

**RADIOLOGICAL AND ENVIRONMENTAL
RESEARCH DIVISION ANNUAL REPORT**

Center for Human Radiobiology

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FOREWORD

During the past year, the Center began a study of the health status of the former employees of a plant that processed thorium ores from the mid-1930's to 1973. Under way are a mortality study, from death certificates, of about 3900 persons who were identified from company records, and a morbidity study, by questionnaire and medical records, of a subpopulation of 558 men who worked one year or more in occupations most exposed to thorium. In this Annual Report, paper 13 reports that measurable amounts of thorium daughter products were found by in vivo measurements of some men randomly selected from the group of 558 for medical and radioactivity examinations.

The reader's attention is also directed to other papers of special interest. Paper 15 reports that soluble plutonium is oxidized to the +6 state when drinking water is chlorinated, and points out that uptake of ingested plutonium, therefore, may be much higher than currently accepted in setting safety standards. Transformation of mammalian cells in culture when irradiated by alpha particles is reported in paper 5, and a mechanism for a linear component in the two-target model for induction of bone cancer by alpha particles is described in paper 20.

We wish to express our gratitude to St. Mary's Hospital, Orange, New Jersey, for its assistance to the Center for many years. The Hospital generously provided office space and back-up services for our New Jersey field office until mid-1977, when its need for more space forced it to discontinue this association. In particular, we thank Sister Mary Fidelise, Administrator, and Mr. Philip G. McAndrew, Associate Administrator of St. Mary's Hospital, for their help.

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MEASUREMENTS OF RADIOACTIVITY IN FORMER THORIUM WORKERS*

J. Rundo, D. R. Huff, and D. R. Kuchta

In the studies of the possible health effects of occupational exposure to compounds of thorium, and of the metabolism of inhaled thorium, 100 men were selected randomly for physical examination from the morbidity study group of 558 men who had worked at a thorium refinery for one year or longer in occupations involving probable exposure to compounds of thorium. Measurements of radioactivity in vivo have now been made on 40 of the 100. Before these subjects visited the Center for Human Radiobiology, we investigated the radioactive content of six other men who were thought to have been exposed to radioactive dust and aerosols. The presence in these men of members of the thorium decay chain showed that we could expect to find radioactivity in at least some of the 100 subjects. We summarize here our findings for these 46 individuals.

Radioactivity confined to the thorax was determined from gamma-ray spectra accumulated from two 29-cm diameter by 10.8-cm thick crystals of NaI(Tl), one above and one below the chest of the supine subject. The background counting rates of the detectors and the counting efficiency to a standardized source of thorium in a lung phantom were such that the statistical standard error for a 30-min measurement was a little less than ± 100 pCi.

The freely emanating content of ^{224}Ra was determined by electrostatic collection of the solid decay products (^{216}Po and especially 10.6-hr ^{212}Pb) of exhaled 55-second ^{220}Rn (thoron). The alpha-particle activity was counted in 4π geometry, and the decay curve was fitted by least squares analysis. For breath sampling times of 50 min, the statistical standard error on the amount of ^{224}Ra equivalent at the mouth of the subject is commonly less than ± 0.5 pCi. A systematic error of $\pm 10\%$ due to uncertainty in the

* Summary of part of paper presented at International Meeting on Toxicity of Thorotrast and Other Alpha-Emitting Heavy Elements, Lisbon, Portugal, June 28-July 2, 1977.

calibration of the system and a random error of $\pm 15\%$ due to uncertainty in the constancy of the fraction of emanating ^{224}Ra are propagated with the statistical error.

The results of the gamma-ray measurements are summarized in Table 1. For six of the subjects with chest contents of less than 0.2 nCi, the results were statistically significant (content $\geq 2\sigma$), so we may say that significant activity was observed in 21 of the 46 men.

The distribution of the emanating ^{224}Ra contents is shown in Figure 1. Of the four cases with less than 1 pCi ^{224}Ra , one gave a significant result (0.6 ± 0.2 pCi), while the other three gave results which were not significantly different from the mean value for 7 control subjects (0.12 ± 0.10 pCi).

The ratio of emanating ^{224}Ra to retained ^{212}Bi varied from 0.013 to 0.47; the median value was about 0.05. There was no significant correlation between the ratio and either the time since first employment or the time since mid-employment. If there had been a slow migration of thorium from lung to lymph nodes, a negative correlation might have been expected.

Table 1. Provisional Results of Measurements of Retained ^{212}Bi , Assumed to be Uniformly Distributed Throughout the Thorax

Thorax content of ^{212}Bi , nCi	Number of subjects
≥ 2.0	2
0.2-1.9	13
< 0.2	31

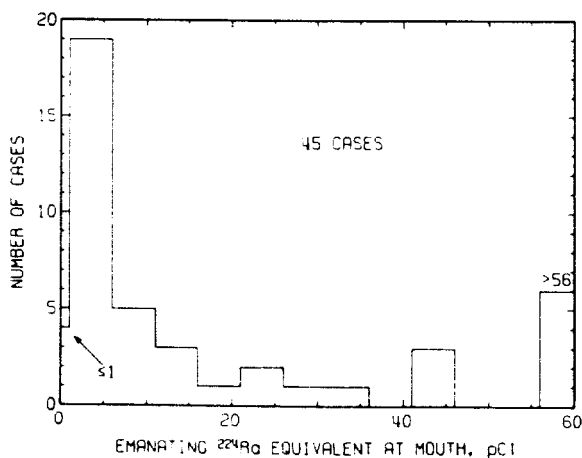


FIG. 1.--Distribution of values of freely emanating ^{224}Ra (as at the mouth of the subjects) for 45 cases; the six highest values ranged from 57 pCi to 161 pCi.