

BLI Class 5 Notes

Radiology – specialty concerned with the application of radiant energy to prevent, diagnose and treat disease. That includes X-ray, CT scans, nuclear scans, MRI, US (Ultrasound)

Radiation is simply a type of energy. The most familiar form of radiation is visible light, like that produced from the sun or a light bulb. Other forms of radiation, such as X-rays and gamma rays, are employed in medicine.

Natural radiation exposure comes from the earth in rocks and soil and from outer space in the form of cosmic rays. A small amount of radioactive material even exists naturally in our bodies. Every year, each person is exposed to this natural radiation and radiation from a variety of other sources, including household smoke detectors and color television sets. Air travel increases exposure to cosmic radiation due to the higher altitudes and less atmospheric shielding.

Naturally occurring background radiation and modern activities such as watching TV and flying in an airplane all contribute to a lifetime exposure that is only slightly increased by medical imaging.

Background radiation millisieverts (mSv)

1. Radon gas – 2.3
2. Other terrestrial sources – 0.2
3. Solar and cosmic – 0.3
4. Natural internal radioactive elements – 0.3
5. Total yearly – 3.1

The absorbed dose of radiation is different from the radiation exposure because it measures the amount absorbed by a given body, not the total amount of radiation in the environment.

One of the most common units to measure the amount of radiation absorbed by an object is a **gray**. One gray represents the amount of radiation present when one joule of energy is absorbed by one kilogram of material. A gray represents a large amount of radiation, much greater than a person would typically absorb. For example, 10 to 20 gray is usually lethal for humans. Therefore, fractions of gray, such as centigray (0.01 gray), milligray (0.001 grays), and so forth are used. Rad is

an obsolete unit proportional to gray. One gray is 100 rad, which makes one rad equal to one centigray. Although it is obsolete, it can still be seen often in publications.

The amount of radiation a body absorbs is not always equivalent to the amount of damage this radiation will cause. Additional units, such as radiation dose equivalent units, are used to describe radiation as relevant to the damage it can cause.

For example, a dose of 1,000 rad or 10 Gy is fatal if absorbed within several hours, but it may not even cause acute radiation sickness (ARS) if spread out over a longer duration of time.

X-ray studies

1. X-ray penetrates tissue, except bone, can provide with visual picture of body structures.
 - a. Chest X-ray
 - b. Dye enhanced cardiac catheterization
2. Radiation
 - a. Gray (Gy) – amount of energy absorbed per unit mass
 - A Gray is the way radiation oncologists measure the dose of radiation therapy. If you were on a 5-week treatment schedule, 45-50 Gray was the usual total amount given over 5 weeks (1.8 to 2 Gray at each of 25 treatments).
 - b. Sievert (Sv) – biological effect of 1 gray of radiation on human body tissue. In medical imaging doses of radiation are measured in millisieverts (**mSv**) or 1/1000 of a sievert
 - 45 Gy = 45000 mSv
 - For example, a generally fatal dose for people is about 4 sieverts (Sv). A person may still be saved if treated quickly, but a dose of 8 Sv is lethal. Generally, people absorb much smaller doses of radiation, therefore often millisieverts and microsieverts are used. 1 millisievert is 0.001 Sv, and 1 microsievert is 0.000001 Sv.
3. Yearly natural background radiation each person receives is about 3 mSv.
 - a. Chest X-ray: **0.1 mSv** = 10 days of natural background radiation
 - b. Dental X-ray: **0.005 mSv** = 1 day

- c. Computed Tomography (CT) of abdomen and pelvis: **20 mSv** = 7 years
- d. CT of chest: 7 mSv = 2 years
- e. CT for lung cancer screening: 1.5 mSv = 6 month
- f. Mammography: **0.4 mSv = 7 weeks** (0.7 mSv = 3 month)
- g. Upper GI study with Barium: 6 mSv = 2 years
- h. Bone Densitometry (DEXA): **0.001 mSv** = 3 hours
- i. Hand, foot X-ray: 0.001, Hip: 0.7
- j. Intravenous pyelography (IVP): 3
- k. Skull: 0.1
- l. Spine (lumbar): 1.5
- m. Virtual colonoscopy (CT): 10
- n. Coronary angiography (CT): 15
- o. Cardiac nuclear stress test: 20-40
- p. Thyroid nuclear scan: 4.8
- q. Brain nuclear scan: 6.9

Radiation is one source of DNA damage. The body usually rapidly repairs this damage. Likelihood of cancer induction increases as amount of radiation exposure increases.

A person has 5% increases risk in developing cancer over lifetime after radiation exposure of 1 Sv (1000 mSv) or more. There is lag time between exposure and cancer diagnosis. The average time 10 years after exposure.

Radiologic studies with larger exposure of radiation should be justified.

1. X-ray – lung tissues, bone tissues (fractures, dislocations, osteoarthritis)
2. Computed tomography – superior image to regular Xray by providing cross sectional images of the body organs and tissue. Lungs, liver, kidneys, pancreas, brain, spine, blood vessels
 - a. Multiple images (slices)
 - b. CT-abdomen, CT-angiography, CT- chest, CT-head, CT-spine
3. Nuclear medicine /Nuclear scans
 - a. In a nuclear medicine imaging test, each radiotracer is attracted to specific organs, bones, or tissues. A special camera (PET, SPECT or gamma camera) takes pictures of the distribution of the

- radiopharmaceutical in the body. The use of radiation in these procedures offers a safe and cost-effective means to provide doctors with diagnostic information that would otherwise require exploratory surgery, would necessitate more costly and invasive procedures, or would simply be unavailable. Radiopharmaceuticals are also used for therapy, to treat overactive thyroids and some cancers.
- b. Nuclear medicine scans detect the radiation coming from a radioactive material inside a patient's body. In contrast, other imaging procedures (for example, X-ray and computed tomography or CT scan) obtain images by using machines that send radiation through the body. **Nuclear medicine is also different from other imaging procedures in that it determines the presence of disease based on biological changes in tissue rather than changes in anatomy.**
 - c. One of the most commonly used nuclear medicine exams, the PET scan, is often performed in conjunction with computed tomography (CT) because the combined images provide physicians with both functional and anatomical information on the body..
 - d. Injection/administration of "radiopharmaceutical"
 - e. SPECT = single photon emission computed tomography
 - f. Whole body bone scintigraphy
 - g. Time is around: 20 to 45 minutes

Magnetic resonance imaging

1. MRI machine uses computer-controlled **radio waves and large magnet** to generate images. Machine creates magnetic field and sends radio waves into the body.
2. Anatomical detail of neurological disorders, musculoskeletal (muscles, tendons, ligaments, capsules, cancer, degenerative disease, inflammation, infection.
3. MRI-body, MRI-head, MRI-spine
4. MRI is more sensitive and more specific for breast evaluation than mammography

Ultrasound

1. Sound waves bounding of organs, tissues create a virtual image
2. OB/Gyn, abdominal (liver, pancreas, gallbladder, kidneys), breast, prostate, arterial, carotid
3. Echocardiograph – evaluation of heart valve, heart wall motion, stress tests. Cannot detect electrical activity
4. Carotid ultrasound – blood flow – high cholesterol patient, TIA (transient ischemic attack) , acute speech defect or visual defects
5. Pelvic ultrasound – fetal growth, fetal umbilical blood flow, fetal position, to evaluate pregnancy and fetus; uterus, ovaries
6. Thyroid ultrasound – confirm thyroid nodule is solid or cystic, monitor tumor treatment
7. Doppler = US

Electrodiagnostic studies

1. Electrocardiography produces electrocardiogram (ECG, EKG). It is a graph of voltage versus time of the electrical activity of the heart using electrodes placed on the skin
 - a. Used to detect dysrhythmias (arrhythmias), MI (myocardial infarctions), monitor medications
 - b. 12-lead ECG
 - c. The main three components: P wave – depolarization of atria, QRS – depolarization of ventricles, T wave – repolarization of ventricles
 - d. A “saw tooth” pattern of QRS complex – atrial flutter
 - e. Absent P wave with “irregularly irregular” QRS complexes – atrial fibrillation
 - f. Absent P waves with wide QRS complex and fast heart rate – ventricular tachycardia (differentiate from sinus tachycardia)
2. Electroencephalography (EEG) – records electrical activity of the brain, electrodes on the scalp. Measures voltage fluctuations resulting from ionic current within the neurons.
 - a. Epilepsy, seizures
 - b. Sleep disorders,

- c. Depth of anesthesia
- d. Coma
- e. Encephalopathies
- f. Brain death
- g. Typical recording 20-30 minutes
- h. If there is no MRI, CT scan EEG can help in diagnosis of brain tumors, brain damage from head injury, encephalitis (inflammation of brain), stroke, encephalopathy
- 3. Cardiac stress test (Stress ECG)
 - a. Treadmill or bike activity and record ECG
 - b. A stress test may be accompanied by echocardiography – done before exercise and after exercise
 - ST segment elevation – possible heart muscle pathology
 - c. Pharmacological stimulation If patient cannot exercise patient is given medication that will stimulate heart activity and perform nuclear stress test, Tc-99 injection. (40 mSv)
 - Treadmill test sensitivity 73-90%, specificity 50-74%
 - Nuclear test: sensitivity 81%, specificity 85-95%
- 4. Electromyography
- 5. Nerve conduction studies
 - a. Median nerve damage – where is damage located in the path of the nerve

Endoscopic studies

- 1. Visualization of cavities, organs by using thin fiberoptic scopes with cameras (flexible)
- 2. Endoscope
- 3. Laparoscope – Laparoscopy: abdominopelvic cavity
- 4. Bronchoscopy
- 5. Cystoscopy – urinary bladder
- 6. Ureteroscopy – ureter visualization
- 7. Esophagogastroduodenoscopy (EGD)
- 8. Enteroscopy – visualization of small bowel
- 9. Colonoscopy

10. Sigmoidoscopy + fecal occult blood test , 5% percent of screened patients referred to colonoscopy
11. Virtual colonoscopy – 2D and 3D imagery reconstructed from CT scan or from nuclear MRI scan.
12. ERCP – endoscopic retrograde cholangiopancreatography – endoscopy + fluoroscopy
13. Diagnostic and therapeutic
14. Rhinoscopy
15. Otoscopy
16. Laryngoscopy
17. Colposcopy – cervix, vagina and vulvar
18. Hysteroscopy – uterine cavity
19. Arthroscopy – joints
20. Thoracoscopy
21. Fetoscopy – access to fetus

Microscopic studies – to detect microorganism in the body tissue

1. Gram stain – used to classify bacteria
 - a. Gram positive – blue: Staphylococcus, Streptococcus
 - b. Gram negative – red: Neisseria gonorrhea, Neisseria meningitis, Escherichia coli
 - c. Cristal violet stain
2. Acid fast stains – mycobacterium, nocardia, cryptosporidium
 - a. Mycobacterium tuberculosis
 - b. Ziehl-Neelsen stain
3. Fluorescent stains
 - a. Pneumocystis carinii
 - b. Fluorescent dye
4. Wet mount
 - a. Fungus, parasites, trichomonas, treponema pallidum (Syphilis)
 - b. Material mixed with salt solution
5. India ink – Cryptococcus neoformans
6. Wright stain – hematologic stain

- a. Parasites in the blood, *Histoplasma capsulatum*
 - b. Regular blood cells
 - c. Eosin and methylene blue dyes
7. Tzanck's smear
- a. Scraping of ulcer base
 - b. Multinucleated giant cell = herpes infection
 - c. Stains that can be used - Wright stain, methylene blue
8. Cultures – sputum, pus, stool, blood, urine, tear, synovial fluid
9. Scotch tape test – pinworm detection
10. Cultures
- a. Bacterial culture
 - b. Viral culture
 - c. Eukaryotic culture