CONF-791103--81

ON ESTIMATING THE RISK ASSOCIATED WITH COMPUTERIZED TOMOGRAPHY DOSES

M.G.Yalcintas, R.W.Leggett, D.E.Dunning
Health and Safety Research Division
Oak Ridge National Laboratory*
Oak Ridge TN 37830
and
O.Nalcioglu
University of California,Irvine
Department of Radiological Sciences
Irvine, CA 92717

The largest annual whole- body dose to the U.S. population from man-made radiation is from medical sources (1,2). According to the BEIR report (1), the use of diagnostic X-rays by the medical profession has increased in recent years at an annual rate of 1 to 4 percent. Risk factors developed by the BEIR committee can be used to estimate the risk to the population due to the exposure incurred through medical radiography. In this paper, these risk factors are employed to obtain an estimate of risk due to radiation exposure from computerized tomography (CT).

CT is considered among many in the medical field as one of the most significant diagnostic advances since Roentgen's discovery of the X-ray. CT was introduced into the medical field in 1973, and has been used rather extensively since that time (3). It has been estimated that by the year 1980, 2.4 million persons will have received diagnostic CT scans for abdominal and mediastinal disorders (4).

A digital computer is employed to process information from X-rays which are transmitted by a source that rotates around the patient. The information is converted to a tomographic image of the part of the body being scanned. The source and the detectors are collimated so that any slice (that is, tomographic image of a portion of the body bounded by two imaginary parallel planes through the patient) under study is exposed to the primary beam. A volume larger than a single slice can be studied by performing multiple scans and stacking the slices to cover the volume. Since the motion of the X-ray source causes a variation in dose, a different method of dose determination from that for standard diagnostic X-rays is required. In general, the average dose to the scanned section of the patient's skin (obtained by integrating the exposure profile) is used for comparison of dose delivered by different scanners (5). The exposure profiles can be obtained by using thermoluminescent chips, ribbons, or powder dosimeters. The same kind of dosimeters may also be used to measure the exposure from scattered radiation in other parts of the patient's body.

There are more than 25 different kinds of CT scanners, with a total of 1200 units currently used in hospitals and private clinics. CT scanners may be broadly classified into three groups, referred to as first, second, and third generation scanners. For the first generation scanners the single scan time is approximately 5 minutes, and the dose delivered to the skin may be as high as 21 rads. Second generation scanners have fast and slow scan times of 12 to 80 and 30 to 180 seconds, respectively, and may deliver a dose of up to 15 rads to the skin. Scan time for the third generation units vary from 1 to 40 seconds; these units may deliver a dose of up to 8 rads to the skin. The multiple scan to single scan dose ratios for all scanners vary between 1.2 and 1.8 average approximately 1.6. The dose at the patient's isocenter is estimated

* Operated by Union Carbide Corporation for the Department of Energy.

to be 40 to 70 percent of the surface skin dose.(6).

Estimates of the probability of premature death due to a CT procedure were made, using risk factors given in the BEIR report (1). Calculations were performed using an actuarial life table approach developed by the Environmental Protection Agency (7). With this approach, consideration is given to the fact that a potential victim of radiation-induced cancer may die from competing causes of death before the cancer develops or becomes fatal. The doses used for the calculations were 13 rads, 10 rads, and 5 rads for the first, second, and third generation scanners respectively. These doses may approximate the doses at isocenter for a typical procedure involving both single and multiple scans. Estimates of probability of premature death resulting from a CT procedure involving a second generation unit and shown in Figure 1. Because of the nonuniformity of the dose, the BEIR risk factors are not directly applicable but may be used to obtain "upper and lower bound" estimates. For example, curve A in Figure 1 may be an upper bound estimate for a procedure involving any area of the body, since risk factors for breast, lung, GI tract, leukemia , bone, and all other cancers were all considered. Curve B may be a lower bound estimate for a procedure involving the lung breast area, since risk factors for leukemia, GI tract, bone, and all other cancers were ignored. Curve C may be a lower bound estimate for a procedure involving the GI tract, since risk factors for lung, breast, leukemia,bone all other cancers were ignored.

CT has been used extensively among other diagnostic procedures, and the benefits of it at the expence of a high risk must be justified for each patient very carefully during the referral procedure.

References

1) "The Effects on populations of Exposure to Low Levels of Ionizing Radiation" Report of the Advisory Committee on the Biological Effects of Ionizing Radiation. National Academy of Sciences (1972).
2) E.C.Gregg, Radiol. 123, 447 (1977).
3) G.Hounsfield. Brit. J. Radiol.46, 1016 (1973).
4) "Comparative cost analysis" Arthur D.Little Inc. San Francisco (1977).
5) M.G.Yalcintas and O.Nalcioglu, Health Physics (in press).
6) E.C.McCullough and J.T.Payne, Radiol. 129, 457, (1978).
7) "A computer code for cohort analysis of increased risk of death" Environmental Protection Agency Report 520/4-78-012 (1978).

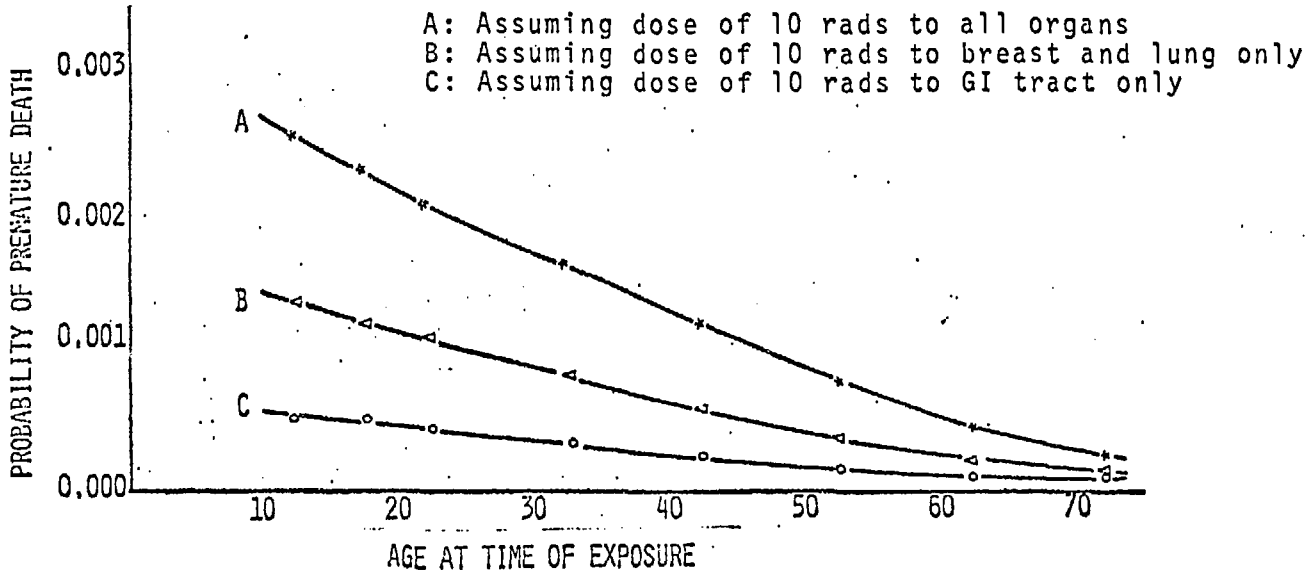

Figure 1. Estimates of probability of premature death from a single procedure involving a second generation CT scanner.