SCIENCE

Why Lung Cancer Is Caused By Radon Decay Products and Not Radon Itself

Phil Jenkins shares his thoughts on a number of topics related to radon measurements on his blog: http://doctor-radon.blogspot.com

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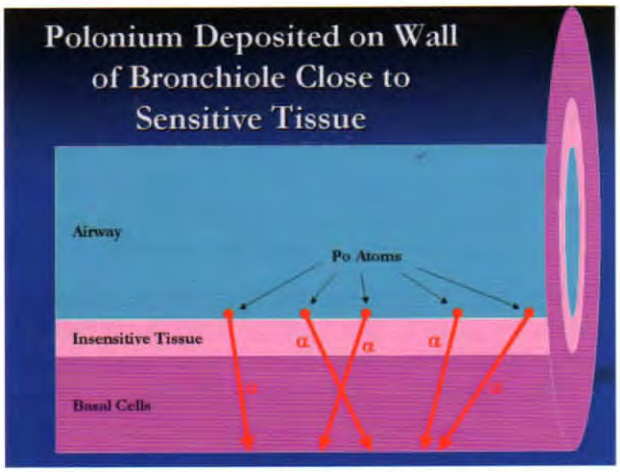
First, it's important to understand what is meant by "radiation dose." When ionizing radiation interacts with an absorbing medium, the amount of energy transferred per unit mass of the medium is the "absorbed dose." The unit of absorbed dose commonly used in the U.S. is the "rad." One rad is defined as 100 ergs of absorbed energy per gram of absorbing medium. For our purposes in discussing the dose from radon and radon decay products, the absorbing medium is the sensitive cells in the walls of the bronchioles, or the "bronchial epithelium." Some forms of ionizing radiation, such as alpha particles, are more "effective" in causing damage in human tissue than other forms, such as beta particles and gamma rays. However, for the purposes of the discussion here, it is sufficient to consider that the greater the absorbed dose the greater the damage to the tissue and thus the greater the risk of causing lung cancer.

Radon-222 is a member of a naturally occurring radioactive decay series that consists of fourteen radionuclides starting with uranium-238 and ending with polonium-210, which decays to stable lead-206 thus ending the series. The sixth radionuclide in the series is radium-226, which decays by emitting an alpha particle, thus forming radon-222. Radon-222 decays in turn to four short-lived decay products; polonium-218, lead-214, bismuth-214 and polonium-214. These five radionuclides are of interest to us here, because they irradiate the lung tissue when radon and radon decay products are inhaled.

Radon-222, polonium-218 and polonium-214 all decay by emitting alpha particles. Lead-214 and bismuth-214 decay by emitting beta particles and gamma rays. Alpha particles are identical nuclei of helium, and are massive compared to beta particles. Beta particles are identical to electrons, which have a very little mass. Gamma rays are electromagnetic waves like light, microwaves, x-rays, etc., and have no mass at all. As long as alpha-particle emitting radionuclides remain outside the body, they cause no harm, because alpha particles have an extremely short range in tissue and they cannot penetrate the outer layer of skin to reach sensitive tissues. However, if they can get into the body, through inhalation for example, they can be in range of sensitive tissues and can be a serious health hazard.



There are several reasons why, of the five radionuclides of interest, it is the two polonium isotopes that cause essentially the entire dose to sensitive tissue in the lung and therefore cause lung cancer. When air containing radon and its short-lived decay products is breathed into the lung, the decay products attach to the walls of the bronchioles. So, in effect the lungs "filter out" the radon decay products from the air.

These radon decay products accumulate on the walls of the bronchioles. There is no mechanism for radon to accumulate in the lung; therefore, the concentration of radon in the air passageways of the bronchioles is no greater than the concentration of radon in the ambient air surrounding the person. Thus, the quantity, or "activity," of the radon decay products accumulated on the walls of the bronchioles can be much greater than the activity of the radon in the air passages of the bronchioles.

The atoms of lead-214 and bismuth-214 that are deposited on the walls of the bronchioles emit beta particles and gamma rays. But since the walls of the bronchioles are "paper thin," the probability of a gamma ray interacting in the tissue as it passes through it is very small. Therefore, the gamma rays emitted by these two radionuclides cause very little radiation dose to the bronchiole epithelium. The beta particles that pass through the walls of the bronchioles also impart very little energy to the tissue, and therefore cause very little radiation dose.

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The story is quite different for the alpha-particle emitting radionuclides; radon-222, polonium-218 and polonium-214. The alpha particles are highly energetic and, because of their short range in tissue, they impart essentially all of their energy as they pass through the bronchiole epithelium, thus causing a large radiation dose. The energies of the alpha particles emitted by radon-222, polonium-218 and polonium-214 are 5.5 MeV, 6.0 MeV and 7.7 MeV, respectively. Thus, just from the comparatively larger amount of energy available, and the consequent larger range in tissue, it is polonium-214 that causes the largest radiation dose, with polonium-218 causing less, and radon-222 causing even less.

The most important factor, however, is one of geometry. Being an inert gas, the radon atoms are distributed throughout the air passages of the bronchioles. The polonium atoms, however, are deposited on the walls of the bronchioles, very much closer to the sensitive cells of the bronchiole epithelium, the cells that can produce lung cancer, than are the radon atoms. Therefore, the probability of interaction with these sensitive cells and amount of radiation dose that can be delivered to them is much greater for the polonium atoms than is the case for the radon atoms. Because of all of these factors combined, but particularly because of the geometry, the two isotopes of polonium cause almost the entire radiation dose to the sensitive tissues of the lung. Therefore, it is the two isotopes of polonium that are the primary cause of lung cancer.