# DETERMINATION OF SKIN DOSE TO THE HANDS OF TECHNOLOGISTS HANDLING SYRINGES CONTAINING RADIOPHARMACEUTICALS

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## INTRODUCTION

In recent years, the use of various radionuclides in nuclear medicine has increased significantly. Technetium-99m is most widely used for gamma imaging of brain, liver, thyroid and kidney. Most often technologists use $^{99m}Tc$ radioactive solution in unshielded syringes for diagnostic and therapeutic injections(1). It is important to know accurate dose delivered to the hands of technologists, who handle $^{99m}Tc$ in syringe, in order to confirm that exposure is within safe limits. The ring and wrist monitors using films and thermoluminescent dosimeters (TLD) do not adequately reflect true radiation burden to the hands (2).

Previous investigations of skin doses have been performed using TLD or films(3,4). The response of TLD or film has been determined in these investigations by measuring the dosimeter's response to pure gamma fluxes. However, in reality the dosimeters are in a mixed flux of photons and particulates including secondary electrons. The darkening of the film and the excitation of the TLD per unit dose is higher from electrons than it is from photons. Therefore by analyzing the dosimeter's response with pure gamma calibration curves may cause underestimation of actual absorbed dose. Henson's (5) results confirm that the skin dose in contact with unshielded syringes is higher than TLD or film measurements, even when he makes no allowance for the dose arising from secondary electrons.

It is the purpose of this paper to evaluate the risk involved in handling unshielded syringes containing $^{99m}Tc$, by providing the results of the calculations which determine dose from photons and particulates as a function of depth in the skin. Also, a estimate of possible hand dose received by the technologists using unshielded syringes has been made on a yearly basis.

## METHOD OF CALCULATION

A Monte Carlo computer program(6) was developed to calculate dose rates at surface sites on syringes containing $^{99m}Tc$. The calculations include dose due to characteristic x rays, gamma rays and beta particles, including the secondary electrons generated in the syringe wall, and make allowances for absorption in the source and syringe wall. In order to simplify the calculations, the geometry of syringe-barrel was considered as a right circular cylinder and water was taken as tissue-equivalent material. A photon cut off energy of 2 keV was introduced, assuning local absorption of photons below 2 keV. The system defined in Monte Carlo dose calculations consisted of the radioactive fluid, plastic syringe wall and the skin-tissue surrounding the syringe. The disintegration of one $^{99m}$Tc atom and absorption of its energies was defined as a history. About 75,000 to 100,000 histories were obtained to get a good estimate of absorbed dose. Due to staistical nature of the problem, errors were upto ±10 percent.

The calculations were performed for commercially available, disposable type, one and five milliliter plastic syringes, filled with 1ml and 5 ml radioactive fluid respectively. The inside radii of the syringes were 2.3 mm and 6.4 mm respectively, and the wall thickness was 0.8mm. The chosen sites in the skin varied from 10 micrometer to 10 centimeter radially in the skin, over various locations on the active volume.

## DISCUSSION OF RESULTS

Results of the Monte Carlo dose calculations for 1 and 5 ml syringes are given in Table 1. Doses at the surface of syringes are extremely high, of the order of $10^5$ mrad/mCi-minute, due to very large dose-contribution from the secondary electrons. Doses due to the secondary electrons drop off rapidly within 0.02 mm away from the surface.

TABLE 1. Radial Dose Distribution for 1ml and 5ml Syringes

| Distance from the syringe-surface(cm) | Dose Rate (mrads/mCi-minute) | |
|---|---|---|
| | 1 ml Syringe | 5 ml Syringe |
| At the surface | $6.25 \times 10^5$ | $4.2 \times 10^5$ |
| 0.02 | 60.5 | 22.0 |
| 0.04 | 45.1 | 15.3 |
| 0.10 | 31.4 | 9.7 |
| 0.25 | 15.6 | 7.0 |
| 0.50 | 10.0 | 5.3 |
| 1.0 | 5.7 | 3.1 |
| 2.0 | 2.8 | 1.8 |
| 3.0 | 1.6 | 1.0 |
| 4.5 | 1.25 | 0.6 |
| 6.0 | 0.57 | 0.3 |
| 8.0 | 0.36 | 0.19 |
| 10.0 | 0.15 | 0.10 |

The axial dose, at various locations over the active volume, does not vary significantly, however, it is peaked at the center of the active volume.

The plot of radial dose rate is shown in Figure 1. It is important to note that the skin dose to the active layer of the skin, few hundred micrometers deep, is only 20-30 mrad/mCi-minute for five milliliter syringes and 35-68 mrad/mCi-minute for one milliliter syringes.

The surface dose to the active layer of skin are compared with the published results in Table 2. The results in publications vary because of differences in syringe dimensions, types of syringes used, and the amount and activity of radioactive fluid in the syringe. As shown in Table 2, the calculated results, both Henson's and the Monte Carlo, are higher than the measured dose.

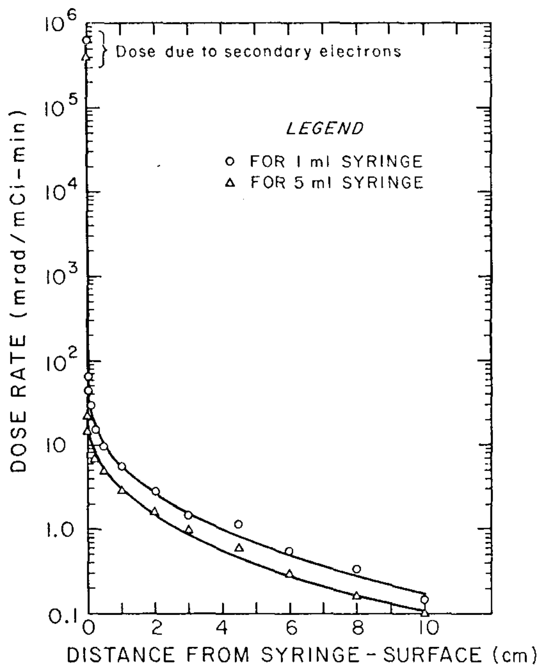


FIGURE 1. Plot of the Radial DoseDistribution

TABLE 2. Comparision of Available Results

| Source of Data | Surface Dose Rate [1] | Reference |
|---|---|---|
| NIH film measurement | | (2) |
| 1 ml syringe | 14-20 | |
| 6 ml syringe | 15-25 | |
| Husak, TLD measurement | | (4) |
| 6 ml syringe | 9 | |
| Henson's calculations | | (5) |
| 1 ml syringe | 25-55 | |
| 5 ml syringe | 15-20 | |
| Monte Carlo Calculations | | (6) |
| 1 ml syringe | 35-68 | |
| 5 ml syringe | 20-30 | |

1 dose rate in mrad/mCi-minute

## CONCLUSION

The calculated surface dose from a $^{99m}Tc$ filled syringe to the active skin layer is about 3-6 times higher than TLD and film measurements. Thus, a technologist can receive 100-300 mrads/year by performing 25 administrations per week of 10 mCi activity each, when the average administration time is 0.4 minute. This dose is 1.3-4 times higher than the permissible occupational hand dose set by the United States Nuclear Regulatory Commission. The appropriate design and use of syringe shields are essential to avoid the undesirable effect of excessive and unnecessary radiation exposure.

## REFERENCES

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