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Radiation Exposure In Pregnancy

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Introduction

Choosing the most appropriate imaging modality for pregnancy patients is a common clinical question encountered daily. The general principle for imaging during pregnancy is similar to imaging for the general population, with the goal of radiation exposure being as low as reasonably achievable (ALARA). What is unique during pregnancy is that fetus radiation exposure is an essential factor in deciding optimal imaging studies. Understanding of consequences of radiation exposure on a fetus, degrees of fetal radiation exposure by each imaging modality, and techniques on reducing fetal radiation exposure is vital in choosing the best diagnostic imaging modality. While it is crucial to minimize fetal radiation exposure as much as possible, it is essential to remember that diagnostic studies should not be avoided for fear of radiation exposure, especially when these studies can dramatically change patient management. This activity will discuss the consequences of radiation exposure on a fetus, degrees of radiation exposure by each modality, and techniques of reducing fetal radiation exposure. Solid understanding of how each imaging modality contributes to fetal radiation dose will significantly help in choosing the most appropriate imaging study that provides the best diagnostic information at the lowest level of radiation exposure.

The consequence of radiation exposure in fetuses is mostly based on observations rather than based on scientific research. Ethical issues prohibit researching on the fetus. Therefore, most of the data on the impact of radiation on the fetus derives from observations of patients who suffered Japan's Hiroshima bombing and the Chernobyl nuclear power plant disaster.[1] [2] Based on the observations made from the victims of the high level of radiation exposure, the consequences of radiation exposure can categorize into four broad groups, including pregnancy loss, malformation, developmental delay or retardation, and carcinogenesis.[1] Pregnancy loss most often happens when radiation exposure happens during early gestation (less than two weeks).[2] Malformations of body parts and developmental delays occur during the organogenesis period (2 weeks to 8 weeks) and are dependent on the radiation dose.[2] Below the threshold level of radiation exposure, there is minimal disruption of organogenesis. Above the threshold, the degree of malformation is related to the dose of the radiation. Lastly, carcinogenesis is considered a stochastic effect. In other words, cancer can develop at any level of radiation exposure. However, the probability of developing cancer increases with the increase in the dose of radiation.

In the United States, the background radiation exposure for the whole body per year is estimated to be 3.1 mSv (310 mrem). United States Nuclear Regulation Commission (USNRC) also recommends total fetus exposure during pregnancy to be less than 5.0 mSv (500 mrem). The fetus radiation dose below 50 mGy is considered safe and not cause any harm. According to the Center for Disease Control (CDC), radiation dose between 50 mGy to 100 mGy is regarded inconclusive in terms of impact on the fetus. Doses above 100 mGy, especially doses above 150 mGy, are viewed as the minimum amount of dosage at which negative fetal consequences will occur, based on observation. The majority of the diagnostic studies performed during the pregnancy are below the threshold level.

The effect of radiation exposure during pregnancy also depends on the gestational age of the fetus. The embryo/fetus is most susceptible to radiation during organogenesis (2 to 7 weeks gestational age) and in the first trimester. The fetus is more resistant to the radiation during the second and third trimester. Dose between 0.05 to 0.5 Gy is generally considered safe for the fetus during the second and third trimester while it is considered potentially harmful during the 1st-trimester fetus. Even though the fetus is more resistant to the radiation during the second and third trimester, a high dose of radiation (greater than 0.5 Gy or 50 rad) may result in adverse effects including miscarriage, growth reduction, IQ reduction, and severe mental retardation. Therefore, clinicians and radiologists should counsel the pregnant patient regardless of the gestational age.[3]

Occupational radiation exposure for a pregnant employee should be monitored to make sure the total amount of radiation exposure is under the regulatory limit. According to the National Council of Radiation Protection and Measurement (NCRP), the total dose equivalent to the embryo/fetus should not exceed 500 mRem during the length of the pregnancy. It should not exceed 50mRem in any month during pregnancy.[4]

The practice decision on selecting the most appropriate imaging modality for pregnancy should have their basis in the expert opinions of the treating clinician. Nonetheless, the American College of Radiology does provide recommendations on the appropriateness of imaging modalities in accessing common clinical conditions. Each imaging modality is categories into usually appropriate, may be appropriate, and usually not appropriate. For instance, for a pregnant patient presenting with right lower abdominal pain concerning for appendicitis, ultrasound and MRI are usually appropriate imaging modality. CT abdomen and pelvis with or without contrast is categorized as may be appropriate. Abdominal radiograph, Tc-99m WBC scan, and fluoroscopy contrast enema are considered usually not appropriate. The American College of Radiology appropriateness criteria provides the current practice policies and guidelines in the US regarding imaging in pregnant patients.

Anatomy

Understanding the anatomic location of the uterus is essential in understanding why a particular type of study contributes to a higher radiation dose. The uterus is located within the female pelvis. Therefore, studies that are further away from the pelvis contribute to less radiation dose than the studies that aim at the pelvis. Additionally, the uterus is located superior and anterior aspect of the pelvis during the pregnancy. X-ray beams that project in a posterior to anterior (PA) direction contribute to less radiation than the beam projected in anterior to posterior (AP) direction because, in PA projection, the X-ray gets attenuated before reaching anteriorly located uterus.

Plain Films

A single plain radiograph does not contribute to a significant radiation dose to the fetus. The estimated radiation dose to the fetus varies and ranges from 0.001 mGy to 10 mGy depending on the type of the study.[5] The highest radiation dose is the lumbar spine radiograph, which has a maximal fetal radiation dose of 10 mGy.[5] Nonetheless, even fetus radiation exposure for the lumbar spine radiograph is significantly lower than the threshold limit of the safe radiation exposure dose of 50 mGy, radiation level that is considered safe and without significant harm.

Regardless of the radiation dose, it is vital to reduce radiation exposure to the fetus as much as possible. Plain films are obtained more frequently than computed tomography (CT), and radiation doses from multiple plains films can easily accumulate. Therefore, it is essential to employee dose reducing techniques as often as possible. When performing plain film examination of non-pelvis structure, pelvic lead apron should always be utilized to reduced unnecessary fetus radiation. PA projection of the pelvis also contributes to the lower dose than the AP projection. Technologists should optimally position patients before taking a radiograph to reduce the number of repeat examinations from unsatisfactory views. Lastly, clinicians should obtain radiographs only when it is helping clinical management.

Computed Tomography

On the other hand, CT contributes to a significant amount of fetal radiation. The amount of fetus radiation exposure again varies by the type of study with CT pelvis contributing the highest amount of fetal radiation of 50 mGy.[5] This dose is right at the limit above which there is a documented negative impact to the fetus.

Because CT contributes to much higher fetal radiation, it is essential always to be considerate of other options when contemplating utilizing CT on pregnancy patients. Other imaging modalities, including MRI, plain radiograph, ultrasound, and nuclear medicine studies, should be considered first before performing CT. Common clinical presentations like appendicitis first require evaluation with MRI instead of CT.[6] Right upper quadrant ultrasound should be utilized if there is a clinical concern for cholecystitis.[7] Renal ultrasound should merit consideration before CT for nephrolithiasis and collecting system obstruction. If CT is the first indicate study of choice as in traumatic pregnancy patients to evaluate for intra-abdominal trauma, it is crucial to optimize CT setting to minimize the dose. Using wide pitch and narrow collimation can reduce the radiation dose. Besides, CT protocols should be optimized to minimize unnecessary radiation exposure. Clinicians should only perform additional delayed imaging when there is a clinical indication. Unnecessary multiphasic protocols should get simplified into a single-phase protocol.

When obtaining CT images of body parts outside of the abdomen and pelvis, the scattered radiation exposure to the fetus is minimal. Therefore, a shield does not significantly reduce the radiation exposure on the fetus during the CT scan. A lead shield may be an unnecessary precaution. However, it does minimally reduce the dose from scatter radiation and may provide patients a sense of reassurance and protection. The use of a lead shield is up to the discretion of the institution and provider.[8]

Magnetic Resonance

MRI uses a magnetic field to generate diagnostic images and does not contribute to ionizing radiation.

Ultrasonography

Ultrasound uses sound waves to generate diagnostic images and does not contribute to ionizing radiation.

Nuclear Medicine

In nuclear medicine, radiopharmaceuticals are injected into patients. These radiopharmaceuticals are distributed throughout the body and emit radiation at the target location. Radiation energies from these radiotracers then convert into diagnostic images. The overall radiation exposure to the fetus depends on how much radiotracer gets delivered to or near the fetus. Fetal radiation exposure in nuclear medicine depends on multiple variables, including maternal excretion and uptake of the radiopharmaceutical, fetal distribution of the radiopharmaceutical, placental permeability of the radiopharmaceutical, tissue affinity of the radiopharmaceutical, the half-life of the radiotracer, the dose of the radiotracer, and type of radiation emitted from the radiotracer. Generally, for nuclear medicine studies utilizing a radiopharmaceutical that gets excreted through the kidneys, patients are encouraged to hydrate and urinate to maximize the urinary excretion of radiopharmaceuticals.

Specific clinical scenarios worth mentioning for nuclear medicine study is pregnancy patient with concern for pulmonary embolism. The first imaging modality should be an ultrasound of lower extremity to look for deep venous thrombosis. If there is still clinical suspicion for pulmonary embolism, CT pulmonary angiogram (CTPA) is preferable to the ventilation-perfusion (VQ) scan. The fetal dose of VQ is much higher than CTPA, even though the maternal dose is much lower. Due to the lower fetal dose, CTPA is the preferred test of choice.[9]

The thyroid iodine scan is not an option during pregnancy. Iodine 121 and 131 are taken up by fetus thyroid and therefore contraindicated.[10]

Angiography

Fetal radiation exposure from angiography and fluoroscopy should only be for emergent clinical settings. A physician performing fluoroscopy should utilize essential dose reducing techniques including pulse fluoroscopy instead of continuous fluoroscopy, last image hold rather than full exposure, and colimitation to appropriate field of view. Magnification increases the radiation dose and should be used only if necessary.

Patient Positioning

Appropriate patient positioning is vital in producing a diagnostic quality of images and prevent repeat examination that increases fetal radiation. Technologists should optimally position patients before imaging to obtain appropriate views for the exam. Obtaining diagnostic imaging at the first attempt eliminates the need for a repeat examination and significantly reduces unnecessary radiation exposure to the fetus.

Clinical Significance

The plain film, CT, nuclear medicine studies, and fluoroscopy uses ionizing radiation to obtain diagnostic images. A high level of radiation has adverse effects on the fetus; therefore, referring clinicians should consider alternative imaging modalities for pregnancy patients. If diagnostic studies that expose radiation to the fetus are clinically required, it should be performed without delay but must take place in a way that minimizes radiation exposure to the fetus. Solid

understanding of how each imaging modality contributes to fetal radiation exposure, techniques to reducing radiation exposure in the fetus, and adverse consequences of high radiation exposure is critical in providing the most appropriate imaging studies for pregnant patients.

Review Questions

- Access free multiple choice questions on this topic.
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References

1. Brent RL. Saving lives and changing family histories: appropriate counseling of pregnant women and men and women of reproductive age, concerning the risk of diagnostic radiation exposures during and before pregnancy. Am J Obstet Gynecol. 2009 Jan;200(1):4-24. [PubMed: 19121655]
2. De Santis M, Cesari E, Nobili E, Straface G, Cavaliere AF, Caruso A. Radiation effects on development. Birth Defects Res C Embryo Today. 2007 Sep;81(3):177-82. [PubMed: 17963274]
3. Williams PM, Fletcher S. Health effects of prenatal radiation exposure. Am Fam Physician. 2010 Sep 01;82(5):488-93. [PubMed: 20822083]
4. McCollough CH, Schueler BA, Atwell TD, Braun NN, Regner DM, Brown DL, LeRoy AJ. Radiation exposure and pregnancy: when should we be concerned? Radiographics. 2007 Jul-Aug;27(4):909-17; discussion 917-8. [PubMed: 17620458]
5. Tremblay E, Thérasse E, Thomassin-Naggara I, Trop I. Quality initiatives: guidelines for use of medical imaging during pregnancy and lactation. Radiographics. 2012 May-Jun;32(3):897-911. [PubMed: 22403117]
6. Vu L, Ambrose D, Vos P, Tiwari P, Rosengarten M, Wiseman S. Evaluation of MRI for the diagnosis of appendicitis during pregnancy when ultrasound is inconclusive. J Surg Res. 2009 Sep;156(1):145-9. [PubMed: 19560166]
7. Wallace GW, Davis MA, Semelka RC, Fielding JR. Imaging the pregnant patient with abdominal pain. Abdom Imaging. 2012 Oct;37(5):849-60. [PubMed: 22160283]
8. Uzoigwe CE, Middleton RG. Occupational radiation exposure and pregnancy in orthopaedics. J Bone Joint Surg Br. 2012 Jan;94(1):23-7. [PubMed: 22219242]
9. Pahade JK, Litmanovich D, Pedrosa I, Romero J, Bankier AA, Boiselle PM. Quality initiatives: imaging pregnant patients with suspected pulmonary embolism: what the radiologist needs to know. Radiographics. 2009 May-Jun;29(3):639-54. [PubMed: 19270072]
10. Jain C. ACOG Committee Opinion No. 723: Guidelines for Diagnostic Imaging During Pregnancy and Lactation. Obstet Gynecol. 2019 Jan;133(1):186. [PubMed: 30575654]

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