Informed Consent for Radiation Risk from CT Is Unjustified Based on the Current Scientific Evidence

Over the past several years, many sources of information have emerged regarding the potential risks of low-dose ionizing radiation from medical imaging. Many published educational materials and scientific studies have heightened awareness among patients, the public, and medical professionals. The press has extensively reported on this topic, sometimes omitting nuances regarding the strength of evidence supporting various statements or conclusions. With this background, some concerned practitioners have questioned whether patients, or the parents of pediatric patients, should participate in informed consent for medical imaging with ionizing radiation. While patients and providers should jointly practice informed decision making when contemplating an imaging examination, the evidence supporting diagnostic radiation carcinogenesis is too uncertain to warrant a formal informed consent process. To date, published studies that suggest significant cancer risks from diagnostic radiation are much weaker than we—as a purported evidence-based field—would normally accept.

We, the authors, contend that informed consent is unjustified based on an objective look at the currently available scientific evidence. Moreover, cloaking uncertain radiation risks with the credibility suggested by an informed consent process does not further patient autonomy or protect patient interests. Until the effects of diagnostic radiation are further clarified, it is not possible to perform a risk-benefit calculation with sufficient certainty to warrant informed consent. Rather, patients and providers should make an informed decision about the use of diagnostic radiation on the basis of what is known and be cognizant of what is not.

The Evidence Regarding the Carcinogenicity of LDR

For many, the current interest in the risks of diagnostic radiation in the field of medicine started in 2006, when the Biological Effects of Ionizing Radiation (BEIR) VII report endorsed a linear no-threshold (LNT) risk model for low-dose radiation (LDR) based on available data (1). The LNT model states that the risk for cancer from radiation exposure proceeds in a linear fashion irrespective of the dose, without a threshold. As such, the LNT model would hold that even the smallest radiation dose could translate into an increased risk for cancer. In reaching their decision to endorse the LNT model, the BEIR VII committee heavily relied on two key pieces of evidence: the atomic bomb survivor data and radiation worker studies. However, since the release of the BEIR VII report, these two sources of evidence have undergone important changes and no longer support the LNT assumption (2,3). In the following sections, we review some of the major literature to date with respect to carcinogenesis from LDR.

Atomic Bomb Survivor Data

The cohort study of Japanese atomic bomb survivors is widely accepted data from which to judge the carcinogenic potential of ionizing radiation. Since the 2006 publication of the BEIR VII report, updated atomic bomb survivor data and radiation worker studies. However, since the release of the BEIR VII report, these two sources of evidence have undergone important changes and no longer support the LNT assumption (2,3). In the following sections, we review some of the major literature to date with respect to carcinogenesis from LDR.
Osaka et al (2) stated that “although the linear model provided the best fit in the full-dose range, statistically significant upward curvature was observed when the dose range was limited to 0–2 Gy,” which appears to result from “relatively lower than expected risks in the dose range of 0.3–0.7 Gy”. These findings underscore the problematic nature of using statistically convenient wide dose ranges as evidence of the linearity of LDR (5).

Radiation Worker Data
Like the atomic bomb survivor data, the radiation workers study has also substantially changed since the release of the BEIR VII report. The original 2005 study analyzed 407,391 nuclear industry workers from 154 facilities in 15 countries (average cumulative dose, 19.4 mSv) and found an increased cancer risk among the workers who were exposed to LDR (6). However, upon closer scrutiny, it was found that the statistically significant increase was driven by a single subgroup of workers that comprised 3088 employees of a single Canadian facility who were hired before 1965 (7). The Canadian data in question have since been discredited because of the likelihood of incomplete dose information for the study cohort in question and were withdrawn from the radiation worker study and all further epidemiologic studies (7). Reanalysis of the remainder of the Canadian data confirms that there is no increased cancer risk among any Canadian nuclear power plant workers for any time period (7). When the Canadian data in question are excluded, the pooled risk estimate of the 15-country study decreases by an astounding 40%, and no increased cancer risk from LDR is detected (3). Moreover, an increased cancer risk was not detected in any of the other 14 country cohorts.

Taiwanese Apartment Residents Study
Hwang et al (8,9) assessed the incidence of cancer in approximately 10,000 Taiwanese residents of an apartment building who were exposed to LDR from building materials contaminated with cobalt-60, a radioactive isotope that emits gamma rays. Study participants were exposed to an average cumulative dose of 50 mSv (range, 0.001–2.4 Sv). The observed incidence of cancer was statistically lower than expected for solid cancers, with a standardized incidence ratio of 0.7. For all cancers combined, excluding leukemia, the standardized incidence ratio was 0.8. Recognizing that the study is limited by varying levels and durations of radiation exposure in the study cohort, the results do not support the LNT model and, instead, may support a protective effect of LDR. Protective effects of LDR against cancer have been suggested by other retrospective studies (10–12).

Childhood CT Exposure Studies
Recently, retrospective cohort studies that demonstrate an increased risk for cancer associated with undergoing computed tomography (CT) in childhood were published (13–15). However, major limitations of these studies make it imprudent to assume a causal relationship (16–22). The greatest problem with these studies is the potential for reverse causation, a result of failure to control for confounding variables (23,24).

For instance, in the study by Mathews et al (13), there was an abundance of certain cancer types not commonly associated with radiation carcinogenesis in population-based studies (eg, melanoma and Hodgkin lymphoma) and a paucity of other cancer types common to population-based studies (eg, breast). Likewise, a large number of the solid cancers occurred only 1–4 years after the first exposure, even though a minimum latency period of 5 years or more is widely accepted for radiation-induced solid cancers. Lastly, the cancer risk after CT exposure was smaller for the 5- and 10-year lag periods compared with the 1-year lag period, even though the risk should increase with the duration of follow-up. All of these findings are atypical of radiation carcinogenesis and suggest an element of reverse causation.

The study by Pearce et al (14) lacked a control group, failed to account for pediatric medical conditions that would confound the study results, and failed to detect a known association between leukemia incidence and the patient’s age at exposure despite detecting more subtle dose response changes. Moreover, while certain commentators have interpreted the study by Pearce et al as indicating an increased incidence of leukemia from diagnostic radiation, compared with reported rates of pediatric leukemia in the United Kingdom, the rates in patients who underwent CT were not increased (21).

More recent retrospective cohort studies in Taiwan, France, and Germany further emphasize why correlation between CT exposure and cancer incidence may not mean causation (15,23,24). In addition to looking at CT exposure, these studies assessed potentially confounding clinical factors, including study indication and patient history, that were not considered by Mathews et al or Pearce et al. For instance, the studies by Mathews et al and Pearce et al, which showed an increased risk for leukemia in children who underwent CT, failed to control for patients with Down syndrome despite their greatly increased risk for childhood leukemia and increased exposure to diagnostic imaging (18). In contrast, the Taiwanese study excluded children with disorders that might increase cancer risk, including Down syndrome, and demonstrated no increased risk for leukemia (15). Likewise, in a retrospective cohort study from France, 67,724 children who underwent their first CT scan before the age of 10 years showed no significant increased cancer risk from CT when...
against a DNA repair-mediated low-dose threshold for cancer initiation” (1). However, recent studies negate this statement. Löbrich et al (42) and Neumaier et al (43) reported that, in healthy individuals, double-strand breaks were effectively repaired back to background levels after exposure to ionizing radiation from CT. Moreover, meta-analyses of experimental animal data have been unable to detect a significant increase in cancer incidence at doses in the range used with CT (28).

Thus, if we were to impose a requirement of informed consent, the process of consent would be circuitous. To be truthful and not misleading—fundamental principles of informed consent—a practitioner would have to state that there is an unproved possibility that the CT study could increase the risk for cancer and then state that there is an unproved possibility that it may not affect, or may even decrease, the risk for cancer.

Beyond Informed Consent

CT is one of the most important medical discoveries of the 20th century, and its use has resulted in invaluable contributions to disease diagnosis, treatment, and monitoring. In recent years, the unproved cancer risks associated with CT have been overemphasized, largely based on the BEIR VII endorsement of the LNT model. However, 8 years after the BEIR VII report, two of the main pieces of evidence used to uphold the LNT model are now used to challenge it. Meanwhile, other convincing evidence that indicate no measurable health effects, or even that beneficial health effects of LDR may exist, seem largely ignored or dismissed. In the absence of a proved radiation risk, our current efforts to protect patients could do more harm than good by discouraging clinically indicated diagnostic imaging or encouraging the substitution of suboptimal non-radiation-based imaging modalities (52).

We look forward to the time when a preponderance of quality scientific evidence provides an answer to this important question. Notwithstanding the substantial complexities associated with implementing an informed consent process for CT radiation, we believe that the available scientific evidence alone fails to justify obtaining informed consent for CT (53). We must be honest about the data regarding LDR carcinogenesis and about what we know. The data are uncertain, confusing, and largely uninformative. Uninformative data cannot, and should not, be the basis of informed consent.

Why Diagnostic Radiation May Not Cause Harm

A large segment of the medical and scientific community believes that the currently available evidence for LDR carcinogenesis indicates a threshold of at least 100 mSv (27–30). Proponents of threshold models of LDR point to in vitro and in vivo radiobiology studies that demonstrate that the human body does not passively accumulate radiation damage but instead actively repairs radiation-induced DNA damage through a host of well-established DNA repair mechanisms (27–38). Moreover, proponents of threshold models point out that the LNT model is incompatible with other known radiobiologic phenomena, including the bystander effect, delayed genomic instability, and low-dose hypersensitivity (39). Experts who believe in radiation hormesis hold that LDR may even protect the body against endogenous carcinogenic processes by inducing radiobiologic effects that may repair naturally occurring DNA damage (40,41). When explaining why it chose not to endorse a threshold model for LDR, the BEIR VII report stated that the “predominance of error-prone nonhomologous end-joining (NHEJ) repair in postirradiation cellular response argues strongly

The Modeling Studies

Some commentators have pointed to the early modeling studies of Smith-Bindman et al (25) and Barrington de González et al (26) as evidence of a carcinogenic risk of LDR. These studies, although robust in design, merely model potential cancer risks of LDR based on the starting premise that there is a cancer risk from LDR. As such, to hold these studies as evidence of LDR carcinogenesis is circular reasoning.
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