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● *Internal Contamination—Assessment*

MEASUREMENTS OF ^{137}Cs IN BLOOD FROM INDIVIDUALS EXPOSED DURING THE GOIÂNIA ACCIDENT

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***Abstract*—Blood samples of some highly internally contaminated Goiânian patients were measured for ^{137}Cs activity. The distribution of activity among the blood components was checked. We found that the majority of the activity was confined to the cellular fraction, mainly to the erythrocytes (red cells).**

INTRODUCTION

CESIUM and K are known to have similar chemical and biochemical behavior, including distribution and metabolism in the body (Leggett 1986). Cesium is soluble in body fluids, distributed more or less uniformly through the body, and rapidly and completely absorbed, with about 10% being excreted within the first 2 d. Considering this metabolism, the most effective means for removing radioactive Cs in man is the oral administration of ferric cyanoferrate (II), commonly called Prussian Blue, Berlin Blue, ferric ferrocyanide, or Radiogardase cesium. Prussian Blue is not absorbed from the intestine, and it binds the Cs ions that are enterically cycled into the gastrointestinal tract so that the Cs is not reabsorbed. The biological half-life during such treatment is reduced to about one-third of its usual value, and the body burden is likewise reduced (IAEA 1988; Lipsztein et al., this issue).

The recent accident involving a ^{137}Cs source in Goiânia, Brazil resulted in internal and external exposure to several individuals. These individuals have been monitored regularly by different bioassays, such as whole-body counting, urinary and fecal analyses, and chromosomal analyses of blood lymphocytes. During follow-up studies, blood samples from some highly internally exposed individuals were measured for Cs activity. If we consider Cs and K as having the same qualitative behavior suggested by the literature (Leggett 1986), we should expect that most of the activity in the blood samples would be contained in erythrocytes. It was observed by Rosoff et al. (1963) that most of the ^{137}Cs activity was in blood cells and not in plasma from treated patients. We found that most of the radioactivity was in the erythrocytes (red cells).

MATERIALS AND METHODS

Five individuals having high Cs body burdens were chosen for the study. Their calculated body burdens, as well as blood activities on the same date of sampling (12 May 1988), are presented in Table 1.

Ten-milliliter samples of venous blood were collected in heparinized vacutainer tubes. One-half milliliter samples of total blood were added to 2.5 mL of phosphate-buffered saline solution (PBS) and transferred to petri dishes for measurement.

To check whether the radioactivity was uniformly distributed among the various components of the blood, 1.5 mL of total blood samples were centrifuged† for 10 min at 1,200 rpm. This resulted in a pellet containing all types of cells and a supernatant of plasma. Both fractions were resuspended in PBS to a volume of 4 mL. The ^{137}Cs activity levels in these two fractions were measured separately. The majority of the activity was in the cellular fraction.

To check the distribution of activity in different cell types, the cells were separated by gradient centrifugation (Boyum 1964). One-half milliliter samples of total blood were diluted with 2.5 mL PBS and layered on the top of a Ficoll-Paque‡ solution and centrifuged at 3,500 rpm for 30 min. This resulted in three fractions, namely, granulocytes and erythrocytes at the bottom, an interphase containing lymphocytes, and a top layer containing

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Table 1. Distribution of ^{137}Cs activity among the blood components in five subjects sampled approximately 8 mo after an internal deposition of ^{137}Cs.

	Activity (Bq)				
Subject	WBC[a]	Total blood	Plasma	Cells	Red cells
DAF	7511 ± 225	34.4 ± 1.5	7.0 ± 0.7	27.0 ± 1.1	24.0 ± 1.1
IAF	1665 ± 50	8.1 ± 0.4	<1.8	7.0 ± 0.4	7.4 ± 0.4
LO	1554 ± 47	7.0 ± 0.4	<1.8	7.8 ± 0.7	4.1 ± 0.4
LNF	592 ± 18	2.6 ± 0.4	<1.8	3.7 ± 0.4	3.3 ± 0.4
LN	296 ± 9	2.2 ± 0.4	<1.8	2.2 ± 0.4	1.9 ± 0.4

[a] Whole-body counting.

thrombocytes. Each of these three fractions was resuspended in PBS, and the activity was checked. The majority of the activity was in the red cell fraction.

The ^{137}Cs blood activity was measured using a 20.3-cm (diameter) × 10.2-cm thick NaI (Tl) scintillation detector.[§] The associated electronics[‖] consisted of a preamplifier, an amplifier, and a multichannel analyzer.[¶] Each sample was positioned on the top of the detector and counted for 10 to 30 min, depending on the ^{137}Cs activity present.

[§] Harshaw Chemical Co., Cleveland, OH 44106.
[‖] EG&G Ortec, 100 Midland Road, Oak Ridge, TN 37830.
[¶] ND 66, Nuclear Data Inc., Schaumburg, IL 60196.

RESULTS AND DISCUSSION

The results obtained through the measurements of these blood samples (Table 1) showed that ^{137}Cs present in circulating blood is distributed as expected, if we consider Cs behaving similar to K. The largest fraction of the radioactivity detected was not in plasma but in the cells, predominantly in the red cells (erythrocytes). The same conclusions were suggested previously by Rosoff et al. (1963); they showed that Cs in blood was not in plasma but in the cellular fraction, probably in red cells, as Cs would exchange for K in erythrocytes.

Considering that blood circulation is greatly responsible for Cs distribution in the organism, a new approach of medicating individuals having internal contamination could be to treat their blood (namely, the erythrocytes).

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