



IMAGING DILEMMA IN PREGNANCY

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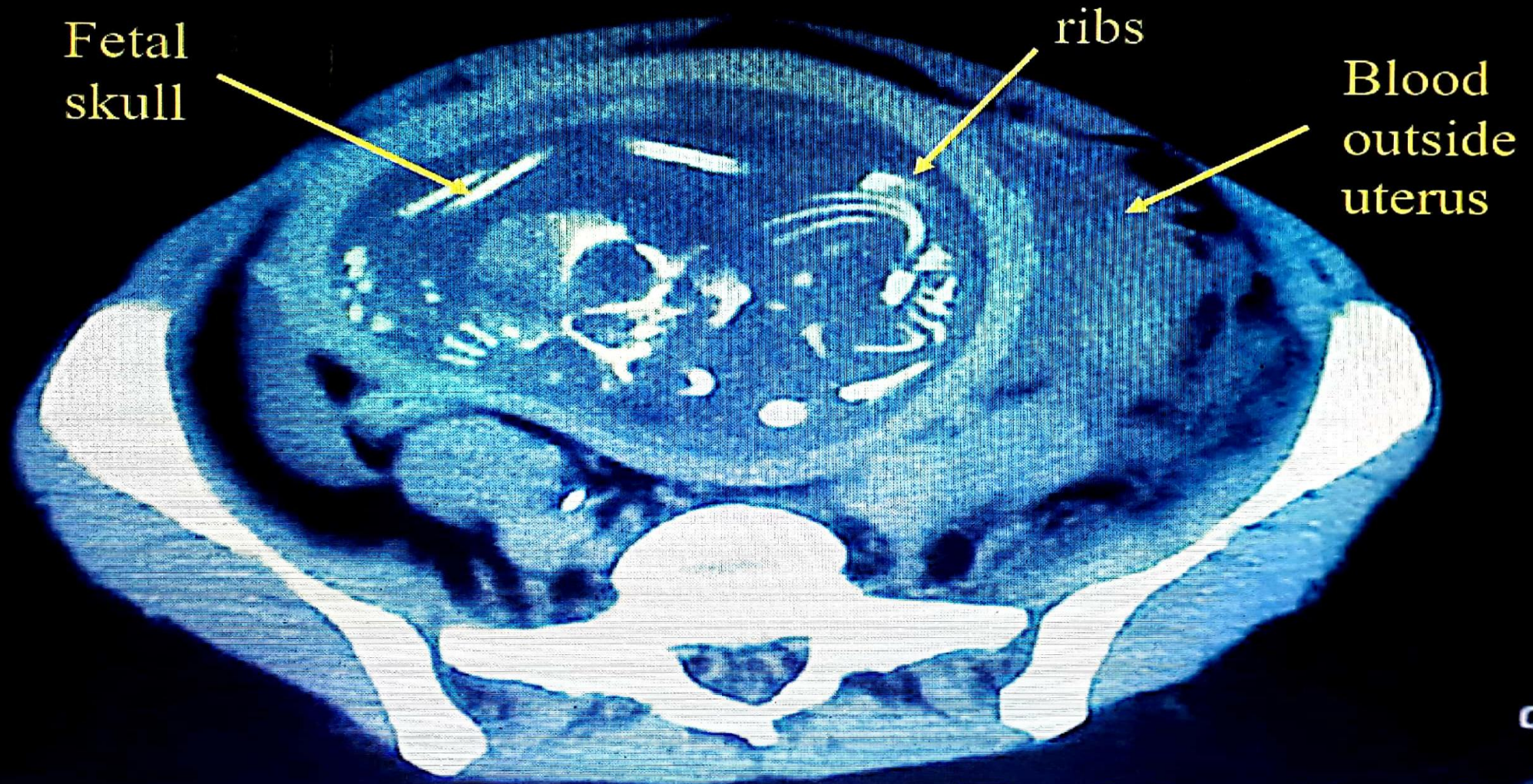
Near East University

Imaging in Pregnancy

- Imaging studies are important adjuncts in the diagnostic evaluation of acute and chronic conditions
- Confusion about the safety of diagnostic imaging techniques in pregnancy; results in unnecessary avoidance of useful diagnostic tests
- We should weight the risk and benefits under the guidance of evidence based medicine

Example: justified use of CT

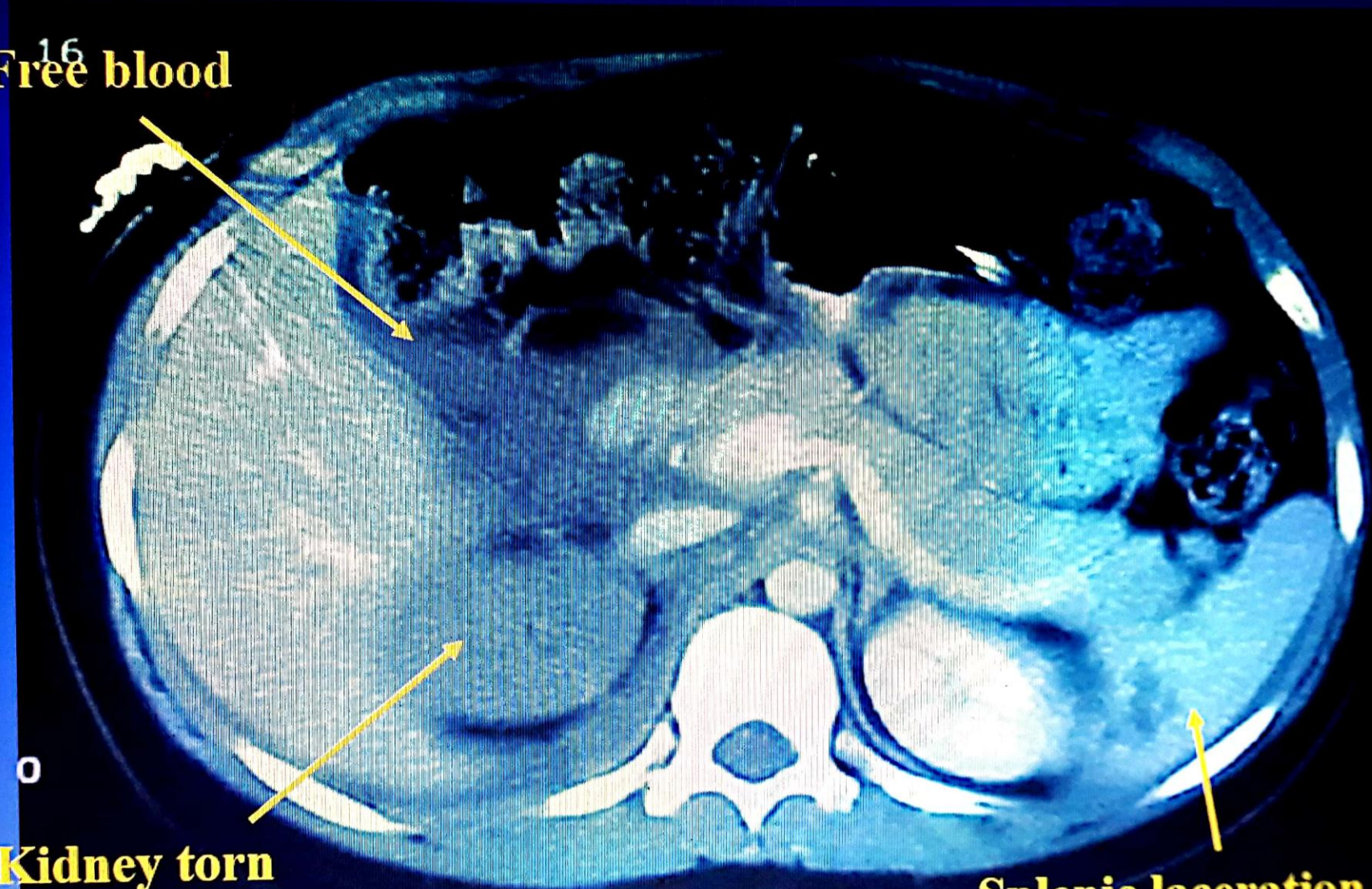
Pregnant female, was in motor vehicle accident



Fetal dose 20 mGy

3 minute CT exam and taken to the operating room. She and the child survived

**16
Free blood**



**Kidney torn
off aorta (no contrast in it)**

Splenic laceration

Terminology-Ionising Radiation

- Absorbed Dose is amount of energy deposited per kilogram of tissue
- 1 RAD = 10 mGy
- Accepted background cumulative dose of ionizing radiation= **5 RAD (50 mGy)**
- Background radiation to fetus during entire pregnancy = **1 mGy (0.5-1.6 mGy)**
- ✓ Cosmic rays
- ✓ Radioactive substance from building materials
- ✓ Radiation emitting from Tv/Handphone

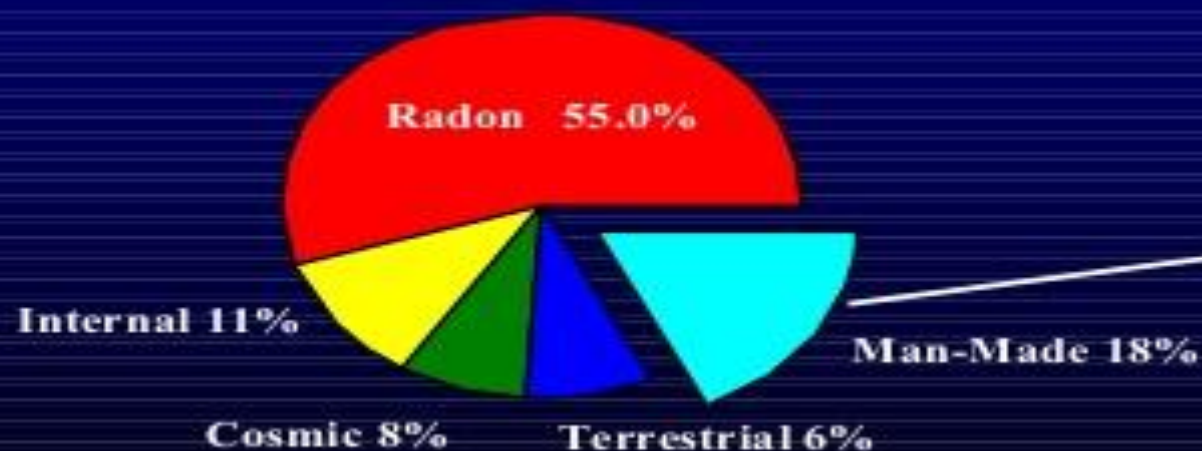
Single X-Ray= 10 days natural exposure to background radiation

What is Background Radiation ?

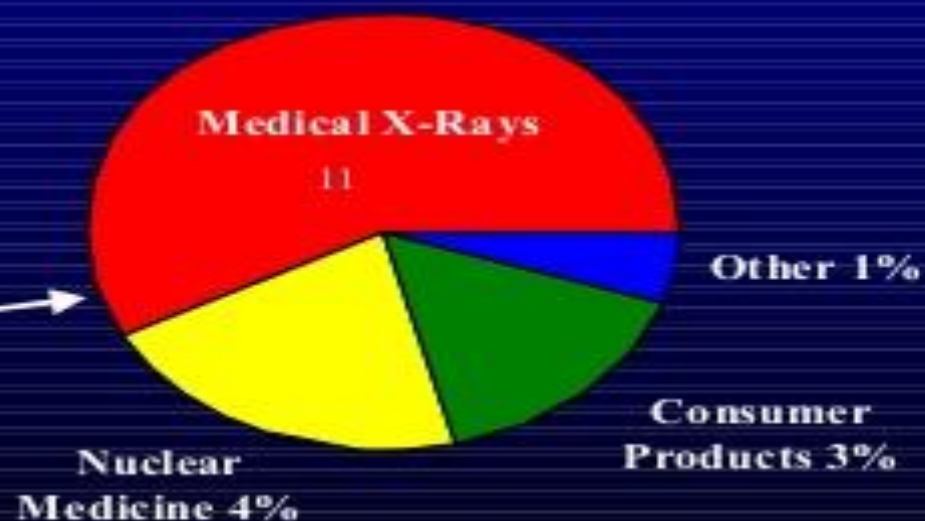
- Radiation is all around us
- It is naturally present in our environment
- Everyone is exposed to low levels of ionizing radiation from natural sources at all times which is called natural background radiation

Annual Dose from Background Radiation average person in the U.S = 360 mrem/year

Total exposure



Man-made sources



Radiation Effects

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graph TD; A[Radiation Effects] --> B[Deterministic Effects]; A --> C[Stochastic Effects]
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Deterministic Effects

- Damage to multiple cells
- Effects are seen above a threshold dose
- Severity increased with radiation dose
- Eg:
 - malformations (teratogenic),
 - mental or growth retardation,
 - death

Stochastic Effects

- Damage to single cell
- No dose threshold
- Eg:
 - childhood cancer (carcinogenic),
 - mutagenic

Risk of Ionizing Radiation in Pregnancy

- Ionizing radiation can result in

Intrauterine cell death

Teratogenicity

Carcinogenesis

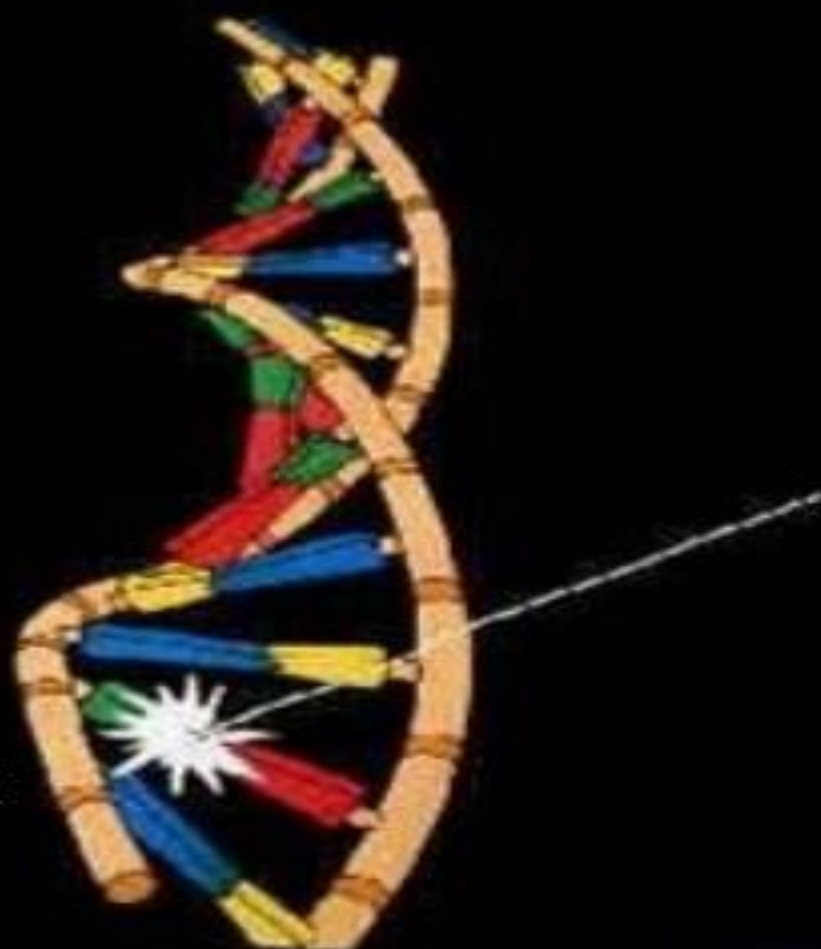
Genetic effects or mutations in germ cells

The most critical target for ionizing radiation in cell is DNA

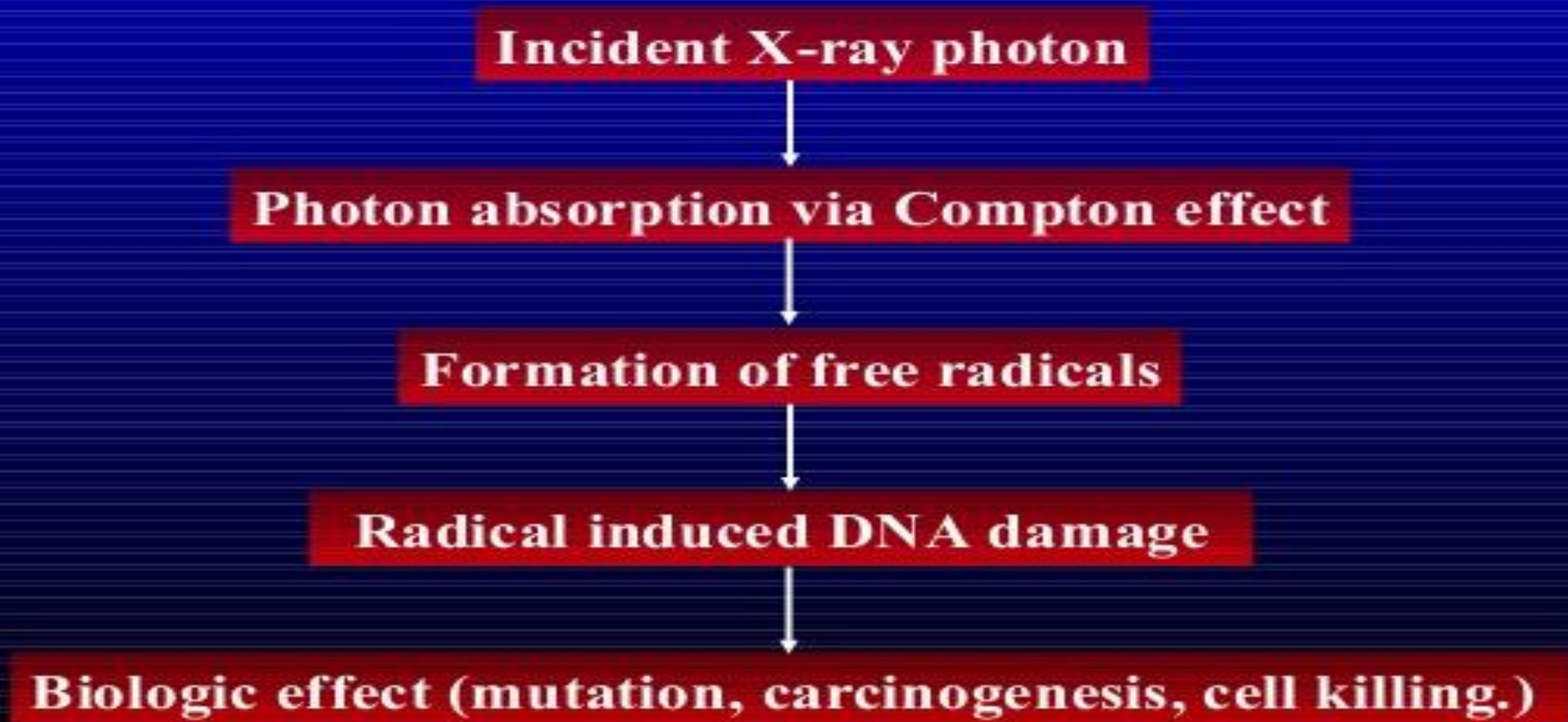


Normal DNA

**DNA damaged
by radiation**



Sequence of Radiation Effects



(American Nuclear Society February 19, 2004)

Fetal Radiation Risks

- Radiation risks are most significant during organogenesis and in the **early fetal period**,
- Somewhat **less in the second trimester**
- The **least in the third trimester**



Table 2. Effects of Gestational Age and Radiation Dose on Radiation-Induced Teratogenesis ↵

Gestational Period	Effects	Estimated Threshold Dose*
Before implantation (0–2 weeks after conception)	Death of embryo or no consequence (all or none)	50–100 mGy
Organogenesis (2–8 weeks after conception)	Congenital anomalies (skeleton, eyes, genitals)	200 mGy
	Growth restriction	200–250 mGy
Fetal period	Effects	Estimated Threshold Dose*
8–15 weeks	Severe intellectual disability (high risk) [†]	60–310 mGy
	Intellectual deficit	25 IQ-point loss per 1,000 mGy
	Microcephaly	200 mGy
16–25 weeks	Severe intellectual disability (low risk)	250–280 mGy*

*Data based on results of animal studies, epidemiologic studies of survivors of the atomic bombings in Japan, and studies of groups exposed to radiation for medical reasons (eg, radiation therapy for carcinoma of the uterus).

[†]Because this is a period of rapid neuronal development and migration.

Reprinted from Patel SJ, Reede DL, Katz DS, Subramaniam R, Amorosa JK. Imaging the pregnant patient for nonobstetric conditions: algorithms and radiation dose considerations. *Radiographics* 2007;27:1705–22.

Fetal Radiation Risks

- Organogenesis occurs predominantly between 2 and 15 weeks of gestation.
- This is the period when the fetus is most susceptible to the teratogenic effects of ionizing radiation,
- Which include microcephaly, microphthalmia, mental retardation, growth retardation, behavioral defects, and cataracts.

Fetal Radiation Risks-Teratogenesis

- Teratogenesis is considered a non-stochastic effect of radiation.
- The threshold radiation dose below which no teratogenic effects occur is not known, but is estimated to **range from 5 to 15 rad**
- Fetal risk of congenital anomalies growth restriction or abortions are not increased with radiation exposure of **less than 5 rad**

ACOG 2004

- In all stages of gestation; radiation induced non cancer health effects are not detectable for fetal absorbs doses **< 5 rad**

CDC 2005

Fetal Radiation Risk-Carcinogenesis

- Carcinogenesis is believed to be a stochastic effect of radiation
- Radiation has been shown to increase the risk for leukaemia and many types of cancer in adults and children
- This relative risk may appear substantial, but it should be remembered that the baseline risk is very low, so that the odds of dying of childhood cancer go from 1 in 2000 (baseline) to 2 in 2000 (after 5 rads).
- Doll R, Wakeford R. Risk of childhood cancer from fetal irradiation. Br J Radiol 1997; 70: 130-139.

Probability of bearing healthy children as a function of radiation dose

Dose to conceptus (mGy) above natural background	Probability of no malformation	Probability of no cancer (0-19 years)
0	97	99.7
1	97	99.7
5	97	99.7
10	97	99.6
50	97	99.4
100	97	99.1
>100	Possible, see text	Higher

Types of Diagnostic Imaging Modalities

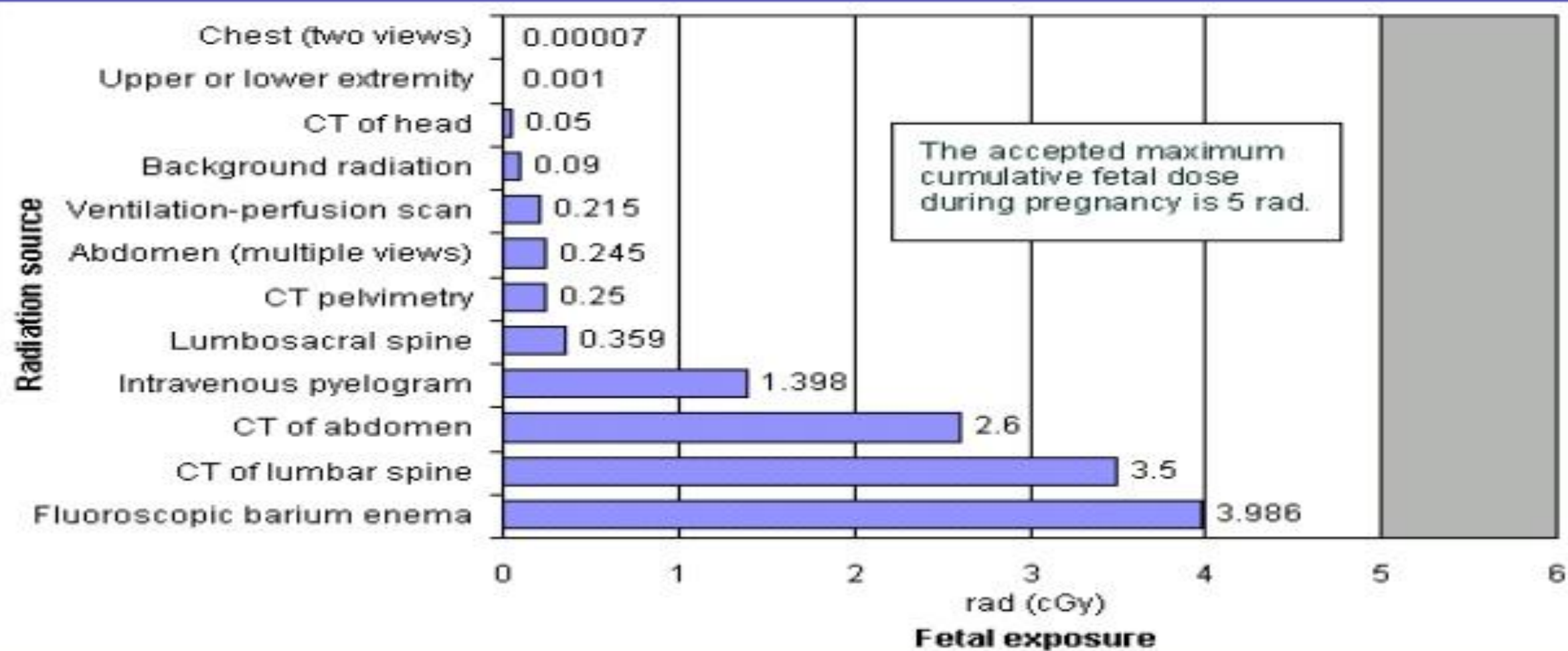
Ionizing Radiation

- X Rays
- Fluoroscopy
- Angiography
- Computed Tomography
- Nuclear Medicine Studies

Non-Ionizing Radiation

- Ultrasound
- Magnetic resonance Imaging (MRI)

Common Radiographic Studies



X- Rays in Pregnancy

- X- rays procedures may be indicated during pregnancy
 - The risk to fetus from ionizing radiation is dependent on the gestational age at the time of exposure and the dose of radiation
-
- In humans growth restriction, microcephaly, intellectual disability are the most common adverse effect from high dose radiation exposure
 - 8- 15 weeks of gestation has the greatest risk of central nervous system effects .Minimal threshold for this adverse effect range from 60-310 mGy
 - But rarely multiple diagnostic X-Ray procedures result in radiation exposure to this degree



X- Rays in Pregnancy- Carcinogenesis

- The risk of carcinogenesis as a result of in-utero exposure to ionizing radiation is unclear but is probably very small
- Pregnancy termination should not be recommended solely on the basis of exposure to diagnostic radiation
- If a pregnant woman undergo multiple imaging studies using ionizing radiation it is prudent to consult with a radiation physicist to calculate the total dose received by the fetus.
- There is no risk to lactation from external sources of diagnostic X-rays

Computed Tomography in Pregnancy

- Use of CT and associated contrast material should not be withheld if clinically indicated but a thorough discussion of risks and benefits should take place
- In the evaluation of appendicitis, small bowel obstruction, the maternal benefit from early and accurate diagnosis may outweigh the theoretical fetal risks
- If accessible in a timely manner, MRI should be considered as safer alternative



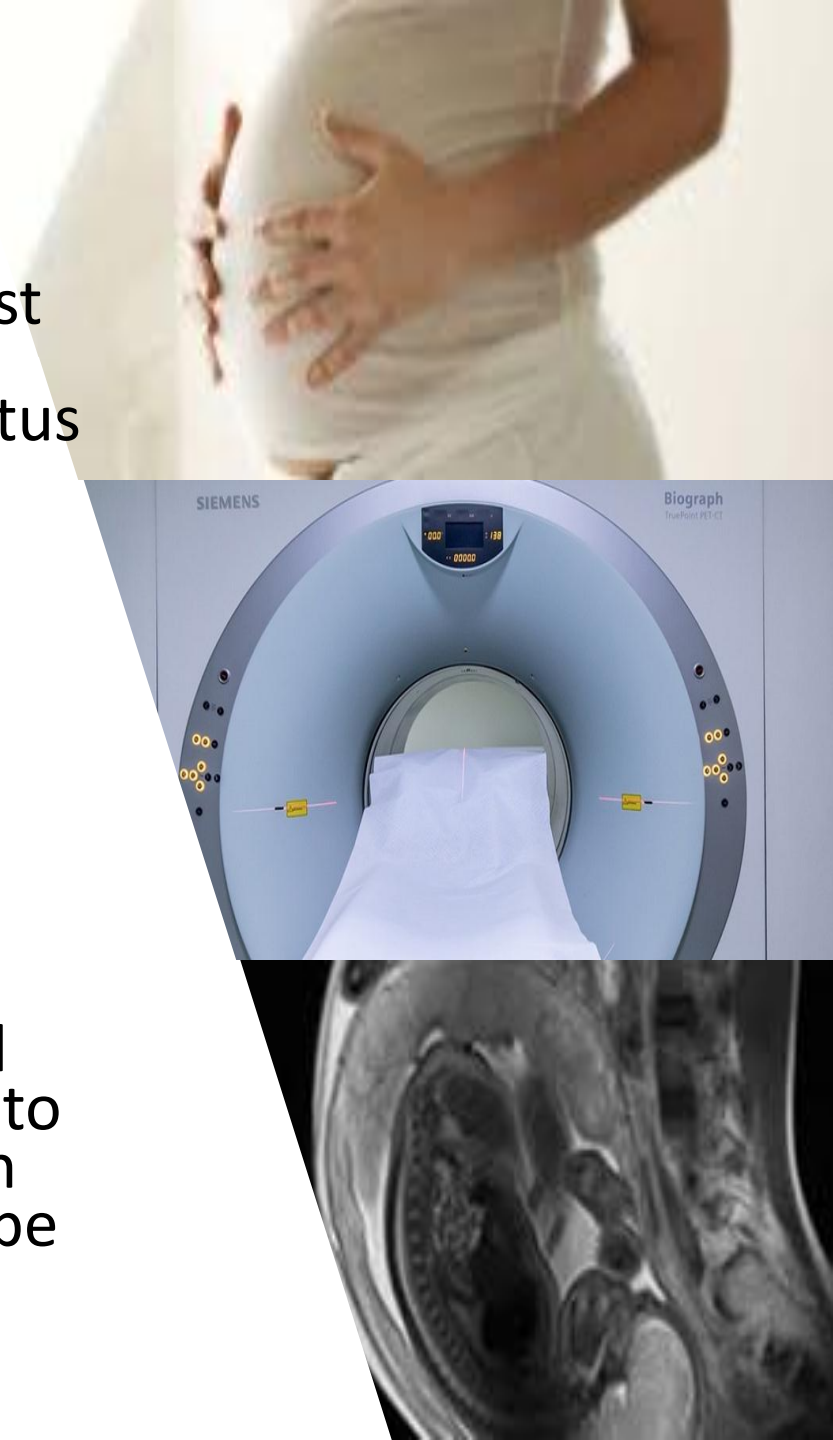
Computed Tomography in Pregnancy

- Radiation exposure from CT procedures varies depending on the number and spacing of adjacent image sections
- In the case of suspected pulmonary embolism CT evaluation of the chest results in a lower dose of fetal exposure to radiation compared with ventilation-perfusion scanning
- Iodinated contrast media can cross the placenta and due to possible adverse effect on thyroid gland of fetus ; recommended that only be used if absolutely required

Pregnancy and MRI

- The conclusion of a recent large cohort study from Ontario, Canada (states, "Exposure to MRI during the first trimester of pregnancy compared with nonexposure was not associated with increased risk of harm to the fetus or in early childhood
- Gadolinium MRI at any time during pregnancy was associated with an increased risk of a broad set of rheumatological, inflammatory, or infiltrative skin conditions and for stillbirth or neonatal death.
- The American College of Gynecology and Obstetrics recommends that pregnant patients should be reviewed on a case-to-case basis, and the risk-benefit ratio needs to be made by the physicians involved. There are no known biological effects of MRI on fetuses. Gadolinium should be avoided when examining a pregnant patient

Ray JG et al. JAMA. 2016;316(9):952-961)



Risk of Acoustic Damage from MRI During Pregnancy

- The results of two studies in 1994-1995 provide reassuring clinical and experimental evidence that there is no significant risk of acoustic injury to the fetus during prenatal MRI



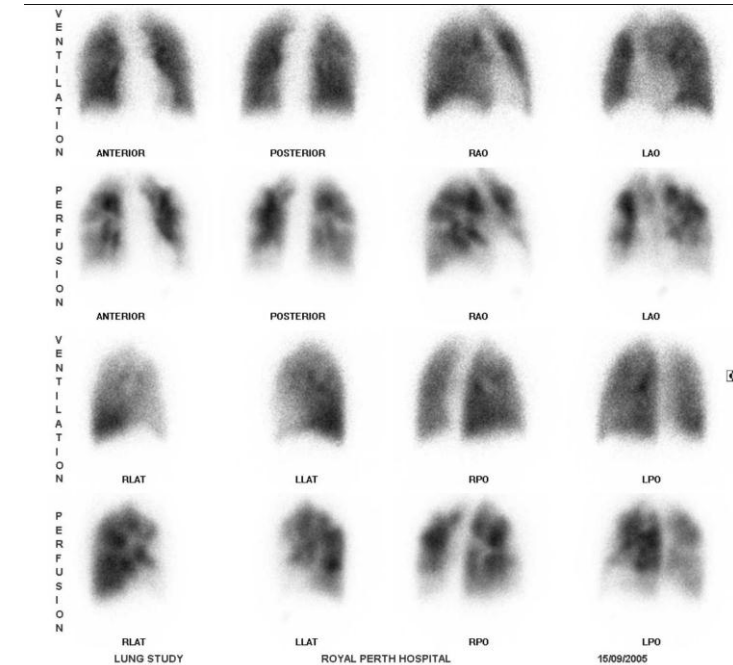
- Gover P, Hykin J, Gowland P, Wright J, Johnson I, Mansfield P. An assessment of the intrauterine sound intensity level during obstetric echo-planar magnetic resonance imaging. *Br J Radiol* 1995; 68: 1090-1094
- Baker PN, Johnson IR, Harvey PR, Gowland PA, Mansfield P. A three-year follow-up of children imaged in utero with echo-planar magnetic resonance. *Am J Obstet Gynecol* 1994; 170: 32-33.

Risk of Teratogenesis from Gadolinium

- It is clear that gadolinium should not be administered in pregnancy unless there is an absolutely essential clinical indication, particularly during the period of organogenesis
- The 2007 ACR guidance document for safe MRI practices recommends that intravenous gadolinium should be avoided during pregnancy and should only be used if absolutely essential; furthermore, the risks and benefits of gadolinium use must be discussed with the pregnant patient and referring clinician
- Gadolinium is classified as a category C drug by the Food and Drug Administration and can be used if considered critical

Nuclear-Medicine Imaging in Pregnancy

- In pregnancy, fetal exposure during nuclear medicine studies depends on the physical and biochemical properties of the radioisotope
- Technetium 99 m is one of the most commonly used isotope in ventilation-perfusion lung scanning and can be used at 5 mGy if indicated
- Iodine 131 can cross the placenta and has a half life of 8 days so can adversely affect fetal thyroid gland



Use of Contrast Media During Lactation

- The traditional and standard recommendation is that lactating women who receive intravascular iodinated contrast or gadolinium should discontinue breast-feeding for 24 hours, and the expressed milk during this period should be discarded
- Only tiny amounts of iodinated or gadolinium-based contrast medium given to a lactating mother reach the milk. For example, a recent study of 20 lactating women found that less than 0.04% of the maternal dose of intravenous gadolinium passes into the breast milk.

Kubik-Huch RA, Gottstein-Aalame NM, Frenzel T, et al. Excretion of gadopentetate dimeglumine into human breast milk during lactation. *Radiology* 2000; 216: 555-558

- Only a tiny fraction of iodinated contrast or gadolinium entering the infant gut is absorbed. For example, only 1-2% of oral iodinated contrast is absorbed into the bloodstream

Mutzel W, Speck U. Pharmacokinetics and biotransformation of iohexol in the rat and the dog. *Acta Radiol Suppl.* 1980; 362: 87-92.

- A recent review in the *New England Journal of Medicine* also concluded that iodinated contrast administered to breast-feeding women posed no risk to the infant

Ito S. Drug therapy: Drug therapy for breast-feeding women. *N Engl J Med* 2000; 343: 118-126

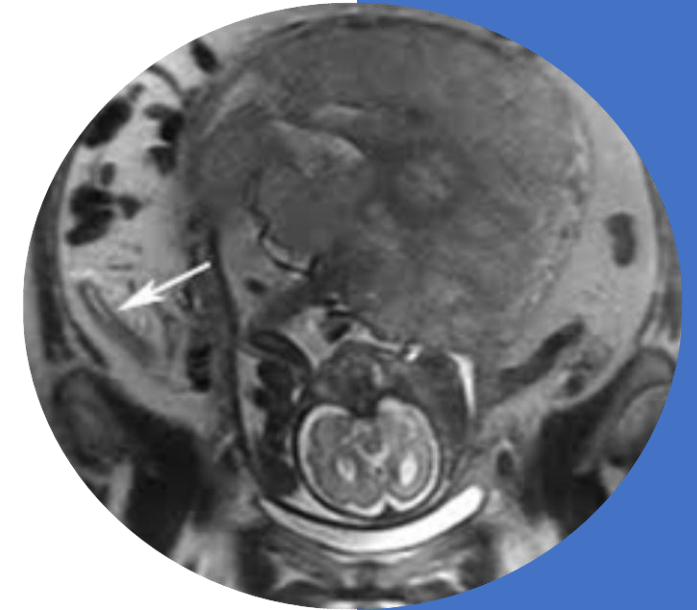
Imaging of Suspected Pulmonary Embolism During Pregnancy

- Three large studies showed that the rate of pregnancy associated pulmonary embolism was approximately 1 to 2 per 7000 pregnancies, and that the majority occurred post-partum, particularly with pre-eclampsia, Caesarean section, and multiple births
- The fetal radiation dose from CT pulmonary angiography is substantially less than that from ventilation perfusion scintigraphy in all trimesters and even if half-dose perfusion-only scintigraphy is used
- **Several considerations suggest that CT pulmonary angiography, rather than ventilation perfusion scintigraphy is the preferred technique for imaging suspected pulmonary embolism in pregnancy**



Imaging of Suspected Acute Appendicitis In Pregnancy

- Acute appendicitis complicates approximately 1 in 1500 pregnancies, and is one of the leading indications for surgery in pregnancy
- The diagnosis of appendicitis in pregnancy can be clinically difficult, particularly in later pregnancy, as evidenced by a perforation rate of 31% for appendicitis occurring in the first and second trimester but rising to 69% in the third trimester
- In the first and second trimesters. ultrasound found to be 100% sensitive, 96% specific, and 98% accurate in diagnosing appendicitis
- ***Ultrasound is the preferred modality for imaging of suspected acute appendicitis in pregnancy, except in later pregnancy (> 35 weeks) when CT or MRI may be required***



ACOG Recommendations 2017 (The American College of Obstetricians and Gynecologists)

- Ultrasonography and magnetic resonance imaging are not associated with risk and are the imaging techniques of choice for the pregnant patient
- But they should be used prudently and only when use is expected to answer a relevant clinical question or otherwise provide medical benefit to the patient.

ACOG Recommendations 2017

- Radiation exposure through Radiography, Computed tomography, nuclear medicine imaging techniques are at a dose **much lower** than the exposure associated with fetal harm ,
- If these techniques are necessary in addition to ultrasonography or MRI they should not be withheld from a pregnant patient
- Gadolinium contrast with MRI should be **limited**
- Breastfeeding **should not be interrupted** after gadolinium administration

Thank You For Your Attention