MEASUREMENT OF ^{124}Sb IN VIVO WITH WHOLE-BODY COUNTER

Cheng Qijun(程祺钧), Qian Shengyuan (钱声运), Zhu Fumin (朱福敏)
and Liu Ruiyuan(刘瑞源)

(*Department of Radiological Medicine, Suzhou Medical College, Suzhou 215007, China*)

ABSTRACT

The ^{124}Sb in vivo exposed person is measured with whole-body counter. The solid point source method is applied to calibrate the counter. The minimum detectable activity of this system for ^{124}Sb is 32 Bq.

Keywords Whole-body counter, Phantom, ^{124}Sb, Internal irradiation

1 INTRODUCTION

The whole-body counter has been one of the mainest means of monitoring internal dose. It has the advantages of accuracy and conveniene, and has been widely applied in health physics.

A person overhauled the nuclear facilities in contamination area in August 1992, where the ^{124}Sb concentration reached 2.2×10^4 Bq/L. His internal contamination was checked with the whole-body counter 60 d later.

2 EXPERIMENTAL FACILITY

The whole-body counter consists of NaI(Tl) (EMI U.K.) detector (ϕ 8 inch, $h = 4$ inch). Four photomultiplier tubes (ϕ 3 inch) are optically coupled onto the crystal. A voltage distribution unit enables the voltage of each tube bo be varied independently for pulse-height adjustment. The data acquisition system including the multichannel analyzer, type S-40 (Canberra U.S.), and computer, type PDP-11/23 (DEC. U.S.)

The detector is vertically mounted above a horizontal bed, and can be moved horizontally and adjusted vertically. The distance between the bed and the detector is 37.5 cm for this study.

To increase the sensitivity the detector is placed in a shielded room, the walls of which are composed of layers of different kinds of materials. From external to internal side they are quartz sand, Pb, Cr, Cu and plexiglass one by one. The internal dimensions of the room are 148 cm, in width and 198 cm in height and 238 cm in length.

For the calibration experiments a water filled phantom composed of rectangular boxes made of polyethylene chloride plate with 6 mm in thickness was applied. The boxes represent the human head, (19×14 × 23), neck (8×9 × 12), arms (51×7 × 10), thorax (21×28 × 24), abdomen cavity (20×25 × 21), palvic (24×28 × 23), upper legs (32×23 × 17), lower legs (38×16 × 12) and feet (7×18 × 20), all units are cm.

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3 METHOD AND MEASUREMENT

The gamma rays with 346 keV, 511 keV, 662 keV, 840 keV, 1280 keV, 1460 keV are used for energy calibration. Every channel of analyzer corresponds to 8.3 keV.

The nuclide of ^{124}Sb emits many gamma rays. The gamma ray of 1690 keV, with which other rays do not interfere, is used to calculate the quantity of ^{124}Sb distributed in the body of exposed subject.

To prevent the shielded room and detector from contamination, the solid point source method is used to calibrate the detector instead of the method of phantom filled with solution. Point sources of known activity of ^{22}Na, ^{137}Cs, ^{54}Mn and KCl solution are used to measure the counting efficiency. The positions of the point sources were varied successively one by one in the phantom. The number of varied positions in every part of phantom are shown as dots in Fig.1. With this way the counting efficiency for radioactivity uniformly distributed in phantom or in some parts of phantom was calibrated.

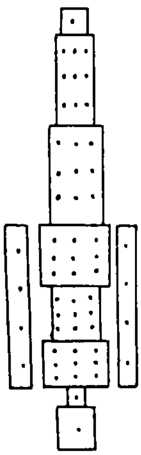

Fig.1 Distribution of souce positions within the phantom

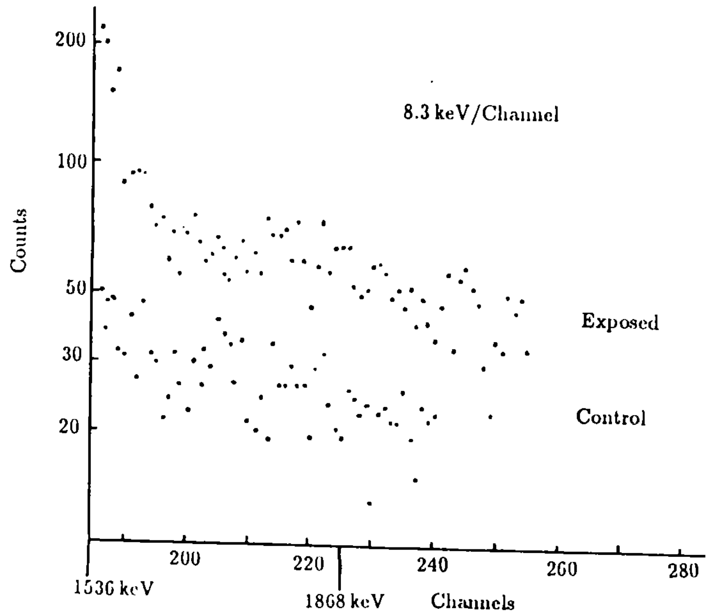

Fig.2 The spectrum of exposed and control subjects

The ^{124}Sb inhaled is nonuniformly distributed in the body. On the basis of ICRP Publication 30[1] and the anatomy, imitating the spatial area in the water filled phantom occupied by the interesting organ, the positions of point sources were varied one by one in the area to measure the counting efficiencies for organs of interest. Then the efficiency curve with water filled phantom was drawn and the counting efficiency for the gamma ray of 1690 keV was obtained.

Both the exposed and control subjects were measured for 1200 s with whole-body counter. Their spectra in the enery range from 1536 keV to 1863 keV were shown in Fig.2.

Comparing both of the spectra, it is clear that significant ^{124}Sb inhalation was indicated. Subtracting the integrating counts of the control from the exposed in the energy range from 1536 keV to 1868 keV, counts N_c caused by the ^{124}Sb distributed in the body of exposed subject could be obtained.

Let A_0 represent the activity of ^{124}Sb in the exposed subject. Thus, it can be determined from the following equation:

$$N_c = A_0 \times R \times E$$

where, $R = 0.49$, absolute intensity of 1690 keV gamma ray emitted by ^{124}Sb. E is the counting efficiency for 1690 keV gamma ray emitted by ^{124}Sb.

4 RESULTS AND DISCUSSION

By solving above equation the ^{124}Sb body burden of exposed subject is 930 Bq. The minimum detectable activity of this system for ^{124}Sb is 32 Bq.

For further simplification, it was suggested that the ^{124}Sb body distribution was uniform. Then the result is slightly higher than the ones being nonuniform distribution. The difference between them is less than 10 %. For the assessement of ^{124}Sb body burden in convenience and quickness an uniform distribution model is feasible.

In whole-body counting method there are some parameters, for example, the shape and dimensions of the subject, the homogeneity of the subjects playing a certain role in measurement. The control subject to match the exposed ones in age, height and weight was not available for the moment in this study. As in health physics a precision of 10 %–20 % is sufficient and the energy of gamma ray used is high, the complications caused by the different shapes and dimensions between the exposed and control were ignored in this study.

REFERENCES

1 ICRP. ICRP Publication 30, Part 3. Limits for intake of radionuclides by workers. Oxford: Pergamon Press, 1981:46–47