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Risk of Low-Level Ionizing Radiation from Medical Imaging Procedures

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Medical imaging procedures with x-ray, computed tomography (CT) and nuclear isotopes use ionizing radiation.[1–4] On the other hand, ultrasound and magnetic resonance imaging (MRI) do not.

When biological tissues are exposed to radiation, the effects are related to the type of radiation and the amount absorbed. Units of *absorbed dose* are grays (Gy) (joules/kilogram). One rad (radiation absorbed dose) is 0.01 Gy.[5] As not all types of radiation affect tissue the same, the *equivalent dose* (measured in Sieverts) takes this into account. X-ray, CT, and gamma ray radiation have a "weighting factor" of 1.0, therefore with these medical procedures 1 Gy = 1 Sv. Medical imaging doses are usually measured in units of milliSieverts (mSv). In addition, one REM is 0.01 Sv (10 mSv).

An average exposure from natural background radiation in the United States for an individual is ~3–5 mSv/year.[5–8] Also, a small amount of radiation exposure occurs with tobacco, the domestic water supply, building materials, and to a lesser extent televisions, and computer screens.[9]

The usual radiation dose of a chest radiograph is 0.02–0.1 mSv.[10–12] Representative radiation doses for other radiological studies are shown in Figure 1.[13–17] These medical studies contribute up to 20% of the total annual radiation exposure to the population of the United States.[18]

The National Research Council's *Committee to Assess Health Risks from Exposure to Low Levels of Ionizing Radiation* has published their most recent report, the BEIR VII Report.[19] The purpose of this report is to advise the U.S. Government on the relationship between exposure to ionizing radiation and human health. The BEIR VII Report describes a cancer risk model (linear no-threshold model) in which cancer risk diminishes proportionately to diminishing radiation exposure.

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This model predicts that about one individual in 100 would be expected to develop a solid cancer or leukemia from exposure to a dose of 100 mSv, and about one person in 10,000 from 1 mSv exposure. In comparison, 42 of 100 persons in the general population would be expected to develop solid cancer or leukemia from other causes.[20,21]

Based on the BEIR VII Report, a review of radiographic studies in the United States performed in the year 2007 estimates that 29,000 future cancers could be related to radiation exposure from that year alone. Those at highest risk include the pediatric population, and middle-aged females.[22]

Epidemiological studies have used the linear no-threshold model to extrapolate cancer rates for medical radiation exposure from Japanese atomic bomb survivor data.[19] Cancer rates from these Japanese World War II atomic bomb survivors along with nuclear workers, and patients receiving multiple exposures of medical radiation studies have been reported to be proportional to those exposed to higher doses.[23–25]

Other investigators believe that below a certain cumulative radiation exposure level (generally 100 mSv) the linear no-threshold model is invalid and cancer is no longer a risk.[26–29] Genes are able to repair DNA breaks from low level irradiation, whereas multiple DNA malfunctions (higher dose irradiation) are required for cancer induction.[27,30,31] Most radiation safety committees, however, use the linear no-threshold model for risk prediction.

The American Nuclear Society (ANS) and also the United States Environmental Protection Agency (EPA) have each developed interactive risk charts for individuals based on environmental and medical radiation exposure:

(ANS) http://www.new.ans.org/pi/resources/dosechart/
(EPA) http://www.epa.gov/rpdweb00/understand/calculate.html

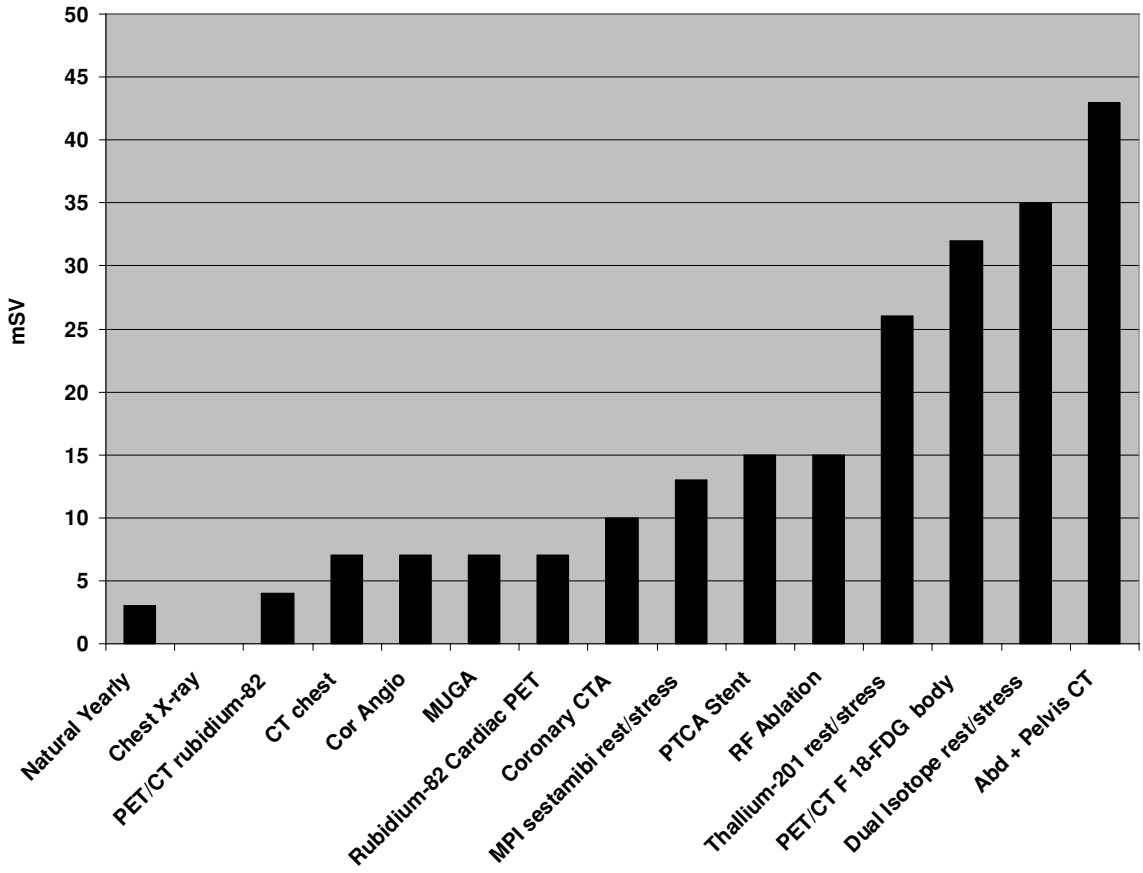

Figure 1. Radiation Exposure. Estimated radiation exposure (mSv) in the natural environment (Natural Yearly) and for various radiological procedures. Each radiological procedure is subject to variation in radiation exposure, dependent on factors including the patient, operator, and manufacturer. (Cor Angio) – coronary arteriography, (PTCA Stent) – percutaneous transluminal coronary angioplasty and stent, (RF Ablation) – cardiac radiofrequency ablation, (Abd + Pelvis CT) – combined abdominal and pelvis CT, (MPI) – myocardial perfusion imaging, (PET) – positron emission tomography.

Although radiological procedures are low risk for future cancers, potential risk versus benefit should be kept in mind when ordering any radiological procedure involving ionizing radiation. Reducing radiation to a minimum for a particular procedure and also use of other imaging modalities that do not use ionizing radiation (stress echocardiography or MRI) should be considered.

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