Medical Findings in Marshallese People Exposed to Fallout Radiation

Results From a Ten-Year Study

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Benign thyroid nodules were removed from three teenage Rongelap girls ten years after exposure from fallout. (The thyroid dose received was estimated at about 1,000 rads, largely from radioiodines absorbed.) No thyroid nodules were detected in 75 unexposed children. Other possible residual radiation effects noted in the 86 exposed Rongelapese were as follows: slight retardation of statural growth and bone maturation in boys exposed at less than 5 years of age; greater incidence of miscarriages in exposed women during the first four years; incomplete recovery of some of the peripheral blood elements; and increased nevus-like lesions in areas of previous beta radiation burns of the skin. General health and mortality has been about the same as in the comparison population. No definite radiation effects on birth rate, aging, leukemia, malignancy, or genotype have been noted.

Ten years have passed since the people of the Marshall islands were accidentally exposed to fallout radiation[1]; complete reports have been published covering findings of the annual medical surveys.[2] The accident occurred March 1, 1954, following the detonation of a high-yield nuclear device during experiments at Bikini in the Pacific proving grounds, when an unpredicted shift in winds caused deposition of significant amounts of fallout on four inhabited atolls to the east. The Table shows the groups of people involved, the number in each group, and the extent of the fallout and exposure.

The present report summarizes the medical findings over a ten-year period of the 82 people of Rongelap Island who were exposed. The initial findings are only briefly reviewed, greater emphasis being placed on the findings of more recent follow-up examinations. A group of relatives, away from the island at the time of the accident, returned with the exposed group to their home island and have served as a comparison population.

Summary of Fallout Effects

Group*	Composition	Fallout Observed	Estimated Gamma Dose (Rads)	Extent of Skin Lesions
Rongelap	64 Marshallese	Heavy (snow-like)	175	Extensive
Ailingnae	18 Marshallese	Moderate (mist-like)	69	Less extensive
Rongerik	28 Americans	Moderate (mist-like)	78	Slight
Utirik	157 Marshallese	None	14	No skin lesions or epilation

*Also exposed were 23 Japanese fishermen who received a sublethal dose.

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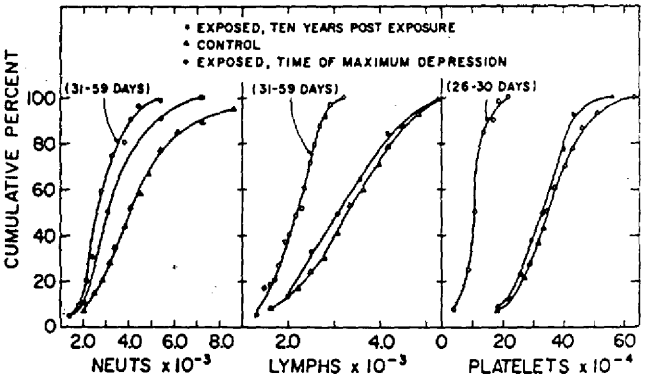
Initial Findings

During the first 24 to 48 hours about two thirds of the Rongelap people experienced anorexia and nausea, a few vomited and had diarrhea, and many complained of irritation of the skin and eyes. These symptoms, however, subsided within a few days.

Depression of lymphocytes and neutrophils to about half and the platelets to about one third the levels of the unexposed population occurred during the first six weeks following exposure, followed by gradual but incomplete recovery. The depression of blood elements was insufficient to result in infections or bleeding, and the radiation dose that they had sustained fortunately proved to be sublethal. No specific therapy was necessary. A slight loss in weight was noted in more than half of the people during the first six weeks, but the possible effects of change of environment could not be ruled out.

Beta radiation burns of the skin and epilation of the scalp were widespread, particularly in the more heavily exposed group. Most of the lesions were superficial but some showed deeper ulceration. Most of them healed within a few weeks with only slight residual changes and regrowth of hair was complete by six months.



1. Cumulative percent distribution curves of neutrophils, lymphocytes, and platelets.

Internal absorption of radionuclides, largely from eating and drinking contaminated food and water, and to a lesser extent from inhalation of fallout, resulted in detectable radioactivity in urine samples. However, during the first few days when the body burdens were highest the maximum permissible concentrations were exceeded only for ^{89}Sr and the radioisotopes of iodine. The dose to the thyroid glands of the adults from the radioiodines absorbed was estimated to be about 150 to 160 rads.

Follow-Up

Health Status.—Medical evaluation of the health status of the exposed people over the years since the accident has revealed about the same incidence of illness and disease as noted in the unexposed population with certain exceptions noted below. General health and nutrition have continued to be satisfactory and comparable to the unexposed comparison population. Annual hematologic follow-up studies revealed that the levels of white blood cells and platelets of the peripheral blood in the exposed group never quite reached the levels of the unexposed comparison population (Fig 1).

Mortality and Aging.—There were ten deaths in the exposed population over the ten-year period; this represents a mortality rate near that observed for the other Marshallese people. A recent study in which certain criteria of aging were put on a numerical basis did not reveal any differences in age scores between the exposed and unexposed groups.[2]

Fertility, Miscarriages, Stillbirths, and Genetic Effects.—Effects on fertility were not apparent as judged by comparison of the birth rates for the exposed and unexposed populations. Possibly related to radiation exposure was the fact that during the first four years after exposure an increase in miscarriages and stillbirths was noted in the exposed women, 41% of the births (13 in 32 births) in this group terminated in nonviable offspring compared with 21% (8 in 38 births) in the unexposed women. No specific genetic studies have been carried out, but no difference in incidence of abnormalities in children of exposed compared with those of unexposed women has been observed.

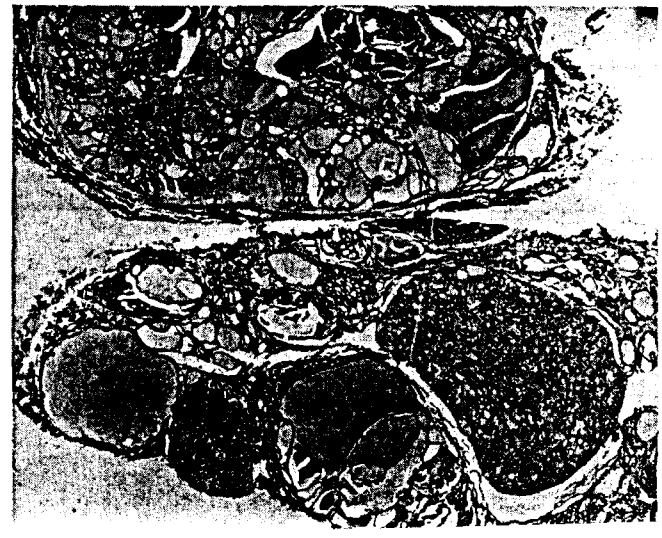
Growth and Development Studies.—Anthropometric examinations of the 42 exposed and 75 unexposed children have been conducted over the past five years. Using nonparametric statistical methods, comparisons of weight, stature, and bone age (the latter determined from roentgenograms of the wrist and knee) were made between exposed and unexposed children of the same age groups. Boys exposed at 1 to 5 years of age showed retardation of statural growth as well as bone age. This was most marked in those boys exposed at 12 to 18 months of age. The average skeletal maturation in the exposed boys was about seven months behind their unexposed peers. Though weight gain also appeared slightly retarded in this

2. Gross picture of sectional thyroid gland showing nodules in 14-year-old Marshallese girl.

group, it was not statistically significant. The exposed girls showed no significant differences compared with unexposed girls. The slight retardation of growth noted in the boys suggests that radiation may be a causal factor, although possible mechanisms are not clear. The dose to the bones from internally absorbed isotopes is believed to have been too small to have affected bone growth. These findings are being published in detail by Sutow et al.[4]

Development of Thyroid Nodules.—Thyroid nodules were detected in three girls nine and ten years after exposure; two girls were 13 and one was 14 years of age at the time of detection. These girls were in the higher dose group in which there were 29 children (<18 years of age); 17 of the 29 were girls, with 6 girls in the 10 to 15 year range. Of 75 unexposed comparison children, 37 were girls and 21 of the girls were in the age range of 10 to 15 years. No thyroid nodules were noted in this latter group. No lymph node involvement was grossly evident. The individuals were hospitalized and two had complete thyroidectomies and the third a partial thyroidectomy. Grossly, the glands had a cobblestone appearance with multiple hard nodules and were at first thought to be malignant. Sections of the tissues were reviewed by a number of pathologists, all of whom agreed that the nodules were not malignant and resembled in many respects adenomatoid goiter seen with iodine deficiency, with its characteristic regenerative rather than neoplastic proliferation. It should be noted that goiters are rare in the Marshall islands since no iodine deficiency exists (Fig 2 and 3).

3. Section of thyroid gland shows characteristic multiple, discrete nodules with wide variation in size and growth pattern. Some consist of microfollicular tissue, some of colloid cysts, while others show hyperplasia with papillary infolding of epithelium.



4. Development of pigmented nevus-like lesions in area of neck previously involved with beta radiation burns.

Most pathologists consulted did not feel that radiation could be implicated as the etiologic agent on the basis of the pathological findings alone, though some considered the findings typical of the lesions seen in children treated medically with radioactive iodine. However, the evidence is strong that the thyroid nodules in the Marshallese girls were induced by radiation. Correlation of the thyroid with radiation exposure was substantiated by statistical analysis which showed the difference in thyroid nodule incidence between the exposed and the unexposed children to be significant at the 1% level. Moreover, Sheline et al[5] and Lindsay and Chaikoff[6] have reported the development of thyroid nodules 5 to 11 years after treatment of children with radioiodine for thyrotoxicosis. Lindsay and Chaikoff reported that the sections of the glands removed from the Marshallese girls were similar to the glands of children who had been given ^{131}I therapy. Based on a calculated dose of approximately 150 rads[1] to the adult thyroids from isotopes of iodine, it was estimated that the smaller thyroid glands of the girls exposed at three to four years of age received a total dose of the order of 1,000 rads (probable range was 700 to 1,400 rads). The fact that a part of the total dose to the thyroid (175 rads) was due to whole body gamma exposure (including the pituitary gland) may be of some significance. In the Marshallese girls the stress of puberty may have been a factor in the development of the nodules.

Malignancy.—No cases of leukemia in either the exposed or unexposed Rongelapese have been detected. Two older exposed women died with a diagnosis of cancer, one at 67 years of age from ovarian malignancy five years after exposure, and the other died at 60 years of age, eight years after exposure, probably from cancer of the cervix. The diagnosis in the latter case was not confirmed by autopsy or biopsy. One unexposed older woman died possibly of cancer of the cervix, but the diagnosis was not confirmed. The question of increased incidence of malignancy in the irradiated Marshallese must be left open for the present.

Beta Radiation Burns.—During the past several years an increased number of pigmented nevus-like lesions have been noted in previously irradiated areas of the skin but these have appeared to be quite benign (see Fig 4). Neither chronic radiation dermatitis nor evidence of cancer of the skin has been noted.

Internally Absorbed Isotopes.—Radiochemical urine analyses and whole body spectrometric analyses revealed that the body burdens of radioisotopes in the exposed Rongelap people fell rapidly, so that by two years after exposure the levels were far below the stated maximum permissible levels. The return of the Rongelap people to their home island was associated with a rise of their body burdens of ^{137}Cs and ^{65}Zn and ^{90}Sr. However, by 1961 the whole body content of ^{137}Cs had apparently reached an equilibrium with the environment at about 14.7 mμc per kilogram of body weight and the ^{65}Zn had fallen to low values. The levels of ^{90}Sr by 1964 showed a slight decline over previous levels to about 10 to 12 mμc for adults and 20 mμc for children (about 5% and 10% respectively of the maximum permissible level for members of the population at large). The possible relation of internal absorption of radioiodines in the fallout initially to the recent development of thyroid nodules was referred to before. No other effects of such exposure have been detected.

It should be noted that the 11th year examination, currently in progress (March 1965), has turned up three more cases of thyroid nodules in exposed people, one in an adult. The type and character of the nodules have not yet been determined.

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Capt C. A. Broaddus, MC, USN, performed the surgery. Sections of tissues were reviewed and reported on by S. Warren, MD, G. H. Klink, MD, C. J. Stahl, MD, H. A. Johnson, MD, and S. Lindsay, MD. Kieth Thompson carried out the chi-square test, and Ralph James and John Gofman, MD, calculated the thyroid dose to the children.

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