CORRESPONDENCE

Computed Tomography and Radiation Exposure

TO THE EDITOR: Computed tomographic (CT) scans deliver a radiation dose of about 20 mSv. Brenner and Hall (Nov. 29 issue)[1] assess the risk associated with CT radiation exposure by using the linear no-threshold extrapolation model, which assumes that cancer induction is proportional to dose even for the smallest doses. An excess of cancers has never been detected in laboratory animals or in humans for doses below 100 mSv. This model is used for analyzing data from cohorts including persons who have received doses higher than 100 mSv. This method is exposed to strong bias.[2] Defense mechanisms against radiocarcinogenesis are much more effective at low doses, and the use of the linear no-threshold model in this dose range is highly debatable[3,4]; it greatly overestimates the risk. After repeated x-ray examinations, induction of cancer has been observed only when the cumulative dose was above 500 mSv. In patients treated with radiotherapy, a threshold was reported for irradiation doses of 0.6 Sv delivered in 30 sessions.[5,6] Overestimation of the risk may deprive patients of beneficial examinations.

Maurice Tubiana, M.D.
Institut Gustave Roussy
94805 Villejuif, France
maurice.tubiana@biomedicale.univ-paris5.fr

1. Brenner DJ, Hall EJ. Computed tomography — an increasing source of radiation exposure. N Engl J Med 2007;357:2277-84.
2. Breckow J. Linear-no-threshold is a radiation-protection standard rather than a mechanistic effect model. Radiat Environ Biophys 2006;44:257-60.
3. Tubiana M, Aurengo A, Averbeck D, Masse R. The debate on the use of linear on threshhold for assessing the effects of low doses. J Radiol Prot 2006;26:317-24.
4. Tubiana M, Aurengo A, Averbeck D, Masse R. Low-dose risk assessment: comments on the summary of the International Workshop. Radiat Res 2007;167:742-4.
5. Rubino C, de Vathaire F, Shamsaldin A, Labbe M, Lê MG. Radiation dose, chemotherapy, hormonal treatment and risk of second cancer after breast cancer treatment. Br J Cancer 2003;89:840-6.
6. Le Pogam MA, Rubino C, Diallo I, et al. Radiation dose fractionation and second cancer risks after breast cancer treatment. Radiat Prot Dosimetry (in press).

TO THE EDITOR: The report by Brenner and Hall is based on the effects of low levels of ionizing radiation from data on atomic-bomb survivors. A linear no-threshold hypothesis derived from the database of survivors has been accepted as a policy for radiation protection. However, the hypothesis is still a subject of controversy[1,2] — that is, neither proved nor disproved — and the excessive risk at low doses is a few percent and decreases with age. Favorable ratios of benefits to risk are essential in medical radiation.

Shigenobu Nagataki, M.D., Ph.D.
Japan Radioisotope Association
Tokyo 113-8941, Japan
nagataki@jrias.or.jp

1. Tubiana M, Aurengo A. La relation dose-effet et l'estimation des effets cancérogènes des faibles does de rayonnements ionisants. Paris: Report of National Academy of Medicine, March 2005. (Accessed February 1, 2008, at http://www.academie-sciences.fr/publications/rapports/pdf/dose_effet_07_04_05.pdf.)
2. Committee to Assess Health Risks from Exposure to Low Levels of Ionizing Radiation, National Research Council. Health

THIS WEEK'S LETTERS

Downloaded from www.nejm.org on November 21, 2009 . For personal use only. No other uses without permission.
Copyright © 2008 Massachusetts Medical Society. All rights reserved.

risks from exposure to low levels of ionizing radiation: BEIR VII phase 2. Washington, DC: National Academies Press, 2006. (Accessed February 1, 2008, at http://www.nap.edu/catalog.php?record_id=11340.)

TO THE EDITOR: Brenner and Hall state that 1.5 to 2% of all cancers in the United States may be attributable to clinical use of CT. This does not comply with any human epidemiologic data that have not been modeled.[1] Doses below about 150 mSv have never been observed to induce clinical cancer with statistical significance. There is, however, clear evidence that in mammalian organisms, including humans, low doses and dose rates of x-radiation and gamma radiation can up-regulate, with a delay and temporarily largely under genetic control, various existing physiological mechanisms of protection against induction, propagation, and accumulation of cellular damage in tissues to evolve into clinical disease.[2-4]

Ludwig E. Feinendegen, M.D.
Heinrich Heine University Düsseldorf
40225 Düsseldorf, Germany
feinendegen@gmx.net

1. Cardis E, Vrijheid M, Blettner M, et al. The 15-country collaborative study of cancer risk among radiation workers in the nuclear industry: estimates of radiation-related cancer risks. Radiat Res 2007;167:396-416.
2. Aurengo A, Averbeck D, Bonnin A, et al. Dose-effect relationships and the estimation of the carcinogenic effects of low doses of ionizing radiation. Paris: National Academy of Medicine, March 30, 2005. (Accessed February 1, 2008, at http://www.radscihealth.org/rsh/Papers/FrenchAcadsFinal07_04_05.pdf.)
3. Feinendegen LE, Neumann RD. Physics must join with biology in better assessing risk from low-dose irradiation. Radiat Prot Dosimetry 2005;117:346-56.
4. Feinendegen LE, Pollycove M, Neumann RD. Whole-body responses to low-level radiation exposure: new concepts in mammalian radiobiology. Exp Hematol 2007;35:Suppl 1:37-46.

TO THE EDITOR: It is estimated that since 1980, more than 550 million CT scans have been obtained in the United States, 75 million of them before 1990, as Brenner and Hall mention. Even assuming multiple CT examinations per patient, this cohort yields an extraordinary power for the detection of significant cancer-related mortality induced by ionization dose exposure in the 50-mGy range, as these same authors have claimed in a previous report.[1] Where are these excess induced cancers?

Dimitri A. Dimitroyannis, Ph.D.
Kansas City Cancer Center
Kansas City, MO 64154
dimitri.dimitroyannis@usoncology.com

1. Brenner DJ, Doll R, Goodhead DT, et al. Cancer risks attributable to low doses of ionizing radiation: assessing what we really know. Proc Natl Acad Sci U S A 2003;100:13761-6.

TO THE EDITOR: We agree with Brenner and Hall's emphasis on CT use only when appropriate and with correct exposure factors. However, the techniques they cite are well beyond cited standards for children,[1,2] and the long-range risk estimates are debatable.[3,4]

The concerns raised are being actively addressed by scientific and educational programs, such as through American College of Radiology accreditation, ALARA (As Low as Reasonably Achievable) conferences sponsored by the Society for Pediatric Radiology, and the Image Gently campaign (www.imagegently.org), which involves several national medical societies and regulatory agencies, with the participation of more than 400,000 health care professionals promoting appropriate, high-quality, and safe pediatric CT.

Donald P. Frush, M.D.
Duke University Medical Center
Durham, NC 27710
frush943@mc.duke.edu

Marylin J. Goske, M.D.
Cincinnati Children's Hospital Medical Center
Cincinnati, OH 45229

Marta Hernanz-Schulman, M.D.
Vanderbilt Children's Hospital
Nashville, TN 37232

1. Boone JM, Geraghty EM, Seibert JA, Wootton-Gorges SL. Dose reduction in pediatric CT: a rational approach. Radiology 2003;228:352-60.
2. Cody DD, Moxley DM, Krugh KT, O'Daniel JC, Wagner LK, Eftekhari F. Strategies for formulating appropriate MDCT techniques when imaging the chest, abdomen, and pelvis in pediatric patients. AJR Am J Roentgenol 2004;182:849-59.
3. Brody AS, Frush DP, Huda W, Brent RL, American Academy of Pediatrics Section on Radiology. Radiation risk to children from computed tomography. Pediatrics 2007;120:677-82.
4. Committee to Assess Health Risks from Exposure to Low Levels of Ionizing Radiation, National Research Council. Health risks from exposure to low levels of ionizing radiation: BEIR VII phase 2. Washington, DC: National Academies Press, 2006. (Accessed February 1, 2008, at http://books.nap.edu/catalog.php?record_id=11340.)

TO THE EDITOR: Radiation dose is a critical issue. An increased radiation dose also may result from new strategies. For example, CT fluoroscopy used as imaging guidance generates a radiation dose of up to 20 times the dose with conventional CT.[1] Similarly, routine cardiac CT will presumably result in a substantial increase in the radiation dose in the general population.

Downloaded from www.nejm.org on November 21, 2009 . For personal use only. No other uses without permission.
Copyright © 2008 Massachusetts Medical Society. All rights reserved.

In contrast, researchers are working on improving protocols to substantially reduce the radiation dose, by means of automatic exposure control[2] and tailoring of the CT data acquisition to the patient's body habitus. To decrease the radiation dose in the general population, magnetic resonance can favorably replace CT for imaging of the liver, small bowel, vascular structures, urinary tract, and pelvis. Whole-body magnetic resonance units provide a comprehensive evaluation of patients with cancer. The major risk of an increased radiation dose mostly involves young patients scheduled to undergo repeated CT examinations. However, in some cases, such patients can be accurately evaluated with magnetic resonance imaging.[3]

Philippe Soyer, M.D., Ph.D.
Hôpital Lariboisière
75010 Paris, France
philippe.soyer@lrb.aphp.fr

1. Silverman SG, Tuncali K, Adams DF, Nawfel RD, Zou KH, Judy PF. CT fluoroscopy-guided abdominal interventions: techniques, results, and radiation exposure. Radiology 1999;212:673-81.
2. McCollough CH, Bruesewitz MR, Kofler JM Jr. CT dose reduction and dose management tools: overview of available options. Radiographics 2006;26:503-12.
3. Fidler J. MR imaging of the small bowel. Radiol Clin North Am 2007;45:317-31.

TO THE EDITOR: Brenner and Hall voice concern about radiation exposure and the subsequent risk of cancer in the population because of increasing numbers of CT scans, but they focus solely on postnatal exposure. The risk of childhood cancer per unit dose of radiation is significantly greater for intrauterine exposure than for exposure in the early years of postnatal life.[1] Case–control studies have shown a 40 to 50% increase in the risk of cancer after intrauterine exposure to medical diagnostic radiation at doses of a single abdominal CT scan (10 to 20 mGy),[2] which is equivalent to 500 chest x-rays. Of particular concern is the overall utilization of CT scans in pregnant women, which has increased by 25% per year during the past 10 years.[3]

Heike Varnholt, M.D.
University Hospital of Cologne
50924 Cologne, Germany

1. Sadetzki S, Flint-Richter P. Transgenerational effects of parental exposure to ionizing radiation. Harefuah 2006;145:516-21. (In Hebrew.)
2. Wakeford R, Little MP. Risk coefficients for childhood cancer after intrauterine irradiation: a review. Int J Radiat Biol 2003;79:293-309.
3. Lazarus E, DeBenedectis C, Mayo-Smith W, Spencer P. Utilization of radiological examinations in pregnant women: a ten-year review 1997-2006. Presented at the 93rd Annual Meeting of the Radiological Society of North America, Chicago, November 25–30, 2007.

THE AUTHORS REPLY: The annual number of CT scans in the United States is now more than 60 million. The concern is that radiation doses from CT are typically 100 times those from conventional x-ray examinations such as chest x-rays or mammograms and that there is now direct epidemiologic evidence of a small but significant increase in the risk of cancer at CT doses.[1-3] Because CT is such a superb diagnostic tool and because individual CT risks are small, the CT benefit–risk balance is generally by far in the patient's favor.

However, there is general acceptance that perhaps one third of all CT scans could be avoided altogether or replaced by a different diagnostic tool. So although CT risks are small, a small risk multiplied by many millions of scans may translate into a public health concern some years in the future, particularly in the case of pediatric CT.

Critiques of these notions have fallen into four main categories. *Critique 1: Cancer risks at very low doses are very uncertain and depend on extrapolating risks from atomic-bomb survivors who were exposed to high doses.* At very low radiation doses, cancer risks are indeed very uncertain.[3] However, at the higher doses corresponding to a few CT scans (5 to 100 mSv), there are direct epidemiologic data from about 30,000 atomic-bomb survivors who were on the peripheries of Hiroshima and Nagasaki and who were exposed in this same low-dose range. This low-dose subpopulation has been followed for more than 50 years and has a small but statistically significant increase in the risk of cancer.[1,2] So we do not have to extrapolate CT-associated risks from those at higher doses, with all the attendant uncertainties that involves.

Critique 2: No studies of persons having CT scans have shown an increased cancer risk. There have, in fact, not been any CT-related epidemiologic studies to date, though one has recently begun, focusing on pediatric CT.

Critique 3: Many persons who need CT scans will not have them because of these cancer-risk estimates. The evidence does not support this: for example, in a recently published study,[4] when parents were informed about CT risks, their willingness to have their child undergo CT did not significantly change, although they became more willing to

Downloaded from www.nejm.org on November 21, 2009 . For personal use only. No other uses without permission.
Copyright © 2008 Massachusetts Medical Society. All rights reserved.

consider other imaging options, if they were equally effective. No CT scans were canceled or deferred after the parents received the risk information.

Critique 4: It will be very difficult to reduce CT usage. We completely agree. Physicians are often subject to significant pressures, from the medical system, the medicolegal system, and the public, to order CT studies, even when they are not really necessary or even when alternatives exist. Our goal was to promote already ongoing dialogues among radiologists, emergency department and other physicians, and indeed the public about practical ways to reduce CT usage and CT doses, without compromising patient care.

David J. Brenner. Ph.D., D.Sc.
Eric J. Hall, D.Phil., D.Sc.
Columbia University Medical Center
New York, NY 10032
djb3@columbia.edu

1. Pierce DA, Preston DL. Radiation-related cancer risks at low doses among atomic bomb survivors. Radiat Res 2000;154:178-86.
2. Preston DL, Ron E, Tokuoka S, et al. Solid cancer incidence in atomic bomb survivors: 1958-1998. Radiat Res 2007;168:1-64.
3. Brenner DJ, Doll R, Goodhead DT, et al. Cancer risks attributable to low doses of ionizing radiation: assessing what we really know. Proc Natl Acad Sci U S A 2003;100:13761-6.
4. Larson DB, Rader SB, Forman HP, Fenton LZ. Informing parents about CT radiation exposure in children: it's OK to tell them. AJR Am J Roentgenol 2007;189:271-5.

Incidental Findings on Brain MRI

TO THE EDITOR: Vernooij et al. (Nov. 1 issue)[1] have contributed valuable knowledge about the prevalence of asymptomatic intracranial lesions. However, we disagree with their statement that many incidental lesions do not merit further evaluation or treatment.

The authors cite results of the International Study of Unruptured Intracranial Aneurysms (ISUIA) to justify not further evaluating small aneurysms,[2] but conventional magnetic resonance sequences used in this study are unreliable in characterizing aneurysms. Digital subtraction angiography or computed tomographic or magnetic resonance angiography is a superior diagnostic technique.[3] Furthermore, a significant proportion of subarachnoid hemorrhages result from small aneurysms, mandating careful risk assessment based on individual factors.[4]

Meningiomas and pituitary macroadenomas were diagnosed only on the basis of non-contrast magnetic resonance imaging (MRI). Although these lesions grow slowly, selected patients will benefit from early treatment: resection of smaller meningiomas is associated with less morbidity,[5] and 9.5% of asymptomatic pituitary macroadenomas develop apoplexy,[6] which may be prevented by early surgery. Malignant neoplasms may also mimic these lesions on MRI.

We agree that the natural history of these conditions is incompletely understood; therefore, we strongly urge that patients with such conditions be evaluated by an appropriate specialist for careful consideration of the individual history and risk factors and for the development of an optimal management plan.

Brandon G. Rocque, M.D.
Mustafa K. Baskaya, M.D.
John S. Kuo, M.D., Ph.D.
University of Wisconsin
Madison, WI 53792

1. Vernooij MW, Arfan Ikram M, Tanghe HL, et al. Incidental findings on brain MRI in the general population. N Engl J Med 2007;357:1821-8.
2. Wiebers DO, Whisnant JP, Huston J III, et al. Unruptured intracranial aneurysms: natural history, clinical outcome, and risks of surgical and endovascular treatment. Lancet 2003;362:103-10.
3. Kouskouras C, Charitanti A, Giavroglou C, et al. Intracranial aneurysms: evaluation using CTA and MRA: correlation with DSA and intraoperative findings. Neuroradiology 2004;46:842-50.
4. Nahed BV, DiLuna ML, Morgan T, et al. Hypertension, age, and location predict rupture of small intracranial aneurysms. Neurosurgery 2005;57:676-83.
5. Alvernia JE, Sindou MP. Preoperative neuroimaging findings as a predictor of the surgical plane of cleavage: prospective study of 100 consecutive cases of intracranial meningioma. J Neurosurg 2004;100:422-30.
6. Arita K, Tominaga A, Sugiyama K, et al. Natural course of incidentally found nonfunctioning pituitary adenoma, with special reference to pituitary apoplexy during follow-up examination. J Neurosurg 2006;104:884-91.

TO THE EDITOR: Vernooij et al. point out that incidental brain findings on MRI are common in the general population. We would like to report similar data from a Chinese population in Taiwan.

Between September 2, 2005, and January 2, 2007, a total of 2164 apparently healthy subjects

Downloaded from www.nejm.org on November 21, 2009 . For personal use only. No other uses without permission.
Copyright © 2008 Massachusetts Medical Society. All rights reserved.