STUDY ON INTERNAL CONTAMINATION DUE TO TELLURIUM ISOTOPE MIXTURE

I. Fehér and A. Andrási

Central Research Institute for Physics, Budapest, Hungary

1. INTRODUCTION

^{131}I is produced by use of the nuclear reactions

$$^{130}Te/n,\gamma/\ ^{131}Te \rightarrow\ ^{131}I$$

and $$^{130}Te/n,\gamma/\ ^{131}Te^{m} \rightarrow\ ^{131}I.$$

On the irradiation of TeO_2, other tellurium isotopes are also formed by /n,γ/ reactions, such as $^{121}Te^{m}$, ^{121}Te, $^{123}Te^{m}$, $^{125}Te^{m}$, $^{127}Te^{m}$, ^{127}Te, $^{129}Te^{m}$, ^{129}Te with half-lives ranging from 34 to 154 days, giving a total activity comparable to that of ^{131}I. The tellurium isotope mixture is removed to the waste after the separation of ^{131}I, however, some radiotellurium contamination may remain in the manipulator boxes and may result in internal contamination of the personnel engaged in the repair of the equipment.

In the past few years we found internal tellurium contamination in 10 cases on persons engaged in ^{131}I production. The observed tellurium retention and the maximum permissible body burden /MPBB/, and maximum permissible concentration in air /MPCa/ calculated from the observed data are discussed in the present report.

2. METHODS

The internal radiotellurium burden was determined from the $^{123}Te^{m}$ 159 keV gamma radiation, as measured by the HY 2.1/IAEA code number/ whole body counter in tilted chair geometry. The presence of ^{131}I could not be detected in the majority of cases since the repair work was carried out after 100-300 days cooling times. The time of intake could be established to an accuracy of 1-3 days. In a few cases the Te-contamination was detected only due to the periodical whole body monitoring control, thus the retention measurement started only 30-40 days after the intake.

The fast clearance taking place in a few days following the TeO_2 intake was observed on two volunteers E.I. and F.I. to whom 0.6 mg and 1.7 mg of irradiated and cooled TeO_2 - ^{131}I suspension were administered. ^{131}I indicated the dissolution of the TeO_2 particles. The thyroid iodine uptake of the volunteers was determined from a simultaneous ^{125}I measurement.

The counting efficiency of the whole body counter was determined by use of a homogeneous BOMAB phantom.

The total dose from tellurium isotope mixture in the whole body was calculated from the effective energy, obtained from the directly measured beta and gamma doses, related to the 159 keV gamma radiation from $^{123}Te^{m}$ (1) .

3. RESULTS

3.1 Fig. 1 shows the values of $^{123}Te^{m}$ retention measured on the persons contaminated during repair work as a function of the time reckoned from the assumed date of intake. During the observation time no further appreciable contamination of the persons in question was likely to occur. A weighted least square fit of the sum of two exponential functions gives for the average effective half-lives

$$T^{1}_{eff} = 11 \pm 4 \text{ days and } T^{2}_{eff} = 45 \pm 11 \text{ days.}$$

The ratio of the coefficients of the two exponential components is 3:1 in the case of G.T. Globally the same value was obtained for the other persons, but their ratios cannot be given individually because of the short observation time.

3.2 For the fast clearance measured on the volunteers the retention functions shown in Fig.2 were obtained. These give

$T^{0}_{eff} = 0.7$ days and $T^{1}_{eff} = 10$ days average effective half-lives.

The latter value agrees well with that found for the persons contaminated during work. The coefficient ratio of the two exponential components is approximately 3:1. For personal reasons the long-lived component could not be studied on the volunteers.

The ^{131}I uptake by the thyroid was slower than the ^{125}I uptake in the first few hours following the $TeO_2 - {}^{131}I$ intake. The two values became equal after 10-15 hours indicating the complete dissolution of TeO_2 in the gastro-intestinal tract. Our earlier in vitro experiments on the $TeO_2 - {}^{131}I$ solubility and on its uptake from the gastro-intestinal tract of rats (2) showed that the rate of ^{131}I release from TeO_2 is proportional to the rate of TeO_2 dissolution.

The smell, like that of garlic, characteristic of dimethyl telluride, was observed in the breath of both volunteers. It disappeared only when the tellurium dioxide content of the body decreased to ~ 0,25 mg, that is in 2 and 6 days in the two cases.

4. DISCUSSION

The ICRP Publication 10 recommends the tellurium fractional retention function

$$R(t) = 0.5 \cdot e^{-\frac{0.693}{0.5}t} + 0.5\, e^{-\frac{0.693}{20}t}$$ calculated from

carrierfree tellurium retention observed on animals.

The $^{123}Te^{m}$ retention function evaluated for the 10 contaminated persons and the fast clearance data observed on the volunteers give

$$T^{0}_{b} \sim 0.7 \text{ days, } T^{1}_{b} = 12 \pm 4 \text{ days and } T^{2}_{b} = 73 \pm 18 \text{ days}$$

for the three biological half-lives characterizing the tellurium dioxide clearance if we accept the physical half-life of $^{123}Te^{m}$ to be 117 days.

The TeO_2 fractional retention function can be written approximately as

$$R(t) = 0.7\, e^{-\frac{0.693}{0.7}t} + 0.23\, e^{-\frac{0.693}{12}t} + 0.07\, e^{-\frac{0.693}{73}t}.$$

Comparing the two retention functions in the case of the 15 mg TeO_2 intake described by Reisert (3), it is found that on the 279-th day after the intake when the characteristic garlic smell was observed to disappear, the ICRP retention function gives 0.4 μg, while on the basis of our recommendation the value is 74 μg TeO_2. If the biological variability is taken into consideration, this latter value is reasonably close to the 250 μg when the garlic smell was observed to disappear in the case of the volunteers, while the ICRP calculations shows a value less by several orders of magnitude. Our retention values are supported also by industrial toxicological observations (4) that the garlic smell is accompanied at least by a tellurium clearance rate of a few μgs/day in the urine and by the fact that no garlic smell was observed in the breath of cases written in 3.1, when the carrier tellurium amount was estimated to $\leq$ 200 μg.

4.2 For the calculation of the internal radiation dose due to the intake of tellurium isotope mixture, the time integrals for unit $^{123}Te^m$ activity

$Q_0 = 1$, $Q_1 = 16$ and $Q_2 = 65$ /activity.days/ are obtained

for the three exponential components, respectively, from the retention function proposed here.

By the assumption of homogeneous distribution an average dose equivalent of 1.3 $\pm$0.5 mrem is obtained for the 10 contaminated workers from the effectiv energy vs. cooling time function. This dose is negligible from the point of view of radiation hazard.

4.3 The values of MPBB given in $^{123}Te^m$ activity measured by whole body counter along with the tellurium quantities corresponding to the MPBB calculated with the usual assumption of an irradiation for 140 hours with 10^{13} cm^{-2} sec^{-1} neutron flux are tabulated for different cooling times as follows

Cooling time /day/	MPBB	
	$^{123}Te^m$ /μCi/	Te /mg/
100	30	89
200	39	206
300	48	454

In our case the chemical toxicity exceeds the radiological toxicity and above 10^{-3} MPBB the garlic smell is already observed in the breath.

4.4 The MPC_a of tellurium isotope mixture in air expressed in $^{123}Te^m$ activity and in quantity of tellurium with an exposure for 40 hours/week, accepting the values T_{eff} = 45 days, $f_2 = 1$ and $f_a = 0.38$ and calculated by use of the recommendation of the ICRP Publication 2 is

$$MPC_a = 1.7 \cdot 10^{-7}\ Ci/m^3, \text{or } 500 μg \text{ of tellurium}/m^3.$$

The MPC_a for inactive tellurium is 10 μg/m^3 (5), thus radiotoxicity is negligible in comparison with chemical toxicity.

5.REFERENCES

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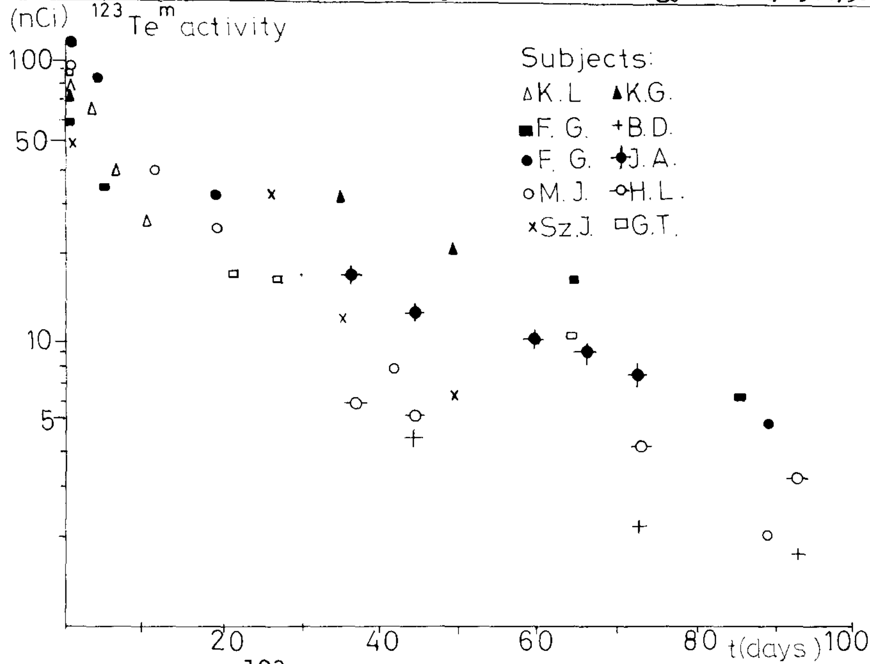

Fig.1:Whole body $^{123}Te^{m}$ activity measurements on contaminated persons

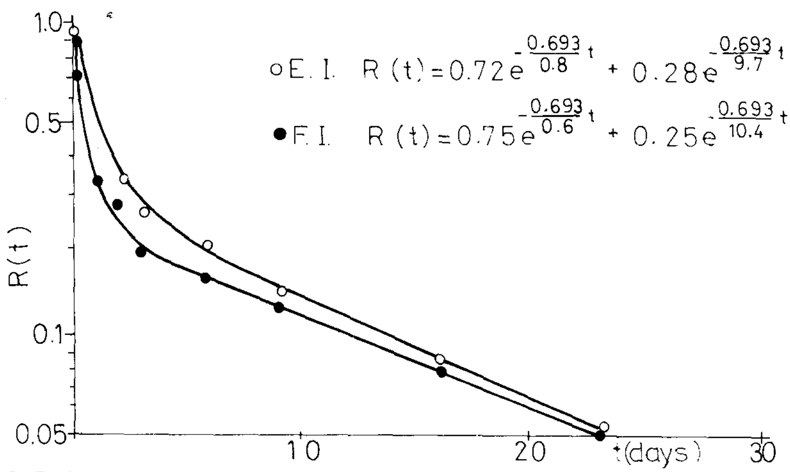

Fig.2:Retention of tellurium dioxide administered to volunteers