NEXUS

Your link with current trends in radiation dosimetry

RADIATION PROTECTION FOR THE PREGNANT WORKER

A candid interview with Stewart C. Bushong, Sc.D., Professor of Radiologic Science, Baylor University, College of Medicine

Editor's Note: Since the publication of this article, regulations have been enacted requiring that dose to the embryo/fetus of declared pregnant workers not exceed 500 mrem over the entire pregnancy. See Title 10 Part 20 of the Code of Federal Regulations or Landauer's Nexus on the new 10CFR20 for details.

Nexus: It is reported to us from time to time that a pregnant radiation worker was furloughed or dismissed from her job because the employer became concerned over possible radiation injury to the unborn child. Is this proper procedure?

Dr. Bushong: Absolutely not. There are a number of protective devices and administrative procedures to ensure that no harm will come to the unborn.

Nexus: Is there a safe dose to which a pregnant worker can be exposed?

Dr. Bushong: There is an easy response to that question, but the true situation is much more complicated. The easy response is that the maximum permissible dose (MPD)—5 mSv (500 mrads) during pregnancy—is safe.

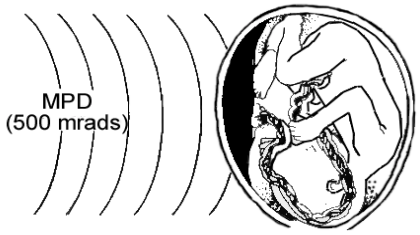
Nexus: Is this radiation level, 5 mSv for nine months, considered an absolutely safe level of radiation?

Dr. Bushong: Simplistically, yes. But since we know that some possible radiation effects on the fetus are nonthreshold, there is theoretically a vanishingly small probability of response following even lower radiation levels.

Nexus: What do you mean by a nonthreshold type of effect?

Dr. Bushong: Let's first consider a threshold type effect. Death, following a single high exposure to radiation, is a threshold type effect. At doses less than approximately 2 Gy (200 rads) no one will die; therefore, 2 Gy is said to be the threshold dose for radiation-induced acute lethality.

Radiation-induced leukemia responds in a nonthreshold fashion. If a large population were to receive a 2 Gy dose, a small percentage of that population, less



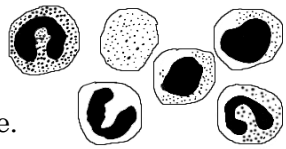
than 5%, would develop leukemia several years later. Following 1 Gy, approximately half of that percentage would develop leukemia. Following even lower doses, a proportionately lower percentage would be expected to develop leukemia. At doses in the occupational exposure range, there is a statistically predictable level of radiation-induced leukemia. However, it is so small that it is not measurable.

Nexus: So even radiation doses less than the MPD have a probability of producing an effect?

Dr. Bushong: Yes, but the probability is so very, very small that even if all pregnant workers received the MPD, no injury to any unborn child would be expected.

Nexus: Can you be more specific? First, tell us what radiation responses are we talking about?

Dr. Bushong: There are basically two. Radiation-induced malignant disease, leukemia and cancer, and genetic change.



Nexus: What about congenital abnormalities?

Dr. Bushong: That type of response to radiation is a threshold type effect and certainly does not occur at doses in the range of the MPD.

Nexus: Then, for example, what is the risk of a newborn developing a childhood malignancy following exposure to the MPD?

Dr. Bushong: To the best of our knowledge, the absolute risk of radiation-induced cancer and leukemia in adults is approximately 30 cases in a population of 1 million, each of whom has received a dose of 1 cGy (1 rad); therefore, following 5 mGy (500 mrad) to 1 million persons, one would expect 15 cases or 1.5 cases per 100,000. That estimate is for adults receiving an abrupt exposure, not one that is extended over time such as that which we receive occupationally. It is, therefore, a worst case estimate. To worsen the estimate further, let's assume that the entire MPD was received during the first trimester of pregnancy when the risk is approximately ten times higher. Therefore, one might expect as many as 15 cases in 100,000. The total number of active radiologic technologists is approximately

100,000, certainly less than 1% of whom would be pregnant at any time, so that the excess risk of such a harmful effect is only about 1/10th of a case.

Nexus: You mentioned genetic effects.

Dr. Bushong: The probability of a harmful genetic effect is only about 1/10th that for malignant disease and, therefore, it is of even less concern.

Nexus: So if you consider the MPD to be a safe dose, what dose is considered to be dangerous?

Dr. Bushong: Let's use the example of a patient who has been exposed to diagnostic x-rays during pregnancy. If the exposure occurred during the first trimester, we would not recommend an alteration in the pregnancy at doses less than about 10 cGy (10 rads). Late in pregnancy, the safe dose rises to approximately 25 cGy (25 rads).

Nexus: Okay, you indicate that the MPD is a safe dose so therefore protective measures are not necessary. Right?

Dr. Bushong: Wrong. Because some responses of the fetus to radiation are nonthreshold in nature, it is important that we reduce the fetal dose as low as possible.

Nexus: How do we do this? Through the use of the devices and administrative procedures you mentioned earlier?

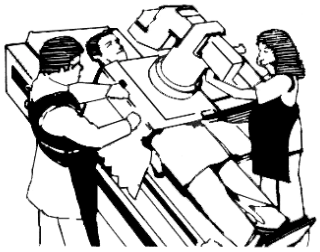
Dr. Bushong: Yes. And, perhaps we could consider the largest population of potentially pregnant radiation workers, radiologic technologists, as an example.

Nexus: What protective devices can be employed?

Dr. Bushong: The principal protective device is one that is routinely used anyway, the lead apron. A radiologic technologist receives nearly all occupational exposure during fluoroscopy and portable radiography where protective aprons are used. These aprons do just what they are designed to do—reduce the radiation dose to near zero.

Nexus: Can you be more specific?

Dr. Bushong: Very few radiologic technologists will exceed an occupational exposure of 1 cSv (1 rem) in a nine-month period as recorded by a radiation monitor positioned at collar level above



the protective apron. Most will get less than half of that, but for simplicity let's assume 1 cSv (1 rem). The dose to the abdomen under the protective apron will be approximately 5% of the collar dose, or 500 μSv (50 mrem). Because of overlying maternal tissues, the dose to the fetus will be only about 1/4th of the abdominal entrance dose, or approximately 125 μSv(12.5 mrem). This is a vanishingly small exposure and certainly absolutely nothing to be concerned about.

Nexus: Can anything else be done?

Dr. Bushong: Yes. There are perhaps two other procedures that should be followed. If staffing permits, one could shift the pregnant employee from her normal position to a job with potentially lower exposure. For instance, the radiologic technologist could be assigned to radiography only, and removed from the fluoroscopy schedule and portable work. However, such a move is not absolutely necessary, especially if temporary help would have to be employed to accommodate such a move.

Nexus: Anything else?

Dr. Bushong: Yes. You can provide the pregnant employee with an additional radiation monitor and instruct her to wear it at waist level under the protective apron. This monitor should be identified as "baby badge" or "fetal badge." This is not specifically a dose reduction measure, but rather to define more clearly the fetal dose that is actually received.

Nexus: So do we understand that there are no circumstances under which a pregnant employee should be terminated because of concern over her radiation exposure?

Dr. Bushong: None. Furthermore, there is no situation in which the pregnant employee should feel that she is placed at undue risk. That situation simply doesn't exist. With proper attention to routine radiation protection practices, the pregnant worker should not feel any more concern for her unborn than she does following the normal experiences and exposures of everyday life.

Stewart C. Bushong, Sc.D., received his B.S. in physics from the University of Maryland. He went on to spend four years as a nuclear reactor physicist for the U.S. Public Health Service and at Westinghouse Atomic Power Laboratory.

In 1966, he earned his Sc.D. at the University of Pittsburgh and joined the staff at Baylor University, College of Medicine. Currently, he holds the position of Professor of Radiologic Science in the school's Department of Radiology.

Bushong has authored more than 100 scientific papers and has written 10 books. One of his books, "Radiologic Science for Technologists," is the popular standard in x-ray technology training.