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“Solid cancer incidence among the Life Span Study of atomic bomb survivors: 1958–2009”

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Study Findings

This study showed that the incidence of all solid cancers was higher with increasing radiation dose, a finding that was similar to previous RERF reports that have explored this relationship. This study investigated the radiation risks of all solid cancers in aggregate and updated the results with 11 additional years of follow-up since the last report. An important new aspect of this study was the inclusion of smoking in the risk analyses. Smoking is known to be a potent carcinogen but when adjusting for its effects, the radiation risks of solid cancer occurrence were found to be unaffected. Future studies will carefully investigate the risks in individual organs or organ systems.

Explanation

We conducted a study on the relationship between solid cancer incidence and radiation dose to the colon among the Life Span Study (LSS) of atomic bomb survivors. Colon dose was chosen because the colon is a large, central organ and was considered representative of the whole-body exposure received by the atomic bomb survivors. Data on solid cancer occurrence was collected from the Hiroshima and Nagasaki cancer registries during the follow-up period 1958–2009. Adjustment for smoking was included in the analysis, and the data on smoking were collected from periodic mail surveys and surveys conducted during clinical visits.

1. Study purpose

An important task of the long-term follow-up of the atomic bomb survivors is to document the occurrence and risks of solid cancers. With aging, cancer is a common health affliction in any population. In the atomic bomb survivors, cancer occurs more often with increasing radiation dose from the bombings. The purpose of this study was to quantify the risks from radiation exposure of solid cancer incidence. This is the third RERF report on the risks of solid cancer incidence.

2. Study methods

LSS cohort members in this study numbered 105,444 and included those who were alive with no cancer history as of January 1, 1958, and had a known radiation dose. First primary incident cancers were identified through linkage with Hiroshima and Nagasaki cancer registries. Follow-up was carried out through December 31, 2009. We used smoking history information based on mail and clinical surveys. Individual radiation doses to the colon were estimated for each cohort member using the revised DS02 dosimetry system (DS02R1). Risks of solid cancers as a function of radiation dose, sex, pack-years of smoking*, age at exposure, and attained age were estimated using statistical models. Estimates of risk were expressed as an excess relative risk (ERR).

ERR is reported as relative to another person without radiation exposure. As background rates of cancers change rapidly with aging, relative risk must be indicated at a particular age. Further, since age at the time of exposure also modifies the relative risk of contracting a cancer due to radiation, age at exposure must also be specified. We reported radiation risks at 70 years for a person exposed at age 30. This practice is common with RERF results and is the same as the methodology used in our previous cancer incidence studies.

*When evaluating health impact of smoking, this index is used to indicate “tobacco consumption per day x number of years of smoking.” In Japan, tobacco consumption per day is calculated as

number of cigarettes; in the case of Western countries, consumption is typically indicated by number of packs (1 pack = 20 cigarettes).

3. Study results

A total of 22,538 incident first primary solid cancer cases were observed over the follow-up period. In the 11 years since the last report, 5,918 new cases occurred. This figure represents 26% of the total number of cases, reflecting the advanced age of the cohort.

(1) Linear dose response with and without adjustment for smoking

Using a sex-averaged, linear dose response relationship, the ERR per gray of radiation (ERR/Gy) was 0.50 (i.e. 50% higher) before adjusting for smoking for a person aged 70 years and exposed at age 30 years. After the adjustment, the ERR value was 0.47, indicating that smoking made almost no difference in the radiation risk estimates.

(2) Sex-specific dose response

In women, a linear dose response described the data most accurately, with a 0.64/Gy ERR at attained age 70 after exposure at age 30. For men, the ERR was 0.20 and the shape of the dose response was curvilinear. Higher ERR values for women are common and are generally thought to be due to the lower natural rates of solid cancers observed in women compared with men. However, the curved dose response shape for cancer incidence data found in the men of this study had not been previously observed.

Study Significance

This study showed that solid cancer risks remain elevated more than 60 years after radiation exposure. For the first time in a major RERF report, we adjusted for smoking. While there was a strong risk of cancers due to smoking, the strength and shape of the radiation dose response was not affected. Mathematical models developed by RERF that describe the radiation risks of cancers are used by many scientific groups around the world to help formulate radiation protection policies for workers and the public. After 11 years of additional follow-up, the linear dose response estimate was nearly unchanged from the value reported in our previous paper. However, the male dose response exhibited a more curved response, which had not been previously observed. We are carefully considering the causes of this change. This study considered all solid cancers in aggregate. We are working on a series of additional studies that will investigate the dose response of specific organs and organ systems.

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 2015: 2.67)