Personnel Radiation Dose from Leukocyte Labeling Procedures: Indium-111 Oxine Versus Technetium-99m HMPAO

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Although technetium-99m (^{99m}Tc) HMPAO leukocytes deliver substantially lower absorbed doses to patients than do indium-111 (^{111}In) oxine leukocytes, we expected that the pharmacist or technologist performing the labeling procedure would receive a higher radiation dose from ^{99m}Tc due to the larger amounts of activity being utilized. Thermoluminescent dosimeters were used to measure radiation doses during actual labeling procedures with ^{99m}Tc HMPAO and ^{111}In oxine. These measurements showed that the radiation doses from ^{99m}Tc leukocyte labeling procedures are 3.3 times higher for the whole body and 4.6 times higher for the hands than are the doses from ^{111}In leukocyte labeling procedures.

In the past few years, the use of leukocytes labeled with technetium-99m (^{99m}Tc) exametazime (HMPAO) has emerged as a practical alternative to the use of ^{111}In-labeled leukocytes in a variety of settings (*1–3*). Advantages of ^{99m}Tc as a radiolabel include convenience, physical characteristics, and radiation dosimetry. For example, the radiation absorbed doses to liver, spleen, and marrow from 5 mCi of ^{99m}Tc-labeled leukocytes are only about 30% of those from 0.5 mCi ^{111}In-labeled leukocytes (*1*).

In contrast to the lower absorbed doses received by patients given ^{99m}Tc-labeled leukocytes, the radiation dose received by the pharmacist or technologist preparing the labeled leukocytes is higher when ^{99m}Tc is used due to the larger amounts of activity. The magnitude of this higher personnel dose was the subject of this study.

MATERIALS AND METHODS

First Approximation of Relative Radiation Exposure Rate

Specific gamma constants for ^{99m}Tc and ^{111}In are 0.8 and 3.2 R/mCi/hr at 1 cm, respectively (*4,5*). Assuming equal times and distances, relative exposures from activities handled during typical labeling procedures were calculated.

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Measurement of Actual Exposures

Radiation doses during leukocyte labeling procedures were measured directly using commercially available thermoluminescent dosimeters (TLDs) (Landauer, Glenwood, IL). Two sets of dosimeters were used, one for ^{111}In labeling procedures and the other for ^{99m}Tc labeling procedures. Each set consisted of three dosimeters: a body badge, a ring, and a control. During each labeling procedure, the appropriate body badge was worn on the chest and the appropriate ring was worn on the palmar base of the right index finger. When not in use, all dosimeters, including the controls, were stored together in a non-radiation area. Doses from a total of 25 ^{111}In labeling procedures and 9 ^{99m}Tc labeling procedures were accumulated on the respective dosimeters over a period of five months. For ^{111}In labeling procedures, starting activities were 0.65–0.70 mCi and patient dosages averaged 0.521 mCi (range: 0.444–0.549 mCi). For ^{99m}Tc labeling procedures, starting activities were 14.0–15.9 mCi and patient dosages averaged 5.1 mCi (range: 4.5–5.5 mCi).

RESULTS

An estimate of relative personnel radiation exposures from typical patient dosages, based on the specific gamma constants, is as follows.

$$\frac{^{99m}\text{Tc}}{^{111}\text{In}} = \frac{0.8\ \text{R/mCi/hr} \times 5\ \text{mCi}}{3.2\ \text{R/mCi/hr} \times 0.5\ \text{mCi}} = \frac{4.0}{1.6} = 2.5$$

Due to differences in labeling efficiency and decay during preparation, relative exposures from starting activities are as follows:

$$\frac{^{99m}\text{Tc}}{^{111}\text{In}} = \frac{0.8\ \text{R/mCi/hr} \times 15\ \text{mCi}}{3.2\ \text{R/mCi/hr} \times 0.7\ \text{mCi}} = \frac{12}{2.2} = 5.4$$

Thus the dose received by a pharmacist or technologist during the labeling procedure would likely be 2.5–5.4 times higher with the ^{99m}Tc procedure than with the ^{111}In procedure.

TABLE 1. Radiation Dose (mrad) from Leukocyte Labeling Procedures

	^{111}In Oxine	^{99m}Tc HMPAO
Body dosimeter (net total)	5*	6†
Finger dosimeter (net total)	24*	40†
Average body dose/labeling procedure	0.20	0.66
Average finger dose/labeling procedure	0.96	4.44

* N = 25

† N = 9

The net total doses and average dose/labeling procedure as measured with TLDs during actual labeling procedures are shown in Table 1. Thus, the pharmacist or technologist doses from ^{99m}Tc leukocyte labeling procedures are 3.3 times higher for the body and 4.6 times higher for the hands, than are the doses from ^{111}In leukocyte labeling procedures.

DISCUSSION

The use of short-lived radionuclides in nuclear medicine has resulted in a substantial reduction in absorbed doses in patients while allowing greater radioactivity dosages to be administered. While advantageous for the patient, this does require the handling of higher amounts of radioactivity and thus greater radiation doses to pharmacists and technologists. Pharmacists and technologists must therefore continue to apply and, if possible, improve upon methods of radiation protection.

REFERENCES

1. Roddie ME, Peters AM, Danpure HJ, et al. Inflammation: imaging with Tc-99m HMPAO-labeled leukocytes. *Radiology* 1988;166:767–772.
2. Vorne M, Soini I, Lantto T, Paakkinen S. Technetium-99m HM-PAO-labeled leukocytes in detection of inflammatory lesions: comparison with gallium-67 citrate. *J Nucl Med* 1989;30:1332–1336.
3. Mountford PJ, Kettle AG, O'Doherty MJ, Coakley AJ. Comparison of technetium-99m-HM-PAO leukocytes with indium-111-oxine leukocytes for localizing intraabdominal abscess. *J Nucl Med* 1990;31:311–315.
4. Ceretec package insert. Amersham, Arlington Heights, IL, July 1990.
5. Indium In-111 Oxyquinoline package insert. Amersham, Arlington Heights, IL, May 1989.