17. PRENATAL RADIATION EXPOSURE

Protection of the unborn from ionizing radiation is an important and well established practice. The risk of harm following in utero exposure requires serious attention because of the severity of the possible effects, because they occur so early in life and because those who suffer the harm are involuntarily exposed. Accordingly, various advisory and regulatory groups have established limits for the radiation dose of a developing child due to the mother's work–related exposure. The US Nuclear Regulatory Commission (NRC) limits the effective dose to the embryo/fetus to 500 millirem if the pregnancy has been declared, in writing, by the mother. After the declaration of pregnancy, the NRC recommends that the embryo/fetus dose rate not exceed 50 millirem per month for the remainder of the pregnancy. Fortunately, the radiation doses incurred by research and laboratory medicine personnel are generally much less than the NRC dose limit for a developing child. Nevertheless, it is appropriate to review the possible adverse consequences of irradiating the unborn and to promote practices that are intended to maintain embryo/fetus doses as low as possible.

17.1 DEVELOPMENTAL EFFECTS

The developmental effects of radiation on the embryo and fetus are strongly related to the stage at which exposure occurs. The greatest concerns are of inducing malformations and functional impairments during early development and an increased incidence of cancer during childhood. The most frequent radiation–induced human malformations are small size at birth, stunted postnatal growth, microcephaly (small head size), microencephaly (small brain), certain eye defects, skeletal malformations and cataracts. Fortunately, most of these effects are observed only for radiation doses larger than those permitted radiation workers.

The current knowledge regarding developmental effects, according to the International Commission on Radiological Protection (ICRP) and the US Nuclear Regulatory Commission (NRC), is summarized as follows:

- Exposure of the embryo to high doses during the first 3 weeks following conception may result in a failure to implant or an undetectable death of the conceptus. Otherwise, the pregnancy continues in normal fashion with no deleterious effects. This "all or nothing" response if thought to occur only for acute doses greater than several rem.

- After 3 weeks, malformations may occur which are radiation dose dependent but with threshold doses generally estimated to be about 10 rem of acute exposure. An important exception may be the risk of small head size. According to the NRC the risk of small head size is a function of gestational age with approximate risks of 5 chances in a thousand per rem at 4 to 7 weeks after conception to a peak of about 9 chances in a thousand per rem at 8 to 11 weeks. For perspective, the NRC points out that the occurrence of small head size occurs in about 40 births out of 1,000 in the US due to causes other than radiation exposure.

- From 3 weeks to the end of pregnancy it is possible that radiation exposure of the embryo/fetus can result in an increased chance of childhood cancer with a risk factor of at
most, a few times that for the whole population. For example, the NCRP concludes that the lifetime risk resulting from exposure during gestation is two to three times that for an exposed adult. The NRC has reviewed the available scientific literature and has concluded that the 0.5 rem limit provides an adequate margin of protection for the embryo/fetus.

- The NRC states that the brain is most sensitive to induced developmental effects during the 8th to 15th weeks of gestation followed by a substantially less sensitive period for the 2 months after the 15th week. Although no brain developmental effects caused by radiation have been observed in humans at doses below the 5 rem occupational dose limit, scientists are uncertain whether they can occur at low doses. Because of this uncertainty, scientific advisory groups consider it prudent to limit the dose to the embryo/fetus to 0.5 rem due to the mother's work–related exposure. The ICRP, based on studies of children exposed in utero to much higher radiation doses than 5 rem, concludes that the irradiation during the development of the forebrain (in the period of 8–15 weeks after conception) may reduce the child's IQ by 0.3 point per rem, on the average.

It should be noted that the combined risk, i.e., the sum of the fatal cancer, small head size and mental retardation risks, for the embryo/fetus exposed to the limit of 500 millirem is 14 chances per 10,000, according to the NRC. This is in fair agreement with a 1987 report issued by the NCRP in which it is concluded that the total risk for the embryo/fetus is about 10 chances in 10,000 for a dose of 500 millirem. This is an unacceptably high risk for many. Hence, it is institutional policy to maintain the embryo/fetus radiation doses of pregnant personnel as low as is reasonably achievable.

In accord with this commitment, the following describes a policy to ensure that the exposure of every pregnant employee (and fetus) is substantially less than 0.5 rem (500 mrem) during the period of pregnancy:

- All radiation workers should be aware and understand the special precautions concerning exposure during pregnancy, especially that the dose equivalent to the embryo or fetus from occupational exposure of the expectant mother should not exceed 0.5 rem (500 mrem) and the reasons for this recommendation.

The US Nuclear Regulatory Commission (NRC) has developed guidance for workers concerning prenatal risks associated with occupational radiation exposure that is more extensive than this summary: Regulatory Guide 8.13, Revision 3, "Instruction Concerning Prenatal Radiation Exposure".

- Personnel exposed to ionizing radiation are encouraged to disclose their pregnancy, in confidence, and in writing, to the Radiation Safety Officer, Radiation Safety Division, WUSM Box 8053. The declaration must include your name, a statement that you are pregnant, the estimated date of conception, and the date you provide the letter to Radiation Safety.

You may use our sample Declaration of Pregnancy form (also on the Forms page of our website: https://radsafety.wustl.edu/documents/forms/pregnancy.pdf). You may use the form
letter or compose your own. The employee's previous exposure history will be reviewed to
determine whether the employee should consider requesting a modification in her work
assignment.

- Radiation Safety personnel will review the employee's previous exposure history to
determine if radiation monitoring is required during the remainder of the pregnancy.

- The reported deep doses for any subsequent monitoring of the worker will be reviewed
each month by Radiation Safety.

- Radiation Safety will notify the individual if any reported deep dose exceeds 10 millirem
  in a month or if the cumulative reported deep dose exceeds 100 millirem.