Radiation-Emitting Products

What are the Radiation Risks from CT?

As in many aspects of medicine, there are both benefits and risks associated with the use of CT[1]. The main risks are those associated with

1. abnormal test results[2], for a benign or incidental finding, leading to unneeded, possibly invasive, follow-up tests that may present additional risks and
2. the increased possibility of cancer induction from x-ray radiation exposure.

The probability for absorbed x rays to induce cancer or heritable mutations leading to genetically associated diseases in offspring is thought to be very small for radiation doses of the magnitude that are associated with CT procedures. Such estimates of cancer and genetically heritable risk from x-ray exposure have a broad range of statistical uncertainty, and there is some scientific controversy regarding the effects from very low doses and dose rates as discussed below. Under some rare circumstances of prolonged, high-dose exposure, x rays can cause other adverse health effects, such as skin erythema (reddening), skin tissue injury, and birth defects following in-utero exposure. But at the exposure levels associated with most medical imaging procedures, including most CT procedures, these other adverse effects would not occur.

Because of the rapidly growing use of pediatric CT and the potential for increased radiation exposure to children undergoing these scans, special considerations should be applied when using pediatric CT. Doses from a single pediatric CT scan can range from about 5 mSv to 60 mSv. Among children who have undergone CT scans, approximately one-third have had at least three scans. The National Cancer Institute and The Society for Pediatric Radiology developed a brochure, *Radiation Risks and Pediatric Computed Tomography: A Guide for Health Care Providers*[3], and the FDA issued a Public Health Notification, *Reducing Radiation Risk from Computed Tomography for Pediatric and Small Adult Patients*[4], that discuss the value of CT and the importance of minimizing the radiation dose, especially in children.

See a recent article from the New England Journal of Medicine (NEJM) titled, "Computed Tomography (CT) - An Increasing Source of Radiation Exposure"[5].

Risk Estimates

In the field of radiation protection, it is commonly assumed that the risk for adverse health effects from cancer is proportional to the amount of radiation dose absorbed and the amount of dose depends on the type of x-ray examination[6]. A CT examination with an effective dose of 10 millisieverts[7] (abbreviated mSv; 1 mSv = 1 mGy in the case of x rays.) may be associated with an increase in the possibility of fatal cancer of approximately 1 chance in 2000. This increase in the possibility of a fatal cancer from radiation can be compared to the natural incidence of fatal cancer in the U.S. population, about 1 chance in 5. In other words, for any one person the risk of radiation-induced cancer is much smaller than the natural risk of cancer. Nevertheless, this small increase in radiation-associated cancer risk for an individual can become a public health concern if large numbers of the population undergo increased numbers of CT screening procedures of uncertain benefit.

It must be noted that there is uncertainty regarding the risk estimates for low levels of radiation exposure as commonly experienced in diagnostic radiology procedures. There are some that question whether there is adequate evidence for a risk of cancer induction at low doses. However, this position has not been adopted by most authoritative bodies in the radiation protection and medical arenas.

Radiation Dose

The effective doses from diagnostic CT procedures are typically estimated to be in the range of 1 to 10 mSv. This range is not much less than the lowest doses of 5 to 20 mSv received by some of the Japanese survivors of the atomic bombs. These survivors, who are estimated to have experienced doses only slightly larger than those encountered in CT, have demonstrated a small but increased radiation-related excess relative risk for cancer mortality[8].

Radiation dose from CT procedures varies from patient to patient. A particular radiation dose will depend on the size of the body part examined, the type of procedure, and the type of CT equipment and its operation. Typical values cited for radiation dose should be considered as estimates that cannot be precisely associated with any individual patient, examination, or type of CT system. The actual dose from a procedure could be two or three times larger or smaller than the estimates. Facilities performing "screening" procedures may adjust the radiation dose used to levels less (by factors such as 1/2 to 1/5 for so called "low dose CT scans") than those typically used for diagnostic CT procedures. However, no comprehensive data is available to permit estimation of the extent of this practice and reducing the dose can have an adverse impact on the image quality produced. Such reduced image quality may be acceptable in certain imaging applications.

The quantity most relevant for assessing the risk of cancer detriment from a CT procedure is the "effective dose"[9]. Effective dose is evaluated in units of millisieverts (abbreviated mSv; 1 mSv = 1 mGy in the case of x rays.) Using the concept of effective dose allows comparison of the risk estimates associated with partial or whole-body radiation exposures. This quantity also incorporates the different radiation sensitivities of the various organs in the body.

Estimates of the effective dose from a diagnostic CT procedure can vary by a factor of 10 or more depending on the type of CT procedure, patient size and the CT system and its operating technique. A list of representative diagnostic procedures and associated doses are given in Table 1.

Table I. - Radiation Dose Comparison

Diagnostic Procedure	Typical Effective Dose (mSv)[1]	Number of Chest X rays (PA film) for Equivalent Effective Dose[2]	Time Period for Equivalent Effective Dose from Natural Background Radiation[3]
Chest x ray (PA film)	0.02	1	2.4 days
Skull x ray	0.1	5	12 days

Lumbar spine	1.5	75	182 days
I.V. urogram	3	150	1.0 year
Upper G.I. exam	6	300	2.0 years
Barium enema	8	400	2.7 years
CT head	2	100	243 days
CT abdomen	8	400	2.7 years

1.Average effective dose in millisieverts (mSv) as compiled by Fred A. Mettler, Jr., et al., "Effective Doses in Radiology and Diagnostic Nuclear Medicine: A Catalog," *Radiology* Vol. 248, No. 1, pp. 254-263, July 2008.

2. Based on the assumption of an average "effective dose" from chest x ray (PA film) of 0.02 mSv.

3. Based on the assumption of an average "effective dose" from natural background radiation of 3 mSv per year in the United States

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