1987 and has reported low toxicity with this radiopharmaceutical at the Society of Nuclear Medicine meeting in San Francisco in 1988 (*2*). Preliminary results were published in 1989 (*3,4*). Sisson et al. make no reference to this.

In order to complete the published experience, we report again the three treatments in two patients that we have conducted.

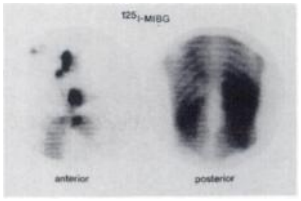

FIGURE 1
Post-therapeutic [^{125}I]MIBG scintigrams of Patient 1 shows intense concentration in the tumor in the neck.

Case 1

In November 1987, a 24-yr-old male with recurrent neuroblastoma was treated with 7.4 GBq (200 mCi) [^{125}I]MIBG, which was administered by i.v. infusion over 4 hr. The patient had originally been referred to our institute from the U.S. in April 1984 for [^{131}I]MIBG treatment of six large recurrent tumors in the lumbar region, which no longer responded to conventional treatment. In contrast to the pessimism expressed by Sisson et al. (*1*) concerning the use of [^{131}I]MIBG as a therapeutic agent, this patient was one of the best (2.5 yr) responders to [^{131}I]MIBG therapy in our series of 75 patients and initially attained complete remission of disease. After 2.5 yr, however, he developed a recurrence in the neck, which was arrested but did not regress following subsequent [^{131}I]MIBG therapy. At that time, it was decided to use [^{125}I]MIBG for treatment. Figure 1 shows the post-therapeutic scintigrams that demonstrate the specific concentration of [^{125}I]MIBG by the tumor and the attenuation of the 35-keV photons by the overlying bones. The treatment was repeated in January 1988, resulting in an objective regression (>50% of tumor volume) of the tumor mass. At the same time, there was progression of disease in the mediastinum, which led us to discontinue treatment. No adverse effects were observed on either occasion.

Case 2

In November 1988, a 4-yr-old girl, in whom previous [^{131}I]MIBG treatment had been successful for Stage IV neuroblastoma (bone metastases after chemotherapy), presented with bone marrow relapse. As no autologous bone marrow was available, further [^{131}I]MIBG therapy was contraindicated. Despite subsequent chemotherapy with carboplatin and 4-Epiadriamycine, the bone marrow disease progressed dramatically. Treatment was therefore attempted using 3.7 GBq (100 mCi) [^{125}I]MIBG. Figure 2 demonstrates the use of all three radioiodine labels of MIBG (^{131}I, ^{123}I, and ^{125}I) for scintigraphy in this patient performed within 4 wk. Iodine-125-MIBG therapy was well tolerated and relieved the patient's pain, but, except for halting the rapid progression of disease for 6 wk, did not induce an objective remission. No hematologic side effects occurred, again demonstrating that therapeutic doses of [^{125}I]MIBG can be given safely, even when the bone marrow is infiltrated by tumor.

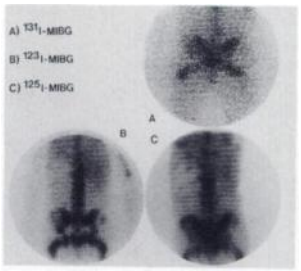

FIGURE 2
Scintigrams using [^{131}I]MIBG (A), [^{125}I]MIBG (B), and [^{125}I]MIBG (C) of Patient 2, each of which shows the diffuse bone marrow invasion by neuroblastoma.