Cumulative Radiation Exposure in Medical Imaging

There's growing concern over increased cancer risk

The announcement that some patients at Cedars-Sinai Hospital were accidentally exposed to high levels of radiation from certain computed tomography (CT) scans brought nationwide attention to an issue that researchers have been concerned about for the past few years—increased levels of radiation exposure due to a dramatic rise in the use of radiological imaging technology.

The use of medical imaging procedures in the U.S. has increased rapidly over the past three decades. Several types of medical imaging procedures, such as x-rays, fluoroscopy, computed tomography (CT) scans, and nuclear medicine scans, expose patients to ionizing radiation, which over time can accumulate to substantial doses. (Ultrasound and MRI tests emit no radiation). According to the National Council on Radiation Protection & Measurement, medical exposure to radiation in the U.S. population increased from 15% of total radiation exposure in the early 1980s to 48% in 2006, due mostly to the higher utilization of computed tomography (CT) and nuclear medicine scans.[1]

The National Cancer Institute states that CT is the largest contributor to medical exposure, contributing approximately 45% of the U.S. population's collective radiation dose from all medical x-ray examinations. Since 1980, the use of CT scans in adults and children has increased 8-fold, from an estimated 3 million per year to 62 million currently, with annual growth at about 10% per year.[2]

While CT represents an important advance in diagnostic radiology, patients undergoing a CT scan receive far greater radiation exposure compared to conventional plain-film x-ray[1] (see table 1). While individual risk for CT-induced cancer is small, the large number of CT scans currently being given may create a public health issue in the future. According to a recent study in the New England Journal of Medicine, "based on risk estimates and data on CT use from 1991 through 1996, it has been estimated that about 0.4% of all cancers in the U.S. may be attributed to the radiation from CT studies. By adjusting for current CT use, this estimate may now be in the range of 1.5 to 2.0%."[3]

Accepted science tells us that exposure to 50 mSv (5000 mrem) is associated with increased cancer risk, 100-1000 mSv results in a clear dose related increase risk of cancer, and 10,000 mSv results in radiation sickness with immediate illnes and death within several weeks. While health care workers are typically monitored and restricted to effective doses of 100 mSv every 5 years with a maximum of 50 mSv per year, radiation exposure to patients undergoing medical imaging is not regularly monitored or restricted, even though procedures like x-rays and CT scans are frequently performed multiple times on the same patient.[4]

Recent studies of claims and utilization data indicate that while most patients accrue small cumulative cancer risks, a sizable minority are receiving effective doses of moderate, high, and very high intensity, or are receiving multiple CT scans that could increase their risk substantively.[4,5]

In light of these considerations, a variety of options for minimizing radiation exposure are being recommended, especially regarding children since they are considerably more sensitive to radiation than adults and receive a higher dose than necessary when adult CT settings are used.

To guide providers, the National Institutes of Health published a list of immediate measures they should take to minimize CT radiation exposure in children,[2] and the U.S. Food and Drug Administration and the National Cancer Institute (NCI) issued notifications and recommendations

(Continued)

Table 1. Typical Organ Radiation Doses from Various Radiologic Studies

Study Type	Organ	Dose*
Dental x-ray	Brain	0.005 mSv
Chest x-ray	Lung	0.01 mSv
Lateral chest x-ray	Lung	0.15 mSv
Mammography	Breast	3 mSv
Barium enema	Colon	15 mSv
Colonoscopy CT	Colon	5 mSv[11]
Adult abdominal CT	Stomach	10 mSv
Neonatal abdominal CT	Stomach	20 mSv

* The radiation dose, a measure of ionizing energy absorbed per unit of mass, is expressed in grays (Gy) or milligrays (mGy); 1 Gy = 1 joule per kilogram. The radiation dose is often expressed as an equivalent dose in sieverts (Sv) or millisieverts (mSv). For x-ray radiation, which is the type used in CT scanners, 1 mSv = 1 mGy.[3]

to radiologists to reduce exposure as low as reasonably achievable by using exposure settings customized for children.[2, 7]

In 2008, The Alliance for Radiation Safety in Pediatric Imagery launched the *Image Gently* campaign. Designed to change practice and encourage increased awareness of opportunities to lower radiation dose in pediatric interventional radiology procedures, the campaign includes information and resources for parents, radiologists, pediatricians, radiologic technicians, and medical physicists.

Parents and patients are being advised to track their radiation exposure by using simple charts like the *My Child's Medical Imaging Record* or *The Patient's Wallet Card for Tracking Lifetime Radiation Exposure*, that they carry with them, or by utilizing tools such as the *American Nuclear Society Radiation Dose Chart*, or the iPhone *Radiation Passport* application.

Researchers recommend that physicians include a patient's CT imaging history and cumulative radiation dose in medical records. A small number of hospitals, including the Brigham and Women's Hospital and the National Institutes of Health Clinical Center, are automatically transmitting radiation data to a patient's electronic medical record. To facilitate the tracking of patient exposure, the International Atomic Energy Agency (IAEA) has launched a project that uses "Smart Card" technology to provide all patients with a cumulative dose history that can be accessed from electronic health cards and/or digital hospital records.

Because CT scans provide fast, accurate, detailed images of organs, bones and tissues in the body, they are an extremely valuable diagnostic tool, and advances in the technology have led to increased and more diverse applications. Researchers warn, however, that there is potential for overuse or inappropriate use, particularly for situations such as trauma, appendicitis, headaches, seizures, and certain heart conditions. Other areas of concern include the use of CT body scans, applications in the emergency room, in pediatric applications, in screening of asymptomatic patients, and in the practice of defensive medicine.[3]

Recent articles in the *New England Journal of Medicine*, the *American Journal of Roentgenology*, *Pediatrics*, *Radiology*, and coverage by the media have brought national attention to this issue, but further studies are needed for an accurate determination of actual over- or inappropriate use. In the meantime physicians are being advised to consider alternative diagnostic options whenever possible. The NCI recommends that all physicians who prescribe pediatric CT continually assess its use on a case-by-case basis,[2] and the American Heart Association issued an advisory that heart scans be used judiciously to minimize exposure to ionizing radiation.[8]

Lack of awareness regarding the radiation risk of CT among patients and physicians is also a concern. In two small surveys of radiologists, emergency and specialty physicians, results indicate that a majority of physicians underestimate the radiation dose from a CT scan; a majority of patients are not given information about the risks, benefits, and radiation dose for a CT scan; and ED physicians and radiologists alike are unable to provide accurate estimates of CT doses regardless of their experience level.[9,10] It is speculated by one researcher that this may be because physicians often view CT studies in the same light as other radiologic procedures even though radiation doses with CT are typically much higher.

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11. RadiologyInfo, www.radiologyinfo.org/en/info.cfm?PG=ct_colo

Other resources:

Image Gently, http://spr.affiniscape.com/associations/5364/ig/

My Child's Medical Imaging Record, http://spr.affiniscape.com/associations/5364/files/Dose_Record_8.5x11_fold.pdfchart

Patient's Wallet Card for Tracking Lifetime Radiation Exposure, http://patientsafetyauthority.org/EducationalTools/PatientSafetyTools/radiation_pregnancy/Documents/patient_wallet.pdf

American Nuclear Society, *Radiation Dose Chart.* http://www.ans.org/pi/resources/dosechart/

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