Routine verification of strength of $^{137}$Cs brachytherapy sources using a NaI detector

Jacek G. Wierzbicki and Richard Meyer
Department of Radiation Medicine, University of Kentucky Medical Center, 800 Rose Street, Lexington, Kentucky 40536-0084

(Received 13 November 1991; accepted for publication 1 October 1992)

An inexpensive and easy method of calibration of brachytherapy $^{137}$Cs tubes is described. Cesium brachytherapy sources are calibrated relative to an NIST-calibrated source. The detection system is a NaI detector and single channel analyzer with the window set on the photo peak.

Key words: NaI detector, $^{137}$Cs tube, source calibration, brachytherapy

One of the advantages of $^{137}$Cs brachytherapy sources is their long lasting usefulness. Properly maintained $^{137}$Cs sources may stay in the clinic for a few decades, decaying with a half-life of 30 years. Therefore, in established brachytherapy centers the renewal of the $^{137}$Cs inventory can be accomplished by the purchase of new high activity sources ($\sim 25$ mg Ra eq) every 10-15 years. One may expect to find in a brachytherapy clinic two or three batches of $^{137}$Cs tubes of different ages, dimensions, and different strength. $^{137}$Cs brachytherapy sources usually have vendor-supplied calibrations that should be verified by the user. In addition to this, routine calibration of brachytherapy sources should be done annually.$^1$ It is important in quality control that the different sources from the different batches not be confused, based upon the original vendor-specified source strength supplied at the time of original purchase.

In our institution we perform up to 200 implants annually using cesium tubes. Our inventory consists of 52 $^{137}$Cs sources of activities from 2.5 mg Ra eq to 35 mg Ra eq. The sources were purchased at different times and are of different ages. Because of extensive use we set up a quality control program requiring calibration of all clinically used $^{137}$Cs sources biannually.

Two methods of calibration of brachytherapy sources have been described in the literature: open-air geometry and measurements in an isotope calibrator. The open-air calibration method in the form described by Task Group 24 (Ref. 2) requires a large volume ionization chamber and nonscatter geometry conditions. That makes this method too elaborate for routine calibration in the clinic. On the other hand, the isotope calibrator response is sensitive to the geometry and position$^{3,4}$ of the calibrated source in the well. Therefore such calibrations require a well-designed, precise jig that would guarantee the same geometry for each calibration measurement.

To avoid the problems described above we implemented the simple method described here.

We calibrate $^{137}$Cs sources against sources that have been calibrated by NIST (formerly NBS) or one of the accredited (ADCL) laboratories. Our reference sources are not used in the clinic. Use of two sources of certified strength allows us to verify linearity of the calibration system. A diagram of our calibration setup is shown in Fig. 1. The NaI detector is connected to the single channel analyzer (SCA). This apparatus is very simple and inexpensive. We take the spectrum of $^{137}$Cs and set the window of the SCA covering the photo peak (Fig. 2). Then we take readings for the two certified $^{137}$Cs tubes and readings for all the sources that we need to calibrate. The counting time is 60 s for weak sources (less than 10 mg Ra eq) and 30 s.

![Fig. 1. Calibration setup.](image)

![Fig. 2. Spectrum of $^{137}$Cs emitted radiation with SCA window covering photopeak.](image)
for strong ones. The count numbers are higher than 50,000 and therefore, statistical errors are less than 0.5%. Tubes are placed in a styrofoam block jig perpendicular to the detector and the source–detector distance is about 1.5 m.

For such a source–detector distance, inaccurate orientation or small displacements of the $^{137}$Cs tube does not affect calibration. The strength of the studied source ($S_k$) can be calculated using the formula:

$$S_k = S_k^{\text{NIST}} M_k / M_k^{\text{NIST}},$$

where $S_k^{\text{NIST}}$ is the strength of the NIST calibrated source, $M_k$ are the readings for studied source, and $M_k^{\text{NIST}}$ are the readings for NIST calibrated source.

The calibration of 52 sources takes about 3 h. The dose to the chest measured with a pocket ionization chamber was in the range 0.07–0.15 mSv.

An inexpensive and convenient method of calibration for $^{137}$Cs brachytherapy sources has been described above. Cesium brachytherapy tubes are calibrated relative to a NIST-calibrated source. The detection system is a NaI detector and single channel analyzer with the window set at the photo peak. The high counting rate of the detection system allowed us to keep the source–detector distance at 1.5 m and therefore make this method insensitive to small uncertainties in positioning of studied $^{137}$Cs sources. In addition, scattering did not affect the calibration of a source relative to the reference source of the same energy of emitted radiation. The uncertainty of the calibration depends on the accuracy of the calibration of the reference source and statistics. The uncertainty of the source strengths measured by this method was 2%. (Uncertainty of calibration of our reference source was 1.2%%.)

---

1) Present address and address for reprints: Radiation Oncology Center, Wayne State University, 4201 St. Antoine, Detroit, MI 48201.


