Exposure to Ionising Radiation And Pregnancy

The exposure of pregnant women to ionising radiation is often a source of concern and provokes many questions. This anxiety is often unjustified and the questions are asked too late. Ignorance of the subject is likely to harm the woman who requires investigative imaging (chest CT scan or lung scan should be performed even in early pregnancy with suspected pulmonary embolism) or lead to inappropriate attitudes to accept or offer a medical termination of pregnancy after low-level exposure to ionising radiation. It is important to review the key elements of the effects of ionising radiation on the embryo and foetus, the doses received during diagnostic investigations and the attitude to adopt in the main clinical situations.

The Effects of Ionising Radiation on the Embryo and Foetus

The deterministic and stochastic effects should be discussed. The deterministic effect to consider is the teratogenic risk and the stochastic effect is the risk of cancer for an unborn child.

1. Teratogenic Risk

Like any deterministic effect, it only appears if a threshold is crossed. The peculiarity of the exhibition is the variable sensitivity of the embryo and foetus during pregnancy. During the first week postconception effect responds to the law of all or nothing because, at this stage, all the cells are not yet differentiated and are totipotent. Either too many cells die and the embryo will not develop, or there are some cells destroyed and the embryo will develop normally.

During the phase of organogenesis (day nine to the ninth week after conception), the death of cells undergoing differentiation will not stop pregnancy, but will stop the development of an organ or a limb. The threshold is set at 100 mGy. Beyond the ninth week, the risk of malformation is gradually reduced as most of the tissue is then differentiated. The organ most sensitive at this age is the brain. Indeed, the process of neuronal migration continues until the 15th week. Disruption of neuronal migration may be responsible for malformation or mental retardation. The threshold for mental retardation is 200 mGy. Accountability of exposure to ionising radiation on the risk of malformation or mental retardation associated with exposure is in practice difficult to assess as the risk for spontaneous malformation or mental retardation is high, estimated at three percent of pregnancies.
2. The Risk of Developing Cancer After Exposure to Ionising Radiation

It is a stochastic risk related to changes in DNA without cell death. Like any stochastic risk, it is random without threshold and increases with dose. Prenatal carcinogenic effects of radiation are assumed to be the same as for children. The increased risk of cancer is estimated at 0.05 percent for 10 mGy received in utero. This figure should be compared to the spontaneous incidence of cancer risk in children, which is 0.25 percent (between birth and 15 years). Monitoring populations exposed to radiation in utero in Hiroshima and Nagasaki did not show an increase in the incidence of cancer. Data from the literature is often contradictory. In 1988 Bithell performed a meta-analysis and found an increased risk of cancer by 40% after exposure to ionising radiation (Bithell 1988). A meta-analysis published in 2008 did not find an increased risk of leukaemia or cancer associated with exposure to ionising radiation for prenatal diagnosis (Schulze-Rath et al. 2008). Cautiously, the authors concluded that their results do not invalidate the previous findings.

From scientific uncertainty derives a rule of prudence, which is limited to what is medically necessary and to optimise the technique of the medical examination to allow for high-quality diagnostic radiation at the lowest cost.

What to Know and Do in Practice

The International Commission on Radiological Protection (ICRP) 103(3) states that the prenatal doses from most correctly performed diagnostic procedures do not cause a measurable increase in the risk of prenatal or postnatal death or damage during development, including malformations or mental retardation compared with normal incidence of these diseases (IRSN 2009). The risk of cancer on life after in utero exposure is assumed to be similar to that after radiation exposure in infancy. Higher doses, especially those involved in therapeutic procedures may cause a poor development. It also specifies the rules to be followed in case of pregnancy.

French law is also very clear. Article R.1333-61 of the Code of Public Health says: "When the exposure to ionising radiation concerns a woman of childbearing age, the requesting physician and the physician performing the procedure must investigate possible pregnancy. If the woman is pregnant or nursing, or if the possibility of pregnancy cannot be excluded, special attention should be paid by each of them on the justification of the act. This must be ensured taking into account the urgency of the situation and the exposure for the woman and her unborn child. If, after justification, exposure by radionuclides occurs in a woman while pregnant or breastfeeding, or if the possibility of pregnancy cannot be excluded, the optimisation of the act reflects this condition."

Concerning radiotherapy and interventional procedures on the abdomen, ICRP 103 states that with pregnant patients, cancers unrelated to the pelvis can usually be treated with radiotherapy: "This, however, requires special attention to treatment planning. The expected radiation dose to the embryo / foetus, including the component of scattered radiation, must be estimated. Cancer in the pelvis can rarely be properly treated by radiotherapy during pregnancy without serious or lethal consequences for the embryo / foetus" (IRSN 2009).

In current practice, in the absence of the late rule, examinations can be performed after checking the justification of the act. The ten day rule is clearly abandoned. If the woman is pregnant, you should check that the act is justified, cannot be postponed until after pregnancy and cannot be substituted by a non-radiating technique. The examination will be conducted using the least radiating technique as possible to establish a reliable diagnosis. If an examination was performed in a pregnant woman without knowing her condition, the radiologist or nuclear physician must meet with the parents and give them all the information. It should be reassuring if the examination did not involve the abdomen because the dose to the foetus is probably less than 100 mGy and usually less than 1 mGy. However, it is necessary to explain to parents that there is a natural exposure to ionising radiation, and the incidence of spontaneous malformations in the population, in the absence of radiation exposure other than natural exposure, is about three percent. Mental retardation (IQ <70)
was also observed spontaneously in three percent of children.

If the examination concerns the abdomen, the dose to the foetus is usually less than 10 mGy if the review did not include more than four effects and less than a minute of fluoroscopy. A dose calculation is not deemed necessary. There is no increased risk of malformation and a very slight increase in cancer risk. It must be noted that in 1000 children born to unexposed pregnancies, 997 children will not be affected by cancer before the age of 19. In case of exposure of 10 mGy, this number is 996. This excess risk is very low and does not warrant medical termination of pregnancy.

For contrast radiology and CT examinations concerning the abdomen and pelvis, the dose received by the foetus in a single pass is less than 50 mGy. However, it is highly recommended to request an assessment of the dose received by the foetus from the medical radiophysicist at the establishment or the national institute for radiological protection and nuclear safety (in France, the IRSN –Institut de Radioprotection et de Sûrété Nucléaire -Institute for Radiological Protection and Nuclear Safety). The risk of malformations is not increased and in 1000 children, 994 will not be affected by cancer before the age of 19. The ICRP reminds that a dose absorbed by the embryo or foetus below 100 mGy should not be considered a reason to terminate the pregnancy.

For CT scans with several passes on the pelvis, a precise calculation of dose is necessary because the dose received by the foetus can exceed 100 mGy. The ICRP recalls that terminating a pregnancy because of radiation exposure is an individual decision that takes into account many factors. The pregnant patient should receive sufficient information to make a decision knowingly based on individual conditions, which include the estimated level of the dose to the embryo or foetus and the risk of serious harm that results to the embryo/foetus and the risk of cancer in later life.

Special Provisions for Pregnant or Breastfeeding Women and Working conditions

Concerning occupational radiation protection, the regulations state that the exposure to the unborn child should be as low as possible (Article D. 4152-5 of the French Labour Code). The unborn child is considered by regulators as a member of the public. Its exposure should not reach 1 millisievert (mSv) for the period between the declaration of pregnancy and childbirth. Pregnant women cannot be assigned to positions requiring classification in Category A (they should receive doses below 6 mSv/a). Finally, breastfeeding women cannot be assigned to a position involving the risk of internal exposure.

Conclusion

In conclusion, the rules of good practice are systematic questioning of women of childbearing age, justification and optimisation to help avoid difficult situations. Good knowledge of the effects of ionising radiation allows medical professionals to act professionally and responsibly. We must never forget to provide parents with fair and reliable information.

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Published on : Fri, 15 Mar 2013

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