CLINICAL FEASIBILITY OF MYOCARDIAL IMAGING WITH $^{13}NH_3$

P. V. Harper, K. A. Lathrop, H. Krizek, N. Lembares, V. Stark, and P. B. Hoffer

Argonne Cancer Research Hospital, Chicago, Illinois*

Hunter and Monahan's report (*1*) on myocardial localization of the 10-min positron emitter ^{13}N as ammonia led us to investigate the clinical applicability of this phenomenon.

MATERIALS AND METHODS

The radionuclide was produced by the method included in a report by Monahan, et al from the Sloan-Kettering Institute (*2*). Methane is rapidly circulated through a glass-lined chamber where it is bombarded with 8-MeV deuterons. Under these conditions ^{13}N resulting from the d,n reaction on ^{12}C in the methane appears principally as ammonia. A small percentage of the activity appears as HCN, and this is largely removed by passing the gas from the bombardment chamber through a small soda lime column. The $^{13}NH_3$ is then almost completely removed from the methane carrier gas by bubbling it through 10–15 ml of sterile, pyrogen-free saline in which the $^{13}NH_3$ dissolves. This solution is then ready for intravenous injection after sterilization by membrane filtration. Using this method, 20–30 mCi of radioactivity have been produced with a 5-μA beam in 20 min and processed for intravenous injection in less than 5 min.

RESULTS AND DISCUSSION

Animal distribution studies in mice indicated that the liver is the primary organ of localization, containing approximately 15% of the intravenously injected radionuclide at 2 and 10 min after intravenous injection. The human total-body absorbed radiation dose was computed (MIRD dosimetry) as 5 mrad/mCi assuming uniform distribution, and the liver dose was 25 mrad/mCi assuming 15% of the dose in the liver. An image of the trunk of a normal human subject made following intravenous injection of $^{13}NH_3$ (Fig. 1) showed no substantial localization of activity except in the liver, myocardium, and bladder. Four and seven-tenths percent of the injected dose was excreted at 35 min. The kidneys were briefly and faintly visualized. The blood disappearance curve was very rapid, 85% of the radioactivity leaving the blood in the first minute both in the mouse and in the human subject. Thus the NH_4^+ ion behaves in a markedly different manner from the potassium ion and its analogs.

Detection and imaging of the positron annihilation radiation from the myocardium was accomplished using a Nuclear-Chicago HP Anger Camera,

Received Oct. 4, 1971; original accepted Nov. 22, 1971.

For reprints contact: Paul V. Harper, Argonne Cancer Research Hospital, 950 E. 59th St., Chicago, Ill. 60637.

* Operated by the University of Chicago for the United States Atomic Energy Commission.

FIG. 1. Image of trunk of normal human subject showing localization of ^{13}N from NH_3 in liver, myocardium, and bladder at 30 min using Nuclear-Chicago HP camera with diverging collimator 4½ feet from subject.

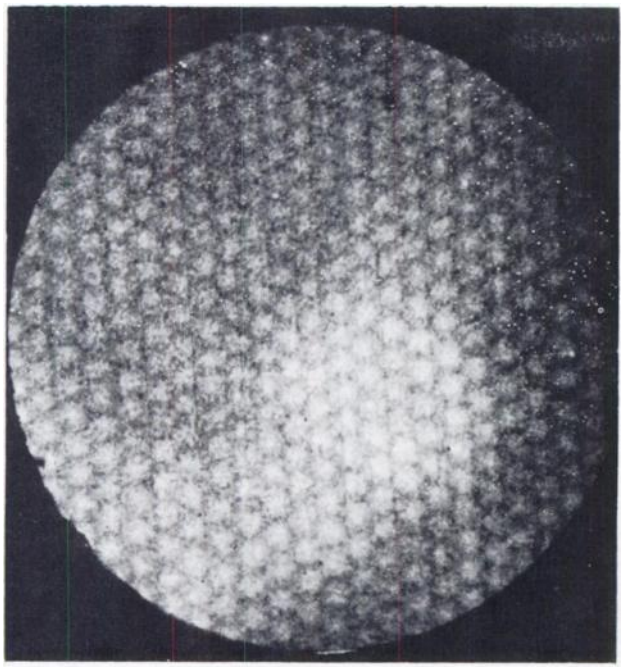

FIG. 2. Myocardial image, anterior view, of normal subject using ^{13}N from NH_3 imaged with Nuclear-Chicago HP camera with 550-keV collimator. Ten mCi were administered intravenously and image was recorded between one and 30 min.

and the output was recorded on videotape for replay to image different phases of uptake and to obtain uptake curves over different regions. A newly available 550-keV collimator (451 round, parallel holes $\frac{1}{4} \times 3$ in. on $\frac{7}{16}$-in. centers) was used which imaged well but because of the septal thickness resulted in an overlying collimator pattern. It is possible to eliminate this pattern by moving the collimator during imaging.

Two volunteer subjects were studied, each receiving 10 mCi of ^{13}N-ammonia intravenously in 15 ml of sterile saline. The myocardial images obtained are shown in Figs. 2 and 3. The subject in Fig. 2 was apparently normal and healthy. The left myocardium is well visualized and resembles closely the realistic heart phantom (*3*) made from a plastic mold of a fixed specimen. The right myocardium is not visible. The subject in Fig. 3 was also apparently healthy but on questioning admitted to an episode of severe crushing chest pain lasting several days which occurred 8 years previously. The myocardial scan shows a defect in the inferior portion of the left myocardium which may well represent an old infarct.

When the videotape was replayed, activities over equal areas of myocardium, lung, mediastinum, and liver were recorded in the normal subject and are presented as counts per minute per square centimeter per millicurie injected as corrected for physical decay (Fig. 4). After the initial bolus leaves the heart chambers (about 30 sec) the myocardium is immediately visible, indicating that the myocardial uptake is largely a first-pass phenomenon. The myocardial radioactivity falls slightly during the next few minutes and then stays virtually constant up to 30 min. Activity over the mediastinum is cleared rapidly, and over the lung more slowly, both reaching a level of about one-half that of the myocardium. The liver activity during the 6–8 min after injection builds up to about the same level over the left lobe as over the myocardium.

The most satisfactory images were obtained by recording between 1 and 30 min in which time 1.5–2 million counts were obtained in the whole image (~3,500 counts/cm^2 over myocardium). Figures

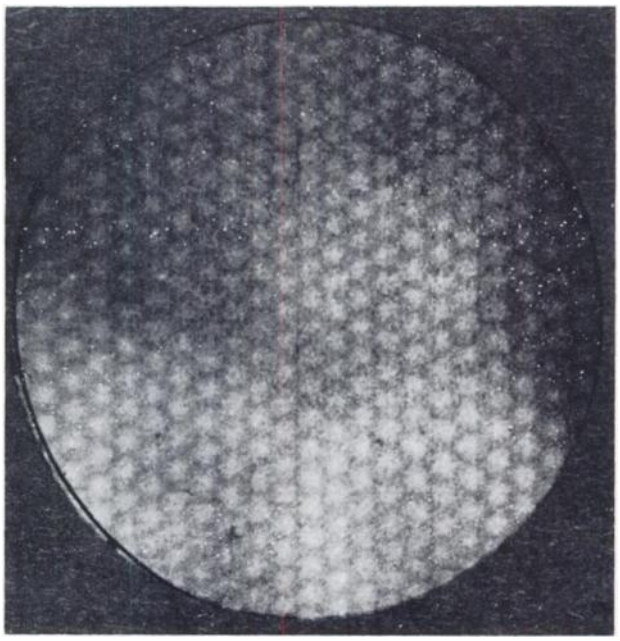

FIG. 3. Anterior myocardial image of human subject with history suggesting old myocardial infarction showing inferior myocardial defect.

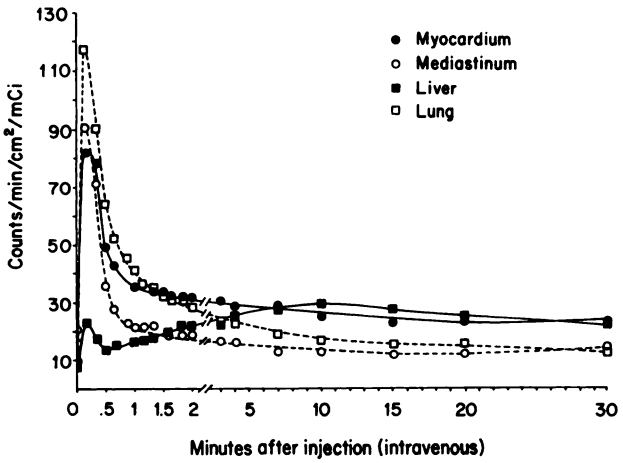

FIG. 4. Uptake curves over myocardium and adjacent regions following intravenous administration of $^{13}NH_3$.

2 and 3 are recorded in this way. At this counting level it would certainly appear feasible to gate the camera with the electrocardiogram in order to reduce the blurring due to cardiac motion. Under these circumstances it might be desirable to increase the dose of the radiopharmaceutical preparation several fold which could be done without excessive radiation absorbed dose.

The clinical indications for myocardial imaging must obviously evolve from more extensive experience. Some possibilities that immediately suggest themselves are: indeterminate ECG findings, screening candidates for coronary angiography, and determination of extent of acute infarct with a view to aggressive therapy before cardiogenic shock appears. Studies of acutely ill patients in the nuclear medicine environment might not be feasible. The use of a portable imaging device under these circumstances has been suggested (*3*) and might extend substantially the use of myocardial imaging.

SUMMARY AND CONCLUSIONS

The use of $^{13}NH_3$ as a scanning agent makes possible clinical myocardial images with high count density, good contrast, and low absorbed radiation dose using commercially available imaging equipment. The imaging equipment and technique are certainly capable of further refinement, and the available count densities should permit significant image processing so that the possibility that this approach will provide a powerful diagnostic tool appears very real.

REFERENCES

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