Radiation Dose and Cataract Surgery Incidence in Atomic Bomb Survivors, 1986-2005


[Findings of this study]
A risk for clinically significant cataracts among the A-bomb survivors was observed at dose levels of less than 1 gray (Gy), in particular, a 32% relative excess in risk (with a 95% confidence interval of 9% to 53%) after an eye dose of 1 Gy. An approximately linear dose-response was observed in the incidence of cataract surgery. The excess was somewhat larger among those exposed at young ages. The best estimate of a possible dose-effect threshold for clinically significant cataract was 0.5 Gy.

[Explanation]
The association between radiation and cataracts has known since it was first found in 1906, about 10 years after the discovery of x-rays, but there have been almost no systematic human data on the radiation induction of serious, vision-impairing cataracts. The traditional view held by radiation risk-assessment agencies was that only high doses of several gray induced clinically significant cataracts (that impair vision and require surgery), and radiation standards for limiting dose to the eye were set accordingly. The present study indicates that clinically significant cataracts are induced at doses well under one gray and estimates that at 1 gray 32% more cataracts (with statistical estimation bounds between 9% and 53%) occur than in the absence of radiation exposure. These findings provide a strong scientific basis for the recently revised guidelines by the International Commission on Radiological Protection (ICRP) that reduced the maximum allowable acute eye dose from 5 Gy to 0.5 Gy. This study was published in the August 2012 issue of Radiology.

1. Purpose: To examine the incidence of clinically significant cataracts in relation to lens radiation doses between 0 and up to 4 Gy with the aim of addressing risks at relatively low acute doses.

2. Materials and Methods: Pursuant to the procedures approved by the human ethics committee at the Radiation Effects Research Foundation, the authors examined cataract surgery incidence among 6,066 A-bomb survivors in the clinical Adult Health Study. During 1986-2005, 1,028 persons underwent cataract surgery for the first time. Sixteen risk factors for cataract, such as smoking, hypertension, and corticosteroid use, were examined statistically and found not to distort the estimates of radiation effects. Radiation dose-response analyses were then performed for cataract surgery incidence, adjusting for city, age, and diabetes mellitus, with results expressed as excess relative risk (ERR). ERR is a measure of how much radiation multiplies the risk above that seen in the unexposed group.

3. Results of the study: The dose-effect ERR model was found to be essentially linear with a 32% excess risk at 1 gray (95% confidence interval of 9% to 53%). The dose-effect plot is shown in Figure 1. The ERR was higher for those who were young at exposure. For an eye dose of 1 gray, the excess risk corresponds to about 100 additional cataract surgeries per 1,000 persons over the course of 30 years. A “dose-effect threshold” analysis was performed to determine if there was some level of dose below which an excess in the risk was uncertain. The analysis results suggested presence of a threshold, with a best estimate of 0.5 Gy.
Figure: Radiation dose response for the ERR model of cataract surgery incidence

ERR = 32% at 1 Gy (95% CI: 9-53%)
Dose threshold = 0.5 Gy (95% CI: 0.1-0.95 Gy)

P < 0.001

(Adjustment made for city, sex, age at exposure, attained age, and diabetes)