X rays: What people need to know

1. What are X rays?

X rays (like those used in CT) are a form of radiation, as is visible light, but they have high penetrating ability and may pass through the human body. By using appropriate devices and techniques, X rays can be detected and produce images of the inner structures of the body to check for disease or other problems.

2. Can medical diagnostic X rays cause harm?

Generally not. The radiation dose involved in most X ray examinations, whether done by conventional technique on film or by digital system, is quite small. But the concern arises with repeated examinations. Relatively high dose examinations such as CT and interventional procedures have more of a chance to increase the risk for radiation related cancer (please see tables on page 5 for dose values).

3. What is the most common radiation dose quantity?

Radiation dose or just dose is often described using the quantity effective dose, expressed in millisievert (mSv). The effective dose represents the whole body dose that would give the same cancer risk as caused by the doses that were imparted to different organs in a specific part of the body. Effective dose offers a way to compare approximately the relative risk between different radiation procedures. There are a number of other ways that professionals use to describe radiation dose and those are not covered here.

4. Is radiation that we receive from natural sources different and how?

Every person is exposed to radiation from surroundings, such as cosmic radiation, radiation from earth, food, and even our own body. This radiation (gamma rays) is similar to X rays used in medical examinations. Depending upon where one lives, an individual is exposed to 1 to 3 mSv every year, with global average of 2.4 mSv. There are some places where in-habitants are exposed to as much as 10 mSv/year. One can compare these with radiation doses involved in X ray examinations as given on page 5.
Segment 4: Biological Effects of Radiation

Check Your Knowledge:

1. Which of the following statements about radiation are true?
   a. Radiation is one of the best-understood health hazards.
   b. The effects of radiation have been studied for over 100 years and we understand how radiation interacts with living tissue.
   c. Radiation at high doses can cause cancer and be lethal.
   d. Radiation can be harmful to the fetus at various stages of pregnancy.
   e. All of the above.

2. What can happen to a cell that is damaged by radiation?
   a. The cell can repair itself and return to normal.
   b. The cell is altered/not repaired and the alteration may eventually lead to cancer.
   c. The cell dies and the body recovers.
   d. All of the above.

3. True or False: If a person receives a radiation dose over an extended period of time, the health impact will not be as severe as if the dose were received all at once.
   a. True.
   b. False.

4. True or False: The health effects of radiation are the same no matter what the dose is or how fast the radiation dose is received.
   a. True.
   b. False.

5. True or False: If a radiation dose is delivered to a portion of the body, the health impact will be more severe than if that dose was delivered to the whole body.
   a. True.
   b. False.

Segment 5: Radiation Protection

Check Your Knowledge:

1. Which of the following are basic protective measures that can be used to minimize radiation exposure?
   a. Time, Distance, Shielding.
   b. Stop, Drop, and Roll.
   c. Decontamination.
   d. All of the above.

2. True or False: ALARA, as low as reasonably achievable, is a guiding principle for controlling exposure that can include any or all three protective actions: time, distance, and shielding.
   a. True.
   b. False.

(Continued on pg. 3)
Check Your Knowledge (Continued):

3. If responders find themselves on the scene of an accident that involves radioactive material, they can:
   a. Minimize the time in the area.
   b. Minimize the distance from the source.
   c. Avoid using shielding.
   d. All of the above.

4. Which of the following actions can you perform to limit your exposure in a radiation emergency?
   a. Listen to instructions from emergency officials on what to do.
   b. Stay inside (shelter in place) until it is safe to leave the area.
   c. If you are in a multistory building, move to the center floors.
   d. If you are in a single story building, stay in the center away from windows, doors, exterior walls.
   e. If you are in a building with a basement, go to the basement.
   f. All of the above.

5. Which type of personal protective equipment measures radiation dose?
   a. Respirators.
   b. Protective clothing.
   c. Dosimeters.
   d. All of the above.

(Continued from pg. 2)

Segment 6: Decontamination

Check Your Knowledge:

1. True or False: Radioactive material, just like any other matter, could be a solid, liquid, or gas.
   a. True.
   b. False.

2. Which of the following statements is NOT true concerning contamination and exposure?
   a. External contamination is unwanted radioactive material on your skin or clothing.
   b. Internal contamination is unwanted radioactive material inside a building.
   c. When you are contaminated, you are also being exposed.
   d. You can be exposed without being contaminated.
   e. All of the above.

3. Which of the following steps should you take if you have been contaminated with radioactive material?
   a. Carefully remove contaminated clothing.
   b. Wash your body from the head down with mild soap and water.
   c. Do not use hair conditioner.
   d. Change into clean clothing.
   e. All of the above.

(Continued on pg. 4)
(Continued from pg. 3)

Segment 7: Environmental Impact of Radioactivity

Check Your Knowledge:

1. True or False: We are exposed to radiation constantly, but our bodies have not adapted to these everyday exposures.
   a. True.
   b. False.

2. True or False: Radioactive contamination in the environment can impact soil, water, and air quality, enter the food chain and affect humans.
   a. True.
   b. False.

3. True or False: Active remediation includes removing soil, cleaning surfaces and objects, and filtering water in order to reduce the amount of radioactive contamination in the environment.
   a. True.
   b. False.

4. True or False: Natural processes like physical decay, dilution, and dispersion all contribute to early increases in radiation levels.
   a. True.
   b. False.

Segment 8: Responding to Radiation Emergencies

Check Your Knowledge:

1. Which of the following is an example of a nuclear emergency:
   a. Radiological Dispersal Device (RDD).
   b. Improvised Nuclear Device (IND).
   c. Nuclear power plant accident.
   d. Both b. and c.

2. True or False: Two forms of radiological terrorism are radiological exposure devices (REDs) and strategic nuclear weapons.
   a. True.
   b. False.

3. True or False: Population monitoring is the process of screening people for radioactive contamination, providing decontamination services, registering people for long-term follow-up, and referring those who need it for medical treatment.
   a. True.
   b. False.

Answers: Segment 4: 1. e, 2. d, 3. a, 4. b, 5. b.
         Segment 5: 1. a, 2. a, 3. a, 4. f, 5. c.
         Segment 6: 1. a, 2. b, 3. e.
         Segment 7: 1. b, 2. a, 3. a, 4. b.
         Segment 8: 1. b, 2. b, 3. a.
Do all examinations impart high radiation dose?

No. Different kinds of examinations impart different amounts of radiation. The most common X ray examination is the chest X ray (frontal view). It imparts an average dose of about 0.02 mSv. In the context of the radiation we are exposed to from natural sources, this is a relatively low dose. In the following tables there is a list of patient doses from common radiological examinations as well as equivalent number of chest X rays for the same effective dose.

<table>
<thead>
<tr>
<th>Examination</th>
<th>Mean effective does (mSv)</th>
<th>Equivalent chest X rays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skull X ray</td>
<td>0.1</td>
<td>5</td>
</tr>
<tr>
<td>Thoracic spine/lumbar spine X ray</td>
<td>1.0-1.5</td>
<td>50-75</td>
</tr>
<tr>
<td>Mammography</td>
<td>0.4</td>
<td>20</td>
</tr>
<tr>
<td>Pelvis/hip/abdomen X ray</td>
<td>0.6-0.7</td>
<td>30-35</td>
</tr>
<tr>
<td>Knee/other extremities</td>
<td>0.001-0.005</td>
<td>0.05-0.25</td>
</tr>
<tr>
<td>Intra-oral/panoramic X ray</td>
<td>0.005-0.01</td>
<td>0.25-0.5</td>
</tr>
<tr>
<td>Spine Computed tomography (CT)</td>
<td>6</td>
<td>300</td>
</tr>
<tr>
<td>Chest CT/ pulmonary embolism</td>
<td>1-16</td>
<td>50-800</td>
</tr>
<tr>
<td>Abdomen/pelvis CT</td>
<td>6-8</td>
<td>300-400</td>
</tr>
<tr>
<td>Head/neck CT</td>
<td>2-3</td>
<td>100-150</td>
</tr>
<tr>
<td>CT coronary angiography</td>
<td>16</td>
<td>800</td>
</tr>
<tr>
<td>CT virtual colonoscopy</td>
<td>10</td>
<td>500</td>
</tr>
</tbody>
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Remember: 1 mSv = 100 mRem
1 Sv = 100 Rem

Is there a limit to the radiation I can receive from X rays?

No. In order not to restrict the benefits of X rays which are generally higher than radiation risk, no international organization has provided a limit for patient dose.

The risk associated with radiation is considered to be acceptable for medically justified examinations. The referring physician and the radiologist are responsible for ensuring that health benefit to the patient from the examination is greater than the radiation risks.

How much is the risk for radiation induced cancer? Is this risk additive?

The risk for radiation induced cancer is low but additive. Each examination the patient undergoes slightly increases the risk. Keeping patient doses minimum while getting images of adequate diagnostic quality is therefore recommended. The probability for radiation induced cancer increases by 5-6% for every 1000 mSv of dose. Cancer risk increase arising from most examinations is relatively small as compared with the risk of naturally occurring cancer which ranges between 14% and 40%.
8. Can pregnant women undergo X ray examinations?  
As long as clinical benefits exceed the very small potential radiation risk, there is nothing precluding the use of X rays in pregnancy. With modern equipment and good technique, examination of the head, feet, neck, shoulder and even chest can be safely carried out during pregnancy. For other examinations specific considerations are needed.

Pregnant women should inform the physician and concerned healthcare provider about pregnancy or even the possibility of pregnancy. Having been made aware of this information, for investigations of the abdominal and pelvic region, especially for relatively high dose procedures (computed tomography and fluoroscopy), the physician or healthcare provider, in cooperation with the radiation protection specialist, will balance benefits and risk.

9. Is it safe for children to be exposed to X ray radiation during a diagnostic examination?  
There are no restrictions to the use of X rays in children, provided that clinical benefit exceeds small potential radiation risks. Some organs in children have higher radiation sensitivity than in adults. Children also have a longer life expectancy. Therefore, imaging techniques that do not use ionizing radiation should always be considered as an alternative. Children’s radiological procedures should be individually planned and limited to what is sufficient for a correct diagnosis.

10. Are there safer alternatives to X ray imaging?  
Yes. Although the risk with single X ray study is mostly very small, it is a question of minimization of risk. Imaging examinations utilizing non-ionizing radiation such as MRI or ultrasound (US) should always be considered for appropriateness.

Unlike X rays, they are not known to increase the risk for cancer. However it may not always be possible to replace X ray with non-ionizing radiation examinations. There are other considerations than this risk, since sometimes in young children sedation is needed for MRI as opposed to a CT examination.

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Radiation Safety Emergency Contacts

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