

Studies spotlight high CT radiation dose, increased cancer risk

By [Eric Barnes](#)

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December 14, 2009

Two studies appearing in this week's *Archives of Internal Medicine* reveal higher-than-expected radiation dose in clinical CT studies and increased lifetime potential cancer risks as a result. At a minimum, the U.S.-funded studies suggest that dose-reduction efforts have not spread widely enough across the U.S.

The ambitious multicenter studies aren't the first to sound the radiation alarm, of course. Trailing just slightly behind the decade's explosive growth in CT imaging studies has been the increase in peer-reviewed articles warning of the dire health consequences of CT scanning.

In 2009 alone, studies published or reprinted in *JAMA*, a sister publication to *Archives of Internal Medicine*, have warned that repeat calcium scans are a [cancer threat](#), and coronary CT angiography doses remain [high and widely variable](#). An August study in the [New England Journal of Medicine](#) warned that radiation exposure to the population is growing -- and largely attributable to the growth of CT imaging.

In response, radiology's defenders have emphasized the challenge of making cancer projections based on atomic bomb survivor data, and the lack of evidence that growth in the number of scans is leading to more cancers. Imaging advocates have also emphasized the value of clinical decisions made possible by CT scans, and the risks of not performing clinically indicated studies.

Two fronts

Today's studies and accompanying editorial approach the CT dose and risk question on two fronts. One, a multicenter study sponsored by the U.S. National Institutes of Health (NIH) and the National Cancer Institute (NCI) in Bethesda, MD, estimates the number of cancers that would arise from all CT studies performed in the U.S. during a single year, 2007.

Some 29,000 future cancers could be related to CT scans performed in 2007 alone, according to Amy Berrington de Gonzales, Ph.D., and colleagues from the NCI, who based their estimates on the 2006 Biological Effects of Ionizing Radiation (BEIR) VII risk models.

The biggest contributors to dose? Abdominal and pelvic scans, followed by chest studies. (Reprinted in [*JAMA*](#) from the [*Archives of Internal Medicine*](#), December 14-18, 2009, Vol. 169:22, pp. 2009-2071.)

A second study, by Dr. Rebecca Smith-Bindman from the University of California, San Francisco (UCSF) and colleagues from several Bay Area institutions, used clinical data from national databases to evaluate the radiation doses from several common CT imaging exams (reprinted from *Archives of Internal Medicine*, December 14-18, 2009, Vol. 169:22, pp. 2072-2078).

The authors of this study, also supported by the NIH and NCI grants, said they were surprised to find that radiation doses for common CT exams were higher and far more variable than previous estimates. Within each type of CT study, effective dose varied significantly both within and across institutions, with a mean 13-fold variation between the highest and lowest dose for each study type.

CT's popularity is high for many reasons, ranging from its speed and increasing ease of use, to the relentless development of new imaging techniques, to a growing body of evidence showing its images throughout the body to be reliable for diagnosis. Unfortunately, drivers of increasing scan volumes also include the lure of monetary rewards, particularly for in-office procedures, and the practice of defensive medicine -- unnecessary scans performed to minimize the threat of a lawsuit resulting from a missed diagnosis.

As these two studies make clear, radiation doses are higher than previously thought. They also demonstrate that radiation dose reduction is not yet a universal phenomenon and raise further doubt about whether the risk/benefit ratios and alternatives to CT scanning are seriously considered for every patient and CT scan.

One year of CT scans: 2007

The use of CT scans has increased more than threefold since 1993, to approximately 70 million scans per year, noted Berrington de Gonzales in her group's study of estimated cancer risks from CT scans.

"The rapid increase in the U.S. has raised concerns about potential cancer risks, because when a large number of people are exposed, even small risks could translate into a large number of future cancers in the population," the authors wrote.

Their study includes detailed estimates of future cancer risks based on current CT use according to sex, age, and scan type. They estimated the frequency of different types of

CT scans performed in the U.S. in 2007 using several data sources, including Medicare claims and a survey of CT scan use from [IMV Medical Information Division](#) of Des Plaines, IL, that covered 2,451 facilities. NCI data were used to address the question of expected survival.

Models based on the BEIR VII report were then combined with age- and sex-specific scan frequencies obtained from survey and insurance claims data.

The results for the projected number of incident cancers per 10,000 scans generally decreased with increasing age at exposure and varied according to scan type, they wrote. Risks were consistently high for chest or abdomen CT angiography and whole-body CT, and still higher in women due to the additional risk of breast cancer and higher lung cancer coefficients.

From a total estimate of 72 million CT scans performed during the year, the authors estimated 29,000 (95% UL, 15,000-45,000) future cancers would develop that could be related to CT scans.

The largest contributors to the risk were scans of the abdomen and pelvis (n = 14,000; 95% UL, 6,900-25,000), followed by chest (n = 4,100; 95% UL, 1,900-8,100), head (n = 4,000; 95% UL, 1,300-5,000), and chest CT angiography (n = 2,700).

Lung cancer was the most common radiation-related cancer (n = 6200; 95% UL, 2,300-13,000), followed by colon cancer (n = 3500; 95% UL, 1,000-6,800) and leukemia (n = 2800; 95% UL, 800-4800).

"The cancer sites with the highest risks were common cancers with a high frequency of exposure to that organ (e.g., colon from CT of the abdomen and pelvis and lung from CT of the chest) or higher radiosensitivity (e.g., red bone marrow and leukemia)," Berrington de Gonzalez et al wrote.

Although most of the focus on CT radiation doses has been on pediatric cases, the study data suggest that greater numbers of adult patients will be harmed from CT-induced radiation doses. The data are unique in that they are based on cancer risks in current U.S. age- and sex- specific scan patterns, they noted.

Age trends were also seen in the results. One-third of the estimated cancers came from patients in the age range of 35 to 54 years, compared to 15% of cancers in patients younger than 18 years. Fully 66% of the projected cancers were in women.

The risks according to the study results are much higher than the commonly quoted estimate of one death per 2,000 scans because of the younger age distribution of patients currently undergoing CT in the U.S., Berrington de Gonzales and colleagues wrote.

"Although cancer risk from CT scans have not been demonstrated directly, radiation is one of the most extensively studied carcinogens, and there is direct evidence from studies of the Japanese atomic bomb survivors, nuclear workers, and patients receiving multiple diagnostic x-rays that radiation doses of the magnitude delivered by several scans (5-10 rad) can cause cancer, and that the magnitude of the risk at these doses is largely consistent with the risks at higher doses," they stated.

Changes made to scanning practices now could help avoid the possibility of rising cancer incidence, they concluded. The estimates "highlight several areas of use in which the public health impact may be largest, specifically abdomen and pelvis and chest CT scans in adults aged 35 to 54 years."

Radiation doses high in common CT exams

In the second study, Smith-Bindman et al sought to estimate the radiation dose associated with common CT studies in clinical practice and quantify the potential cancer risk associated with these examinations.

"Although CT is associated with substantially higher radiation exposure than conventional radiography, typical doses are not known," they wrote.

The retrospective cross-sectional study described the radiation dose associated with the 11 most common types of diagnostic studies, including head; chest, cervical, thoracic, and lumbar spine; CT angiography of the chest and other regions; whole-body CT; virtual colonoscopy (also known as CT colonography or CTC); calcium scoring; and other CT exams.

The data covered 1,119 consecutive adult patients at four institutions in the San Francisco Bay Area who were scanned during the first half of 2008. Using their risk models, the investigators estimated lifetime attributable risks of cancer by study type from the measured doses.

The results showed that radiation doses varied significantly between different types of CT studies -- and within the same types of CT studies. Among different exam types, median effective doses ranged from 2 mSv for a routine head CT to 31 mSv for a multiphase abdomen and pelvis CT.

"Within each type of CT study, effective dose varied significantly within and across institutions, with a mean 13-fold variation between the highest and lowest dose for each scan type," they wrote. "The estimated number of CT scans that will lead to the development of a cancer varied widely depending on the specific type of CT examination and the patient's age and sex."

For example, an estimated one in 270 women who underwent CT coronary angiography at age 40 will develop cancer from that CT scan (one in 600 men), compared with an estimated one in 8,100 women who had a routine head CT scan at the same age (one in 11,080 men).

For head and neck scans, the median effective dose varied from 2 mSv for a routine head scan (IQR, 2-3 mSv) to 14 mSv (IQR, 9-20 mSv) when imaging for suspected stroke. In the chest, the median effective dose varied from 8 mSv (IQR, 5-11 mSv) for a routine chest to 22 mSv (IQR, 14-24 mSv) for coronary angiography. For abdominal and pelvic scans, a routine CT scan without contrast had the lowest median effective dose (15 mSv; IQR, 10-20 mSv), whereas a multiphase abdominal and pelvis CT scan had the highest median effective dose (31 mSv; IQR, 21-43 mSv).

The authors attributed the surprisingly high median effective doses to three causes. First, they said, estimated doses in the study were received by real patients in clinical practice, which may routinely deliver higher doses than those logged in idealized settings or using a phantom.

Second, most reported doses in the literature are from single-center studies where the protocols may be standardized, in contrast to doses in the present study gleaned from individual patients across multiple institutions, the group explained.

Finally, most prior studies grouped together exams from the same anatomic area, even though not all CT scans involve similar doses due to differences in patients (increasing scan length for some) and the clinical question being addressed by the imaging study.

Two factors loomed as dose drivers in the study. In every anatomic area, studies that included an assessment of arteries, as well as multiphase studies, had higher exposures due to the use of repeated scans for these study types.

How to lower dose

Recommendations for lowering the doses include:

- Standardizing protocols across sites

- Reducing multiple imaging series within each exam (multiphase studies)
- Implementing dose-reduction strategies
- Participating in accreditation programs such as those offered by the Reston, VA-based American College of Radiology (ACR)

Reducing the number of CT exams is also important because reports suggest that 30% or more of CT scans may be unnecessary, they stated. Cumulative patient dose information should be tracked and monitored.

"A searchable electronic health record will help educate patients and healthcare providers about radiation exposure, and could facilitate activities to minimize dose when possible," they wrote. "Understanding exposures to medical radiation delivered through actual clinical studies is a crucial first step toward developing reasonable strategies to minimize unnecessary exposures."

Commentary

An accompanying editorial questions why so many CT scans are being performed in the U.S.

There were an estimated 72 million CT scans conducted in 2007 alone, delivering radiation doses that were "eye opening," wrote Dr. Rita Redberg, a cardiovascular imaging specialist at UCSF and health policy advisor for healthcare giant Blue Cross/Blue Shield.

Citing an earlier study on the radiation delivered by CT scanning (Fazel et al, *New England Journal of Medicine*, August 27, 2009, Vol. 361:9, pp. 849-857), Redberg noted that "although most patients receive relatively low doses, nearly 20% of the study's population received 'moderate' exposures of between 3 and 20 mSv." Moreover, some 1.4 million patients received "high" doses of 20 mSv to 50 mSv, she added.

The two studies appearing today help answer the question of risks posed by CT and whether they are really justified, wrote Redberg, who has been criticized for her support of earlier efforts to restrict [coronary CTA](#) and [virtual colonoscopy](#).

Smith-Bindman et al found a "13-fold variation between the highest and lowest doses for each CT type studied," Redberg wrote. "There was no discernable pattern to the variation, which occurred within and across institutions. ... Even the median doses are four times higher than they are supposed to be, according to the current quoted radiation dose for these tests."

In the study by NCI researchers, CT scan use frequency in the U.S. was determined using several large databases. Excluding scans conducted after a diagnosis of cancer and those performed in the last five years of life, Berrington de Gonzales and colleagues projected 29,000 excess cancers as a result of the CT scans performed in 2007, Redberg wrote.

"These cancers will appear in the next 20 to 30 years and by the authors' estimates, at a 50% mortality rate, will cause approximately 15,000 deaths annually," she wrote. "In light of these data, physicians (and their patients) cannot be complacent about the hazards of radiation or we risk creating a public health time bomb."

Redberg called for a multifaceted approach to radiation reduction beginning with a requirement that all institutions use the lowest-dose technique, considering that Berrington de Gonzales found that the "usual" protocol "sometimes unwittingly increased radiation." Redberg also called for reexamination of the paradigm that "more testing and more technology inevitably lead to better care."

Study conclusions criticized

In an e-mail to *AuntMinnie.com*, imaging advocate Dr. U. Joseph Schoepf, associate professor of radiology and medicine at the Medical University of South Carolina in Charleston, called the conclusions inherently flawed because they rely on atomic bomb survivor data and other unproven assumptions of risk.

"The healthcare reform debate is heating up on the Hill and the hordes brawling for the redistribution of our increasingly limited healthcare funds are coming out again," Schoepf wrote. "They are armed with pocket calculators and 50-year-old data on atomic bomb survivors. They claim 'known risks of radiation' and that 'the large doses of radiation from [CT] scans will translate, statistically, into additional cancers' creating a 'public health time bomb.'"

"Such statements are intended to create fear, but their line of logic breaks down due to the simple fact that a connection between radiation from medical imaging and cancer has never been established," Schoepf wrote. "On the contrary, while the numbers of medical imaging procedures are clearly on the rise, the mortality rates from cancer are dramatically dwindling in step."

According to a recent analysis by the U.S. National Bureau of Economic Research (Lichtenberg 2009), life expectancy increased more rapidly in states where the fraction of advanced diagnostic imaging procedures increased more rapidly, Schoepf wrote. "Such observations are conveniently ignored in this and related publications," he stated.

"Still, there are aspects to the current debate on radiation exposure that should give us pause," Schoepf wrote. "Overutilization of medical imaging unfortunately does occur; however, it is well recognized that this is not driven by radiologists, but by other medical specialties who perform imaging in their offices."

"There is indeed a need for greater transparency and involvement of the patient in the decision process that leads up to an imaging study," Schoepf continued. "However, this should not be pursued with the ulterior motive of scaring patients out of an indicated imaging test by raising the specter of radiation risk, but rather by explaining the expected benefits and discussing the current uncertainties surrounding radiation from medical imaging."

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