In-Flight Radiation: Addressing Patients' Concerns

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ABSTRACT: **Several years ago, mainstream media outlets discussed the controversial implementation of passenger X-ray screening devices at major airports. In an attempt to assuage passengers' fears, various experts made comparisons between the radiation from those units to the significantly higher levels that would be experienced as a result of the expected increase in radiation exposure associated with airline travel at high altitudes. Although these X-ray scanners were removed from service in 2013 and replaced with devices using radiofrequencies rather than ionizing radiation, numerous Internet discussion forums have increased the public's awareness of radiation exposure associated with airline travel. In these web-based comments, readers' responses to the postings (and sometimes the postings themselves) often misstate facts about the risks associated with in-flight radiation. We will provide guidance here that should allow radiology nurses and their colleagues to answer patient questions about the hazards of exposure to this radiation for adults and children, and, as well, address the issue of fetal risks for pregnant passengers. (J Radiol Nurs 2014;33:46-52.)**

KEYWORDS: **Radiation risk; Radiation; Atmospheric; Radiation; Technological enhancement.**

INTRODUCTION

As an inhabitant of planet Earth, everyone of us is constantly exposed to radiation (National Council on Radiation Protection and Measurements [NCRP], 2009). This "background" radiation comprises three principal components, namely emissions from naturally occurring radioactive materials present in the external environment (soil, water, and so on), exposures received from radioactive substances that have been incorporated into our bodily structures, and radiation directed toward the Earth that has been produced by all of the stars in our galaxy, including our own Sun. This latter component is called "cosmic radiation."

The background levels of the first component, terrestrial radiation, vary widely from place to place on the planet. Radioactive minerals, the source of this exposure, are not uniformly distributed across the globe. As an example, most homeowners in certain locales are aware that levels of radon (produced by the radioactive decay of uranium in the soil) may impact some structures more than others as a result of differing local concentrations.

Cosmic radiation intensities also vary from one place to another, primarily as a function of altitude and secondarily as a function of geographic latitude, the relative position of a place with respect to the Earth's equator. The major dependence on altitude can be easily understood by recognizing that although we generally consider air to be a relatively insubstantial substance, at sea level every square inch of the planet has almost 15 lb of air pressing down on it. And the higher one goes in altitude, the lower is the mass of air above. That air serves as an absorber of cosmic radiation impacting the Earth. In an airplane, tens of thousands of feet up, most of the air is below the aircraft, not above it, and the cosmic radiation intensity impacting the aircraft's occupants is significantly increased (Friedberg, Snyder, Faulkner, Darden, & O'Brien, 1992).

COSMIC RADIATION

All stars, including our own Sun, are thermonuclear furnaces where the mechanism of atomic fusion produces heat, light (photons), and subatomic particulate radiation. The principal subatomic particles thrown off by stellar activity are protons and electrons (the basic building blocks of atomic structure) as well as

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some more exotic species. Because protons have a positive electrical charge, their path toward Earth is influenced by the magnetic field surrounding our planet. They tend to follow the lines of magnetic force that have a greater intensity toward the North and South poles and a lesser intensity toward the equator. This influence of the Earth's magnetic field accounts for the variation of dose rate with latitude, mentioned earlier. When these energetic particles interact with the atmosphere, they transfer energy by both collision and electrical interaction with the air molecules, and in doing so release what are called "secondary" particles—primarily neutrons. Because neutrons have no electrical charge, their absorption is very much dependent only on collision with the molecules of air. So with only that single mechanism slowing them down, they have a greater range of penetration through the atmosphere than the charged particles that created them (O'Sullivan, Zhou, & Flood, 2001).

RADIATION UNITS AND QUANTITIES

As we have discussed, the radiation level at high altitudes is increased by the thinner layer of absorbing air above the place of interest. To make sense of the magnitude and significance of this, it is necessary to introduce some quantitative values for these exposures. In the field of diagnostic radiology, the exposure of patients to radiation may be from several different sources, such as X-rays from conventional radiographic or fluoroscopic devices, γ-rays from injected nuclear medicine compounds, and electrons or positrons from radiopharmaceuticals. The first two of these are photons, that is, electromagnetic radiation, the others are particulate radiation, subatomic species possessing both mass and electrical charge.

To make meaningful comparisons of the biological damage produced by differing types of radiation like these, a scheme has been created whereby "equivalent doses" of radiation of different types are those that cause essentially identical biological damage, although the actual absorbed dose may be quite different. "Absorbed dose" is a true physical quantity, defined as the amount of energy transferred into something when it is struck by radiation. Absorbed dose is specified in units called gray (Gy) where 1 Gy represents the absorption of 1 J of energy per kilogram of exposed material, independent of the nature of that material. Equivalent dose is expressed in units of sievert (Sv) where the true absorbed dose has been modified by a factor that functionally builds-in the biological harm from that particular radiation type for the specific irradiated tissues. Both gray and sievert are very large quantities of radiation and exposures in diagnostic radiology are most often expressed in milligray (mGy), millisievert (mSv), or even microgray (μGy) or microsievert (μSv), values that are 1,000 and 1,000,000 times smaller, respectively. For X-rays and γ-radiation, the modifying factor converting gray to sievert is unity, and this is the reason that radiological publications often use both terms interchangeably when discussing patient doses from radiological procedures (International Commission on Radiation Units and Measurements [ICRU], 1993).

BACKGROUND RADIATION LEVELS

Typical annual background radiation exposures in the United States for the three major components described earlier are: 0.28 mSv (terrestrial), 0.39 mSv (internal), and 0.27 mSv (cosmic). An additional 2 mSv is, on average, received by people living in areas where there is a high radon concentration. For high-altitude cities like Denver, CO, the cosmic radiation background goes up to 0.5 mSv. The terrestrial component in Denver, CO, is also elevated to about 0.46 mSv because the soil in that area has higher concentrations of radioactive minerals than in other areas of the United States. When looking at the increased exposures associated with in-flight radiation, it will be useful to keep these "normal" values in mind. Recent government publications put the average annual exposure total at somewhere between 4 and 10 mSv per year from natural background sources (NCRP, 2009).

REGULATORY EXPOSURE LIMITS

Personnel working in the field of medical radiology are certainly aware that regulatory agencies have placed limits on the radiation exposures that they may receive from activities in the workplace—exposures that are supplemental to those received as background. In a medical environment, these exposures come from the transmission of radiation to adjacent areas through the walls of X-ray, nuclear medicine, and other procedure rooms and will usually occur when staff attends to those patients undergoing interventional studies or who receive tests or treatments involving radioactive materials. The basis of these personnel limits are regulations of the United States Nuclear Regulatory Commission (NRC) that are generally adopted by the health departments in each state, whether the exposures come from radioactive materials or from radiation-producing machines (U.S. Nuclear Regulatory Commission [USNRC], 2011). The same limits are enforced for other radiation workers, those people using radioactive materials or radiation equipment in mining or industrial settings, nuclear power generation, and any other activity where personnel are exposed. The same regulatory documents also specify acceptable exposure limits for members of the public who