

Effects of A-bomb Radiation on Survivors

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Summary: The relative risk of cancer in A-bomb survivors increased with radiation dose. In a dose range of 300-599 cGy, the relative risk of cancer was above 1 ($p < 0.05$ for male, $p < 0.01$ for female). The relative risk of noncancer for males was significantly lower than 1 in a dose range of 50-99 cGy ($p < 0.05$).

Introduction

Dose response relationship for cancer death has been observed in A-bomb survivors.^{1,2,3,4)} We analysed the effect of A-bomb radiation on the risk of death and cause of death.

Materials and Methods

From a database of A-bomb survivors in Scientific Data Center for the Atomic Bomb Disaster, Nagasaki University, we selected 3456 survivors exposed to A-bomb radiation to analyse risk of death and cause of death and observed from 1970 to 1988 to analyse dose dependency of risk of death. The survivors were divided into 7 groups according to exposed dose; 1-29, 30-49, 50-99, 100-149, 150-199, 200-299, 300-599 cGy. Table 1 shows number of subjects analysed and their mean doses. Age-matched controls of three times subjects, 3 x 3456, were selected. We used BMDP statistical software⁹⁾ and significant test for the assumption was carried out with the Chisquare-test.

Table 1. Number of subjects

Dose (cGy)	Male		Female	
	Number	Mean dose (cGy)	Number	Mean dose (cGy)
1- 29	333	18.7	583	18.3
30- 49	229	39.7	355	40.3
50- 99	182	69.9	168	69.6
100-149	108	108.0	158	106.0
150-199	196	167.3	267	161.9
200-299	351	254.1	309	248.3
300-599	89	435.4	128	418.5
Total	1,488		1,968	

Results and Discussion

Table 2 shows the relative risk of death by all causes, cancer and noncancer. For death by all causes, the relative risk of males was 0.88 and 1.29 for the dose ranges of 50-99 cGy and of 300-599 cGy, respectively, and for females 0.94 and 1.55 for the dose ranges of 30-49 cGy and of 300-599 cGy, respectively. However, these low and high values were not statistically significant. The relative risk of cancer for males is 1.96 for the dose range of 300-599 cGy, and for females 1.73 and 2.79 for 200-299 cGy and 300-599 cGy, respectively. These high values for cancer were statistically significant ($p < 0.05$ for males and $p < 0.01$ for females). For noncancer, the relative risk for males is 0.65 for the dose range of 50-99 cGy. This was statistically significant ($p < 0.05$). The relative risk of death by all causes, cancer and noncancer for males is shown in Fig. 1, and that for females in Fig. 2.

Table 3 shows number of deaths from specific cancer for males. The number in parenthesis is of control (observed number divided by 3), asterisks indicate that the number of deaths for exposed survivors was larger than for controls. The number of lung cancer for exposed survivors was larger than controls for all dose ranges. For the doses larger than 150 cGy, the number of liver cancer for exposed survivors was larger than controls.

Table 4 shows number of deaths from specific noncancerous disease for males. The asterisk indicates that the

Table 2. Relative risk by A-bomb radiation

Dose (cGy)	All Causes		Cancer		Noncancer	
	Male	Female	Male	Female	Male	Female
1- 29	1.00	0.98	0.73	1.35	1.10	0.88
30- 49	1.01	0.94	0.97	1.06	1.03	0.91
50- 99	0.88	1.12	1.56	1.10	0.65*	1.12
100-149	0.91	1.12	1.34	1.86	0.77	0.95
150-199	1.01	1.00	1.58	1.60	0.85	0.84
200-299	1.11	1.22	1.17	1.73**	1.06	1.08
300-599	1.29	1.55	1.96*	2.79**	1.19	1.17
Total	1.03	1.06	1.22	1.46	0.98	0.94

*: $p < 0.05$, **: $p < 0.01$

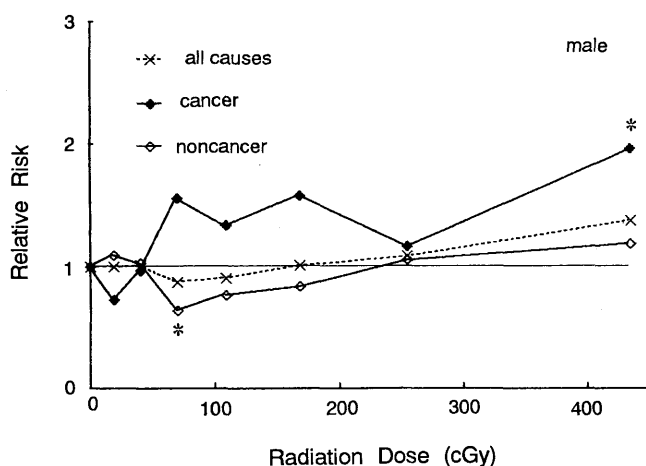


Fig. 1. Relative risk of death for males.
*: $p < 0.05$

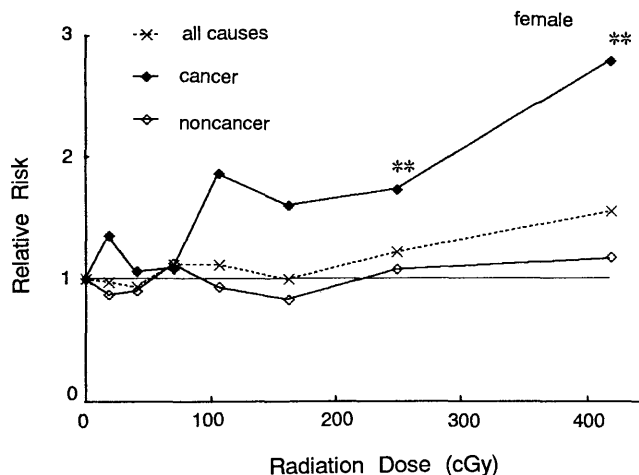


Fig. 2. Relative risk of death for females.
**: $p < 0.01$

Table 3. Number of deaths from specific cancer (male)

Site	Dose (cGy)						
	1-29	30-49	50-99	100-149	150-199	200-299	300-599
Stomach	8 (8.0)	4 (7.0)	8* (6.3)	2 (3.3)	4 (4.7)	9 (12.3)	3* (2.7)
Colon	1 (1.7)	1* (0.7)	0 (1.0)	0 (0.3)	1* (0.7)	2* (1.3)	0 (0.7)
Liver	2 (3.0)	2 (3.3)	5* (2.0)	2 (2.0)	7* (3.3)	9* (4.7)	2* (0.7)
Pancreas	0 (1.0)	0 (1.3)	1 (1.3)	0 (0.7)	1* (0.7)	2* (1.7)	0 (0.3)
Lung	2 (3.7)	6* (4.3)	5* (2.0)	5* (1.7)	3* (2.0)	8* (6.0)	3* (1.7)
Leukemia	0 (0.3)	0 (0.0)	0 (0.3)	1* (0.3)	1* (0.3)	0 (0.3)	1* (0.0)

parenthesis: number of control

*: number for exposed group is larger than for control

Table 4. Number of deaths from specific noncancerous disease (male)

Disease	Dose (cGy)						
	1-29	30-49	50-99	100-149	150-199	200-299	300-599
Heart disease	11 (9.7)	10* (10.3)	9 (6.7)	6 (5.0)	6 (6.3)	13 (12.3)	3 (3.3)
Hypertension disease	5 (3.0)	5 (0.7)	0* (1.3)	0* (2.3)	1* (2.3)	2 (2.0)	1* (1.3)
Cerebrovascular disease	13* (14.3)	10* (15.7)	4* (11.7)	4* (7.7)	8* (12.7)	25 (22.0)	5 (5.0)
Pneumonia	11 (7.7)	9 (6.7)	3* (5.0)	4 (4.0)	4* (4.3)	9* (11.0)	2 (2.3)
Liver cirrhosis	4 (3.3)	3* (3.3)	0* (4.3)	0* (1.7)	3* (3.3)	4* (4.3)	0* (1.3)
Others	18* (24.0)	15* (17.3)	5* (11.0)	5* (5.7)	10 (9.3)	25* (32.0)	11 (9.0)

parenthesis: number of control

*: number for exposed group is smaller than for control

number of death for exposed survivors was smaller than that for controls. Deaths whose relative risk was low for the doses from 50 cGy to 199 cGy were hypertension disease, cerebrovascular disease, pneumonia and liver cirrhosis. Small values of deaths from noncancerous disease were observed in low dose ranges.

Table 5 shows number of deaths from specific cancer for females. For the doses from 200 to 599 cGy, the deaths from stomach cancer, pancreas cancer, lung cancer and breast cancer were larger than that for controls.

Table 6 shows number of deaths from specific noncancerous disease for females. The asterisk indicates that the number of deaths for exposed survivors is smaller than that

for controls. Deaths whose relative risk was low in a dose range of 1-29 cGy were hypertension disease, cerebrovascular disease and liver cirrhosis.

The relative risk of cancer and of noncancer was analysed in respect of the age of exposed survivors at time of bombing (ATB). The relative risk of cancer for different ATB age groups for males is shown in Fig. 3. There was a tendency that the relative risk increased with radiation dose for each age group, but it was not significant statistically. The relative risk of noncancer for males for different ATB age groups is shown in Fig. 4. The relative risk was less than 1 for the doses from 50 cGy to 199 cGy for all ATB age groups.

Table 5. Number of deaths from specific cancer (female)

Site	Dose (cGy)						
	1-29	30-49	50-99	100-149	150-199	200-299	300-599
Stomach	7* (6.0)	3 (5.3)	3* (1.0)	4* (0.7)	2* (1.7)	4* (2.3)	4* (0.7)
Colon	0 (2.3)	1 (1.3)	0 (0.3)	0 (0.3)	0 (0.3)	0 (1.0)	0 (0.3)
Liver	3* (2.0)	0 (1.3)	1* (0.7)	2* (0.3)	2* (0.7)	1* (0.3)	0 (0.7)
Pancreas	2* (1.3)	0 (1.0)	0 (0.7)	0 (0.0)	1* (0.0)	2* (0.0)	1 (0.3)
Lung	3 (3.0)	4* (3.3)	2* (1.7)	0 (2.0)	4* (2.0)	3* (1.3)	2* (0.3)
Breast	3* (2.0)	0 (1.0)	0 (1.0)	0 (0.3)	3* (1.0)	1* (0.7)	1* (0.7)
Uterus	1 (1.3)	3* (0.7)	0 (0.3)	2* (0.3)	0 (0.7)	0 (0.7)	1* (0.3)
Leukemia	2* (0.3)	1* (0.0)	0 (0.0)	0 (0.0)	2* (0.0)	0 (0.0)	1* (0.0)

parenthesis: number of control

*: number for exposed group is larger than for control

Table 6. Number of deaths from specific noncancerous disease (female)

Disease	Dose (cGy)						
	1-29	30-49	50-99	100-149	150-199	200-299	300-599
Heart disease	22* (22.7)	13 (13.0)	5* (5.3)	7 (4.3)	3* (5.7)	4* (6.7)	5 (3.7)
Hypertension disease	5* (5.3)	8 (4.3)	0* (2.3)	2 (1.3)	2 (1.7)	2 (1.7)	0* (0.3)
Cerebro vascular disease	18* (21.0)	14* (14.3)	12 (7.0)	7 (5.7)	11 (8.3)	7 (5.3)	6 (3.3)
Pneumonia	8 (8.0)	4* (5.7)	4 (2.7)	2 (2.3)	4 (2.3)	2 (2.3)	2 (2.0)
Liver cirrhosis	1* (2.7)	1 (0.3)	1 (0.3)	1 (0.7)	1 (0.7)	0* (1.0)	0* (0.3)
Others	21* (27.0)	16* (19.0)	8 (5.3)	3* (7.7)	10* (10.7)	12 (10.0)	4 (3.3)

parenthesis: number of control

*: number for exposed group is smaller than for controls

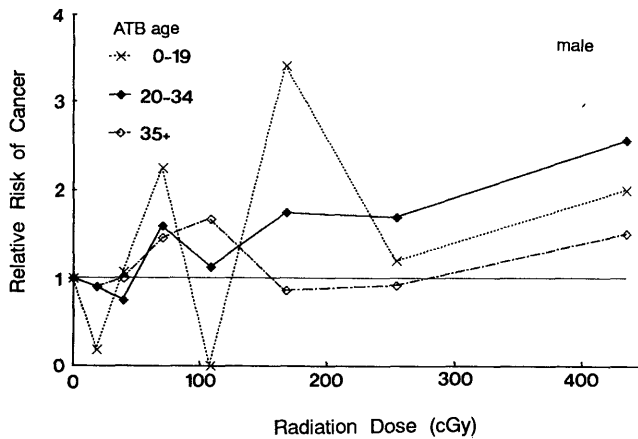


Fig. 3. Relative risk of cancer for different age at time of bombing (ATB) for males.

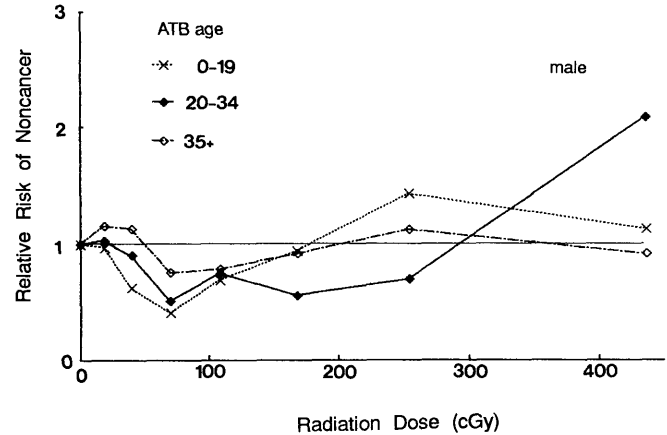


Fig. 4. Relative risk of noncancer for different age at time of bombing (ATB) for males.

The relative risk of cancer for females for different ATB age groups was shown in Fig. 5. There was a tendency of increase in the relative risk with radiation dose for groups

of ATB ages of 0-19 and 20-34 years old. In Fig. 6, the relative risk of noncancer for females is shown. There was no clear dependency of age and dose.

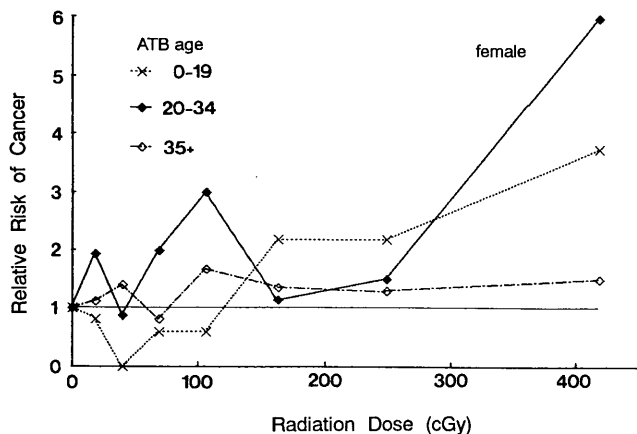


Fig. 5. Relative risk of cancer for different age at time of bombing (ATB) for females.

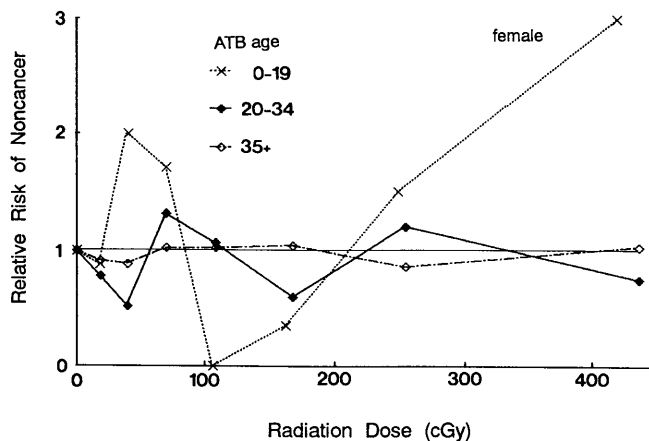


Fig. 6. Relative risk of noncancer for different age at time of bombing (ATB) for females.

References

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