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REVIEW OF MEDICAL FINDINGS IN A MARSHALLESE POPULATION TWENTY-SIX YEARS AFTER ACCIDENTAL EXPOSURE TO RADIOACTIVE FALLOUT

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PREFACE

A 20-year report published 6 years ago (1) covered in detail the medical findings in the Marshallese exposed to radioactive fallout in 1954. The present report updates these findings with emphasis on the data collected during the past 6 years.*

Much of the material presented in the 20-year report will not be repeated. The reader is referred to that report for a review of topics such as the general history of the Marshall Islands, past health status of the Marshallese people, use of the islands from 1946 to 1958 as the Pacific proving grounds for testing nuclear devices, the accidental exposure in 1954 of the people of Rongelap and Utirik Atolls, their evacuation and subsequent return to their homes, organization of the medical teams and surveys, relationship with the Navy and Trust Territory (TT) governing bodies, etc. The findings previously reported in detail will only be summarized in this report.

The Brookhaven National Laboratory (BNL) Medical Program has been limited by its mandate: to observe the people who had been exposed to fallout radiation on Rongelap, Ailingnae, and Utirik Atolls in 1954 and unexposed comparison populations, and to ascertain those diseases in the exposed population that are related to prior exposure to radiation and initiate appropriate treatment for these diseases. However, a number of developments have resulted in expansion of the program. Further thyroid abnormalities developed in the exposed Rongelap people and in several exposed Utirik people. An exposed Rongelap male died of leukemia in 1972. The exposed Rongelap and Ailingnae people who had been placed on thyroid hormone treatment were not adhering strictly to the treatment program; as a result many of those who had had thyroid surgery showed evidence of reduced thyroid function, giving rise to concern that they might develop clinical hypothyroidism unless they complied with the treatment. Another important consideration was the urgent request of the unexposed people living on Rongelap and Utirik (not in the group regularly examined) to be given annual checkups by the BNL medical team. For the above reasons a number of steps have been taken to expand the program. A physician from BNL was stationed in the Marshall Islands in 1972 as resident physician. His principal responsibilities included (a) monitoring the thyroid treatment program, (b) visiting Rongelap, Utirik, and Bikini Atolls for health care purposes every 3 to 4 months, and (c) assisting the TT medical services with the care of Rongelap and Utirik patients at the hospitals at Ebeye and Majuro.

A Marshallese nurse was hired by BNL in 1977 and has been of great assistance to the resident physician. In 1978 a clinical laboratory was established in a trailer at the Ebeye Hospital as a supplement to the hospital laboratory to aid the resident physician in making definitive diagnoses. A medical technician from BNL has been stationed in the islands since 1978.

In 1976 an agreement was formalized between DOE/BNL and the TT which provided for examinations and health care of all Marshallese living on Rongelap and Utirik by the BNL medical team at the time of their visits; for the resident physician to assist TT medical personnel in the care of Rongelap and

*The thyroid section (IX) includes more recent data which became available just before publication of this report.

Utirik patients at the hospitals at Ebeye and Majuro; and for the TT health services to furnish personnel to help with the examinations on Rongelap and Utirik.

In order to determine the possible association of thyroid tumors with radiation exposure in the Utirik group, more data were needed on the incidence of thyroid abnormalities in unexposed Marshallese populations. Thyroid surveys (neck palpations) were conducted in 1973 on 192 people at Likiep Atoll and in 1976 on 162 people at Wotje. In addition, during the past 6 years, nearly all the unexposed Rongelap and Utirik people living on various atolls (more than 900 people) have been included in these examinations.

As part of the expanded medical program certain other diseases not found to be associated with radiation exposure have been given special attention. Diabetes is one of the most common diseases in the Marshall Islands; it is being studied (see Section VII) in the hope that helpful advice will be provided to the Marshall Islands medical service group on its nature and treatment. Intestinal parasitism is widespread in the Marshall Islands. Since 1977 a program of diagnosis and treatment has been carried on at Rongelap and Utirik Atolls (see Section VI). Other special studies (possibly associated with radiation exposure) include those on growth and development in exposed children (see Section IV); on detection of mutant proteins as a possible index of genetic effects in children of exposed parents; and on the frequency of isoleucine substitution in hemoglobin as a possible index of somatic mutation (see Section V.C.2).

Since low levels of residual radiation persist on Rongelap, Utirik, and Bikini, radiological monitoring of personnel on these islands has continued. Urine samples have been radiochemically analyzed on about an annual basis for the radionuclides ^{137}Cs and ^{90}Sr, and more recently for the isotopes of Pu. In addition, gamma spectrographic analysis (whole-body counting) for ^{137}Cs has been done at intervals. These examinations, formerly the responsibility of the BNL medical team, have been carried out since 1975 under the direction of the Safety and Environmental Protection Division of BNL.

The 20-year report (1) outlined a number of problems affecting the medical program in the Marshall Islands. Some of these problems relate to carrying out the examinations, such as the language barrier, cultural differences, scarcity of demographic data, and inadequacy of follow-up medical care in patients seen by the medical team. Criticisms of the BNL medical program, voiced by some, stem largely from lack of understanding of the limited mandate for the program. Other problems relate to the accident, to misconceptions and fears of the people about radiation effects, and to objections to needed continued medical examinations. In the past 5 to 6 years increased efforts to correct misunderstandings among the people have involved expansion of the educational program by discussions at village meetings and special lectures. One member of the team spent several weeks on Rongelap and Utirik for this purpose, and this was greatly appreciated. The necessity of again removing the Bikini people from their home island in 1979 because of unexpectedly high radioactivity levels in the food crops was unfortunate. Misunderstandings have arisen concerning bills for compensation and hospital benefits (travel payments, etc.) for the exposed people. The Burton Bill passed by Congress charges the Department of the Interior with development of a plan for delivery of health care to Marshallese affected by fallout.

With the writing of this report I am ending 26 years of affiliation with this program. During the past year, since my retirement in 1979, I have acted as Consultant to Drs. H. Pratt and E.P. Cronkite, my successors.* This has been a most gratifying and stimulating experience for me and I am happy that we have been able to contribute to the medical evaluation and health care of these people and help expand the knowledge of radiation effects in human beings. In spite of criticism and misunderstandings I am convinced that the Marshallese people have basically maintained strong feelings of friendship and respect for the medical team, and I personally am most grateful to them for this and believe that they know these feelings are mutual.

We have been most fortunate in obtaining the dedicated help of many first-rate physicians and technicians including those from the Trust Territory. My heartfelt thanks to them all. Also the program could not have been carried out without the staunch support of people at Brookhaven National Laboratory, the Departments of Energy and Interior, the Trust Territory, the Army at Kwajalein, and others, to whom I am most grateful.

With the further development of thyroid abnormalities and the possibility that other late effects of radiation may appear, it is imperative that the special medical examinations and health care of these people be continued. I stand ready to help my successors in any way that I can.

The Marshall Islands are entering an era of widespread change, and I sincerely hope that with the greater awareness of the need for improved medical care in the Islands by the new Marshallese Government and the U.S., the future will be brighter for better care of these people.

Robert A. Conard, M.D.

*On June 1, 1981, Dr. William H. Adams (from Texas Tech Academic Health Center, El Paso) came to BNL to take charge of the program.

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X. RADIOLOGICAL MONITORING OF PERSONNEL AND ENVIRONMENT

Radiological monitoring of personnel and environment of the islands affected by the 1954 fallout accident is reviewed in detail in Appendix II (Dose Assessment) and in the 20-year report (1). The findings will only be briefly summarized here.

A. Background

The medical team assumed responsibility for the personnel monitoring of the Rongelap and Utirik people in 1954 and for that of the Bikini people returning to live on their home island in 1969. In 1978, both environmental and personnel monitoring responsibilities were transferred from the Medical Department to the Safety and Environmental Protection Division of this Laboratory. Numerous radiological surveys for environmental contamination have been carried out on Rongelap, Utirik, Bikini, and Enewetak (210-225). These studies have provided important information on the movements of radionuclides through marine and terrestrial life to man and have aided in the evaluation of the body burdens of radionuclides in the inhabitants of these islands.

B. Methods

Methodology for personnel monitoring has been discussed in detail in previous reports (8,18,22). Personnel monitoring has consisted of regular radiochemical analyses of urine specimens from inhabitants along with whole-body gamma spectrographic analyses for gamma emitters with special shielding arrangements (first a 21-ton steel room and later a "shadow-shield" bed and chair arrangement of lead bricks).

C. Results and Comments

1. Rongelap and Utirik

The radionuclides absorbed at the time of the fallout from consumption of contaminated food and water and inhalation are tabulated for the Rongelap people in Table 2 of Appendix II. Only radioiodines were absorbed to above acceptable levels. The full impact of the thyroid injury resulting from absorption of radionuclides of iodine was not appreciated until much later when development of thyroid nodules and stunting of growth in some of the children occurred. As discussed in Appendix II, the dose calculations for the thyroid have been subject to many uncertainties and can only be considered approximate. The absorption of radionuclides other than iodine has not resulted in any detectable injury, and the doses to the target tissues from these radionuclides are thought to have been quite low though no precise doses have been calculated.

By six months, radiochemical urine analyses revealed barely detectable levels of radionuclides in the Rongelap people. When they returned to their island in 1957, they accumulated low levels of radionuclides (principally ^{65}Zn, ^{137}Cs, ^{90}Sr, and ^{55}Fe) from marine and plant foods -- primarily pandanus, coconuts, breadfruit, coconut crabs, and fish. (The crabs are a food delicacy, which, because of unexpectedly high levels of absorbed radiocesium and strontium, had to be banned from the diet until recently when the levels became acceptable.) The people were also exposed to low levels of residual gamma radiation over and above the natural background radiation. Figures 1 and 2 of Appendix II show the changes in estimated body burdens of ^{137}Cs, ^{65}Zn, and ^{90}Sr in the Rongelap people. ^{90}Sr reached its highest levels of about 12 nCi in adults and 22 nCi in children between 1962 and 1965 and thereafter showed a downward trend. ^{137}Cs body burdens in adults reached a peak in about 1965 of roughly 0.7 μCi (23% of the permissible level for general populations). The ^{65}Zn level reached a peak of 0.5 μCi during the first year or so after the return, generally below the ^{137}Cs level, and became nondetectable thereafter. From the data in Table 4, Appendix II, the total-body dose for inhabitants living full-time on Rongelap from 1957 to 1979 was estimated to be nearly 4 rads. It should be noted that the actual dose was probably lower because the people spent about half their time away visiting other atolls.

Since 1957, the people who had returned to live on Utirik Island have been included in the personnel monitoring program. The estimates of initial exposure for the Utirik people, particularly for the thyroid gland, were subject to greater uncertainties than those for the Rongelap people. Not the least of these uncertainties was the degree of exposure to short-lived isotopes of iodine in the Utirik population. Available data, however, indicate that exposure of the Utirik people was considerably below that of the Rongelap people, perhaps 1/10 as much. (Radioanalyses of animal, plant, and other samples from Utirik shortly after the accident showed levels about 1/10 of those for samples from Rongelap.) Following their return, the levels of accumulated long-lived radionuclides in the Utirik people, measured at the same time as in the Rongelap people, were only about 1/3 as high. However, since these people returned to live on Utirik in July 1954 (three years before the return of the Rongelap people in 1957), during the first few years they were exposed to somewhat higher levels of radionuclides, particularly ^{65}Zn, than were the Rongelap people on their return. This accounts for the higher body burdens estimated in Appendix II for the Utirik inhabitants during the first few years after their return. The total-body dose for inhabitants living on Utirik full-time from 1954 to 1979 was estimated to be about 17 rads, due mostly to the early contribution of ^{65}Zn. Again, the actual exposure was probably lower because the people were away about half the time visiting other atolls.

Reexamination of dosimetry analyses for the Rongelap and Utirik people, for both initial and residual exposures, is being carried out at this Laboratory. Personnel and environmental monitoring are being continued on a regular basis.

2. Bikini

In 1946, before Operation Crossroads, the residents of Bikini were evacuated. After stays at Rongelap and Kwajalein which proved unsatisfactory, they were relocated on Kili Island in the southern Marshalls, which also proved unsatisfactory. The Enewetak people were relocated at Ujelang Atoll to the south after their evacuation.

After the 1958 moratorium on atmospheric nuclear testing, numerous radiological surveys were done on Bikini and later on Enewetak Atoll. In 1967, the principal radionuclides contributing to the gamma radiation field on Bikini and its neighboring island of Enue were ^{137}Cs, ^{60}Co, ^{125}Sb, and ^{155}Eu; slight amounts of plutonium were also found. Considerable variation was seen in the degree of contamination of individual islands comprising the atolls of Bikini and Enewetak.

In 1968, an Ad hoc Committee reviewed the survey results for Bikini and decided that Enue and Bikini Islands were safe for habitation, with certain measures recommended to reduce exposure. In 1969, about 30 people started work on Bikini Atoll (living on Enue), and in 1971 several Bikini families moved back to Bikini Island. The number of people increased to about 145 by 1978 before their relocation. Annual radiological monitoring of personnel was carried out beginning in 1969 as well as numerous radiological surveys of the island (13,218-221,225). Personnel monitoring consisted of annual radiochemical urine bioassays and whole-body gamma spectrographic analyses in 1974 and 1977 by the medical group. Since that time whole-body counting and other personnel monitoring as well as environmental studies have been carried out by the BNL Safety and Environmental Protection Division.

The estimated doses to the Bikini people from the environmental contamination were so low that medical examinations were not indicated. However, on visits to the island, the doctors have held "sick call," and in 1978 the people were given complete physicals by the visiting medical team. Since the relocation of the people in 1979, medical examinations have been done on these Bikini people living on Majuro Atoll. No thyroid or other radiation-related problems were noted. Personnel monitoring has also continued on this population.

When the people returned to Bikini, they received a continuing complete food subsidy from the Trust Territory Government. Before locally grown fruits (coconuts, pandanus, breadfruit, etc.) became available, radioassays showed body burdens well within acceptable ranges. When these fruits became available, radioassays showed radionuclide levels (particularly ^{137}Cs and ^{90}Sr) that were higher than expected, and the people were admonished not to eat the locally grown foods. In spite of this warning, radiochemical urine analyses and whole-body counting of personnel showed a continuing increase in body burdens of these radionuclides to levels that were considered unacceptable. Also, low levels of plutonium were thought to be detected, but this finding has not been verified, and contamination of the samples is thought to have been a factor. Because of these unexpected and unfavorable developments, the people were again removed from Bikini in August 1978.

The results of personnel monitoring of the Bikini inhabitants are presented in Appendix II. From the residence period between 1969 and 1978, exposure data indicate that a maximally exposed person on Bikini received a dose equivalent commitment of 3 rem, and the population average dose equivalent commitment was 1.2 rem (223).

The Bikini inhabitants are now living on atolls in the southern Marshalls and are being monitored at intervals. The results show a continuing reduction in their body burdens.

XI. SUMMARY AND COMMENTS

Until 1954, the Japanese at Hiroshima and Nagasaki were the only human populations exposed to significant radiation from nuclear detonations. As a result of the Bravo accident in 1954, following the detonation of a megaton nuclear device in the Pacific, 250 Marshallese, 28 American servicemen, and 23 Japanese fishermen were exposed to a relatively unknown hazard, radioactive fallout. The medical observations of the exposed Marshallese over the past 27 years have resulted in significant findings reported in numerous publications. Health care and treatment of the exposed people during the course of the surveys and examinations also represent an important contribution. The medical findings provide the only knowledge about the effects of radioactive fallout on human beings from detonation of nuclear devices.

The exposure of the Marshallese to fallout radiation differs in several important respects from the exposure of the Japanese at Hiroshima and Nagasaki. In Japan, there were many casualties from blast and heat effects, and psychological trauma was extreme. The Marshallese, being far removed from the site of detonation, had no effects from blast or burns, and the psychological effects of their experience appeared to be minimal. Radiation effects in the Japanese were due to whole-body exposure to gamma and neutron radiation from the detonating bomb with insignificant fallout. Their exposure resulted in acute effects with high early mortality, and in late effects involving principally the development of malignancies, with leukemia appearing first and solid tumors later. Radiation effects in the Marshallese were related only to fallout exposure: whole-body gamma irradiation (no neutron exposure); skin irradiation from deposition of fallout on the body; and internal exposure due to absorption of radionuclides (principally radioiodines) from ingestion of radioactively contaminated food and water and inhalation of fallout particles.

As emphasized in this report, many uncertainties were involved in calculating the early radiation dose received by the Marshallese prior to their evacuation. This was particularly true for the internal dose calculations (thyroid dosimetry). Estimates of early exposures for whole-body gamma radiation were 175 rads on Rongelap, 69 rads on Ailingnae, and 14 rads on Utirik. Clinical findings (principally hematologic) generally supported these estimates. For Rongelap, thyroid dose estimates varied from 335 rads in adults to 700-1400 to perhaps >2000 rads in young children. For Ailingnae and Utirik Atolls, thyroid dose estimates were roughly parallel to gamma dose estimates.

People living on Rongelap, Utirik, and Bikini since the 1954 accident have been exposed to low doses of radiation, delivered at a slow dose rate, from residual contamination (see Appendix II). No detectable effects of this low exposure have been noted, and it is unlikely that any will be. Periodic personnel and environmental radiological monitoring is carried out on these atolls and on inhabitants who have moved to other atolls.

It now appears that the early thyroid dose calculations may have resulted in underestimation, and all the dosimetry calculations are being reevaluated at this Laboratory on the basis of more recent data that have become available.

The findings in the exposed Marshallese populations are briefly summarized as follows.

A. Early Observations

Whole-body gamma exposure in the Rongelap and to a lesser extent in the Ailingnae people resulted in transient anorexia, nausea, and vomiting. Depression of blood leukocytes and platelets to about half normal levels by 4 to 6 weeks was not accompanied by any detectable increase in infections or bleeding tendency, and there was no associated mortality. The exposed Utirik population had no early gastrointestinal symptoms, and only a slight depression of blood platelets was detectable on a statistical basis. Recovery of blood elements to near normal levels was evident by one year, though a slight continuing lag in complete recovery was noted in the Rongelap people during the first decade.

Fallout deposition on the skin resulted in transient superficial radiation ("beta") burns and spotty epilation of the head in about 90% of the Rongelap people. Skin findings were less prevalent in the Ailingnae people and absent in the Utirik group.

Of the spectrum of radionuclides absorbed internally, only the isotopes of iodine exceeded the maximum permissible concentration and resulted in detectable effects later. No early symptoms due to the internally absorbed nuclides were noted. Radiochemical urine analyses at 6 months showed the presence of barely detectable radioactivity.

B. Late Observations

The general health of the exposed Marshallese people (except for abnormalities associated with thyroid injury) has remained good and about the same as that observed in the unexposed populations examined. Vital statistics suggest that mortality and fertility rates have been about the same in the exposed as in the unexposed people. During the first four years there appeared to be an increase in incidence of miscarriages and stillbirths in the exposed Rongelap women, but this observation was uncertain in view of the small numbers involved. Genetic studies and examinations of the newborn did not reveal any detectable abnormalities in the children of exposed parents that might have been related to radiation exposure. Probably related to radiation exposure was the finding of a slight increase in chromosomal aberrations in the lymphocytes of some Rongelap people at 10 years after exposure. No increase in degenerative diseases (cardiovascular, arthritis, neuromuscular) or diabetes has been detected in the exposed people. Ophthalmological examinations (including slit-lamp studies) have not shown any remarkable differences in eye abnormalities between exposed and unexposed groups. No radiogenic cataracts have been noted.

In 1972 a Rongelap male, exposed at one year of age, died of acute myelogenous leukemia, and another Rongelap male died from carcinoma of the stomach. These diseases may have been related to radiation exposure. No other malignancies (except for thyroid carcinoma) have been noted which were likely to be related to radiation exposure. No skin malignancies have been detected.

The most widespread late effect of fallout exposure in the Marshallese has been the development of thyroid abnormalities - benign and malignant neoplasms and hypofunction of the gland. These, as well as growth retardation associated with thyroid injury in some of the children, have been discussed in detail in this report. The greatest incidence of these abnormalities has been in the higher-dose Rongelap group, particularly in children exposed at <10 years of age, with less incidence in the Ailingnae group and least incidence in the lower-dose Utirik group. The recent development of thyroid nodules in two Rongelap males exposed in utero indicates that radioiodines may be passed from mother to fetus.

Almost all patients, including those in the unexposed group with thyroid nodules, have had thyroid surgery in U.S. hospitals. A wide spectrum of lesions has been found.

Thyroid hypofunction, not related to thyroidectomy, was first noted in two Rongelap boys who developed frank hypothyroidism with growth retardation. Biochemical (subclinical) hypothyroidism has been noted in some prior to thyroid surgery for nodule removal. More recently, about 6 adults (5 Rongelap, 1 Ailingnae), who received lower doses than the children and showed no detectable thyroid nodularity, have developed biochemical hypothyroidism. No hypofunction of the thyroid has been detected in the exposed Utirik population.

C. Comments

From the Marshallese experience it is clear that in any future accident involving radioiodines the use of oral stable iodine to suppress radioiodine uptake by the thyroid, particularly in children and pregnant women, should be considered (249). To ascertain the degree of radioiodine absorption, it would be helpful to have direct instrument readings over the thyroid, with leg or arm readings as a control; also, urine levels of radioiodine would be helpful.

With regard to late effects in persons receiving significant radiation doses to the whole body or thyroid, regular follow-up examinations should be done over the ensuing years with particular attention to hematological status, development of cancer, and thyroid abnormalities. Even though the prophylactic value of thyroid hormone treatment in preventing development of thyroid abnormalities has not been proved in the Marshallese or other humans, such treatment is sound and should be considered. During follow-up thyroid examinations, determination of serum TSH levels would be desirable, since the Marshallese experience has shown this test to be a most sensitive indication of reduced thyroid function. In addition, thyroid uptake studies of radioiodine and scans of the gland should be considered. Any distinct thyroid nodules should be surgically removed. If thyroxin treatment is not already a part of the treatment regimen, it should be instituted in surgical cases as well as any cases showing deficiency of thyroid function. Patients who have had malignant lesions removed should of course have regular follow-up examinations.

Although the later development of thyroid malignancy is a serious problem, the consequences are not as likely to be fatal as those of other types of malignancies. With the medical and surgical treatment of thyroid disease now available, death associated with malignant tumors of the thyroid is unlikely except in the case of the most malignant types, which appear to be rare in irradiated groups.

As has been pointed out, the uncertainty of dose estimates in the Marshallese has hampered evaluation of dose-response relationships, particularly with regard to the thyroid. More information would be desirable concerning certain aspects of thyroid exposure. More data are needed on the contribution of short-lived iodine radioisotopes, including relative abundance and distribution as a function of time, dose fractionation, etc. Also, the dose-response relationship of these isotopes in the thyroid compared with ^{131}I and gamma radiation needs further investigation; such studies should be done in large animals, perhaps sheep or swine, having thyroid glands comparable in size to human glands.

Since radioelements other than iodine may have been involved in the thyroid exposure of the Marshallese, further information is needed on such elements that might be present in fallout. Certain elements are known to show relatively greater affinity for deposition in the thyroid than in other organs. Radium and thorium (226,227), barium (226), americium (228,229), plutonium (228-230), and calcium (226,231,232) have been found in animal thyroid glands. Robison et al. (231) have shown that calcium is concentrated in the lining of thyroid follicles with small localized areas of calcification in human thyroid glands. Haeberli et al. (232) have reported rapid incorporation of ^{45}Ca in the rat thyroid. In view of the abundance of calcium in the atoll environment, perhaps consideration should be given to the possibility of a neutron-induced calcium isotope that might have been involved in the thyroid exposure of the Marshallese. Autoradiographic and other studies of animal thyroids removed at surgery or autopsy might be helpful in this regard. It should be noted that the elements referred to above are absorbed by the thyroid to a much smaller degree than iodine, and it seems unlikely that they would contribute significantly to the thyroid dose.

Very little is known about the effects of low doses of radioiodine radiation on the thyroid. One source of information comprises thyroid studies on people given diagnostic doses of ^{131}I in the early days, when doses were higher than now used. It is hoped that further information from such studies will be forthcoming so that a better evaluation can be made of low-dose effects and of the relative importance of ^{131}I exposure on the thyroid.

The development of thyroid nodules in two of three Rongelap children exposed in utero emphasizes the probable importance of radioiodine absorption by the fetus from the mother. More precise information regarding fetal iodine uptake at various stages of gestation is needed. ^{129}I, a long-lived isotope with low radioactivity and a high cross section for neutron activation, might be administered to pregnant women in cases where abortion is indicated. Neutron activation of ^{129}I in the thyroid gland removed from the fetus would provide precise information on uptake of iodine by the gland at the given stage of gestation.

In view of the greater relative sensitivity of the child's thyroid, further information on thyroid weights and thyroid function in children of various ages would be helpful.

In conclusion, in view of the possible further development of thyroid abnormalities and other late effects of radiation in the exposed Marshallese people, it is necessary that regular examinations and provision for adequate health care be continued throughout their lifetime.

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