A Technique for Measurement of Strontium-89 in a Dose Calibrator

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Objective: Strontium-89 (Metastron®, Medi-Physics Inc., Arlington Heights, IL) has recently received U.S. Food and Drug Administration approval as a therapeutic agent for relief of bone pain in patients with painful skeletal metastases. However, there are no calibration settings specified for measurement of ^{89}Sr in a dose calibrator.

Methods: Our institution developed a technique to determine the correct dose calibrator setting for measurement of ^{89}Sr both in the vial, as received from the manufacturer, and in the syringe for patient administration. The labeled activity in the ^{89}Sr vial was initially decay-corrected to the current date and time. The vial was then placed in a dose calibrator (CRC®-12, Capintec, Inc., Ramsey, NJ), and the potentiometer was adjusted until the displayed activity and the calculated activity were the same (after the displayed reading was multiplied by a conversion factor of 100). This technique was then repeated using another Capintec dose calibrator. The same procedure was applied to the ^{89}Sr measurement in the syringe. The amount of ^{89}Sr activity withdrawn into the 6-ml syringe was determined by subtracting the residual activity contained in the vial (using the same dial setting for the vial) from the original vial activity.

Results: The calibration settings obtained for ^{89}Sr measurement in a vial or syringe were very similar on both dose calibrators.

Conclusion: This technique may be useful to others who wish to determine dose calibrator settings for measurement of ^{89}Sr.

Key Words: strontium-89; dose measurement; dose calibrator

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Strontium-89 Chloride Injection (Metastron®, Medi-Physics, Inc., Arlington Heights, IL) was recently approved by the U.S. Food and Drug Administration for the relief of bone pain in patients with bony metastases (*1–4*). The current Nuclear Regulatory Commission (NRC) regulations are not clear regarding the necessity for measurement of patient doses of ^{89}Sr prior to administration. The NRC regulations do not seem to require measurement of doses of beta-emitting radioisotopes prior to patient administration, but rather allow the user to rely on the calibration information as supplied by the manufacturer. It should be noted, however, that proposed changes to the NRC regulations may require measurement of all patient doses of beta-emitting radionuclides in the future. Regardless of what the NRC regulations state at this time, we feel it is good practice to measure all doses of ^{89}Sr in a radionuclide dose calibrator to further verify the calculated ^{89}Sr dosage by the volumetric method based upon the calibration data from the manufacturer.

The use of a beta liquid scintillation counter for the measurement of ^{89}Sr radioactivity is inconvenient, and not every nuclear medicine department would have this device, whereas the dose calibrator is essential equipment for the nuclear medicine facility and is readily available. However, in order to do this with the radionuclide dose calibrator, the user must determine the calibration setting to be used to measure ^{89}Sr in the dose calibrator, since there are no settings specified by the manufacturer for ^{89}Sr. Therefore, the purpose of this study was to develop a technique to determine the correct dose calibrator setting for measurement of ^{89}Sr both in the vial, as received from the manufacturer, and in the syringe for patient administration.

MATERIALS AND METHODS

Commercially Supplied Strontium-89

Metastron is a sterile, nonpyrogenic solution of ^{89}Sr chloride. Each milliliter of solution in a Metastron vial contains 10.9–22.6 mg of ^{89}Sr chloride diluted to 1 ml with water for injection, USP. The specific concentration of ^{89}Sr chloride injection is 37 MBq/ml (1 mCi/ml) at 6 a.m. CST on the calibration date. The total radioactivity of ^{89}Sr in the Metastron vial is usually 148 MBq (4 mCi) on the calibration date, and the total volume of solution in the vial is 4 ml. The radioactivity at the time and date of calibration of the Metastron vial as stated by the manufacturer was used as the reference activity and assumed to be correct. Upon receipt of the Metastron, the total radioactivity in the vial was decay-corrected to the measurement time and date.

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Calibration Setting for ^{89}Sr Vial

The Metastron vial was placed in a dose calibrator (CRC®-12R Radioisotope Calibrator, Capintec, Inc., Ramsey, NJ), and the potentiometer setting on the dose calibrator was then adjusted until the displayed activity agreed with the calculated activity (i.e., decay-corrected activity). A conversion factor of 100 was applied to the display reading in order to make it agree with the calculated radioactivity. The same procedure was repeated on another dose calibrator.

Calibration Setting for ^{89}Sr Syringe

The approximate volume of ^{89}Sr for patient dosage was calculated using calibration data from the manufacturer and the specific concentration of Metastron. The calculated volume was then withdrawn into a 6-ml syringe (Monoject®, Sherwood Medical, St. Louis, MO). The specific concentration of the Metastron vial was multiplied by the withdrawn volume of ^{89}Sr injection to give the total radioactivity in the syringe. The residual activity in the vial was measured in the dose calibrator at the same dial setting for the ^{89}Sr vial. The difference between the displayed activity and the original activity in the original Metastron vial was assumed to be the activity withdrawn into the syringe. The syringe was then placed in the dose calibrator, and the dial setting was adjusted until the calculated syringe activity was obtained. The conversion factor of 100 was also applied to the measurement of the ^{89}Sr syringe activity. The syringe setting for ^{89}Sr was used to measure the residual activity in the syringe after dosage administration in order to calculate the true amount of injected ^{89}Sr activity to the patient. An identical procedure was repeated on another dose calibrator.

RESULTS AND DISCUSSION

Table 1 shows that the calibration settings obtained either for vial or for syringe were not significantly different for the two dose calibrators. This technique may be useful to others who wish to determine the dial settings of the dose calibrator for the measurement of ^{89}Sr radioactivity. In this study, only the full dose of Metastron (i.e., 148 MBq, 4 mCi) was measured.

Since the signal produced in the Capintec dose calibrator for the measurement of ^{89}Sr was very small, resulting in a much lower than expected activity reading, even the potentiometer setting was adjusted to the maximum. Consequently, a conversion factor of 100 must be introduced and applied to the displayed activity in order to obtain the desirable activity. Therefore, for the Capintec dose calibrator (CRC-12R) used, the radioactivity reading on the calibrator display would be 1.48 MBq (40 μCi). This displayed activity would then be multiplied with 100 to obtain the final calculated activity of 148 MBq (4 mCi).

There are several factors that may affect and limit ^{89}Sr measurement in a dose calibrator:

1. **Geometry:** This is especially important in the case of the vial measurement, since the vial is not held in a constant position and tends to slide around inside the well of the dose calibrator while the measurement is taken. The dipper on the Capintec dose calibrator holds the syringe in a more constant position so geometrical variation is not as much of a concern.
2. **Presence of radionuclidic impurities:** This can vary from one lot of Metastron to another and its affect on the dose measurement has not been determined.
3. **Linearity:** All of the measurements were performed with dosages of 148 MBq (4 mCi) of ^{89}Sr. The dial settings for the higher or lower radioactivity of ^{89}Sr will be dependent upon the linear response of the dose calibrator for this particular radioisotope. One cannot assume that other levels of activity will have the same calibration dial settings. In fact, we have done a couple of ^{89}Sr samples at 37 MBq (1 mCi) and at 74 MBq (2 mCi), and the dial settings which we determined for measurement for the syringe are significantly different than the mean calibration settings that we determined for this study for 148 MBq (4 mCi) ^{89}Sr. The linearity of the dose calibrator for the measurement of ^{89}Sr is currently being evaluated in our laboratory.
4. **Decay day and time for calculation:** Precise activity calculation is needed to give a more accurate calculation of ^{89}Sr radioactivity in the vial, which you then use to determine the dial settings for the vial. We decided to use the Nuclear Medicine/Nuclear Pharmacy Manager® computer system (The DuPont Merck Pharmaceutical Co., Billerica, MA), which uses the decay equation, to give us a closer calculation of the amount of ^{89}Sr actually present in the vial, not only on the day, but also at the time that the measurement is being performed. This gives a more accurate target to aim for when determining the dial settings for the vial.
5. **Calibration setting for different type or size of syringe:** The dial setting for one syringe type or size may be different from the setting for another type or size, so new settings must be established for each type and size of syringe to measure ^{89}Sr activity in a dose calibrator.
6. **Different types of dose calibrators:** The same argument will hold true for different types of dose calibrators.

All of the measurements performed in this study were done using Capintec CRC-12R dose calibrators. Obviously if

TABLE 1
148 MBq (4 mCi) Strontium-89 Radioactivity Measurement in a Dose Calibrator

Dose Calibrator	n	Calibration Settings	
		Vial	Syringe
A	18	598.8 ± 10.3	708.8 ± 13.2
B	18	591.2 ± 9.5	707.1 ± 13.5
		*p = 0.6770	*p = 0.7008

*Two-tailed t-test

you were to use other makes and/or models of dose calibrators, the dial settings which would be determined could be different than those we have determined in this study. The same limitations apply to different types or sizes of syringe for patient dosage.

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