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Beta Radiation Lesion of the Skin

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During the course of improvement in design of nuclear devices, several accidents have occurred involving irradiation of personnel with radioactive materials resulting from experimental detonations. Knowlton and associates¹ described burns on the hands of four persons who were handling fission-product material. Beta lesions and epilation in a large number of Marshall Island people have been described* resulting from fall-out contamination following detonation of a large thermonuclear device in the Pacific in the spring of 1954. This was the same incident in which 23 Japanese fishermen on the "Lucky Dragon" were involved. The lesions in this group were similar to those in the Marshallese.⁴ There were also a number of American service men who received minor skin lesions in this incident. This report concerns an additional case of an Air Force Officer who developed a skin lesion which was apparently due to contamination with fission products following the same detonation.

Report of a Case

This 42-year-old Air Force officer was in charge of transportation of radioactive samples from the Pacific proving grounds to the United States. He had no specific knowledge that he had become

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*References 2 and 3.

contaminated at any time, but remembers an accident involving spillage of radioactive samples in the aircraft. Several weeks later he experienced a tingling, itching sensation on the right side of his forehead and noted a pink, slightly depigmented area about an inch in width extending from the hairline down to and including the upper right eyebrow and eyelid. The lesion was hyperesthetic to touch or washing. A dry, scaly desquamation was observed. The surface at no time was moist or "weeping." He also noted an increased tendency of the area to become reddened and irritated on exposure to sunlight while the surrounding unaffected skin tanned without symptoms. These symptoms gradually subsided over the next few months but did not entirely disappear. About three to four months after he first noticed the lesion, he noted that he was losing hair from his right eyebrow (in the inner two-thirds), and this continued over a period of several weeks. Regrowth of hair occurred within a month or two, but the new hair was white. Minimal symptoms of hyperesthesia and sensitivity to sunlight have persisted.

Examination at this time shows a slightly erythematous, depigmented area about 1 in. wide extending from the hairline on the right side of the forehead to the right eyebrow (Fig. 1). The right eyebrow, upper lid, and a small area lateral to the eye on the malar region show less depigmentation. The lesion stands out in contrast to the normally pigmented area surrounding it. The affected area on the forehead is slightly elevated but not atrophic. No desquamation is evident at this time. The lesion is hyperesthetic to touch. The right eyebrow is white in the inner two-thirds and black in the outer one-third. The hair of the left eyebrow is black with no white hairs. The white hair of the right eyebrow is longer than the hair of the left eyebrow.

Histopathology.—The biopsy material was taken to include the margin of the lesion and a portion of adjacent normally pigmented skin. The region from which the tissue was taken is indicated by the arrow in the insert, the smaller area of normally pigmented skin extending to the left. This is taken as a basis of comparison of the two portions of the section.

The entire surface shows a thin keratin layer, slightly thicker over the nonpigmented portion of the epithelium. The epithelium otherwise is of relatively uniform thickness. There appears to be no variation in the distribution of cells or cell

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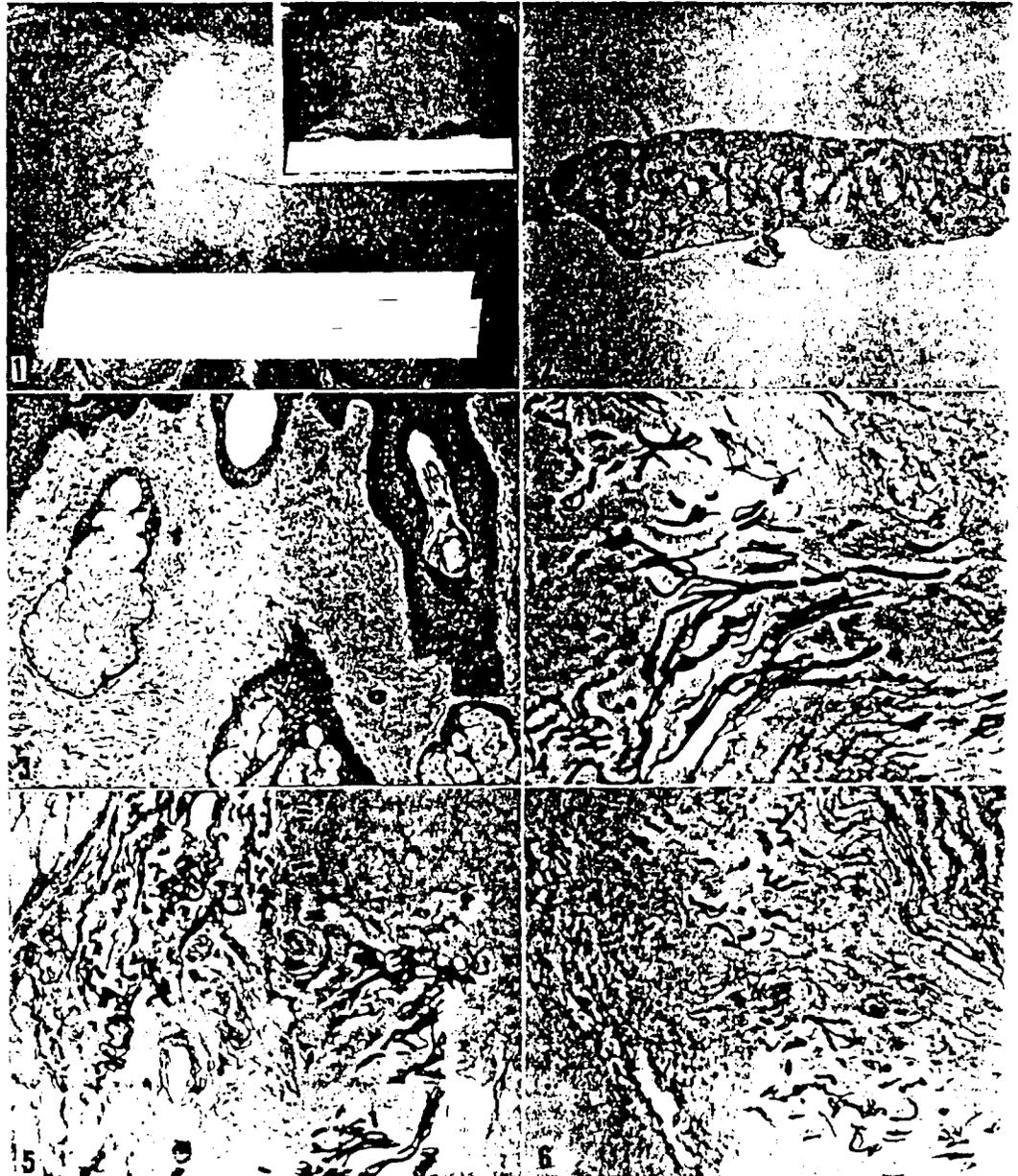


Fig. 1.—Clinical appearance of lesion, approximately 14 months after onset. (June, 1955). Insert shows approximate location of biopsy section. Fig. 2.—Low-power view of biopsy section stained by Gomori aldehyde fuchsin technique. There is no significant variation in the number or appearance of the special skin structures. The dark superficial subcutaneous areas indicate degenerative elastosis more or less evenly distributed throughout the tissue section. Vertical arrow indicates the approximate site of the pigmented-nonpigmented junction. Blocks in the subcutaneous area indicate areas photographed to indicate qualitative changes in elastic tissues. These were taken at a fixed distance below the surface in the area underlying the pigmented and nonpigmented surface as indicated. Reduced about 35% from mag. $\times 16$ (AFIP Neg. No. 55-19596). Fig. 3.—A portion of the subcutaneous area underlying the nonpigmented epithelium, showing at the central portion an area of connective tissue with an irregular pattern suggestive of radiation damage. Hematoxylin and eosin; reduced about 35% from mag. $\times 95$ (AFIP Neg. No. 55-16767). Fig. 4.—Section taken from the area indicated in Figure 2, showing normal configuration of elastica. This is taken from the area outside the depigmented zone.

types. The difference in pigment in the region of the basal layer has been noted. The superficial corium shows relatively uniform papillae. There is moderate vascularity with no apparent changes within the vessel walls. There are relatively frequent groups of mononuclear cells present in the subcutaneous area, often in relation to the small vessels, but with no appreciable difference in distribution throughout the subcutaneous area. There are, in the superficial corium regularly spaced areas of basophilic hyaline and granular degeneration of the collagenous and elastic tissue. These are well circumscribed and appear with regularity in the superficial corium beneath both pigmented and nonpigmented areas. There are large numbers of sebaceous gland structures through the subcutaneous tissue placed with regularity in association with hair structures. No abnormalities of these sebaceous glands or of the sweat structures are noted. The surrounding connective tissue varies in density, appearing less dense in the superficial areas. A few areas (center of Fig. 3) show the irregular pattern of connective tissue with large fibroblasts suggestive of radiation effect.

The collagen and elastic tissue was examined in relation to vertical distribution through the entire subcutaneous area beneath the pigmented and nonpigmented areas. The deepest portions of the subcutaneous tissues beneath pigmented and nonpigmented skin showed completely similar appearance of the collagen and elastica, the latter appearing as sharply staining and well-defined strands of elastica (Gomori aldehyde fuchsin stain for elastica). The intermediate areas of the subcutaneous tissue displayed, however, some differences in the distribution and staining of the elastic tissue. Figures 4, 5, and 6 represent areas of the intermediate (in depth) subcutaneous tissue, each photomicrograph taken at exactly the same distance beneath the skin surface, orientation as indicated in Figure 2. The elastica beneath the pigmented area is sharply outlined and normal in appearance. The elastica beneath the nonpigmented area is irregular in outline, fragmented, beaded, and variable in staining reaction.

Diagnosis and Comment

A diagnosis of beta radiation lesion was made in this case on the basis of the following considerations. The history of the case strongly suggests radiation damage since

the lesion developed several weeks after handling and spillage of radioactive materials. In addition, this officer has had a long-standing habit of massaging the right side of his forehead and right eyebrow region with his thumb and index finger so that any contamination of his hands would likely be rubbed into the skin of that area. The erythematous, scaling lesion with symptoms of itching and burning, sensitivity to sunlight, hyperesthesia, and epilation of hairs of the eyebrow is consistent with radiation damage.

The tissue changes are of minimal degree when considered by general morphologic criteria. Comparison of pigmented and nonpigmented areas does reveal differences in the elastic tissue below the superficial corium. It is apparent that the moderately extensive elastosis, not unusual for this location and age group, might well mask changes in the superficial subcutaneous tissue. Epithelial changes particularly are absent, other than pigmentary disturbance. It must be presumed that the degree of exposure falls in the range which results in reversible epithelial changes as described by Moritz and Henriques.⁵ In spite of certain difficulties in interpretation of the histologic picture, it is felt that the pattern is not only consistent with, but suggestive of radiation damage and that the differences in the pattern of elastic tissue tend to support this conclusion.

The regrowth of white hair in the affected region in contrast to normal dark hair of the unaffected region is unusual. Regrowth of white hair in regions previously dark has been noted in irradiated animals,[†] but so far as the authors are aware has not been reported in human beings. The more rapid growth of hair in the affected regions

† References 6 and 7.

Gomori aldehyde fuchsin for elastica. Reduced about 35% from mag. $\times 490$ (AFIP Neg. No. 55-19589). Fig. 5.—Area beneath depigmented epithelium, presumably involved by radiation, at the area indicated in Figure 2, taken at exactly the same distance beneath the surface as Figure 4. Note the marked degenerative changes in the elastica. This is distant from and without any apparent relation to the elastosis changes noted superficially. Fig. 6.—From area indicated in Figure 2 taken at the same depth as Figure 4. Note the marked irregularity, fragmentation, and beading of elastica. Gomori aldehyde fuchsin for elastica; reduced about 35% from mag. $\times 490$ (AFIP Neg. No. 55-19593).

which was noted is not an unusual finding associated with radiation effects.⁸

This lesion has a certain similarity to vitiligo in regard to depigmentation and appearance of white hairs. But vitiligo is not usually accompanied by symptoms, and epilation does not occur. Sensitivity to ultraviolet light is also common to vitiligo, but in both diseases this sensitivity may be related to lack of pigment. Scleroderma is another disease that might bear certain similarities. However, in this disease the skin usually assumes an ivory-colored, shiny appearance with adherence of the skin to underlying parts which was not true in this case. Pityriasis versicolor was considered in the differential diagnosis, but the lesions of this disease rarely occur on the face, are fawn-colored, and epilation and sensitivity to ultraviolet light are not characteristic. The microscopic picture does not conform to the well-recognized patterns of vitiligo, scleroderma, or pityriasis versicolor.

It was considered worth while to present this case since lesions resulting from contamination with radioactive materials may be more commonly encountered in the future in view of the increasingly widespread use of atomic energy.

Summary

A case history of a lesion on the forehead and right eyebrow region, presumably due to irradiation from contamination with fission-product material, is presented. The erythema, dry desquamation, depigmentation, symptoms of burning and itching, increased sensitivity to sunlight, hyperesthesia, epilation of the eyebrows (with regrowth of hair), and minimal histological changes (17 months later) particularly in the elastic tissue were considered consistent with radiation damage to the skin. The

most unusual feature of the lesion was the regrowth of white hair in the affected region of the right eyebrow, which was formerly black in color.

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