Dynamic Chiropractic

X-RAY / IMAGING / MRI

CT and Radiation-Related Cancer Risk

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The use of computed tomography (CT) is increasing exponentially. Providers and patients are not well-informed about the relative latent cancer risks associated with repetitive exposure to ionizing radiation. Conservative estimates indicate that more than 60 million CT examinations are performed annually in the U.S.

A 2009 report[1] evaluated the radiation exposure of almost 1 million adults in five U.S. health-care markets over a two-year period. Nearly 70 (68.8) percent of individuals underwent at least one procedure associated with ionizing radiation exposure. CT scans accounted for 48 percent of the exposures; 30 percent of exposures were specifically abdominal and/or pelvic CT.

The typical abdominal CT scan radiation dose is about 10-20 mSv. Many patients, however, are exposed to multiple exams and screening performed at intervals of 5-10 years after the age of 50, leading to a cumulative exposure 4-6 times that single exam dose. In addition, obese patients often will have an increase in dosage in order to adequately image the region.

If radiation exposure exceeds a threshold of 5 mSv, the risk for cancer increases over the general risk in patients not exposed to that dose of radiation. Of all cancers in the U.S., 2-3 percent are attributed to iatrogenic radiation exposure. Putting these percentages into perspective, most of the quantitative estimates relating radiation dose to cancer risk are calculated on the data from studies of atomic-bomb survivors in Japan in 1945. Studies demonstrate an increase in overall risk of cancer in survivors who received low-dose radiation, which is defined as a 5-150 mSv dose. The mean exposure, 40 mSv, approximates the radiation exposure from a few CT scans.

ThresholdDoses for Certain Deterministic Effects (based on single-exposure absorption,specific body parts)

- 2 Gyincrease in number of chromosomal aberrations in bone marrow and lymphocytes
- 3 Gytemporary sterility in males
- 5 Gydepression of hematopoiesis (formation and development of blood cells)
- 1.0 Gyacute radiation syndrome
- 2.0 Gydetectable opacities (lens)
- 5.0 Gyvisual impairment
- 2.5-6.0 Gysterility in females, permanent
- 3.5-6.0 Gysterility in males, permanent
- 3.0-10.0Gy skin injury

Note: Gy = unit of radiation dose absorbed by biological matter. Dose equivalent ismeasured in Sv; for electron and gamma radiation, 1 Gy = 1 Sv.

For the individual patient, a single CT scan in a 25-year-old provides an incremental lifetime risk of about 0.6 percent for death from cancer. In a 50-year-old patient, that risk declines considerably, but it is still a relative risk that's carried forward for the rest of life.

The potentially consequences of ionizing radiation are divided into deterministic and stochastic effects.

Deterministic effects of ionizing radiation[2] result from the killing of cells and tissues, and include gastrointestinal syndrome, central nervous system syndrome and hemopoietic syndrome. These effects occur only at doses above a certain threshold and are proportional to the dose given. The radiation doses from medical diagnostic procedures are far below this threshold.

The term *stochastic radiation effect* is used when an irradiated cell is modified rather than killed. Modified cells may become cancerous after a latency period of years. In principle, stochastic effects have no specific dose threshold. Individuals exposed to radiation for diagnostic and screening purposes do not demonstrate recognizable ill effects, but subsequently have higher statistical chance of latent radiation-related toxicity, including the development of cancer. Doses delivered in diagnostic or screening procedures are large enough to cause stochastic radiation effects, and the probability of such effects increases with the magnitude of the dose and is cumulative.

We can't avoid background radiation; background radiation in the U.S. plus all other sources (airplane flights, medical tests, etc.) is an average of 6.2 mSv/yr per person. However, 20-30 years ago that exposure was only 3.6 mSv/yr. Medical imaging is part of the reason for this increase. It is estimated that 55 percent of that increase is due to CT scans alone. Below is a list of common exposures:[3]

- One backscatter wave scan at an airport = 0.001 mSv for about 5 seconds of full-body exposure.
- Living near a nuclear plant = 0.01 mSv/year of full-body exposure.
- One dental X-ray, Panorex, digital = 0.014 mSv for about 18 seconds of partial-body exposure.
- One airplane cross-country flight = 0.03-0.05 mSv of full-body exposure.
- Eating one banana per day for a year = 0.036 mSv/year of full-body exposure. (Brazil nuts are higher because of both potassium and radium, but for some reason the banana seems to be the fruit most popular to measure, i.e., the banana equivalent dose.)
- One skull X-ray = 0.1-0.2 mSv for about 0.4 seconds of partial-body exposure.
- One chest X-ray = 0.1-0.5 mSv for about 0.4 seconds of partial-body exposure.
- One mammogram = 0.3 mSv for about 0.4 seconds of partial-body exposure.
- One abdomen X-ray = 0.6-1.7 mSv for about 0.4 seconds of partial-body exposure.
- Airline crew, short flights = 2.2 mSv/year of full-body exposure.
- One head CT scan = 2.0-4.0 mSv for about 10 minutes of partial-body exposure.
- One barium X-ray = 3.0-8.0 mSv for about 0.4 seconds of full-body exposure.
- Airline crew, non-polar flights, 900 hours/year = 3-6 mSv/year of full-body exposure.
- Cooking with natural gas (radon) = 10 mSv/year of full-body exposure.
- One full-body CT scan = 5.0-15.0 mSv for about 20 minutes of full-body exposure.
- One chest CT scan = 6.0-18.0 mSv for about 10 minutes of partial-body exposure.
- Airline crew, polar flights, such as NYC-Tokyo, 900 hrs/yr = 9 mSv/year of full-body exposure.
- Smoking one pack of cigarettes per day for a year = 13 mSv/year of full-body exposure.
- Limit for nuclear plant workers = avg 20 mSv/year for five years, or 50 mSv for one year of full-body exposure.
- Cardiac catheterization, coronary angiogram, other heart X-ray studies = 50 mSv for about 60 minutes.
- Lowest clearly carcinogenic level = 100 mSv/year of full-body exposure.

We need to be more thoughtful about the use of not just CT scans, but all forms of ionizing radiation. Patients also need to be proactive. Patients need to keep a personal record of the procedures they're received, especially procedures performed on children.

Support for the practice of obtaining informed consent for CT is increasing. Often, however, the format of the information given in an informed consent form is not particularly beneficial to the patient. It simply serves as medicolegal protection for the clinician.

GeneralQuestions for Patients to Ask Before Any Diagnostic Test Involving Ionizing Radiation

- Is thisscan truly needed? How will it impact my care?
- Have youor another doctor done this test on me before (if patient cannot recall)?
- Are therealternatives, such as ultrasound or MRI?
- How manyscans will be done? Could one or two be enough?
- Will the dosebe adjusted for my gender, age and size?
- Will leadshields be used to keep radiation away from places it can do harm?
- How muchradiation will I be exposed to from the scan?
- Do youhave a financial stake in the machine that will be used?
- Can I havea digital copy of my scan? (Patients can bring a blank CD or thumb drive tothe procedure with them.)

Patients need to be informed about the risks of ionizing radiation in language that is understandable by the average person; for example, by comparing the average effective doses for a particular CT to, say, the number of chest radiographs, transcontinental flights, or additional days of background exposure. Furthermore, these risks should be expressed in light of the immediate benefits of obtaining a CT for any acute condition.

It should also be stressed that any theoretic risk in increase of radiation-induced cancer from a single CT is actually a very small risk on top of the baseline cancer rate of 42 percent in the United States. For instance, since lifetime associated risk of fatal cancer from a single CT is estimated at around 0.1 percent an abdominal CT effective dose is expected to increase the risk of developing cancer from 42 percent to 42.1 percent.

As of July 1, 2012, California now requires[4] that facilities performing CT scans record the dose of radiation in the radiology report or attach the protocol page (which includes the dose of radiation) to the radiology report. In addition, facilities will soon be required to report to the California Department of Public Health any adverse events in the administration of radiation. The details of this new law, Senate Bill 1237, are available online.

This bill was created in reaction to a number of very unfortunate events in which a significant number of patients were inappropriately exposed to high doses of radiation from CT scans. CT scanners capable of producing radiation dose reports fall under the law, and facilities also are required to have CT scanners accredited by approved Centers for Medicare & Medicaid Services (CMS), Medical Board of California, state department or public organizations by July 2013.

According to SB 1237, California providers are now required to report scans that are repeated (unless advised by clinicians) and scans to the wrong body part that result in an effective dose that exceeds 0.05 Sv; a dose in excess of 0.5 Sv to any organ or tissue or shallow dose of 0.5 Sv to the skin; and permanent damage.

As of July 1, 2012, radiology facilities are also required to record CTDI vol and DLP in their radiology reports, meeting the letter of the new law. However, the ongoing discussion among radiology thought leaders in California will result in recommended best practices for documenting radiation dose, and including information that provides the highest value to the ordering clinician and ultimately, the patient.

References

1. Fazel R, et al. Exposure to low-dose ionizing radiation from medical imaging procedures. *N Eng J Med*, Aug, 27, 2009;361:849-57.
2. Recommendations of the International Commission on Radiological Protection. www.icrp.org
3. List of common radiation exposures compiled by Willem Post, Willem Post BSME New Jersey Institute of Technology, MSME Rensselaer Polytechnic Institute, MBA, University of Connecticut. P.E. Connecticut. Consulting Engineer and Project Manager. Performed feasibility studies, wrote master plans, and evaluated designs for air pollution control systems, power plants, and integrated energy systems for campus-style building complexes.
4. California Senate Bill 1237: Radiation control; health facilities and clinics; records. Signed into law Sept. 29, 2010.

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