EDUCATIONAL TRACK: RADIATION SAFETY AND HANDLING PHYSICIANS SHOULD KNOW ABOUT－REVIEW ARTICLE

Nuclear Cardiology Radiation Accidents

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Abstract

The most common form of spill of radioactive liquids in Nuclear Cardiology facilities occur in conjunction with exercise tests during rapid injection of a bolus of activity through an indwelling intravenous line and stop-cock mechanism. While minor spills are those involving 3.7 MBq or less of activity, most Nuclear Cardiology stress tests employ considerably larger amounts of radioactivity and produce major spills requiring a methodical response in order to limit radiation dose to patients and occupationally exposed radiation workers. Following a major spill the recommended procedure is to seal off the contaminated area until safe levels of radiation exposure survey meter readings are reached, considered to be less than 1 mR/hr. Diligent adherence to a quality assurance program schedule is necessary in order to guarantee that radiation measuring equipment is operating reliably. By following reasonable precautions and with adequate training of personnel, the majority of major radiation spills encountered in Nuclear Cardiology laboratories are easily avoidable.
Keywords: Exercise testing, Nuclear Cardiology, Quality assurance, Radiation exposure, Radiation protection, Radionuclides

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Among the problems that can confront Nuclear Cardiology practitioners in the laboratory are the possibilities for radiation accidents, i.e. spills of radioactive materials. These most frequently occur while the patient is exercising, with injection of radionuclide administered through an indwelling intravenous line through a stop-cock apparatus. Spills often arise because of failure to securely couple the intravenous line, or the syringe containing radionuclides (housed in a lead shield), to the “female” port of the stopcock. The assembly separates when the attempt is made to inject activity rapidly as a bolus. Most conventional Nuclear Medicine imaging procedures, which involve direct intravenous injections, are less likely to result in spills.

Steps to prevent radiation spills

These accidents most often occur due to inexperience, often affecting residents and fellows in training to conduct Nuclear Cardiology studies. The first step in handling radioactive spills, is to prevent them, and in that sense, the following reminders to trainees are critical:

1) For intravenous line, utilize veins that are just below the antecubital fossa, anteriorly, and feed into the median basilica vein. If possible, avoid small distal veins, particularly of the hand and wrist. These often are too small for pressured bolus injections, and cause the IV apparatus to separate and radionuclide to spill.
2) Be certain to securely attach all aspects of the apparatus, intravenous catheter, IV tubing and stopcock.
3) At the beginning of exercise, flush the line with saline solution, to confirm the IV line is patent, and no infiltration occurs.
4) If there is resistance to radionuclide injection, it usually means the line is not patent. Exercise should be immediately discontinued and the problem investigated. DO NOT PUSH HARDER!

If these simple rules are followed, most radioactive spills during nuclear cardiology procedures can be avoided.

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Minor radiation spills

For minor spills, such as those likely to involve less than 3.7 MBq (100 μCi) of activity in a small volume of liquid, it is usually sufficient to alert people in the area and the radiation safety office, have medical radiation workers don protective clothing, cover the radioactive liquid with absorbent pads, dispose of cleaning materials and contaminated protective clothing in plastic bags designated for the removal of radioactive waste, and monitor the area with a survey meter until radiation levels are down to normal background levels.

Major radiation spills

However, in response to a major radioactive spill once one has occurred, the sequence of events should be to remove contaminated persons (e. g. patients) from the area, notify everyone in the vicinity and the radiation safety office personnel, seal off the affected area, and only decontaminate the area when there is no other recourse. Major spills are those involving more than 3.7 MBq (100 μCi) of activity, and/or large volumes of liquid such as a liter or more. Common Nuclear Cardiology exercise tests use 93-130 MBq (2.5-3.5 mCi) Tl-201, or 148-1,110 MBq (4-30 mCi) Tc-99m agents (1). Consequently, most spills associated with injections administered as part of an exercise treadmill study would constitute a major radiation incident. Whenever possible, the room in which a spill of this nature has occurred should be closed until survey meter exposure readings indicate that radiation levels are below those deemed safe for occupationally exposed medical radiation workers, considered to be ~1 mR/hr.

The reason to remove contaminated persons (e.g. patients) from the area is to reduce their cumulated exposure from proximity to the source, ingestion and inhalation. Maximizing distance and shielding, while minimizing the amount of time the individual is exposed to a radiation source, ultimately will minimize their radiation dose. Potentially contaminated individuals should be kept in one area until they have been measured by survey meter. Contaminated clothes should be removed and stored until safe exposure levels are recorded, as these would otherwise be in immediate proximity to the contaminated person.

The reason to notify everyone in the vicinity is to limit the dissemination of radioactive sources. Radioactive liquids are easily spread further beyond the spill area, such as by foot traffic. The Radiation Safety Officer and his staff are specifically trained to assist in major radiation spills, and their expertise should be accessed. They also are the most experienced at removing higher levels of radioactive waste.

Safe radiation exposure levels

The origin of the recommendation to limit the average radiation exposure level in a Nuclear medicine facility comes from the most recent International Commission on Radiation Protection (ICRP), which advises that total body dose equivalent to occupationally exposed individuals should not exceed 20 mSv/year averaged over 5 years, with no individual exposure per year to exceed 50 mSv (2). For a 2,080 hr work year, this translates to a survey meter reading of exposure of ~1 mR/hr. In non-radiation areas, survey meter readings should be $1/10^{th}$ as much or less, or ~0.1 mR/hr. This level of exposure is consistent with average background dose-equivalent values to the general population of ~2.4 mSv/year (3).

It is also necessary to routinely monitor surfaces in radiation areas, such as treadmill rooms, camera rooms, hot labs and wet labs. These procedures are performed daily with wipe tests to detect removable radioactivity, typically using cotton swabs that are subsequently measured in a scintillation well counter. Logs are kept of specific radiation measurements, keyed to a list and map of areas from which samples are collected. Survey meters also are used on a daily basis, continuously in use in hot labs near sites used for dispensing radiopharmaceuticals and preparing syringes.

Radiation monitoring equipment quality assurance

The mechanism through which occupationally exposed personnel can have confidence in the accuracy of radiation measurements is through diligent adherence to standard quality assurance procedures. Calibration procedures for well counters are performed on a daily basis, usually using a Cs-137 source, along with measurements of background radiation readings. Annually, well counters also undergo activity-linearity, geometry, and multi-energy tests. Survey meters also are checked daily with a standard source and checked for zero-adjust and background values. They are calibrated against a higher activity source annually, with assessment of accuracy and precision, as well as activity-linearity and electrical safety. Daily tests usually are performed by technologists, while annual tests are performed by a certified medical physicist. Results of all tests are documented and stored, so as to be available for review by radiation inspectors.

Conclusions

In summary, the majority of major radiation spills encountered in Nuclear Cardiology laboratories occurs in conjunction with exercise tests and are easily avoidable with reasonable precautions. When spills do happen despite all precautions, following methodical procedures will minimize undue radiation exposure to patients and to occupationally exposed radiation workers.

See related self-assessment program: Go to ANC URL http://anc.jsncjournal.org/

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Conflicts of interest

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