Radiation Dose to Hands from Radiopharmaceuticals—Preparation Versus Injections

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Since there has not been a great deal in the literature on personnel radiation exposure, particularly to the hands, we investigated the question of which phase of radionuclide handling causes the greatest radiation dose to the hands: preparation or injection. Results indicate that the major radiation dose occurs during preparation. The total dose, however, is well below the maximum permissible dose set by the National Council on Radiation Protection. Lead foil wrapped around the syringe cuts the dose to the hands somewhat, but the overall exposure to the hands while injecting is quite small.

Because of the rapid increase in the number of patient studies done in nuclear medicine departments, a greater need for further study of personnel hand exposure has developed. The number of patients receiving diagnostic studies rises approximately 10% each year at University Hospital in the Indiana University Medical Center. At St. Francis Hospital Center in Beech Grove, IN, the number of studies has increased from 3,037 in 1974 to 4,810 in 1975.

There is no absolute agreement that a radiation threshold (a dose below which no effects will be incurred) exists. A conservative approach would be to assume that there is none. If there is no radiation threshold, there is some risk associated with a dose of any size. Since it is virtually impossible for the technologist to avoid some exposure, a maximum permissible dose (MPD) has been set by the National Council on Radiation Protection (NCRP) at 75 rems to the hands in one year (*1*). However, the Nuclear Regulatory Commission (NRC) recently recommended that exposures be kept "as low as is reasonably achievable" (*2*).

A study by Lombardi et al. concluded that approximately 95% of the total hand dose is received during preparation and injection of the scanning agent. Five percent is received during assay (*3*). What was not determined was whether the higher exposure phase was during the preparation or the injection of the scanning agent. The primary purpose of this study was to determine which was the higher exposure phase. The secondary purpose was to evaluate the effectiveness of lead foil for protection during injection.

Materials and Methods

Thermoluminescent dosimeters (TLDs) were used in this study. Unlike commercial film badge services, they afford immediate feedback. In addition, the accuracy and reliability of commercial film badge products have been questioned (*4*). Despite some handling difficulties with TLDs, in areas controlled by a health physicist or a radiation safety officer, the TLD is the best choice (*5*).

Calcium fluoride (TLD-200) thermoluminescent dosimeters (Hawshaw 1/8 in. × 1/8 in. × 0.035 in.) were used because of their extreme sensitivity, wide range of exposures, and long-term response retention. They were calibrated against a cobalt-57 source, whose energy range is approximately that of technetium-99m, the radionuclide used almost exclusively.

Three TLD rings were worn proximally on the palm side of the right index finger (Fig. 1), since this finger received the highest dose on the hand (*3*). One of the rings was worn all of the time. The other two were worn

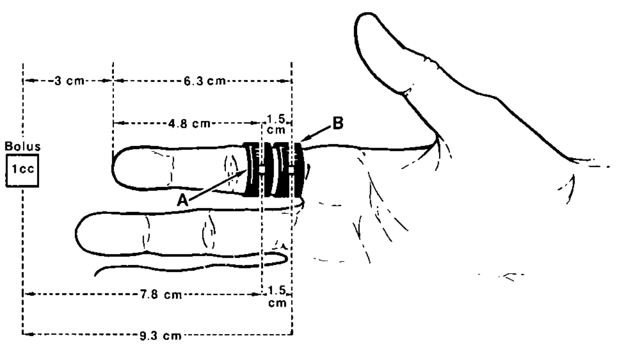

FIG. 1. Approximate distances of the chips in the rings in relationship to bolus and each other. A indicates preparation ring; B indicates ring worn all the time.

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TABLE 1. Radiation Doses to Hands during Phases of Radionuclide Handling

Week	Injections	Dose (mCi)	Background* (mrem)	Total (mrem)	Preparation (mrem)	Injection (mrem)
1	30	394	7±3	96±36	88±36	11±3
2	41	512	11±3	151±35	133±36	16±3
3	28	345	4±3	70±35	70±36	9±3
4	37	544	4±3	150±35	161±36	10±3
Sum			26±6	467±70	452±72	46±6

**Error is ± one standard deviation. Background is not subtracted out. Protective lead foil was used during injection in third and fourth weeks.*

only when performing one of the two functions under investigation. When not in use, all the rings were deposited in protective lead containers to prevent unwanted radiation from contaminating the results. Control TLDs were used to check the background activity.

This study was conducted in a 500-bed, private hospital with a nuclear medicine department consisting of two technologists and two assistants. The investigator, one of the two technologists, conducted the experiment with the help of a radiation health physicist. The study ran for four weeks (five-day work week) with the TLDs being read at the end of each week.

All radiopharmaceutical preparations (i.e., elution, assay, kit preparation, dispensing and administration), were carried out by the same technologist. During the last two weeks of the experiment, a leaded foil (Slim-Line Syringe Shield, Atomic Development Corp.) rolled around the syringes was used for protection while injecting. The procedure for using the lead foil during preparation was found to be awkward and time-consuming, and this protection was discarded during the preparation phase.

Results and Discussion

During radiopharmaceutical preparation the radiation dose was 9.8 times as high as the dose during injection (Table 1). The radiation dose resulting from preparation was approximately equal to the total dose. During the fourth week, the preparation dose was higher. One possible reason for this was the fact that the ring worn all the time was worn 1.5 cm more proximally on the right index finger than the other two rings. Using the inverse square law, this small difference in distance can make a large difference in dose when working with such short distances in relation to the syringe bolus. Assuming a 1-cc bolus and the approximate distances shown in the illustration, if the preparation ring had been worn as proximal as the ring worn all the time, the dose would have been 30% less during preparation.

During the injection phase of the experiment the doses were approximately twice background level. Although lead foil was used as protection during the last two weeks of the study and the radiation dose was reduced slightly, we believe the overall injection dose was not significant enough to warrant the extra trouble of using lead foil. The control chips were not kept in lead as the other chips were. This could have elevated the actual background reading somewhat. Error in determining doses of less than 20 mrem is also much higher (Table 1).

The total dose to the right index finger was less than 500 mrem per four-week period and averaged 117 mrem per week. This exposure is well below the MPD of 1500 mrem (1.5 rem) per week. The doses in Table 1 are not, however, necessarily representative of the highest dose to the hands. Since the rings were worn proximally on the finger, it is possible that the finger tip, being closer to the bolus in the syringe, received a much greater dose. Again, assuming the distances used (Fig. 1) the finger tip would have received approximately 6.7 times the dose received at the proximal end where the preparation ring was worn. This is a considerably higher dose and when trying to keep the radiation doses as low as reasonably achievable, it is advisable to use more radiation protection during preparation.

Summary and Conclusion

This study evaluated radiation exposure to the hands during two phases of radionuclide handling: preparation and injection. These two phases account for most of radiation exposure to the hands. We also investigated the effectiveness of lead foil for protection during injection. On the results we base the following conclusions:

1. Most radiation exposure occurs during preparation of radiopharmaceuticals.
2. The amount of radiation measured during the injection phase, at least in this small department, was almost insignificant.
3. Lead foil wrapped around the syringe during injection appears to reduce the dose slightly, but hardly seems worth the extra trouble.
4. In a larger department with more patients per technologist, lead foil might be more important during injection.
5. The total dose to the right index finger was well

below the NCRP maximum permissible dose, but probably not as low as reasonably achievable.

6. Hand exposures can be reduced by improving preparation methods.

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