Lead Pig for Use with Screw Cap Vials

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A lead pig specifically designed for use with solid screw cap vials is described. **Methods:** The salient features of this design include a compressible polyethylene sleeve, which is housed in the lower section of the pig, and a partially recessed O-ring, which is housed in the upper section of the pig. These features permit both the vial and the cap to be secured independently without the risk of overtightening. Fingertip radiation exposure associated with repetitively opening and closing a screw cap vial containing a sample of ^{18}F was monitored by use of a fingertip dosimeter. **Results:** The cumulative fingertip radiation exposure resulting from opening and closing a screw cap vial containing 200 MBq of ^{18}F-FDG 3 times was 307 μSv without the aid of this lead pig, as compared with 6 μSv when using this device. **Conclusion:** Use of this lead pig with screw cap vials can significantly reduce fingertip radiation exposure and decrease the likelihood of accidental radioactive contamination of research personnel.

Key Words: lead pig; radiation protection; screw cap vials

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The Nuclear Regulatory Commission requires that all individuals who handle radioactivity conform to the ALARA principle, which states that efforts shall be made to keep radiation exposure "as low as reasonably achievable." The current practice in the preparation of positron-emitting radiolabeled compounds involves the use of highly sophisticated remote-controlled radiosynthesis systems. These systems have dramatically reduced the exposure of radiochemists to radiation. However, after the completion of radiosynthesis, various biologic studies or radioanalytic procedures require that small samples of the radiolabeled product be withdrawn from the product vial. Two types of vials are routinely used to store radioactive material: crimp-sealed vials and screw cap vials. A variety of vial shields are commercially available for use with crimp-sealed vials, and samples may be withdrawn from a vial via direct puncture of the septum with a needle-tipped syringe. Some investigators prefer using a screw cap vial, which permits unencumbered access to a sample without the need to puncture a septum. They may use such a vial when obtaining samples for radioanalytic high-performance liquid chromatography or when using a pipette to remove samples for in vitro binding studies. Although the actual contact time necessary to manually open and close a screw cap vial is small, the cumulative effect of performing several such procedures involving millicurie amounts of radioactivity represents a significant source of unnecessary radiation exposure.

This article describes the design and construction of a lead pig for use with solid screw cap vials containing positron- or γ-emitting radiolabeled compounds. The use of this pig can significantly reduce fingertip radiation exposure while also decreasing the likelihood of accidental spillage of solutions containing radioactive material.

MATERIALS AND METHODS

Antimonial lead rods were obtained from either McMaster-Carr or Atlantic Nuclear and machined on-site. The thickness of the lead walls of the pig was ~1.9 cm (0.75 in.; approximately 4.5 times the half-thickness value of lead [i.e., the thickness of lead necessary to reduce by 50% the amount of radioactivity penetrating the lead shielding] for 511 keV). The lower section of the lead pig was machined to accept a borosilicate glass V-Vial (Wheaton Glass Co.) housed in a removable split-sleeve collar. The collar was made from ~0.32-cm (0.125-in.)-thick ultra-high-molecular-weight (UHMW) polyethylene. An ~0.32-cm (0.125-in.) cut slot extends over the entire length of the sleeve. The length of the sleeve was matched to the length of the cylindric portion of the vial. A drilled hole with a stainless steel helicoil insert was positioned 1.27 cm (0.5 in.) from the top of the lower section of the pig to accept a nylon-tipped thumb screw. A hole was also drilled into the UHMW polyethylene sleeve to accept the thumb screw. The upper section of the pig was machined to accept a Vitron O-ring (style 213; Small Parts, Inc.) located ~0.64 cm (0.25 in.) from the bottom of the upper section of the pig. The top surface of the lower section of the pig had an ~0.95-cm (0.375-in.) circular recessed surface (undercut), and the bottom surface of the upper section of the pig had a matched raised surface (boss) to prevent radiation leakage. Enamel spray paint was used to cover all exterior lead surfaces.

RESULTS

We have developed a lead pig for use with screw cap vials (purchasing information may be obtained from either of the 2 potential vendors of the device, Capintec, Inc., and Medi-Ray, Inc.) (*1*). When this pig is used, the vial is restrained in the lower section of the pig by use of a UHMW

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polyethylene sleeve that is compressible. Compression of the cut slot sleeve is accomplished by turning a wing nut that is threaded through the pig and is adjusted from the outside surface. Once tightened, the wing nut prevents the vial from moving in the lower section of the pig. A partially recessed O-ring in the upper section of the pig provides sufficient resistance to grip the cap of the vial but also serves as a slip clutch to prevent accidental damage to the cap because of overtightening. Applying or removing the cap from the vial is then accomplished simply by turning the upper section of the pig with one hand. Once removed, the cap remains fixed in the upper section of the pig until the cap is reapplied to the vial with a similar but opposite motion (Figs. 1–3). Simply lifting the upper section of the pig with the wing nut still engaged is sufficient to remove the upper section of the pig from the vial cap. Alternatively, relieving the pressure on the wing nut on the sleeve permits the entire vial to be removed from the lower section of the pig by simply lifting the upper section of the pig. This feature is useful if the vial is to be temporarily placed in a heating block (Fig. 4).

To demonstrate the reduction of exposure that can be realized with the use of this device, a 200-MBq (5.4-mCi) sample of ^{18}F-FDG (PETNET Pharmaceuticals, Inc.) dissolved in saline (1 mL) was placed in a 5-mL conical screw cap vial. An Unfors fingertip radiation dosimeter (nuclear-educational-dosimeter style; Unfors Instruments, Inc.) was attached to the distal medial aspect of the right index finger of one of the authors and covered with 2 pairs of latex examination gloves. The highest dose rate observed with direct contact of the gloved finger with the glass vial containing the radioactive solution was 68 mSv/h. The highest dose rate observed with the lead pig for screw cap vials was 1.03 mSv/h. This dose rate was found 3.5 cm

FIGURE 2. Actual placement of screw cap vial in lower section of pig before removal of cap and upper section of pig showing partially recessed O-ring and boss (raised surface).

FIGURE 1. Lower section of pig, showing vial, sleeve, and wing nut.

FIGURE 3. Removal of cap from vial and retention of cap in upper section of pig.

FIGURE 4. Insertion of reaction vial into heating block. In this procedure, top of pig is allowed to remain on vial throughout heating cycle.

from the bottom of the pig and corresponded to the middle of the radioactive solution. No dose rate was detected at the top of the lead pig for screw cap vials. Working behind an L-Block (Capintec, Inc.), the author placed the vial containing the radioactive sample into a conventional lead pig. The vial was then manually removed from the pig, the cap was taken off and placed on the laboratory bench, and the vial was placed back in the pig. After a few seconds, the reverse operation was conducted. This procedure was repeated 3 times, resulting in a cumulative fingertip radiation dose of 307 μSv. Replicating this protocol when the vial was housed in the lead pig for screw cap vials resulted in a cumulative fingertip radiation dose of only 6 μSv.

DISCUSSION

The use of a solid screw cap vial permits multiple samplings of vials without the need to puncture a septum with a needle. This feature is particularly useful for obtaining samples for radioanalytic high-performance liquid chromatography or when a hand-held pipette is used. Removal of the cap from a vial containing radioactive material is frequently performed manually, resulting in unnecessary radiation exposure to the hands and fingers. Additionally, once the cap is removed from the vial, the vial is often placed in a lead pig that permits some movement of the vial. Refastening the cap to the vial also requires additional handling, resulting in additional radiation exposure. The use of pliers or similar tools to grip the vial and remove the cap is often cumbersome and increases the risk of damaging the vial, the cap, or both, and unnecessary radiation exposure still occurs. Finally, the movement or temporary storage of an open vial containing radioactivity increases the likelihood of accidental spillage of radioactive material.

In this experiment, we demonstrated a dramatic reduction in the cumulative fingertip radiation dose (6 μSv vs. 307 μSv) when using the lead pig for screw cap vials instead of using a manual procedure. Although there was no spillage of the radioactive solution regardless of the method used to open the vial, the left glove of the investigator (used to remove the cap) was found to be contaminated when the procedure was done manually. There was no contamination of either glove when the lead pig for screw cap vials was used.

CONCLUSION

A lead pig specifically designed for use with screw cap vials containing radioactive material was described. In procedures requiring multiple samplings of a radioactive solution, this device has been shown to significantly reduce fingertip radiation exposure as well as to decrease the likelihood of radioactive contamination of research personnel.

REFERENCE

1. Dischino DD, Mongillo JJ, inventors. U.S. continuation-in-part patent application 11/430578. May 9, 2006.