A MEANS OF REDUCING RADIATION EXPOSURE FROM TECHNETIUM GENERATOR OPERATIONS

Modern molybdenum-technetium generator assemblies have been designed to minimize radiation exposure of the technician by paying attention to shielding and configuration and by the development of simple elution procedures. Quite a bit of concern has been shown in protecting the operator from the 740 and 780-keV radiation from ^{99}Mo. Considerable opportunity exists, however, for radiation exposure from the handling of the ^{99m}Tc eluate.

We have been concerned that technicians are exposed needlessly despite the relatively low energy (140 keV) of the ^{99m}Tc gamma rays. Although this low-energy radiation can be stopped by smaller thicknesses of lead, there seems to be a tendency to handle large millicurie amounts of ^{99m}Tc with little or no protection. One possible reason for this may be a false sense of security derived from the low energy of the radiations. Another reason might be the development of a casual attitude related to repetitious use. Still another reason may be that the usual lead bricks are neglected because they are so cumbersome. The most important reason may be that many of the operations involving ^{99m}Tc eluate require high visibility. It may be that shielding is neglected because it interferes with close vision. Moreover, the usually available lead glass bricks are expensive and are difficult to see through. The usual thickness of 2 in. is considerably beyond that needed for protection at this low energy.

FIG. 1. Face-and-body shield for use in eluate manipulations, modeled after radium body shields. Face plate is cell made of acrylic plastic with ⅜-in.-thick walls and a ¾-in.-thick compartment for lead perchlorate solution. Note excellent clarity of cell and solution.

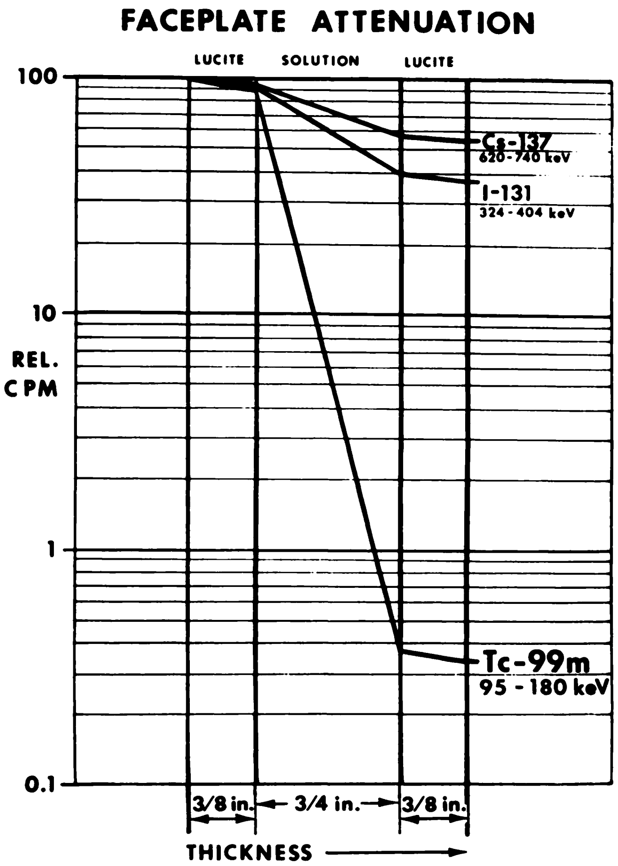

FIG. 2. Attenuation plot for certain gamma-ray photons showing reduction in intensity due to passage through plastic cell filled with lead perchlorate solution. Thickness of ¾-in. of solution and ¾-in. of plastic attenuates primary radiations of ^{99m}Tc by factor of about 300.

In providing the necessary protection for our own technicians we have devised body-and-face shields, similar in appearance to the protection blocks used in the handling of radium needles. The main body of the protection block is made of lead plates the size of lead bricks but only ⅝-in. thick. These plates are sandwiched between pieces of ½-in. plywood, and the surfaces of the L-shaped protection block are covered with formica. The top of the protection block (see Fig. 1) is a face shield made of a plastic cell filled with a nearly saturated solution of lead perchlorate, $Pb(ClO_4)_2$.

Lead perchlorate is available* at about $6.50/lb in the reagent grade as $Pb(ClO_4)_2 \cdot 3H_2O$. This chemical is remarkable in that about 500 gm of it can be dissolved in 100 cc of water. The resulting solution occupies about 200 cc; it therefore has a density of 3 gm/cc and is over 35% lead by weight. When the solution is first made, it has a muddy appearance. When this solution is filtered to remove gross impurities, it becomes as clear as water. Thus a plastic cell filled with this solution provides an effective shield that affords excellent visibility (Fig. 1) and protection for the worker (Fig. 2).

Narrow-beam absorption of radiations of three energies are shown in Fig. 2. It is seen that a thickness of ¾ in. of this solution provides only trivial reduction of high-energy radiations but attentuates the radiation of ^{99m}Tc by a factor of about 300.

The cost of the solution is about $35/liter. This expense is not negligible, but this approach provides adequate protection at this low energy at about half the cost of the lead-glass materials known to us at this time. We have made plastic cells in other sizes and shapes, including those of standard lead brick dimensions. We find them useful for general shielding, and they are especially useful in certain steps in radiopharmaceutical preparations, such as titrations and pH determinations. The cells can be made by anyone who can use a band saw to cut acrylic plastics and then cement the pieces together with ethylene dichloride.

The flexibility of shielding configurations afforded by this approach seems to be a definite advantage. In addition, the high visibility afforded by the transparency of the solution facilitates rapid and accurate procedures.

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* Lead perchlorate available from G. Frederick Smith Chemical Co., Columbus, Ohio.

IRON KINETICS AND WHOLE-BODY SCANNING OF IRON USING LESS THAN 5 μCi OF ^{59}Fe

Complete iron kinetics analysis is a powerful tool for quantitation of heme synthesis, mean red cell turnover time and rates of iron storage exchange (*1–3*). However, a complete iron kinetic study is laborious and time consuming, and for this reason we have devised a simplified protocol by which one can rapidly obtain most of the clinical information needed for evaluation of patients.

A 4–5-μCi dose of ^{59}Fe as ferrous citrate is incubated with autologous or homologous plasma having a sufficiently high latent iron-binding capacity to insure complete binding of the iron to transferrin (*3*). The plasma containing the transferrin-bound iron is administered intravenously, and plasma samples are obtained at 10, 15, 20, 30, 45, 60 and 90 min following the injection. A plasma iron-turnover rate is then calculated in a routine fashion (*1*). The patient is advised to return within one day and again 7–14 days after the administraiton of the radioiron, and posterior-view whole-body scans are obtained (*4*). A blood sample is obtained at the latter time to estimate ^{59}Fe incorporation into circulating RBC. The plasma iron-turnover rate and the fractional incorporation of iron in circulating RBC can be used to roughly estimate hemoglobin synthesis rate and mean circulating RBC turnover time (*1*). However, these calculations must be cautiously interpreted in view of the complex variables controlling their determination (*2,3,5*).

In general, when the serum iron concentration is normal or low and the latent iron-binding capacity is normal, the distribution of radioiron within the body at 24 hr is representative of the distribution of erythropoietic tissue. When the serum iron concentration is elevated and the latent iron-binding capacity is low, some of the initial distribution of radioiron in the body may represent deposition of iron in stores, which occurs primarily in the liver. The distribution of radioiron in the body at 7–14 days is representative of the iron which had been incorporated into red cells, and, in the case when storage iron deposition has occurred, radioiron which has been deposited in stores. When there is localized sequestration of circulating red cells, such as in hypersplenism, on the 7–14-day scan there will be an accumulation of ^{59}Fe-labeled red cells in sites of sequestration as is shown for the spleen in the example presented in Fig. 1. It should be noted that in the present technique satisfactory estimates of distribution of erythropoietic marrow and the subsequent distribution of radioiron labeled red cells were obtained with a 44-min whole-body scan using the Anger Mark II whole-body scanner (*4*) following administration of only 4–5 μCi of ^{59}Fe (as little as 2 μCi has been successfully used in children). Theoretically, similar results (but at lower efficiencies) should be obtainable with other *in vivo* radioisotope imaging devices equipped with appropriate