AN INFORMATIONAL NOTE TO CLINICIANS CONCERNING THE POSSIBLE RISKS OF RADIATION EXPOSURE TO PREGNANT PATIENTS

1. A concise explanation of the known radiation risks to the conceptus of pregnant patients due to radiographic examination, along with the typical conceptus doses expected from radiographic examination.

2. An explanation of radiation risks written in terms understandable to the patient.

First a short summary of radiation and radiation units:

The basic unit of radiation dose is the rad. A more modern unit that you may run across is the Gray (Gy) (100 rad = 1 Gy). The radiation dose to different parts of the body may be very different, therefore we talk about the dose to a particular part of the body. In the discussions below concerning the effects of radiation on the conceptus, we will always be referring to the dose to the conceptus, NOT the dose to the surface of the patient which will always be significantly higher.

A lethal dose of radiation is about 500 rad (5 Gy) to the entire body. 100 rad (1 Gy) can produce significant GI symptoms. Background radiation is the equivalent of about 0.3 rad or 300 mrad per year to the entire body.

Next, guidance as to typical radiation doses to the conceptus for various radiographic exams:

For properly performed radiographic examinations in which the uterus is not within the primary radiation field and is greater than 10 cm from the primary radiation field, the fetal dose is less than 0.01 rad (10 mrad). Here, the typical fetal dose is equivalent to a few hours to a few days of background radiation, and is therefore negligible. These examinations include the following:

> Chest, all extremity examinations (excluding the femur), skull, cervical spine, scapula, shoulder, humerus, thoracic spine, ribs, and CT exams (other than those of the lumbar sacral spine, pelvis, hip, or lower abdomen).

For properly performed radiographic examinations in which the uterus is within the primary radiation field or is less than 10 cm from the primary radiation field, the fetus/embryo will typically receive a small but non-negligible radiation exposure.

> **Typical fetal doses for these examinations are:**
> **0.1 rad for each AP film,**
> **0.25 rad for each lateral or oblique film,**
> **2 rad for a single CT exam using contiguous slices, and**
> **1 rad per minute of fluoro time.**
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> These examinations include the following:
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> Pelvis, abdomen, lumbar-sacral spine, hip, femur, IVP, cystogram, CT of the lumbar-sacral spine, pelvis, hip, or lower abdomen, and any fluoroscopy of the lower abdomen. Note that any of these listed exams *may* irradiate the fetus/embryo as indicated above. However, in some cases significant irradiation will not occur if the position of the radiation field is not proximal to the fetus/embryo.

If properly performed: Radiographic exams involving only films, with no CT or fluoroscopy, seldom give conceptus doses greater than 1 rad. Exams involving fluoroscopy may give conceptus doses up to 5 rad and, rarely, up to 10 rad.

The risks given in the "To the patient" information sheet at the end of these notes are based on a 1 rad conceptus dose "for most x-ray exams" and on a 5 rad conceptus dose "for some higher dose exams".

Finally, information on the effects of radiation on the conceptus:

The natural incidence of birth defects is approximately 3 to 6 birth defects per 100 births (3-6%).

The natural incidence of childhood cancer in 1 in 1500.

The primary effects of radiation on the conceptus are prenatal death, growth impairment, small head size, severe mental retardation, intellectual deficit, congenital malformations, and the induction of childhood cancer. We will look at each of these in turn.

Prenatal Death: The only untoward effect produced by radiation received by the conceptus before implantation in the uterus (which occurs about the 10th day post-conception) is radiation induced prenatal death (resorption). There are indications that this may occur at doses as low as 10 rad, but this level is generally beyond that received by the conceptus except in extraordinary circumstances.

Growth Impairment: Data from Hiroshima and Nagasaki indicate that this effect exists only for conceptus doses of 20 rad or greater. This is much greater than the radiation delivered in any diagnostic exam.

Small Head Size (Microcephaly), Severe Mental Retardation, and Intellectual Deficit: Data for these defects come principally from Hiroshima and Nagasaki. The data from Hiroshima seem to show an effect from radiation, while the data from Nagasaki shows *no effect* for conceptus doses below 100 rad. Therefore there is significant doubt whether the defects seen in Hiroshima below 100 rad were actually caused by the radiation exposure. If, however, we assume there is a radiation cause-effect relationship, then the following risks follow from the data: a risk of 1% per rad for microcephaly and 0.4% per rad for severe mental retardation for radiation received during the sensitive period described below. One further caveat for the risk of mental retardation: The latest studies suggest a threshold of 10 to 40 rad, below which there is no risk. If this is correct, *diagnostic studies would pose no risks.*

The possibility of radiation causing more minor intellectual deficits has also been studied. Here the same data from Hiroshima and Nagasaki has been used to estimate the loss in IQ scores due to radiation exposure. In this case the loss of IQ would average 0.2 to 0.3 points per rad of exposure to the conceptus during the sensitive period. At a conceptus dose of 5 rad, this would result in a loss of only 1 to 1.5 IQ points. And even this loss assumes that the threshold of 10 to 40 rad does not exist.

These effects were seen only during the most sensitive periods of development of the nervous system. For microcephaly the period at risk is 2 to 15 weeks post-conception (4 to 17 weeks post-LMP). For severe mental retardation and intellectual deficit the period at risk is 8 to 15 weeks post-conception (10 to 17 weeks post-LMP).

Congenital Malformations: There is no good evidence of congenital malformations in humans due to radiographic studies. There is some animal evidence of congenital malformations down to doses of 5 to 25 rad if the radiation is applied during the period of major organogenesis. This sensitive period in humans extends from about 2 to 8 weeks post-conception (4 to 10 weeks post-LMP). The animal data supports the conclusion that the risk to the human conceptus would be extremely small for doses below 10 rad.. Thus the risk from radiographic examination would be extremely small since it would be quite unusual for the conceptus dose to exceed 5 rad and rare for it to exceed 10 rad.

Induction of Childhood Cancer: Earlier studies in the 1970's indicated a correlation between radiation exposure *in utero* and increased incidence of childhood cancer. Later studies and re-analysis of the earlier studies indicate the possibility of a significantly lower risk. Using the original risk estimates, the risk is estimated to be about 1 in 2000 per rad (0.05% per rad). Even for conceptus dose of 5 rad, the risk would only be 1 in 400. In the past, some patients have been scared by the statement that this last risk represents a four to five-fold increase in the natural occurrence of childhood cancer, but this is an emotionally misleading statement since childhood cancer is quite uncommon (1 in 1500).

Conclusions: The radiation risks for conceptus doses below 10 rad is quite small and generally much less than the risk of NOT performing medically indicated procedures that cannot reasonably be postponed.

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