Introduction:

Ionizing radiation is known to cause harm in mammalian organisms. Deleterious effects of radiation include carcinogenicity, mutagenicity and organ system toxicity. As general rule, the sensitivity of a tissue to radiation is directly proportional to its rate of proliferation. Therefore, one could infer that the human fetus, because of its rapid progression from a single cell to a formed organism in nine months, is more sensitive to radiation than the adult. This inference is supported by the results of experiments in animal models, and experience with human populations that have been exposed to very high doses of radiation (atomic bombing victims).

In humans, the major deleterious effects on the fetus include miscarriage, teratogenicity (birth defects), mental retardation, intrauterine growth retardation and the induction of cancers (such as leukemia) that appear in childhood. Birth defects and mental retardation are the adverse effects which are of the most immediate concern for expectant mothers. Fortunately, not all exposures to ionizing radiation result in these outcomes.

The risk to the fetus is a function of gestational age at exposure and the radiation dose.

Those who work in or visit areas where nuclear substances are used need to understand the biological risks radiation presents to your unborn child.

Risk Related to Gestational Age

Early Gestation / First Trimester – At this point, the rate of fetal growth is very rapid and the fetus, as an organism, is at its most radiation-sensitive stage if fetal demise is taken as an end-point. The incidence of miscarriage consequential to radiation exposure at this stage of gestation is not known, since (a) many women were never aware they were pregnant at the time of the exposure or miscarriage, and (b) the "background" rate of miscarriage is believed to be high (25 - 50 percent of conceptions). It is believed that radiation injury during early gestation is an "all-or-nothing" effect.

Second Trimester – During this period, the overall growth rate of the fetus has slowed. However, the major organ systems are beginning to differentiate. From a standpoint of future development, the fetus is in its most sensitive stage. The incidence of gross congenital malformations and mental retardation are dose-related and appear to have thresholds; i.e. doses below which the incidence above "background" is not elevated.
Third Trimester – Irradiation during this period may deplete cell populations at very high doses (over 50 rem), but will not result in gross organ malformations.

Risk Related to Radiation Dose

The risk of deleterious effects increases with increasing dose. The nature of this dependence, i.e. the shapes of the dose-response curves for humans in the low-dose range (under 500 mSv), is controversial. For some prenatal irradiation effects, there is epidemiological basis for the existence of threshold doses. For others, such as childhood cancer induction, the existence of a threshold is not clear-cut. Despite these uncertainties in the dose-effect relationship, some broad generalizations based on fetal dose ranges may be made.

Fetal Dose less than 10mSv – There is no evidence supporting the increased incidence of any deleterious developmental effects on the fetus at diagnostic doses within this range.

Fetal Dose between 10mSv and 100mSv – The additional risk of gross congenital malformations, mental retardation, intrauterine growth retardation and childhood cancer is believed to be low compared to the baseline risk. However, the lower limits (in terms of statistical confidence intervals around the mean) for threshold doses in some studies, especially those related to cancer induction, fall within this range.

Fetal Dose Exceeding 100mSv – The lower limits (in terms of statistical confidence intervals) for threshold doses for effects such as mental retardation and diminished IQ and school performance fall within this range. Overall, exposure at levels exceeding 100mSv could be expected to result in a dose-related increased risk for deleterious effects. For example, the lower limit (95% confidence interval) for the threshold for mental retardation is about 150mSv, which an expectation value of about 300mSv.

Legislative Requirements

The International Commission on Radiological Protection (ICRP) regularly reviews the biological evidence of the detrimental effects of ionizing radiation and publishes appropriate recommendations regarding acceptably safe practices for the exposure of occupational workers, patients undergoing treatment/diagnosis, and for members of the public.

In Canada these recommendations have been incorporated into law in the Nuclear Safety and Control Act. The law is administered by the Canadian Nuclear Safety Commission. The Canadian Radiation Protection Regulations require that the dose to a pregnant NEW, after the licensee is informed of the pregnancy, shall not exceed 4 mSv.

Responsibilities

Responsibility of female radiation workers

As a NEW becomes aware of her pregnancy they shall immediately inform the RSO. The Declaration of Pregnancy Form must be completed and submitted to the RSO.
During pregnancy, the employee is expected to perform their duties within the restrictions applied by the RSO. The employee is encouraged to monitor her embryo/fetus dose by reviewing the personnel dosimeter reports and discuss these reports with the RSO.

**Radiation Safety Officer Responsibilities**

An assessment of the work situation shall be done to ensure that Radiation Safety Principles are being adhered to and that radiation dose limits are not exceeded and remain ALARA.

The RSO will review the workers previous dose history and current and/or planned work practice to determine the need for additional dosimetry.

Radiation exposures of pregnant NEW’s shall be monitored to ensure that the dose limit of 4 mSv for the balance of the pregnancy is not exceeded, in accordance with the Canadian Radiation Protection Regulations.

**References**


DECLARATION OF PREGNANCY FORM  
Nuclear Substance Workers

I declare that I am pregnant, for the purposes of lowering the dose received by me and/or my embryo/fetus.

I understand and agree that additional monitoring may be required of me during the balance of my pregnancy to ensure that the dose limit of 4 mSv is not exceeded.

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