The Royal Australian and New Zealand College of Radiologists

Diagnostic Radiology and Pregnancy

Policy

1. Scope

This document discusses the effects of radiation on the fetus, and then provides some guidance to radiologists on the management of patients who are or may be pregnant. The primary objective is to prevent unwarranted radiation exposure of the fetus when medical diagnostic procedures are indicated during pregnancy.

2. Radiation dose specification[1]

There are several ways to quantify the dose of radiation to the body. Terms used include absorbed dose (Gy), equivalent dose (Sv) and effective dose (Sv). Dose levels in diagnostic radiology are usually recorded in mGy or mSv. For x-rays, the equivalent dose to an organ or tissue is numerically equal to the average absorbed dose to that organ or tissue. Effective dose is a weighted average of the equivalent doses to all the organs and tissues in the body, intended as a measure of the overall risk to the person from the radiation. In the pregnant patient it is the effective dose to the fetus which is important and this is approximately equal to the absorbed dose or equivalent dose to the patient's uterus.

3. The effects of ionising radiation on the fetus[2,3,4,7]

There are several phases of development during pregnancy. The terms conceptus or blastocyst are commonly used during the initial phase from conception or fertilisation to implantation. Implantation occurs during week 2 or 3 post conception. The term embryo is used during the main period of organogenesis which occurs from weeks 3 to 8, and the term fetus thereafter. In this document, for brevity, the term fetus is used to include all stages of development.

Fetal development is most accurately quantified as gestational age in weeks from the date of conception. However, since the date of conception is often unknown, in clinical obstetric practice, the duration of pregnancy is usually stated as the time from the date of the last menstrual period (LMP). There is therefore typically a two-week difference between these two methods of recoding fetal development. Sometimes fetal age is deduced from the size on ultrasound.

The effects of radiation are related to the fetal effective dose and to the stage of pregnancy. Post implantation, the main risks are induction of childhood cancer and leukaemia, as well as neurological effects[2,3].

3.1 Miscarriage or fetal death

Radiation doses of 100 – 500 mGy in the first few weeks after conception are associated with an increased risk of fetal death[3]. In animal studies high doses are associated with failure of implantation[3].

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3.2 Neurological effects

Nervous system abnormalities characterised by reduced IQ and a higher frequency of severe mental retardation, occur at high radiation doses. There is a non-linear dose-response relationship for neurological effects with a high frequency of abnormalities at radiation doses of 500 mSv to the brain with a lower rate of abnormalities at 100-200 mSv. There appears to be a threshold for neurological effects with no evidence of abnormalities at doses less than 100 mSv. Neurological effects mainly occur with irradiation between 8 and 25 weeks gestation with the highest risk during the 8 to15 week period[2,3].

3.3 Carcinogenesis

The epidemiological evidence for carcinogenesis comes mainly from studies of women who underwent abdominal irradiation or pelvimetry during the 1950s[4]. The largest study was the Oxford Survey of Childhood Cancers and that reported an increased rate of childhood cancer and leukaemia[5,6,7]. In recent reviews, Doll and Wakeford[5], and Wakeford and Little[6] conclude that doses of 10 mGy or higher to the fetus are likely to cause a small increase in the risk of childhood cancer and leukaemia. They state that the magnitude of the effect from the radiation is uncertain, but it is greater than zero and up to a possible maximum effect of 8% per Gy but probably closer to 6% per Gy. The NRPB[3] review of the data concludes that following fetal doses of 10 mGy or greater, the excess risk is 6% per Gy; i.e, the excess risk per mGy up to the age of 15 years, is estimated to be 1 in 17,000 for induction of cancer or leukaemia. The NRPB also estimates that the excess risk per mGy for death from cancer or leukaemia is 1 in 33,000[3]. For comparison, in the UK the baseline risk of cancer or leukaemia in the first 15 years of life is about 1 in 650 (0.15%)[3].

The risk of cancer induction for a given fetal effective dose is considered to be uniform throughout pregnancy after the first 3-4 weeks of gestation (5-6 weeks from LMP). There is some controversy about the relative risk in the first 3-4 weeks of gestation[3,5,7].

3.4 Genetic effects[3]

The risk of heritable effects from fetal irradiation is very low, being much lower than the risk of radiation induced carcinogenesis, and also very much lower than the natural risk of heritable disease[3]. The natural frequency of heritable disease manifesting at birth is 1%-3%, or 5%-6% if minor or uncertain congenital abnormalities are included.

3.5 Gonadal irradiation

Preconception irradiation of either parent's gonads has not been shown to result in increased cancer or malformations in their children[2].

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4. Doses from diagnostic radiological procedures[2,3,8]

Table 1 shows doses to the uterus from common diagnostic procedures, taken from recent UK surveys[3]. It should be noted that there can be considerable variation in the doses, depending upon the technical factors used during the investigation[2,3]. If the pelvis or abdomen is not in the direct beam the fetal dose is usually <1 mGy. If the pelvis is in the direct beam the fetal dose is higher, usually in the order of 1-10 mGy depending upon the procedure. Some radiological procedures such as interventional radiology, CT of the abdomen and pelvis, or prolonged fluoroscopy of the pelvis involve a much higher radiation dose to the fetus and consequently an increased risk. For instance, from a pelvic CT examination with the uterus in the field, the absorbed dose to the fetus is usually in the order of 10-40 mGy but it may be higher.

Table 1 Fetal doses from common diagnostic procedures; taken from UK survey of 1995[3].

	Fetal Dose (mGy)	
Examination/procedure	Mean	Maximum
Conventional x-ray		
Abdomen	1.4	4.2
Barium meal	1.1	5.8
Barium enema	6.8	24
Chest	<0.01	<0.01
IVP	1.7	10
Lumbar spine	1.7	10
Pelvis	1.1	4
Skull	<0.01	<0.01
Thoracic spine	<0.01	<0.01
Computed tomography		
Abdomen	8.0	49
Chest	0.06	0.96
Head	<0.005	<0.005
Pelvis	25	79
Pelvimetry	0.02	0.04

Note: Fetal doses cited are those assumed from estimates of uterine doses.

The dose to the fetus from mammography is negligible.

In Australia a survey was done in 1997 of radiation doses from CT[8]. It showed that for CT of the abdomen there was a wide distribution of doses to the uterus ranging from 1 mGy to 40 mGy with a mean of 7.1 mGy. The authors state that a large component of the spread of doses has come about because, depending upon technique, the uterus may have been fully, partially or not at all covered by the scan.

While it is often assumed that irradiation of the pelvis will result in a uniform radiation dose to the fetus, that is usually only true in early pregnancy. In the third trimester there may be significantly different doses to different parts of the fetus.

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If the specific radiation dose to the fetus needs to be determined, it is important to obtain an estimate of the actual dose delivered, rather than use a published mean fetal dose for a procedure. In this case a radiation medical physicist should be consulted.

The following sections provide guidance for the radiologist according to the status of pregnancy[2,3,6].

5. The pregnant patient [2,3].

5.1 Informed consent of the pregnant patient

The radiologist responsible for the radiological examination should take all reasonable steps to advise the pregnant patient of the potential risks of radiation exposure of the fetus. Similarly, the referring doctor should also advise the patient of the risks of radiation. This advice should be given before the examination is performed unless there are compelling practical reasons, such as in an emergency situation, when the advice has to be delayed until after the examination. In order to advise the pregnant patient, the radiologist responsible for the procedure must be familiar with the effects of ionising radiation on the fetus, be able to estimate the risks associated with the particular examination and be able to communicate the risks to the patient in a meaningful manner. For pregnant patients written informed consent is recommended if the pelvis is in the direct beam.

5.2 Justification and optimisation

The medical irradiation of pregnant patients must be justified on an individual basis.

Examinations that cause direct exposure of the abdomen or pelvis of a woman who is pregnant or likely to be pregnant should be avoided unless there are strong clinical indications for conducting such examinations. If the uterus is likely to be in a direct radiation beam from an x-ray procedure, consideration should be given to the use of other imaging modalities that involve non-ionising radiation such as ultrasound, to address the clinical problem. The referring doctor's input is very important as they will have the most information about the clinical importance of the diagnosis.

Depending upon the clinical problem, there may be good reasons to use ionising radiation for diagnostic purposes to enable optimal care for the mother and indirectly, potential benefit for the fetus. If a diagnostic radiological examination is medically indicated, the risk to the mother from not doing the procedure is usually greater than the risk of potential harm to the fetus. It is very unlikely that the fetal effective dose from diagnostic radiological procedures will exceed 100 mGy even if the uterus is in the direct beam. Most diagnostic radiological procedures pose no substantial risk to the mother or fetus compared to other risks throughout the pregnancy.

If it is decided that an x-ray procedure is necessary in a woman who is pregnant and the uterus is going to be in the direct beam, the technical factors for the procedure must be optimised to minimise the radiation dose to the fetus. The technical details must be recorded to enable a medical imaging physicist to estimate the dose received by the fetus.

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If the fetal dose will be <1 mGy from the procedure, the examination can proceed normally. This can only be assumed to be the case for x-ray examinations of areas of the body remote from the lower abdomen[3].

6. Procedure if the fetus has been inadvertently irradiated[2,3]

If the uterus was in the direct beam of a high dose procedure, the dose received by the fetus from the procedure must be determined by a medical imaging physicist.

The patient must also be questioned about any other radiological or nuclear medicine procedures that may have taken place during gestation.

The risk to the fetus from the radiation doses must be assessed.

The patient must be informed about the magnitude of the radiation dose to the fetus and counselled about any potential risks from that dose. It is usually appropriate that such counselling be done in conjunction with the patient's obstetrician.

The referrer should not, on purely dosimetric considerations, recommend termination of the pregnancy at a fetal dose of less than 100 mGy[3].

7. Procedures to avoid unintentional or unnecessary irradiation of the fetus[2,3]

The referrer should question a female patient of child-bearing age regarding the possibility of her being pregnant.

Illustrated signs must be posted in prominent places such as waiting rooms within the radiology department advising patients to notify staff if they are pregnant. For example such a notice might read:

"If it is possible that you might be pregnant, notify the radiographer or other staff before you have the x-ray examination."

Prior to an x-ray procedure being performed, all female patients of child-bearing age must be questioned by the operator regarding the possibility of being pregnant, and the patient's response should be recorded.

As a means of avoiding unintentional irradiation of a fetus, in the early 1970s some authorities recommended that women of childbearing age who were having routine radiological procedures should have the x-rays done during the first two weeks of the menstrual cycle and not in the latter part of the menstrual cycle. That recommendation became known as the "ten-day rule". By the 1980s it was recognised that that recommendation was unnecessary[9].

It is now recommended that all patients be booked routinely. If there is concern about a particular patient when they attend, a decision regarding the appropriate course of action is made then, based on the recommendations below.

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The following recommendations depend upon the radiation dose to the uterus from the planned procedure and upon an assessment of the presence or absence of pregnancy[3]:

7.1 No possibility of pregnancy

If there is no possibility of pregnancy, for instance the last menstrual period was within ten days, proceed with the examination.

7.2 Pregnant patient

See discussion in section 5.

7.3 Pregnancy possible and unable to be confidently excluded

This group includes patients where the menstrual period is overdue, those who are in the latter part of the normal menstrual cycle, or who have irregular periods.

The radiologist then needs to assess the potential dose to the uterus from the procedure, which is mainly determined by whether the uterus is in the primary beam. It is helpful to have knowledge of the magnitude of doses from procedures in individual departments.

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7.3.1 Low dose (<1 mGy) to the uterus

If the pelvis or abdomen is not in the direct beam the dose to the uterus is likely to be < 1 mGy. Proceed normally with the examination provided it is justified in the usual way. For example, plain radiography of the extremities, chest or skull gives doses of <1 mGy to the uterus (see table 1).

7.3.2 Moderate dose (1-10 mGy) to the uterus

The risk of harm from this dose of radiation to a fetus is extremely low.

In such cases it is important to review the probability of pregnancy, the clinical indications for the test, and the details of the procedure to be undertaken. Usually a decision is made to proceed with the test, particularly if the only concern is that the patient is in the latter part of the menstrual cycle. The radiologist should take particular care to ensure that the procedure uses the lowest radiation dose that will provide the required diagnostic information. The technical details of the exposure need to be recorded to enable doses to be calculated subsequently.

7.3.3 High dose (>10 mGy) to the uterus

The most common radiological procedure that delivers high doses to the uterus is CT of the pelvis. However, some fluoroscopic, barium and IVP contrast studies also can give doses of this magnitude.

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Where practicable, procedures that give doses of the order of >10 mGy to the uterus should be avoided if there is a possibility of pregnancy and the pregnancy status is unknown or uncertain.

When a patient attends a radiology department to have a high uterine dose procedure, a decision needs to be made by the radiologist about whether to defer the procedure until a time when pregnancy can be confidently excluded, or to perform biochemical pregnancy testing with serum HCG, or to proceed with the study. In such cases it is important to review the probability of pregnancy, the clinical indications for the test, and the details of the procedure to be undertaken. It should be remembered that delaying an essential diagnostic procedure until later in pregnancy may present a greater risk to the fetus than performing the procedure during the period of unknown pregnancy status[2]. The amount of discussion with the patient about the effects of radiation depends upon the particular circumstances. If a decision is made to proceed, the radiologist should take particular care to ensure that the procedure uses the lowest radiation dose that will provide the required diagnostic information. The technical details of the exposure need to be recorded to enable doses to be calculated subsequently.

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November 2005
Adopted by Council: November 2005

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