Pediatr Radiol (2003) 33: 815–817
DOI 10.1007/s00247-003-1021-7

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Reply

Published online: 16 September 2003

Sir,

I welcome the chance to respond to the letter [1] commenting on my 2002 Neuhauser Lecture, "Lessons we have learned from our children: cancer risks from diagnostic radiology" [2].

I will not attempt to rebut all of the points made in the letter by Drs. Lentle and Charron since it covers the ball-park and raises many of the old chestnuts that have been argued about for years. Most points are not relevant to the present discussion, and some I agree with anyway. I will simply defend the three points that they attack, in the context of my paper, which addressed the risks associated with helical CT in children. In my paper, I never once mentioned the linear no-threshold hypothesis, nor was it my goal to either defend or attack it. The three quotes from my paper that were attacked were:

1. "The A-bomb survivors represent the best source of data for risk estimates of radiation-induced cancer."

Over the limited range of doses for which data are available, this is widely accepted as the gold standard. The irradiated population of close to 100,000 has been studied for over 50 years at a cost of over half a billion dollars and there is a suitable control group. There has never been a more careful study, and for finan-

This reply refers to the letter to the editor at http://dx.doi.org/10.1007/s00247-003-1020-8

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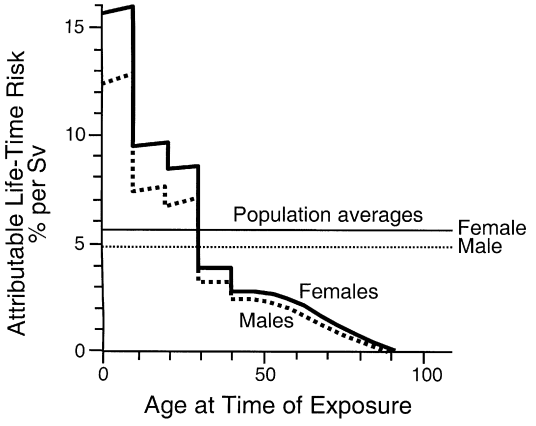

Fig. 1 The attributable lifetime risk from a single small dose of radiation at various ages at the time of exposure. Note the dramatic decrease in radiosensitivity with age. The higher risk for the younger age groups is not expressed until late in life. (Adapted from [5])

cial reasons alone, nothing like it will ever be done again. Both the BEIR and UNSCEAR committees as well as the ICRP depend almost entirely on the A-bomb survivors as a primary source [3, 4, 5], I am therefore in good company.

2. "It is clear that children are ten times more sensitive than adults to the induction of cancer."

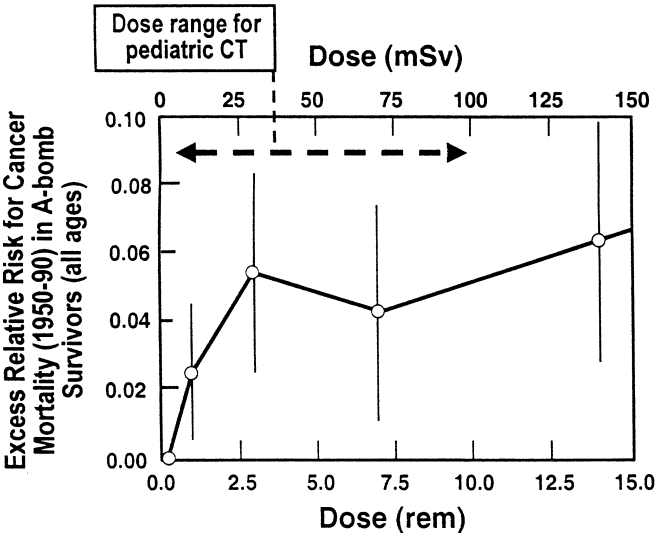

Fig. 2 Radiation-related excess relative risk (and standard errors) for solid cancer mortality among A-bomb survivors. The low-dose data are from Pierce and Preston [12]. Also shown is the range of organ doses characteristic of helical CT (Adapted from [9])

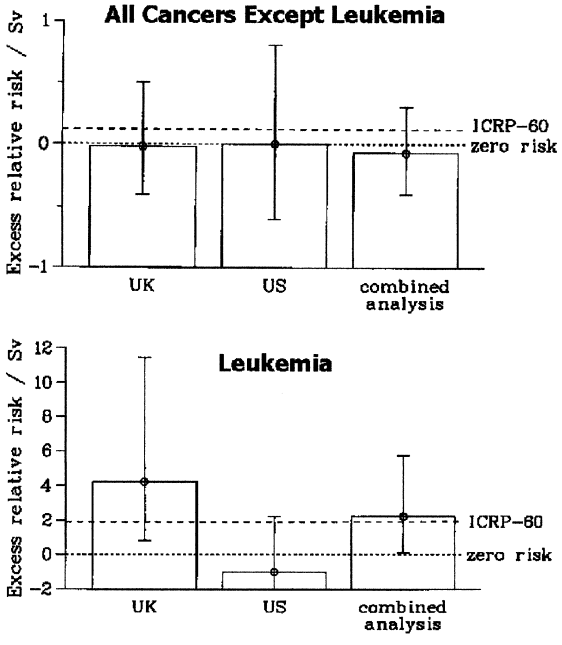

Fig. 3 Excess relative risk for leukemia (*top*) and solid cancers (*below*) from the International Agency for Research on Cancer study. The data are consistent with either zero risk or a risk appropriately extrapolated from the A-bomb survivor data (labeled ICRP-60), referring to the report which recommends 4% per Sievert as the cancer risk. (The figure was prepared by Dr. David Brenner based on the data of Cardis et al. [13])

I am astonished to be challenged on this point. The sensitivity of children to radiation-induced cancer is not a hypothesis, it is an observed fact. The diagram in my paper, reproduced as Fig. 1, comes, with very small changes, from the ICRP-60 [5].The observation that children are extremely radiosensitive to cancer induction comes directly from the Japanese study. Individuals exposed at young ages in 1945 are now at the cancer-prone age, and it is evident that there is a significant cancer incidence. This is supported by the Chernobyl experience, where the only clear result is thyroid cancer in children, not seen in adults. This also agrees with the long-term experience that thyroid cancer is often a consequence of irradiation in children (radiotherapy for enlarged thymus [6] and radiotherapy for tinea capitis [7]) but not seen in adults (The Saenger study of patients with Graves disease treated with I^{131} [8]).

3. "There are no assumptions, and no extrapolation indicated."

When we made our first estimates of the risks associated with helical CT [9], few efforts were made to reduce the doses to children by varying the machine parameters. In the case of an abdominal CT in a small child, it was not unusual for organ doses to be of the order of 5–15 rad. The study of mortality in atomic bombs survivors, published by Pierce et al. [10], goes down to these doses. The risk of a helical CT in a child can be evaluated directly from data of individuals exposed to the same doses in Japan more than 50 years ago. This is illustrated in Fig. 2; no theories, no assumptions, no extrapolations. The linear no-threshold assumption is not involved; there is no extrapolation involved. I would add the comment that at much lower doses (a chest X-ray for example), there are no human data available, and risks then can only be estimated, based on a model of some sort. That is a different story.

Two final comments are in order:

The statement of The Health Physics Society [11] that the health risks from exposure to up to 10 rem is "either too small to be observed, or non-existent" was made in 1996, without reference to the mortality study by Pierce et al. in 1996 [10] or the low-dose incidence study by Pierce and Preston in 2000 [12]. I doubt whether any responsible body would make that statement today. If one reduces the dose from 10 rem to 1 rem, then I would agree that the risk is "either too small to be observed or non-existent." The trouble is, we do not know which.

It is true that the huge IARC study of over 100,000 monitored radiation workers in the USA, UK, and Canada found cancer risks not statistically significant from the general population—but they were also not significantly different from the cancer risk one would expect using the ICRP risk estimate, based on a linear extrapolation of the A-bomb data [13]. This is illustrated in Fig. 3. Thus the IARC study does not contradict the linear no-threshold hypothesis; in fact the only thing this study does show is that 100,000 is too small a sample to get significant data from nuclear workers, where the average dose in a protracted exposure was only 40 mSv, and most received less than 10 mSv. The cohort would need to be ten to one hundred times larger. Consequently, the linear no-threshold hypothesis is likely to remain a hypothesis, since studies that are sufficiently large have not been performed, nor are they planned. Fortunately, it is not relevant to the discussion of helical CT.

References

1. Charron M, Lentle BC (2003) Is it really this simple? (letter). Pediatr Radiol (in press). DOI 10.1007/s00247-003-1020-8
2. Hall EJ (2002) Lessons we have learned from our children: cancer risks from diagnostic radiology. Pediatr Radiol 32:700–706
3. Committee on the Biological Effects of Ionizing Radiation: Health Effects of Exposure of Low Levels of Ionizing Radiations (1990) National Academy of Sciences/National Research Council, Washington, DC
4. United Nations Scientific Committee on the Effects of Atomic Radiation: Sources and Effects of Atomic Radiation. (1994) UNSCEAR 1994 Report to the General Assembly, with Scientific Annexes. E 94 IXII. United Nations, New York
5. International Commission on Radiological Protection: Recommendations (1990) Annals of the ICRP Publication 60. Pergamon Press, Oxford
6. Shore RE, Hildreth N, Dvoretsky P, et al (1993) Thyroid cancer among persons given x-ray treatment in infancy for an enlarged thymus gland. Am J Epidemiol 137:1068–1080
7. Ron E, Modan B, Preston D, et al (1989) Thyroid neoplasia following low-dose radiation in children. Radiat Res 120:516–531
8. Saenger EL, Thoma BE, Tompkins EA (1968) Leukemia after treatment of hyperthyroidism. JAMA 205:855–862
9. Brenner DJ, Elliston CD, Hall EJ et al (2001) Estimated risks of radiation-induced fatal cancer from pediatric CT. Am J Radiol 176:289–296
10. Pierce DA, Shimizu Y, Preston DL et al (1996) Studies of the mortality of atomic bomb survivors. Report 12, Part 1, Cancer: 1950–1990. Radiat Res 146:1–27
11. Health Physics Society (1998) Radiation risk in perspective: Position statement of the Health Physics Society (adopted January 1996). In: Health Physics society directory and handbook. 1998–1999. Health Physics Society, McLean, VA, p 238
12. Pierce DA, Preston DL (2000) Radiation-related cancer risks at low doses among atomic bomb survivors. Radiat Res 154:178–186
13. Cardis E, Gilbert ES, Carpenter L, et al (1995) Effects of low doses and low dose rates of external ionizing radiation: Cancer mortality among nuclear industry workers in three countries. Radiat Res 142:117–132