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A Review on the Effect of Radiation in Pregnant Women

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Abstract

The effects of ionizing radiation on the fetus, the prenatal period, parental exposure, the pregnant clinician, and the pregnant patient are discussed in the context of their exposure to radiation. Seasons and Vitamin D are factors that are directly and indirectly related to Ultra Violet (UV) radiations and can affect pregnancy. The potential biological effects of in utero radiation exposure of a developing fetus include prenatal death, restriction, small head size, mental retardation, organ malformation and childhood cancer. The risk of each effect depends on the gestational age at the time of exposure, fetal cellular repair mechanisms, and the absorbed radiation dose level. A comparison between the dose levels associated with each of these risks and the estimated fetal doses from typical radiologic examinations lends support to the conclusion that fetal risks are minimal and, therefore, that radiologic and nuclear medicine examinations that may provide significant diagnostic information should not be withheld from pregnant women. However, although the risks are small, it is important to ensure that radiation doses are kept as low as reasonably achievable.

Keywords: Ionizing radiation; Biological effects; Pregnancy

Introduction

The transmission or emission of energy in the form of waves or particles through space or through a material medium is termed as radiation [1]. Radiation is often classified as ionizing or non-ionizing depending on the energy of the radiated particles. Ionizing radiation carries more than 10 eV, which is enough to ionize atoms and molecules, and also break chemical bonds . This is an essential distinction due to the huge difference in harmfulness to living organisms. A common source of ionizing radiation is the radioactive materials that produce α, β, or γ radiation, consisting of helium nuclei, electrons or positrons and photons, respectively. Other sources include Xrays from medical radiography examinations and muons, positrons, neutrons, mesons and other particles that makes the secondary cosmic rays which are produced after primary cosmic rays interact with the earth's atmosphere. X-rays, Gamma rays and the higher energy range of ultraviolet light constitute the ionizing part of the electromagnetic spectrum. The word "ionize" refers to the breaking of one or more electrons away from an atom, an action that requires the relatively high energies that these electromagnetic waves supply.

Further down the spectrum, the non-ionizing lower energies of the lower ultraviolet spectrum cannot ionize atoms, but can disrupt the inter-atomic bonds which form molecules, thereby breaking down molecules rather than atoms, a good example of this is sunburn caused by long-wavelength solar ultraviolet. The waves of longer wavelength than UV in able to be seen light, infrared and microwave frequencies cannot break bonds but can origin vibrations in the bonds which are sensed as heat. Radio wavelengths and below generally are not regarded as harmful to biological systems. These are not sharp delineations of the energies, there is some overlap in the effects of specific frequencies [2]. During pregnancy the radiation exposure is a health concern for both the mother and her unborn child. The exposure in utero to ionizing radiation can be quite different, ranging from low-dose/dose-rate exposures (such as diagnostic radiography) to very high-dose/dose-rate exposures (such as the bombings of Hiroshima and Nagasaki). Other factors, counting the timing of exposure (with respect to gestational age of the developing offspring), the type of radiation and the route of exposure, must also be measured when evaluate the risk. An emerging area of concern is the potential for long-term effects on children due to prenatal radiation exposure. There are significant proofs that are supporting the thought of developmental programming. The change in offspring phenotype or body processes due to an insult experienced in utero [3,4].

Even though a variety of triggers have been known, for example the exposure of an external stressor to the mother (i.e, hypoxia) or poor intrauterine environment (i.e, due to malnutrition), the concept of developmental programing centers around the mother experiencing stress, and developing fetus challenge to adapt to the stress due to move across the placenta [5].

Effects of Ionising Radiation

Much and more of our information concerning the outcome of radiation on humans has come from study of the atomic bomb survivors who were irradiated with the high doses while in utero in Nagasaki and Hiroshima in Japan [6]. Ionising radiation can lead to deterministic effects, for which there is a threshold dose below which clinically apparent effects are not observed. The severe effect of high dose is threshold [5,7]. There effects include lethal effect (miscarriage) diminished cell division (fetal growth restriction); mental injury and microcephaly and teratogenic effects (fetal malformation). On the other hand, stochastic effects of radiation are those which have their origins in the probability of induction of damage to single cells in tissues, for which there is believed to be no dose threshold. These effects include mutogenic and carcinogenic effect. All these effects are related to the stage of pregnancy. The commonly teratogenic effects of exposure to high dose radiation are the central nervous system changes. The risk of microcephaly and the severe mental retardation with high exposure begins at 10 weeks of gestation.

This risk is greatest at 10-17 weeks, with less risk at 18-27 weeks. There is no proven risk before 10 weeks or after 27 weeks even with doses exceeding 500 mG [8]. Additionally, a non-threshold, linear, dose-related association between the severe mental retardation and radiation has been found following exposure during weeks 10-17 of gestation [9,10]. So that even very low doses cause a slight increase in mental retardation incidence. This trend reaches 40% at 100 rad (1000 mGy), while it is not statistically significant at doses produce by diagnostic radiographs (Hall, 1991). Nevertheless, until more data are available delineating potential fetal risk, it is prudent to delay non-urgent radiographs during the sensitive period of 10-17 weeks of gestation. The accepted background cumulative dose of ionising radiation during pregnancy is 5 rad (50 mGy), which is much more than the exposure dose of most of the diagnostic radiological examinations [11]. Current evidence suggests that there is no increased risk of major malformations, growth restriction or miscarriage from radiation doses of 5 rad (50 mGy), compared with the background risks in non-exposed foet uses, which are 3%, 4%, and 15% respectively [12]. There is also evidence that gross congenital malformations would not be increased in a human pregnant population exposed to a dose of 20 rad (200mGy), which is considered the threshold dose [13,14]. A dose of 250 mGy may be associated with a0. 1% risk of fetal malformation [15]. However, the microcephaly, microphthalmia, genital and skeletal malformations, cataracts and small for gestational age have been clearly experienced in human embryos and fetuses exposed to 1000 mGy [5].

Prenatal Exposure to Ionizing Radiation in Humans

One of the most common uses of ionizing radiation is in the field of medical radiography and nuclear medicine. There are reports of rough estimates for various diagnostic procedures; there are a number of factors to consider, such as the timing of exposure in pregnancy. (Winer,2002) reported a greater average fetal absorbed dose of helical computed tomography scans in the third trimester relative to the second trimester. The dose delivered to the fetus from the majority of diagnostic nuclear medicine procedure exposures is often well below the threshold dose for deterministic effects [16]. Therefore, the major area of perceived risk from prenatal diagnostic radiation exposure is excess cancer risk. Since the 1950s, a large number of case-control and cohort studies have been conducted on exposure in utero from diagnostic imaging procedures. The results of these studies are inconclusive as to whether prenatal exposure results in increased cancer risk. These studies have been previously reviewed by Boice and Miller [17,18]. Available data on prenatal exposure to high doses is predominantly from studies on the survivors of the Hiroshima and Nagasaki atomic bombings who were pregnant at the time of exposure. The maximum consent regarding effects from prenatal exposures at these high doses are reports of microcephaly and mental impairments. Microcephaly, defined as a head edge of 2 or more standard deviations below the average for a given age and gender, was observed in 62 children exposed in utero to the Hiroshima atomic bomb 4.21% of a total of 1,473 who were irradiated prenatally and whose head edge was measured between 9 and 19 weeks of age [19].

A greater proportion of children presenting with microcephaly were irradiated in the first (55%) or second (31%) trimester with Miller (27) reporting only a single case of microcephaly later in gestation (between 26 and 40 weeks of gestation at a distance of 1201-1500 m from the hypocenter), which may suggest a more resistant period later in development [19]. There does not appear to be a clear association between reduced head size and reports of reduced IQ scores. The mean IQ scores of cases who were assessed and clinically identified to be mentally retarded with or without microcephaly were 63.8 and 68.9, respectively, with no considerable difference between these two groups. Both the groups evaluate with mental retardation (with or without additional microcephaly) had significantly lower IQ scores compared to cases of children with reduced head size but not assessed with mental retardation [19]. It is reported no significant increases in the incidences of stillbirth, preterm births, low birth weight, congenital malformations and neonatal death during the first year of the offspring's life in women treated with 131I radioiodine therapy. This was reported even in rare cases in which the total dose delivered to the ovaries can be on the scale of 140 to upwards of 1,000 mGy.

Conceptus Effects from Radiation Exposure

Data concerning the likely biological effects on the conceptus after in utero radiation exposure are based on the results of animal studies and human exposures. The primary sources of human data are studies of the 1945 atomic bomb survivors from Hiroshima and Nagasaki, a group that includes approximately 2800 pregnant women who were exposed to radiation, 500 of whom received a conceptus dose of more than 10 mGy [1].

The potential effects of radiation on a conceptus include prenatal death, small head size, severe mental retardation, reduced intelligence proportion, organ malformation, and childhood cancer. These effects depend on the radiation dose to the conceptus and the stage of conceptus development at which the exposure occurs [3].

Radiography and Fluoroscopy

If the uterus is located outside the field of view, higher conceptus dose values occur when the uterus is positioned within the field of view. In this case, the radiation dose to a conceptus from a radiographic or fluoroscopic examination depends on the thickness of the patient (ie, the amount of tissue the x-ray beam must penetrate), the direction of the projection (antero-posterior, postero-anterior, or lateral), the depth of the conceptus from the skin surface, and x-ray technique factors.

Computed Tomography

Computed Tomography (CT) is associated with higher levels of radiation exposure than is radiography. Some CT scanner vendors have introduced automated exposure control capabilities that provide real-time x-ray tube current accent based on the tissue attenuation. Such mechanisms help minimize the radiation dose delivered to a patient with a small body habitus, and hence to the conceptus, by preventing unjustly high tube current settings. In large patients, the radiation dose is increased to ensure enough image quality, yet much of the additional x-ray dose is absorbed by the additional adipose tissue [20].

Thus, doses to internal organs do not increase linearly with increases in tube current settings [9]. Monte Carlo simulations indicate that an increase of the scanner output by a factor of two in very large patients (weight, approximately 100 kg; lateral thickness, 50 cm or less) results in an increase of only 25% in the effective dose. This is because the effective dose is strongly dependent on the dose delivered to internal organs [6]. The CT projection radiograph is required for most preset introduction control implementations, as an aid in the initial selection of tube voltage and current settings before scanning. At CT, lead defensive of the abdomen and pelvis may be used if it will not interfere with the scan field, although the dose from external scattered radiation is minimal [21].

Nuclear Medicine and Radiography

The dose to the conceptus from radionuclide examinations is variable and depends principally on factors related to maternal uptake and excretion of the radiopharmaceutical, passage of the agent across the placenta, and uptake in the conceptus. Radiotherapy during pregnancy might cause harm to the developing fetus. Generally, pregnant women are advised with malignant disease to delay radiotherapy until after delivery. In general, the expected radiation effects, such as mental retardation and organ malformations probably only arise above a threshold dose of 0.1-0.2 Gy [22-24].

This threshold dose is not generally reached with healing radiotherapy during pregnancy, provided that tumours are located sufficiently far from the fetus and that precautions have been taken to protect the unborn child against leakage radiation and collimator scatter of the tele-therapy machine; such protection also reduce the risk of radiation-induced childhood cancer and leukaemia in the unborn child. This first measurement is called exposure and its unit is the Roentgen (R). Once the exposure and the nature of the radiation beam is known, it is possible to calculate the energy absorbed in tissue. This quantity is called the absorbed dose and is stated in terms of energy absorbed per gram of tissue, similar to the pharmacologic concept concentration [25-28].

Conclusion

It is concluded that the health effects from radiation to a fetus exposure mostly depend on the radiation dose and gestational age. The radiation exposure to fetus may raise the risk of cancer and other disease in the offspring, particularly at radiation doses>0.1 Gy, that are well above typical doses received in the diagnostic radiology. In humans the exposure to low doses of radiations during pregnancy is often a concern due to well-known detrimental effects at high doses. In humans the majority of medical exposures are low-dose exposures and their effects are mostly related to developmental program and other changes in offspring phenotype are important to consider when evaluating the risk to the fetus. The lifespan study of the Japanese A-bomb survivors is continuing as the cohort ages. Future analyses of the accumulating data should provide a better understanding of the lifetime risk of cancer and other diseases from the prenatal and early childhood radiation exposure.

References

1. Weisstein, Eric W (2014) Radiation. Eric Weisstein's World of Physics: Wolfram Research.
2. (2014) Radiation. The Free Dictionary by Farlex. Farlex, Inc.
3. Barker DJ, Godfrey KM, Gluckman PD, Harding JE, Owens JA, et al. (1993) Fetal Nutrition and Cardiovascular Disease in Adult Life. The Lancet 341:938-941.
4. Reynolds LP, Borowicz PP, Caton JS, Vonnahme KA, Luther JS, et al. (2010) Developmental Programming: The Concept, Large Animal Models and the Key Role of Uteroplacental Vascular Development. J Animal Sci 88:e61-e72.
5. Kusama T, Ota K (2002) Radiological Protection for Diagnostic Examination of Pregnant Women. Congenital Anomalies 42:10-14.
6. Yamazaki JN, Schull WJ (1990) Perinatal Loss and Neurological Abnormalities among Children of the Atomic Bomb: Nagasaki and Hiroshima revisited, 1949 to 1989. JAMA 264:605-609.
7. Brent RL (2006) Counseling Patients Exposed to Ionizing Radiation During Pregnancy. Pan Am J Public Health 20:198-204.
8. (1990) Committee on Biological Effects of Ionizing Radiation, National Research Council. Other Somatic and Fetal Effects. In: Beir V (Eds) Effect of Exposure to Low Levels of Ionizing Radiation. (Edn), National Academy Press,Washington, DC.
9. Otake M, Schull WJ (1984) In Utero Exposure to A-Bomb Radiation and Mental Retardation: A Reassessment. British J Radiol 57:409-414.
10. Hall EJ (1991) Scientific View of Low-Level Radiation Risks. Radiographics 11:509-518.
11. Brent RL (1986) The Effects of Embryonic and Fetal Exposure to X-ray, Microwaves and Ultrasound. Clin Perinatol 13:615-648.
12. Brent RL (1999) Utilization of Developmental Basic Science Principles in the Evaluation of Reproductive Risks from Pre and Postconception Environmental Radiation Exposures. Teratology 59:182-204.
13. Miller RW (1990) Effects of Prenatal Exposure to Ionizing Radiation. Health Physics 59:57-61.
14. Robert S, Soutter P, Stanton S (2003) In: BuckettW, Regan L (eds) Gynaecology. Sporadic and Recurrent Miscarriage. (Edn), 3rd edn. London: Churchill Livingstone, p. 346.
15. Doll R, Wakeford R (1997) Risk of Childhood Cancer from Fetal Irradiation. British J Radiol. 70:130-139.
16. Steenvoorde P, Pauwels EK, Harding LK, Bourguignon M, Marière B, et al. (1998) Diagnostic Nuclear Medicine and Risk for the Fetus. Europ J Nuc Med. 25:193-199.
17. Boice Jr JD, Miller RW (1999) Childhood and Adult Cancer after Intrauterine Exposure to Ionizing Radiation. Teratology 59:227-233.
18. Brent RL (2015) Protection of the Gametes Embryo/Fetus from Prenatal Radiation Exposure. Health physics 108:242-274.
19. Otake M, Schull WJ (1993) Radiation-Related Small Head Sizes among Prenatally Exposed A-Bomb Survivors. Inte J Radiat Biol 63:255-270.
20. (2015) The Electromagnetic Spectrum. Centers for Disease Control and Prevention.
21. Blot WJ, Miller RW (1973) Mental Retardation Following in Utero Exposure to the Atomic Bombs of Hiroshima and Nagasaki. Radiology 106:617-619.
22. Brent RL (1989) The Effect of Embryonic and Fetal Exposure to X-ray, Microwaves and Ultrasound: Counseling the Pregnant and Non-Pregnant Patient About These Risks. Seminar Oncol 16:347-368.
23. Garsi JP, Schlumberger M, Rubino C, Ricard M, Labbé M, et al. (2008) Therapeutic Administration of 131I for Differentiated Thyroid Cancer: Radiation Dose to Ovaries and Outcome of Pregnancies. J Nuc Med. 49:845-852.
24. Miller RW (1956) Delayed Effects Occurring within the First Decade after Exposure of Young Individuals to the Hiroshima Atomic Bomb. Pediatrics 18:1-8.
25. Mulder EJ, De Medina PR, Huizink AC, Van den Bergh BR, Buitelaar JK, et al. (2002) Prenatal Maternal Stress: Effects on Pregnancy and the (unborn) Child. Early Human Development 70:3-14.
26. Osei EK, Faulkner K (1999) Fetal Doses from Radiological Examinations. British J Radiol 72:773-780.
27. Wakeford R, Little MP (2003) Risk Coefficients for Childhood Cancer After Intrauterine Irradiation: A Review. Inte J Radiat Biol 79:293-309.
28. Winer-Muram HT, Boone JM, Brown HL, Jennings SG, Mabie WC, et al. (2002) Pulmonary Embolism in Pregnant Patients: Fetal Radiation Dose with Helical CT. Radiology 224:487-492.