CHAPTER 5
Effects of Radiation on the Embryo, Fetus & Child
LEARNING OUTCOMES

• To understand the effects of radiation on the fetus in doses greater than 10 Rem.
• To understand the reason for “Declaring your pregnancy”.
• To understand that low doses (<500 mrem) do not cause measurable harm to the fetus.
Our Bodies Are Resilient

• DNA damage is most important and can lead to cell malfunction or death.

• Our body has ~ 60 trillion cells
  – Each cell takes “a hit” about every 10 seconds, resulting in tens of millions of DNA breaks per cell each year.
  – BACKGROUND RADIATION causes only a very small fraction of these breaks (~ 5 DNA breaks per cell each year).

• Our bodies have a highly efficient DNA repair mechanisms
Dividing Cells are the Most Radiosensitive

- Rapidly dividing cells are more susceptible to radiation damage.
- Examples of radiosensitive cells are
  - Blood forming cells
  - The intestinal lining
  - Hair follicles
  - **A fetus**

This is why the fetus has a exposure limit (over gestation period) of 500 mrem (or 1/10th of the annual adult limit)
Types of Exposure & Health Effects

• **Acute Dose**
  – Large radiation dose in a short period of time
  – Large doses may result in observable health effects
    • Early: Nausea & vomiting
    • Hair loss, fatigue, & medical complications
    • Burns and wounds heal slowly
  – Examples: medical exposures and accidental exposure to sealed sources

• **Chronic Dose**
  – Radiation dose received over a long period of time
  – Body more easily repairs damage from chronic doses
  – Does not usually result in observable effects
  – Examples: Background Radiation and Internal Deposition

Inhalation
Pre-conception irradiation

- Pre-conception irradiation of either parent’s gonads has not been shown to result in increased risk of cancer or malformations in children (This statement is from comprehensive studies of atomic bomb survivors as well as studies of patients who had been treated with radiotherapy when they were children).

- **Permanent Sterility**
  - Female: >250 rem
  - Male: >350 rem
Fetal radiation risk

• There are radiation-related risks throughout pregnancy that are related to the stage of pregnancy and absorbed dose.

• Radiation risks are most significant during organogenesis and in the early fetal period, somewhat less in the 2nd trimester, and least in the 3rd trimester.
Fetal radiation risk

• 0 – 2 Weeks: The embryo is very resistant to the malforming effects of x rays. The embryo is, however, sensitive to the lethal effects of x rays although doses much higher than 5 rad or 50 mSv is necessary to cause a miscarriage.

• 3 – 8 Weeks: The embryo is in the period of early embryonic development but is not affected with either birth defects, pregnancy loss, or growth retardation unless the exposure is substantially above the 20 rad (200 mSv) exposure.
Fetal radiation risk

- 8 – 15 weeks: The embryo or fetus is sensitive to the effects of radiation on the central nervous system. But here again, the exposure has to be very high. Fetal doses in excess of 10 Rem can potentially result in some reduction of IQ (intelligence quotient) while fetal doses in the range of 100 Rem can result in severe mental retardation and microcephaly, (and to a lesser extent at 16-25 weeks). Malformations have a **threshold of about 20 Rem or higher** and are typically associated with central nervous system problems.

- 16 weeks on: The fetus is completely developed, it has become more resistant to the developmental effects of radiation. In fact, the fetus is probably no more vulnerable to many of the effects of radiation than the mother in the latter part of pregnancy.
Leukaemia and Cancer

• Radiation has been shown to increase the risk for leukaemia and many types of cancer in adults and children

• Throughout most of pregnancy, the embryo/fetus is assumed to be at about the same risk for carcinogenic effects as children
Leukaemia and Cancer (cont’d)

• The relative risk may be as high as 1.4 (40% increase over normal incidence) due to a fetal dose of 1 Rem

• For an individual exposed in utero to 1 Rem, the absolute risk of cancer at ages 0-15 is about 1 excess cancer death per 1,700
Protecting the Embryo/Fetus

• The only way to protect the embryo/fetus from excess radiation is to protect the mother. When a mother “DECLARES” her pregnancy:
  • a “Belly” badge for the baby is issued
  • Bioassay for radioactive material intake may be initiated and repeated monthly
  • Pregnant woman will be administratively limited to work with less than 10% of the ALL activity (can be obtained by the RSO) to ensure an intake dose of less than 500 mrem.
Protecting the Embryo/Fetus

• Additional information is available through the Radiation Control Office

• You have the right to have confidential discussions with RSO about radiation risks to embryo/fetus (Even if just planning to get pregnant)

• If you are uncomfortable discussing this with the Radiation Safety Officer, arrangements may be made to discuss your concerns with female radiation health professional.
THANK YOU