64

401871

THE EFFECTS OF FALLOUT RADIATION ON MARSHALLESE CHILDREN

WALTER W. SUTOW* and ROBERT A. CONARD†
*Department of Pediatrics, The University of Texas M. D. Anderson Hospital and Tumor Institute, Houston, Texas, and †Medical Research Center, Brookhaven National Laboratory, Upton, Long Island, New York

ABSTRACT

In March 1954, 82 people of Rongelap Island in the Marshall Islands were accidentally exposed to sublethal doses of fallout radiation during the atomic bomb testing program. Of these people 64 received about 175 rads of whole-body gamma-ray exposure and 18 received about 69 rads. Additional radiation exposure occurred from radioactive material deposited on the skin and hair and from ingested radionuclides. This report summarizes the medical findings in the exposed children over a 15-year period as compared with findings in the adults.

On Mar. 1, 1954, native inhabitants of several atolls in the Marshall Islands were exposed accidentally to fallout radiation following the experimental detonation of a large thermonuclear device at Bikini Island. The heaviest fallout occurred on Rongelap Island, downwind and about 100 miles east of Bikini. Since that time the exposed people have undergone regular and intensive medical examinations, the results of which have been documented in a number of publications.[1-4] This report summarizes the findings on the exposed Rongelap people who were children at the time of exposure. In particular, these findings are compared to those noted in the exposed adult population.

FALLOUT AND RADIATION DOSES

At the time of the atomic bomb test, the fireball touched the surfaces of the earth and ocean. Tremendous amounts of incinerated particulate matter were sucked up into the cloud. Because of an un-

The Medical Research Center
Brookhaven National Laboratory
Upton, L. I., New York

predicted shift in wind direction, radioactively contaminated fallout was deposited on Rongelap, Ailingnae, and Utirik atolls.

On Rongelap, the fallout, which coated the ground and vegetation and formed deposits on the hair and skin of the people, was described as "snow-like." Less dense "mist-like" fallout was noted on Ailingnae. Ailingnae, some 40 miles south of Rongelap, was actually closer to Bikini, but it was situated more out of the line of the cloud passage. No visible evidence of fallout was observed on Utirik, 250 miles from Bikini.

Fallout commenced on Rongelap and Ailingnae 4 to 6 hr after the detonation of the bomb. The radioactive cloud reached Utirik about 22 hr after the explosion. The contaminated islands were evacuated approximately 48 hr after the commencement of fallout.[5]

Exposure to radiation involved whole-body gamma doses from environmentally deposited radioactive fission products, superficial doses from beta and soft gamma radiation, and doses from internal absorption (through inhalation and ingestion) of radionuclides.

The external whole-body gamma dose has been computed to be 175 rads on Rongelap, 69 rads on Ailingnae, and 14 rads on Utirik (Table 1). Based on calculations from radiochemical urine analyses, it has been estimated that the thyroid gland accumulated about 11.2 μCi of ^{131}I. In addition, the shorter lived isotopes, ^{132}I, ^{133}I, and ^{135}I, added considerably to the dose. The most probable dose to the thyroid gland of Rongelap Island children less than 4 years of age[5,6] has been calculated to be in the range of 700 to 1400 rads. Except for the thyroid gland, the dose from absorbed radioactive material appears to have been minimal with no discernible biological effects.[7]

Subsequent to the return of Rongelap people to their home island, the body burdens of ^{137}Cs, ^{65}Zn, and ^{90}Sr rose to low levels, but these

Table 1

ESTIMATED RADIATION DOSE IN MARSHALLESE POPULATIONS

Population	Gamma dose, rads	Thyroid dose, (I), rads
Rongelap		
Age <10 years	**175**	**700 to 1400**
Age >10 years	**175**	**160**
Ailingnae		
Age <10 years	**69**	**275 to 550**
Age >10 years	**69**	**55**
Utirik		
Age <10 years	**14**	**55 to 110**
Age >10 years	**14**	**15**

reached equilibrium with environmental sources by 1961. No effects from these isotopes have been detected.[8,9]

POPULATIONS UNDER STUDY

A total of 64 men, women, and children were present on Rongelap Island. The 18 who were exposed to fallout on Ailingnae were Rongelap inhabitants who had gone to the adjacent atoll for fishing. On Utirik Island, 157 Marshallese people received fallout radiation. In addition, 28 American servicemen on Rongerik Island and 23 Japanese fishermen on the boat "Lucky Dragon," were subjected to sublethal doses of radiation from the fallout (Table 2).

Table 2

MARSHALL ISLAND POPULATIONS

	Age in 1954		
	Under 10 years	10 to 15 years	16+ years
Rongelap exposed	19	11	34
Rongelap exposed (in utero)	4	0	0
Ailingnae exposed	6	0	12
Utirik exposed	54	9	94
Rongelap unexposed	48	8	125

In the Rongelap group, 12 of the 64 were under 5 years of age, 18 were between 5 and 16 years, and 34 were over 16 years of age. Among these children, 19 were under the age of 10 years. Four fetuses were exposed in utero on Rongelap. In the Ailingnae group, 6 of the 18 were children, all under the age of 10 years. On Utirik, 63 of the 157 were children 15 years of age and younger. Of the 63, 54 were under 10 years of age.

Rongelap was considered to be habitable in 1957. At that time the people were transferred back to their home island. When repatriation took place, a group of about 200 unexposed people also moved to Rongelap. This nonexposed group, mostly relatives and former inhabitants of the island, has served as the comparison population for the continuing studies of the exposed people. Among the nonexposed group, 48 were under 10 years of age in March 1954 and 8 were between 10 and 15 years of age.[10]

EXAMINATIONS

Following the initial intensive medical studies, follow-up examinations of the Rongelap and Ailingnae people have been conducted at 6

months and then at annual intervals in March. Systematic and comparable examinations of the Rongelap unexposed population were started in 1958 and have been conducted at least biennially. People on Utirik have been seen at less frequent intervals. The pediatric surveys have also included examination of all children born after March 1954 to parent or parents exposed to the fallout and to parents in the unexposed control group. The children of exposed parents now number 88 and children of nonexposed parents number 121.

EARLY EFFECTS

The acute early effects of fallout radiation involved primarily the skin, the hair, the gastrointestinal system, and the hematopoietic tissues. During the first 2-day period following exposure and before evacuation from the island, itching and burning of the skin were noted. Anorexia and nausea with some vomiting also occurred. These symptoms subsided promptly within a few days with no recurrence. A tabulation of incidence of these symptoms (Table 3) suggests that the gastrointestinal manifestations were more frequent and more severe among younger children than among older children and adults.[11]

Radiation burns resulting from deposits of fallout material on the skin developed about 2 weeks after the exposure. Hyperpigmentation, desquamation, depigmentation, and, in severe cases, ulceration followed. Spontaneous healing and repigmentation occurred during the next few weeks. The skin lesions were more extensive in the younger children. Some variation in the anatomical distribution of the burns was recorded among several age groupings.[12,13]

Epilation, generally spotty in nature, began 2 to 3 weeks after exposure. Regrowth of hair started at about 3 months and was complete by the sixth month. The new hair seemed normal in color, texture, and abundance. Both the frequency and the severity of epilation were more marked among children than among adults (Table 4). Thus 100% of the children under 5 years of age showed some degree of epilation, 90% of them moderate to severe in degree. Only 27% of those over 16 years of age manifested epilation.[12,14]

In respect to hematologic findings and particularly as they relate to age (Table 5), the following observations have been made:[13,14]

1. At maximum depression of lymphocytes (third day), the values were lower in those under 5 years of age (25% of normal) than in those over 5 years of age (55% of normal). Recovery was more rapid in the younger age group, and age differences became less marked after the fourth week.

2. Platelet values (as percent of control values) during the first 12 months were consistently lower among those under 10 years of age

Table 3

NAUSEA AND VOMITING IN RONGELAP GROUP

Age at exposure	Number	Incidence, % Nausea	Vomiting
5 years and younger	13	85	38
Over 5 years	51	44	4

Table 4

EPILATION IN RONGELAP GROUP

Severity of epilation	Incidence, % Age, 0 to 5 years (13)	Age, 6 to 15 years (13)	Age, 16+ years (38)
Slight (1+)	7.6	38.4	13.8
Moderate (2+)	38.6	30.7	5.5
Severe (3+)	53.8	23.0	8.3
Total	100.0	92.1	27.6

Table 5

MEAN BLOOD COUNTS AT PEAK DEPRESSION IN RONGELAP GROUP

	Percent of control Age under 5 years	Age over 5 years
Neutrophils	56	64
Lymphocytes	25	55
Platelets	23	34

as compared to those over 10 years of age. Maximum depression occurred by 30 days.

3. Granulocyte values dropped during the second week and showed a second drop during the fifth week. By 12 weeks the levels had returned nearly to the control range. Although the patterns of change were the same, the values for children under 5 years of age were below those of the older age groups throughout most of the first year of observation.

4. Complete recovery to normal levels of peripheral blood elements was slow. Mean levels for platelets, granulocytes, and lymphocytes remained slightly, but consistently, below the control levels

during the follow-up surveys until the eleventh year (1965). These differences were statistically significant at various examinations. In 1965 the mean counts for all blood elements reached control values. Inspection[3] of the mean values calculated for children aged 15 years or younger at the time of each examination showed essentially the same pattern of variation from the control values, reaching control values in 1965.

LATE EFFECTS

The significant late effects of the fallout radiation have been the retardation of growth and the development of thyroid abnormalities among the Rongelap children exposed at young ages.

Longitudinal anthropometric data, including skeletal age assessments, have been accumulated on these children. Analyses of these measurements showed, in the exposed boys only, a slight but consistent retardation in body size (expressed as stature) during growth from the fourth through the sixteenth year as compared to the statural growth curve of the unexposed boys. This difference, however, was not statistically significant. No difference in the growth curves was noted among girls.[15] Further examination of the data suggested that the retardation noted in the boys was most marked among those who were 5 years of age or younger at the time of the fallout.[15] (For growth and development studies, because of the relatively small numbers of children in the various age groups, the Ailingnae and Rongelap populations have been combined.)

When this youngest age group was considered separately (Fig. 1), a significant retardation in statural growth was shown among the boys. These children were smaller than both the control boys and those exposed at older ages. Girls exposed at similar young ages had normal statural growth curves. No significant difference in weight curves was found between exposed and control children for both boys and girls.

Although there were individual cases in which the skeletal maturation lagged markedly behind expected norms (particularly in the hypothyroid subjects), the overall curves for exposed and control children showed no statistically significant differences.

In 1963 a nodule was palpated in the thyroid gland of a 13-year-old girl who was exposed to fallout on Rongelap at the age of 3 years and 4 months. A total thyroidectomy was done. The surgical specimen showed multiple nodules with cystic and hemorrhagic changes. The histological diagnosis was adenomatoid goiter. During the next 5 years, thyroid nodules have developed in an additional 14 of the 19 Rongelap children who were under 10 years of age at time of exposure to the fallout (Table 6). Two other children in this age group manifested

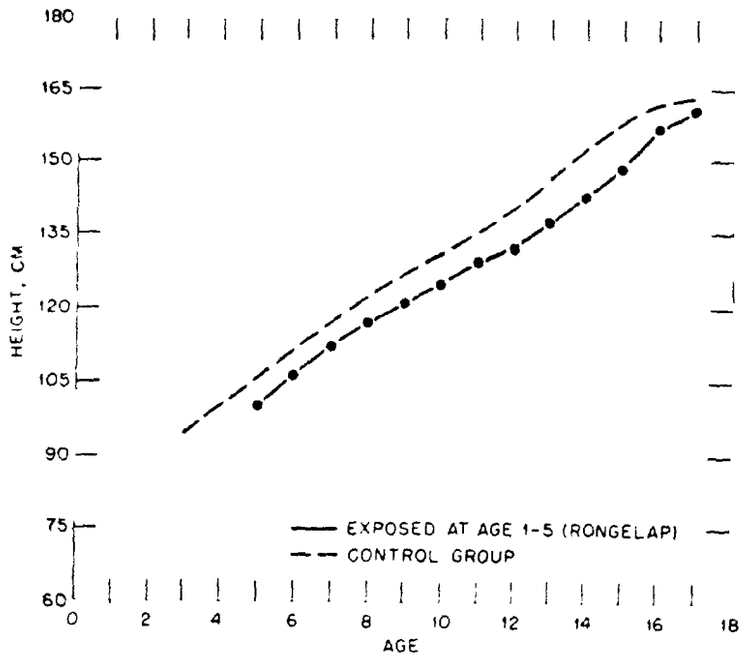

Fig. 1 — Effects of fallout radiation on growth in Rongelap children.

Table 6

THYROID LESIONS

Population	Incidence of thyroid lesions * %	
	Age, 10 years (in 1954)	Age, 10+ years (in 1954)
Rongelap exposed	89.5 (17/19)	5.8 (3/51)
Ailinginae exposed	0 (0/6)	12.5 (1/8)
Utirik exposed	0 (0/40)	3.4 (2/59)
Rongelap unexposed	0 (0/48)	2.3 (3/133)

*Calculated on basis of numbers of people examined for thyroid status.

frank hypothyroidism, making the total incidence of thyroid abnormalities 90% among this group of 19 children.[16,17]

Up to the conclusion of the 1969 survey, operative procedures have been carried out in 12 children with thyroid nodules. In all instances multiple benign adenomatous lesions were found. No malignant changes have been noted in any of the specimens.

The pattern of thyroid-nodule development suggested several relations to age and developmental status of the exposed children.

Almost all the tumors appeared to develop during the adolescent period (Fig. 2). For comparable ages at exposure, the tumors were first noted at chronologically earlier ages among girls, consistent with the normal earlier occurrence of adolescent changes in girls. The "latent period" between radiation exposure and tumor development for 13 of the 15 lesions was 10 to 13 years.

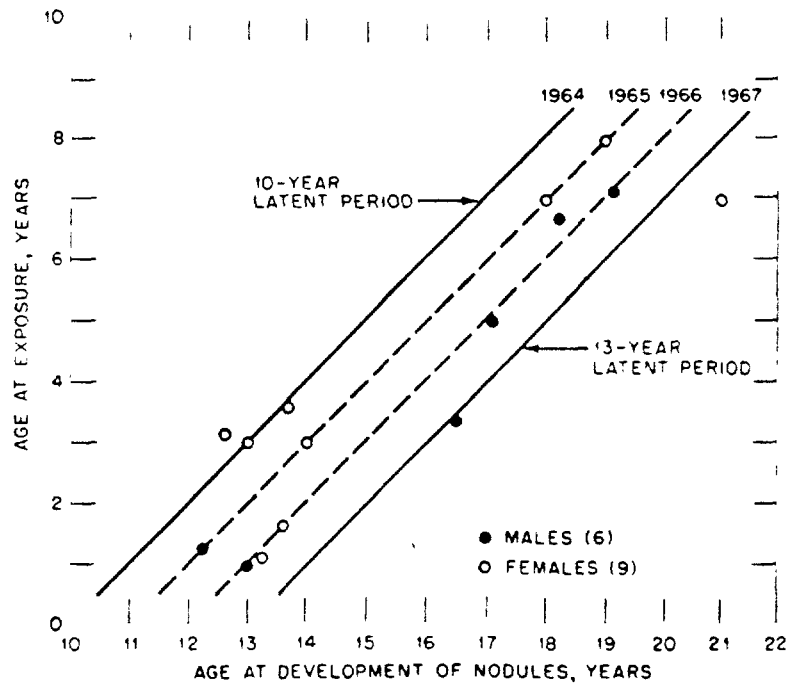

Fig. 2 — Thyroid nodules in Rongelap children.

No thyroid tumors have been palpated in 48 unexposed Rongelap children in the age range comparable to the 19 exposed children. No nodules have been noted in the 4 children exposed in utero and in the 6 children exposed on Ailingnae. Among the original 45 subjects exposed to fallout on Rongelap at ages greater than 10 years, three abnormalities of the thyroid gland have been found up through the 1969 examination. These abnormalities consisted of mixed papillary and follicular carcinoma in one and adenomatoid goiter in two.

In the Ailingnae group of 12 who were older than 10 years of age at exposure, a tumor (neurofibroma) lateral to the thyroid gland has been found in one adult. Among the 54 children exposed at Utirik to fallout at ages under 10 years, no thyroid abnormality has occurred. Of the 59 Utirik people exposed at ages greater than 10 years and in whom adequate palpatory thyroid studies were done, 2 had nodules. Of

133 unexposed Rongelap inhabitants, 3 that were older than 10 years of age in March 1954 have nodular thyroid glands.

In the fall of 1965, the routine administration of thyroid hormone to the exposed people on Rongelap was begun. This regimen was intended to decrease, if possible, the further development and progression of the thyroid nodules. The immediate effect of thyroid hormone has been the sudden marked spurt in the growth and development of the hypothyroid children, manifested most dramatically in statural gain and accelerated skeletal and sexual maturation.

DISCUSSION

Age differences in the acute and late manifestations of injury following exposure to radiation fallout have been documented in the Rongelap population. The severity and frequency of several abnormal findings appeared to be correlated inversely with chronological age, i.e., more severe in the younger subjects. The data, however, do not indicate whether the differences are due to increased biological sensitivity of the tissues of young children or to dose differences.

Observations during the annual surveys indicate that the children wear less clothing and that they spend considerably more time in the open, away from houses and overhead protection, than do adults. Young children play on the open ground with great frequency. Thus, during the 2 days before evacuation, they would have had greater and more prolonged contact with fallout material and would have been closer to the surface deposits than would adults. Moreover, the physical sizes of the children were such that they would have received a greater dose at midline than adults receiving the same air dose. These factors no doubt contributed to the skin lesions and greater depression of blood elements in children as compared to adults. The greater incidence of thyroid abnormalities in the children was probably related not only to increased radiation dose to the children's glands but also to the greater proliferative activity of the growing gland with lack of replacement of injured cells.

Clinical and laboratory data indicated that total destruction of the thyroid gland occurred in two youngsters. That partial destruction of the glands may have resulted in others is suggested by increased thyroid-stimulating hormone (TSH) levels, lowered thyroxine values, reduced uptake of radioiodine, and the inability of the thyroid glands to respond to further TSH stimulation.[3,17] The timing of the nodule development suggests that growth stresses associated with adolescence could have been a precipitating factor in nodule formation. However, the nodules occurred early in adolescence in the younger exposed children and late in adolescence in those who were older at exposure.

The finding of thyroid nodules in so many subjects raises the question of the existence of goitrogenic factors unrelated to radiation. However, the overwhelming concentration of the nodules within a specific age–exposure category would seem to eliminate such possibilities as familial goiter or environmental factors other than fallout radiation. The lack of development of thyroid abnormalities in children of the same ages of less heavily exposed groups (6 Ailingnae and 54 Utirik children) as well as in 48 unexposed children all living in the same or similar environment substantiates the preceding conclusion.

Although no thyroid cancer has been detected as yet in the Rongelap children, the risk of malignancy should be considered increased. It is now 15 years from the time of exposure, well within the 3- to 27-year latent period for cancer development reported in the literature.[17–20] The subjects are in the late teens and early twenties, where the peak incidence of radiation-related thyroid cancers has been noted.[15,19] The physical doses of radiation to which the thyroid glands of the Rongelap children were subjected are higher than those doses which have been associated with late development of cancer.[14,21,22] It is possible that in the Marshallese children the latent period may be prolonged, compared with reported cases,[20] since exposure was largely due to radioiodines. Under conditions of the fallout, the dose to the thyroid gland was received over a period of hours.

Thyroid cancer has developed in one adult. Although this single occurrence is not definitive evidence, the possible relation of carcinogenesis to fallout radiation must be seriously evaluated. The effect of exogenously administered thyroid hormone on the risk of cancer of the thyroid gland in the irradiated human is unknown. However, the suppression of nodule formation in the irradiated thyroid gland of the rat has been reported.[23]

The early clinical and endocrinologic evaluations had not delineated clearly the mechanism for growth failure in some of the Rongelap children.[15] Later studies have demonstrated abnormalities that indicate, with increasing probability, that the growth retardation has been the result of hypofunction of the thyroid gland in these children.[16,17] The significant growth spurt in the most retarded children following administration of thyroid hormone can be considered strong corroborative evidence.

ACKNOWLEDGMENTS

The research for this report was supported by the U. S. Atomic Energy Commission and, in part, by Public Health Service Research Career Award CA-02501 (to Sutow) from the National Cancer Institute.

REFERENCES

1. L. P. Cronkite, V. P. Bond, and C. L. Dunham, Some Effects of Ionizing Radiation on Human Beings, USAEC Report TID-5358, 1956.
2. Robert A. Conard and Arobati Hicking, Medical Findings in Marshallese People Exposed to Fallout Radiation—Results from a Ten-Year Study, *J. Amer. Med. Ass.*, *192*: 457-459 (May 10, 1965).
3. R. A. Conard, L. M. Meyer, W. W. Sutow, J. S. Robertson, J. E. Rall, J. Robbins, J. E. Jesseph, J. B. Deisner, A. Hicking, I. Lanwi, E. A. Gusmano, and M. Eicher, Medical Survey of the People of Rongelap and Utirik Islands Eleven and Twelve Years After Exposure to Fallout Radiation (March 1965 and March 1966), USAEC Report BNL-50029, Brookhaven National Laboratory, 1967.
4. Bibliography of Marshall Island Studies, Appendix I, in USAEC Report BNL-50029, pp. 69-75.
5. C. A. Sondhaus, R. Sharp, V. P. Bond, and L. P. Cronkite, Radiation Characteristics of the Fallout Material and the Determination of the Dose of Radiation, USAEC Report TID-5358, pp. 1-12.
6. R. A. James, Estimate of Radiation Dose to Thyroids of the Rongelap Children Following the Bravo Event, USAEC Report BNL-50029, pp. 79-83.
7. S. H. Cohn, R. W. Rinehart, E. K. Gong, J. S. Robertson, W. L. Milne, V. P. Bond, and L. P. Cronkite, Internal Deposition of Radionuclides in Human Beings and Animals, USAEC Report TID-5358, pp. 65-91.
8. R. A. Conard, J. S. Robertson, L. M. Meyer, W. W. Sutow, W. Wolins, A. Lowrey, H. C. Urschel, Jr., J. M. Barton, M. Goldman, H. Hechter, M. Eicher, R. K. Carver, and D. W. Potter, Medical Survey of Rongelap People, March 1956, Four Years After Exposure to Fallout, USAEC Report BNL-534, Brookhaven National Laboratory, 1959.
9. R. A. Conard, H. L. MacDonald, L. E. Meyer, S. Cohn, W. W. Sutow, D. Karnofsky, A. A. Jaffe, and E. Riklon, Medical Survey of Rongelap People Seven Years After Exposure to Fallout, USAEC Report BNL-727, Brookhaven National Laboratory, 1962.
10. R. A. Conard, L. M. Meyer, W. W. Sutow, A. Lowrey, B. Cannon, W. C. Moloney, A. C. Watne, R. E. Carter, A. Hicking, R. Hammerstrom, B. Bender, I. Lanwi, E. Ricklon, and J. Anjain, Medical Survey of the People of Rongelap and Utirik Islands Nine and Ten Years After Exposure to Fallout Radiation (March 1963 and March 1964), USAEC Report BNL-908, Brookhaven National Laboratory, 1965.
11. Brookhaven National Laboratory, Appendix IC, p. 133, USAEC Report BNL-90-
12. R. A. Conard, N. R. Shulman, D. A. Wood, C. L. Dunham, E. L. Alpen, L. L. Browning, V. P. Bond, and L. P. Cronkite, Skin Lesions and Epilation, in USAEC Report TID-5358, pp. 25-41.
13. L. P. Cronkite, V. P. Bond, R. A. Conard, N. R. Shulman, R. S. Farr, S. H. Cohn, C. L. Dunham, and L. E. Browning, Response of Human Beings Accidentally Exposed to Significant Fallout Radiation, *J. Amer. Med. Ass.*, *159*: 430-434 (1955).
14. V. P. Bond, L. P. Cronkite, R. S. Farr, and H. H. Hechter, Hematologic Observations, USAEC Report TID-5358, pp. 43-63.
15. W. W. Sutow, R. A. Conard, and K. M. Griffith, Growth Status of Children Exposed to Fallout Radiation on Marshall Islands, *Pediatrics*, *36*(5): 721-731 (November 1965).
16. R. A. Conard, J. E. Rall, and W. W. Sutow, Thyroid Nodules as a Late Sequela of Radioactive Fallout—in a Marshall Island Population Exposed in 1954, *New Engl. J. Med.*, *274*: 1392-1399 (June 23, 1966).
17. Jacob Robbins, Joseph E. Rall, and Robert A. Conard, Late Effects of Radioactive Iodine in Fallout, *Ann. Intern. Med.*, *66* (6): 1214-1242 (June 1967).

18. S. A. Beach and G. W. Dolphin, A Study of the Relationship Between X-ray Dose Delivered to the Thyroids of Children and the Subsequent Development of Malignant Tumors, *Phys. Med. Biol.*, 6: 583-596 (1962).
19. S. Hagler, P. Rosenblum, and A. Rosenblum, Carcinoma of the Thyroid in Children and Young Adults. Iatrogenic Relation to Previous Irradiation, *Pediatrics*, 38: 77-81 (1966).
20. R. A. Pincus, S. Reichlin, and L. H. Hempelmann, Thyroid Abnormalities After Radiation Exposure in Infancy, *Ann. Intern. Med.*, 66: 1154-1164 (1967).
21. L. H. Hempelmann, Risk of Thyroid Neoplasms After Irradiation in Childhood, *Science*, 160: 159-163 (1968).
22. I. Doniach, Effects Including Carcinogenesis of I^{131} and X-rays on the Thyroid of Experimental Animals: A Review, *Health Phys.*, 9: 1357-1362 (1963).
23. C. W. Nichols, Jr., S. Lindsay, G. E. Sheline, and I. L. Chaikoff, Induction of Neoplasms in Rat Thyroid Glands by X-irradiation of a Single Lobe, *Arch. Pathol.*, 80: 177-183 (1965).

OPEN DISCUSSION

ROSENTHAL. Have any children been born to these people?

SUTOW: Yes, we have followed approximately 60 children who were born subsequent to Mar. 1, 1954, and compared them to the children born over the same period of time to unexposed parents. There are no nodules among them and no differences between the children in each group.

ROSENTHAL: How about the four who were irradiated in utero?

SUTOW: They looked normal clinically, and we have not found any abnormalities. Two of them were exposed at the point between the first and second trimesters, and the other two were about midway between the second and third trimesters.

SCHJEIDE: How does the rate of hair growth in very young children compare to that in adults? Are the hair follicles much more active in the children?

SUTOW: I do not know whether the hair grows differently in the adults and the children in this population. As far as regrowth after epilation was concerned, a review of the records indicates recovery was about the same in the children and adults, and about six months or so later they were all back to normal.

SCHJEIDE: There was a striking difference, I thought.

SUTOW: In the epilation, yes. In that respect, the younger children roll about in the dirt a lot and they possibly got more of the fallout material directly on the hair.

SCHJEIDE: The children might not have washed it off, and the adults did.

SUTOW: That's possible, yes.

CONARD: The skin of the scalp of the child is a little thinner than the adult, and the hair follicles are closer to the surface. Since the

beta radiation to which they were exposed was superficial, the hair follicles probably got a larger dose in the child.

YAMAZAKI: I think the external dose was 175 R at 3 ft, and the thyroid of the 1- year-old child is probably much closer to this level.

CONARD: Yes, and one has to make all these adjustments.

YAMAZAKI: I would like to know if they are multinodular or are single nodules?

SUTOW: They are usually multinodule, although many times we see only a single nodule clinically.

ALPEN: The depth of the hair follicles with respect to the beta radiation that Dr. Conard mentioned is probably most important.

YAMAZAKI: It might be to have some measure of the dose rate as the various speakers come up. To remind ourselves, the background dose is approximately 125 to 150 mrads/year and the added body burden from fallout is 5% of this dose.

December 1, 1969

JAMA

THE JOURNAL of the American Medical Association

Vol 210, No 9

Paul Van Hoyedenck

Museum of Contemporary Art, Chicago

Samples of Paul Van Hoyedenck's "cybs," the sculptured hand, legs and torso consisting of wheels, rods, nuts, bolts, and bits of electronic equipment, simulate the form and function of their natural counterparts. Whether conceived by the artist as components of a cybernetic man (p 1752) or as independently functioning entities, these metal and plastic creations project a disturbing image of a future surfeited with uncontrolled devices. Planned control of medical, mechanical, and electronic devices is discussed on page 1745.