Commentary on: “Occupational radiation exposure of medical staff performing ^{90}Y -loaded microsphere radioembolization”

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Within 1 year of the discovery of radiation, 1896, the three basic tenets of practical radiological protection – time, distance, and shielding – had been established by an American engineer Wolfram Fuchs [1]. However, it was not until 1928 that an international group was established to consolidate guidance on radiological protection. Today, that group is known as the International Commission on Radiological Protection (ICRP). Among the latest ICRP reports dealing with radiological protection in medicine will be a report on occupational protection in brachytherapy, due to be released in early 2016. Unfortunately, the latest draft of this report did not include radioembolization treatment with ^{90}Y microspheres. Despite being in clinical use since 2001, extensive research on occupational exposure has not been presented until now by Garin’s research group.

In order to confirm compliance with ICRP recommended occupational limits and the ALARA principle, Laffont and colleagues determined the radiation exposure of the medical staff while preparing the therapeutic dose and administering ^{90}Y -loaded glass and resin microspheres. According to their findings, the radiation exposure of staff from using either device should be less than the ICRP recommendations. That is, whole-body or chest and extremity or hand effective doses received in 1 year would be less than 50 mSv and 500 mSv,

respectively. Another interesting result from this study dramatically illustrated the engineering control differences between the two devices, resulting in significant differences in handling, manipulation and calibration of source vials. The mean effective dose to the radiopharmacist’s dominant finger was 13.9 $\mu\text{Sv}/\text{GBq}$ from preparation of the ^{90}Y -loaded glass microspheres, and was 295.2 $\mu\text{Sv}/\text{GBq}$ from preparation of the ^{90}Y -loaded resin microspheres. Therefore, this study suggests that individuals preparing/measuring the dosage vials would receive a dose to the finger approximately 21 times higher from preparing resin microspheres than from preparing glass microspheres. Similarly, the physician administering the microspheres would receive a dose to the finger approximately 17 times higher using resin than glass microspheres.

Assuming 13.97 μSv per 2.5 GBq administered, the user with the highest extremity exposure would have to perform 1,432 procedures to receive in excess of 50 mSv. However, today’s goal is to follow the ALARA principle, which is often taken to be 10 % of the recommended limits (5 mSv/year for extremities). For procedures involving glass microspheres, only 143 procedures per year could be performed by the same user with the highest ring reading. For procedures involving resin microspheres, the limit would be 14 procedures. For larger institutions with multiple users and staff, the 5 mSv/year limit should not be difficult to comply with given that the exposure would be shared among several people. Despite this, in keeping with ALARA principle, if procedure safety is to be optimized, we as prudent users should make every effort to decrease exposure.

Neither the use of beta-emitting pharmaceuticals and sealed sources nor the safety procedures that have been proven effective are new to medicine. In fact, both radioembolization devices have incorporated the shielding technology required for protection from the beta particles. That is, the microspheres are shielded in a low-density material (acrylic) sufficient to

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stop the beta particles when administering the products. Without this shielding, the user could be exposed to beta effective dose rates ranging from 120 to 43,500 mSv/h [2].

However, the two devices differ in the approach used to shield the user from the secondarily produced Bremsstrahlung radiation, which is produced when the beta particles interact with the shielding material. For both products, the radioactive source is housed in a v-vial surrounded by 12 mm of acrylic. However, the glass microspheres are additionally shielded by leaving the source inside the lead shipping container. Since the user is wearing a lead apron during the use of X-rays, the user should be protected from Bremsstrahlung produced from both the patient and the devices.

Both available ^{90}Y microsphere devices require some preparation and dose preparation is approached differently with each. The only preparation required for the glass microspheres is to remove the dose vial from the lead shipping container for activity measurement or verification. Unfortunately for the user, the resin microspheres must be removed from the shipping vial and transferred to the dosing v-vial manually. As suggested by Laffont et al., the radiation dose to the user manipulating the microspheres would be greatly reduced with an automatic dose fractionation system. In the mean time, the exposure can be reduced by using some simple procedures. First, leave the shipping vial in the lead container for drawing up the resin microspheres. To suspend the microspheres, we vigorously shake the vial in the lead container. The microspheres will remain suspended long enough for the user to draw up the specified amount. Second, the syringe used for drawing up the microspheres should be shielded with a beta shield with a wide acrylic disk near the needle tip. Although these shields are not provided by the manufacturer of the resin device, the shields are available commercially.

Ultimately, radioembolization with ^{90}Y microspheres offers lower occupational radiation levels when compared with other ^{90}Y therapeutic procedures. In an extremity exposure

study performed in European nuclear medicine centres, the mean effective dose per administered activity was measured for the preparation and administration procedures for both ^{90}Y -DOTADOC and ^{90}Y -Zevalin therapies. For ^{90}Y -DOTADOC, the mean extremity dose was 0.65 mSv/GBq for administrations and 1.65 mSv/GBq for preparations. The ^{90}Y -Zevalin mean extremity doses were even higher at 2.46 mSv/GBq for administrations and 3.52 mSv/GBq for preparations [3].

Additional research into occupational safety is needed. The current published studies have not addressed the radiation dose to the lens of the eye, in which the recommended limit is 150 mSv/year. There is still the question as to whether the user should wear lead safety goggles or some type of acrylic safety goggles. Both radioembolization devices result in personnel exposure inherent to their respective designs. The next step should involve proactive studies involving multiple institutions that address exposure of nuclear medicine staff, interventional radiologists and all other personnel involved in the management of patients treated with radioembolization. The Garin group should be commended for being first to highlight the critical issue of operator and personnel exposure associated with radioembolization.

References

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