Development of a Correction Factor for Xe-133 Vials for Use with a Dose Calibrator

Gerald L. Gels and Harley V. Piltingsrud

Nuclear Medicine Laboratory and Division of Electronic Products, BRH, FDA
University of Cincinnati Medical Center, Cincinnati, Ohio

Manufacturers of dose calibrators who give calibration settings for various radionuclides sometimes do not specify the type of radionuclide container the calibration is for. The container, moreover, may not be of the same type as those a user might purchase. When these factors are not considered, the activity administered to the patient may be significantly different from that intended. An experiment is described in which calibration factors are determined for measurement of Xe-133 activity in vials in a dose calibrator. This was accomplished by transferring the Xe-133 from the commercial vials to standard NBS calibration ampuls. Based on ten such transfers, the resulting correction factor for the dose calibrator was 1.22.

J Nucl Med 23: 357–359, 1982

Users of dose calibrators* have generally had only the manufacturer's calibration for a specific radionuclide to rely on for making activity determinations for clinically used radioactive materials. This creates a problem when the containers of the sources differ significantly from those that the manufacturer used either to calibrate the instrument or to develop a generalized correction factor table for a particular type of "dose calibrator" instrument (*1*). Standards of Xe-133 from the National Bureau of Standards (NBS) are used routinely in our facility to recalibrate instruments used for assaying Xe-133. However, the type of container used by NBS (see Fig. 1) appears to be quite different from that in which Xe-133 is received from some vendors.† It can be seen that the variation in wall thickness of the commercial vial is much larger than the variation in NBS ampul wall thickness. An increase of 0.8 mm in wall thickness will increase the absorption of 30-keV photons by ~18%, and of the 80-keV photons by ~4%. Also, standards from the manufacturer are stated to have less than 5% uncertainty in activity, while NBS standards have a stated uncertainty of approximately 2%. Thus, in order to have a reproducible standard against which to compare dose-calibrator response, we used the NBS standard in this study. In order to determine a correction factor to apply to calibrations of a dose calibrator‡ for use with the Xe-133 containers, the following experiment was performed. In addition to this model calibrator, a cursory check was made on two other models of dose calibrators.‖

Received May 20, 1981; revision accepted Nov. 18, 1981.

For reprints contact: Gerald L. Gels, Nuclear Medicine Lab, Cincinnati General Hospital, Cincinnati, OH 45267.

MATERIALS AND PROCEDURE

An NBS-calibrated Xe-133 standard in a glass ampul and a number of similar empty glass ampuls were obtained from NBS. A calibration factor of 1.01 was obtained for Xe-133 activity in the NBS ampul in the dose calibrator‡ and this factor was subsequently applied to all measurements of Xe-133 activity in the NBS ampuls in that model dose calibrator. A commercial† vial containing about 7 mCi of Xe-133 was then assayed in the dose calibrator‡ and the contents were transferred to an NBS ampul as follows (see Fig. 1):

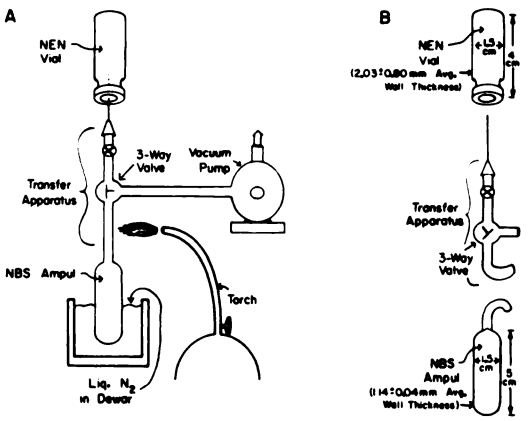

FIG. 1. Experimental apparatus during (A) and after (B) transfer.

TABLE 1. INDICATED ACTIVITIES, TRUE ACTIVITY, AND CORRECTION FACTOR FOR EACH TRANSFER EXPERIMENT USING DOSE CALIBRATOR.*

Transfer Experiment No.	Indicated activity: Vial before trans.‡ (mCi)	Indicated activity: Vial after trans.‡ (mCi)	Indicated activity: Transfer apparatus (mCi)	Indicated activity: Net transferred (mCi)	True activity in NBS ampul (NBS ampul × 1.01) (mCi)	Correction factor (true activity / net trans.)
1	6.41	1.10	0.00	5.31	6.62	1.25
2	6.26	0.99	0.01	5.26	6.53	1.24
3	6.51	1.09	0.02	5.40	6.59	1.22
4	6.30	1.01	0.03	5.26	6.54	1.24
5	6.52	1.23	0.05	5.24	6.36	1.21
6†	6.54	0.20	0.00	6.34	7.78	1.23
7†	6.89	0.19	0.00	6.68	8.13	1.22
8†	7.61	0.22	0.00	7.39	9.06	1.23
9†	7.53	0.19	0.00	7.34	8.70	1.19
10†	6.97	0.20	0.00	6.77	8.13	1.20
					Average	1.22
					Avg. 1.223 ± 0.038 (2σ)	

* Capintec CRC-2N.
† Molecular sieve in NBS ampul.
‡ New England Nuclear.

(1) The NBS ampul was evacuated to less than 1 mm Hg pressure using a mechanical vacuum pump. For the last five trials, each NBS ampul contained approximately 0.2 g of type 13X molecular sieve, which resulted in a greater transfer of xenon.
(2) The vacuum pump was isolated from the system by use of the three-way valve.
(3) The lower half of the NBS ampul was immersed in liquid nitrogen.
(4) The commercial† vial was pierced by the transfer apparatus needle and the contents of the vial transferred to the NBS ampul by operating the three-way valve.
(5) The NBS ampul was flame-sealed and the commercial† vial removed from the system.
(6) The commercial† vial, before and after transfer, the NBS ampul after transfer, and the transfer apparatus (glass and Tygon tubing with a small metal valve) were assayed in the dose calibrator.‡

Owing to wall thickness variations in the commercial† vials, the above process was repeated ten times in order to obtain a representative sample of measurements with several vials such as one would normally encounter in routine clinical use.

A correction factor for the commercial† vial in the dose calibrator‡ calibrated with an NBS-calibrated Xe-133 ampul was then calculated using

$$\text{C.F.} = \frac{N_B}{N_I - N_r - T_r},$$

where N_B = activity in NBS ampul after transfer, N_I = activity indicated in commercial† vial before transfer, N_r = activity indicated in commercial† vial after transfer, and T_r = activity indicated in transfer apparatus after transfer.

In addition to the above measurements, we used a commercial vial† calibrated using the dose calibrator‡ and a correction factor determined by the above method to check the calibration of two other dose calibrators.‖

Table 1 lists the results of the various measurements with the correction factor arrived at for each of the transfer experiments.

Using the data from all ten transfer experiments, an average correction factor of 1.22 ± 0.04 (2 s.d.) was found for the dose calibrator.‡

One of the dose calibrators‖ had a correction factor of 1.22 for one measurement, and the other‖ had correction factor of 1.21 for one measurement.

DISCUSSION AND CONCLUSIONS

As indicated above, this laboratory's dose calibrator,‡ used with the manufacturer's recommended settings for Xe-133, has a calibration factor for NBS calibration sources of about 1.01. Use of this calibration factor and manufacturer's recommended settings when assaying commercial† vials containing Xe-133 will result in an underestimate of the activity in the vial by approximately 18%. The two other dose-calibrator models‖ tested displayed response characteristics similar to those of the dose calibrator.‡

The NRC Regulatory Guide 10.8 (*2*) states that doses administered to patients be assayed to an accuracy of 10%. The United States Pharmacopeia (*3*) states that a Xe-133 agent "contain not less than 85.0% and not more than 115.0% of the labeled amount of Xe-133 at the date and time indicated in the labeling." Consequently, application of a correction factor (to commercial† vial measurements) is necessary to comply with these guides.

FOOTNOTES

* Capintec.
† New England Nuclear.
‡ Capintec model CRC-2N.
‖ Capintec, CRC-6A and CRC-10R.

ACKNOWLEDGMENT

The use of any trade names of commercial products used in this

study does not represent an endorsement of these products by the United States Food and Drug Administration.

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2. *NRC Regulatory Guide 10.8.* Revision 1. Washington, D.C., U.S. Government Printing Office, 1980, p 10.8-6
3. *The United States Pharmacopeia*, Twentieth Revision. Rockville, Maryland, United States Pharmacopeial Convention, Inc., 1980, p 852

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