AUTHOR COMMENTARIES - 2010

March 2010

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Anthropomorphic phantom used to measure dose from CT scans.

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David J. Brenner

Featured PaperInterview

According to Essential Science Indicators℠ *from Thomson Reuters, the paper, "Current concepts—computed tomography—an increasing source of radiation exposure" (Brenner DJ, Hall EJ,* N. Engl. J. Med. *357[22]: 2277-84, 29 November 2007), is ranked at #5 among Clinical Medicine Hot Papers and at #12 among Hot Papers overall, with 416 cites up to October 31, 2009. In the* Web of Science®, *this paper currently has 504 cites.*

Lead author Dr. David Brenner is the Higgins Professor of Radiation Biophysics and the Director of the Center for Radiological Research at the Columbia University Medical Center in New York. His citation record in our database includes 96 papers, classified under Clinical Medicine and Biology & Biochemistry, cited a total of 4,060 times between January 1, 1999 and October 31, 2009.

In the interview below, Dr. Brenner talks with* ScienceWatch.com *about this paper and its impact on the medical community.

SW: What factors prompted you and your coauthor to undertake this study?

In the US, the average radiation dose to which we are exposed has doubled in the past 30 years. The average dose from natural background sources has not changed, but what has changed is a more than six-fold increase in the average radiation dose from medical imaging. The biggest contributor to this increase in the radiation dose from medical imaging is from CT: In 1980, about 3 million CT scans were done each year in the US, whereas the number now is over 70 million. Radiation doses from CT are typically more 100 times those from conventional x-ray exams, such as a chest x-rays or mammograms, and there is now direct epidemiological evidence of a small but statistically significant increased lifetime cancer risk at CT doses.

SW: Would you sum up the major conclusions of the paper?

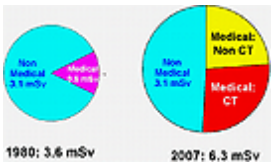
First, there is compelling, though not definitive, epidemiological evidence that radiation doses typical of those given in a CT series are associated with a small but statistically significant increase in lifetime cancer risk, particularly for children. Individual risks from CT are small, but the increasing population dose resulting from greatly increased CT usage leads to concerns about future public health problems. We estimated that if the current practices continue, up to 2% of all cancers in the US might, in the future, be associated with the radiation from diagnostic imaging (we are frequently misquoted as suggesting that this 2% refers to current cancer rates—rather it is a projection some decades into the future).

Of course when a radiological imaging procedure is clinically appropriate, the benefit-risk balance is almost always overwhelming. But the key here is "clinically appropriate." In particular, of the more than 70 million CT scans that are being performed in the US this year, it is appropriate to ask how many of these scans are actually clinically justified. Based purely on medical considerations, perhaps one third of all CT scans could be avoided all together, or replaced with a different diagnostic tool. We suggested that it is possible, though hard, to reduce this large number of CT scans which are clinically unwarranted.

SW: What was the reaction of the medical community?

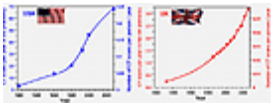
The reaction of the medical community, understandably, has been mixed. While there is general agreement that more CT scans are being performed than might be considered clinically necessary, critiques have generally fallen into four categories:

Figure 1 [+] enlarge



Sources of average individual total radiation dose in the US:1980 vs. 2007.

Figure 2 [+] enlarge



Frequency of CT scans per year in the US and the UK.

Critique 1: "*Cancer risks at very low doses are very uncertain, and depend on extrapolating risks from A-bomb survivors who were exposed to high doses.*" At extremely low radiation doses, cancer risks are indeed highly uncertain. However, at the doses corresponding to a few CT scans there are direct epidemiological data from about 30,000 A-bomb survivors who were on the peripheries of Hiroshima and Nagasaki, and who were exposed in this low-dose range. This low-dose subpopulation has been followed for more than 50 years, and shows a small but statistically-significant increased cancer risk. Thus, in the context of CT doses, we do not need to extrapolate cancer risks from higher doses, with all the attendant uncertainties which that involves.

Critique 2: "*No studies of individuals having CT scans have shown an increased cancer risk.*" This is certainly true. Because CT is a relatively recent modality, only now has it become practical to start such studies. So, to date, the risk estimates have come from studies of atomic bomb survivors (see above) who were a considerable distance from the explosions, and so were exposed to doses similar to those from typical CT scan series. This is not an unreasonable approach, but it is pleasing that direct epidemiological studies of CT risks in children have now been initiated in the UK, Ontario, Israel, and Australia. It is disappointing that such studies are not being undertaken in the US, but tracking health-care records is much harder here.

Critique 3: "*Many who need CT scans will refuse them because of the publicity associated with cancer risk estimates.*" The evidence does not support this: for example, in a published study, when parents were informed about CT risks and benefits, their willingness to have their child undergo a CT did not significantly

change, although they became more willing to consider other imaging options, if equally effective. No CTs were cancelled or deferred after receiving this information.

Critique 4: *"It will be very difficult to target the medically unwarranted CT scans."* This is certainly true. Physicians are subject to significant pressures, from throughput, to medico-legal, to economic, to patient pressure. Our goal was to promote already ongoing dialogues among radiologists, emergency department and other physicians, and indeed the public, as to practical ways to minimize medically unwarranted CT scans, without compromising patient care.

SW: How concerned should ordinary patients be about having CTs done?

The individual risks of a CT scan are small, and if the CT scan is medically warranted, the benefits will greatly outweigh these small risks. It is perfectly appropriate, however, for a patient/parent to talk to their physician about the CT scan, and ask if it is indeed warranted based on clinical guidelines.

SW: Do you envision these findings having a significant effect on clinical practice, or is a seemingly prevalent mentality of "order more tests" becoming too firmly ingrained?

Reducing the number of CT scans that are not clinically justified is a hard task, because there are a variety of very real factors pushing in the other direction, ranging from throughput, to economic, to patient preference, to legal.

We see the solution in terms of the application of clinical decision guidelines (decision rules, appropriateness criteria, etc.). Based on a mix of clinical data and expert judgment, decision guidelines provide scenarios as to when a given imaging procedure is medically justified. Many decision guidelines are now available for the appropriate use of CT in different settings. When used, decision guidelines have the potential to "trump" some, though not all, of these factors that result in CT scans being over-prescribed, and so represent a potentially powerful tool for optimizing CT usage. Of course decision guidelines are not useful if they are not applied, and this is too often the case. A successful approach to increasing utilization of CT decision guidelines has been to incorporate them into computerized imaging ordering systems.

It is pertinent here to mention the financial implications. If one could eliminate the perhaps 1/3 of CT scans that are clinically unnecessary, there would of course be a corresponding reduction in imaging costs.

To sum up, it is impossible to imagine the current practice of medicine without modern-day imaging and, in the final analysis, the clinician is in the best position to assess the imaging needs of his/her patient. But, along with all the high-tech imaging tools that are now available, optimization of imaging usage with the aid of clinical decision guidelines is essential. This is not easy to implement, but it can be done, and it should be done.

David J. Brenner, Ph.D., D.Sc.
Center for Radiological Research
Columbia University Medical Center
New York, NY, USA

David J. Brenner's current most-cited paper in *Essential Science Indicators*, with 557 cites:

Brenner DJ, *et al*., "Estimated risks of radiation-induced fatal cancer from pediatric CT," *Amer. J. Roentgenol*. 176(2): 289-96, February 2001.

Note: This interview pertains to the paper, Brenner DJ, Hall EJ, "Current concepts—computed tomography—

an increasing source of radiation exposure," *N. Engl. J. Med*. 357(22): 2277-84, 29 November 2007, with 416 cites.

Source: *Essential Science Indicators* from Thomson Reuters.

KEYWORDS: COMPUTED TOMOGRAPHY, CT, RADIATION EXPOSURE, CANCER RISK, AVERAGE DOSE, CHILDREN, BENFIT-RISK BALANCE, CLINICALLY APPROPRIATE, A-BOMB SURVIVORS, CLINICAL DECISION GUIDELINES, IMAGING COSTS.

PDF

back to top