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“Association of Acute Radiation Syndromes and Rain after the Bombings in the Atomic-bomb Survivors”

Kotaro Ozasa, Ritsu Sakata, Harry M. Cullings, Eric J. Grant

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Study Findings

Association between exposure to rain that fell soon after the atomic bombings and development of acute symptoms was examined based on responses to interview surveys of Life Span Study (LSS) members conducted during the 1950s. Although the frequency of development of such acute symptoms was slightly higher in those who reported exposure to rain, the association was not thought to be caused by uniform radioactivity in the rain with potential effects equivalent to a level of several hundred milligray (mGy); rather, recall bias, and other factors, were thought to be more plausible explanations. Nevertheless, such issues as insufficient data available for use in the study limited the effectiveness of the study analysis.

Explanation

1. Study purpose

Based on various experiences of atomic bomb (A-bomb) survivors, it has been thought that acute radiation syndrome, which includes symptoms such as epilation and bleeding that appeared after the bombings, was associated with exposure to radiation from rain that fell soon thereafter. However epidemiological analysis had not been conducted. The association was examined by comparison of information involving exposure to rain soon after the bombings and development of acute symptoms. This information was obtained in interviews of Life Span Study (LSS) members in the 1950s, with direct radiation effects from the A-bombings taken into consideration.

2. Study methods

Several interviews of LSS members were conducted in the late 1940s to collect information regarding their situation at the time of the bombings, and in the 1950s the interviews included questions about exposure to rain that fell soon after the bombings and development of acute radiation symptoms. The responses obtained consisted of: “was exposed” (in this case, information on location at exposure was requested), “not exposed,” and “unknown.” This study analyzed typical acute radiation symptoms such as epilation, bleeding, and oropharyngeal lesions in relation with responses to questions regarding exposure to rain.

3. Study results

The frequency of the development of acute symptoms differed significantly among levels of direct radiation from the A-bombings : 30–80% at the level of 3 Gy or higher, 1–6% at around 100 mGy, and 0.04–2% at less than 5 mGy, for a variety of symptoms. At the same level of direct radiation, the reported frequency of the development of acute symptoms was slightly higher in those who indicated they had been exposed to rain than in those who did not, both in Hiroshima and

Nagasaki. The frequency of many acute symptoms, however, was significantly lower in those who were exposed to rain and to direct radiation of <5mGy than in those who were not exposed to rain but exposed to direct radiation of 100–500 mGy. Thus, it is unlikely that the rain contained uniformly high levels of radiation to produce effects equivalent to those experienced at a level of several hundred mGy.

Odds ratio (OR) was used to evaluate, in this study, the association between exposure to rain and frequency of development of acute symptoms (i.e., what percentage increase), and a larger OR indicates a stronger association. The OR of reporting exposure to rain somewhere in Hiroshima was 1.19 ($p = 0.08$) among those who developed severe epilation (defined as >2/3 of scalp), 1.23 ($p < 0.01$) in cases of at least slight epilation (>1/4 of scalp), 1.48 ($p < 0.01$) for bleeding, and 1.47 ($p < 0.01$) for oropharyngeal lesions. The ORs in Nagasaki were 1.76 ($p = 0.11$), 2.10 ($p < 0.01$), 2.01 ($p < 0.01$), and 2.46 ($p < 0.01$), respectively. As for survivor location at exposure to rain in Hiroshima, the OR was largest for those who reported exposure to rain in an area southeast of the hypocenter. The ORs for those who indicated they had been exposed to rain in the areas where rainfall was reported, i.e., clockwise from west-southwest to northeast, including the west-southwest area beyond 2 km that included the Koi/Takasu districts where high residual radiation was detected, were similar to the OR for exposure to rain somewhere in Hiroshima. In Nagasaki, the ORs tended to be bigger for those who reported exposure to rain in the western half of the area centered on the hypocenter than for those in the eastern half. The frequency of acute symptoms was not high among those who had reported exposure to rain in the area beyond 2 km from the hypocenter to the east that included the Nishiyama district, where heavy rainfall and high residual radiation were observed soon after the bombing.

Study Significance

The association between radiation exposure and development of acute symptoms was, in general, strongest for severe epilation and weakest for epilation of lesser degrees, as well as bleeding and oropharyngeal lesions, because the latter symptoms contained a larger number of cases not caused by radiation exposure. In this study, reports of exposure to rain were associated with development of symptoms other than severe epilation; this association was similar to, or slightly stronger than, the association with severe epilation. Also, the association tended to be stronger in those who were exposed to rain in areas where there were few reports of rainfall than in those who were exposed to rain in areas where rainfall was frequently reported. The association was not stronger in the areas where ground residual radiation levels were high in post-war surveys than in other areas. This trend in association is thought to be somewhat inconsistent with the hypothesis that acute symptoms developed due to radiation exposure from rain.

Potential reasons for the observed association between exposure to rain and development of acute symptoms included: a strong radioactive fallout contained in the rain and a high radiosensitivity of the individuals exposed to the rain; synergistic effects between radiation and poor hygienic conditions; as well as inaccuracies and recall bias in memories and in reports of locations at the time of the bombings and exposure to rain and timing related to the development of symptoms (recall bias is the tendency for people to believe they might have developed acute symptoms because they had been exposed to rain, or vice versa). Although there may have been some individual cases of development of acute symptoms caused by radioactive fallout in rain, the overall trend in the results is

inconsistent with the conclusion that acute symptoms were generally caused by radioactive fallout in rain. Rather, recall bias, and other factors, were thought to be more plausible explanations for the association. However, insufficient data imposed limits on the assessment of whether the reports of rainfall after the A-bombings and development of acute symptoms were attributed to actual radioactive fallout or uncertain memories and other such factors.

The Radiation Effects Research Foundation has studied A-bomb survivors and their offspring in Hiroshima and Nagasaki for around 70 years. RERF's research achievements are considered the principal scientific basis for radiation risk assessment by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and for recommendations regarding radiation protection standards by the International Commission on Radiological Protection (ICRP). RERF expresses its profound gratitude to the A-bomb survivors and survivors' offspring for their cooperation in our studies.

[§]*Radiation Research*, which is an official monthly journal of the Radiation Research Society, publishes original peer-reviewed papers and review articles on radiation effects and related issues in the fields of physics, chemistry, biology, and medicine. (Impact factor in 2014: 2.911)