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What You Should Know About Radiation and Nuclear Medicine

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Thanks to Cybil Nielsen, S. James Adelstein, and S. Ted Treves

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What is nuclear medicine?

- Nuclear medicine imaging uses safe, painless, and cost-effective techniques to image the body and treat disease.
  - It uses very small amounts of radioactive pharmaceuticals and traces their progress through your body.
  - Nuclear medicine is unique, because it helps doctors “view” how your body is functioning.
    - This is different from x-rays or CT scans, which show how your body looks rather than how it works.
- Nuclear medicine therapy uses larger amounts of radiation to treat thyroid disease and cancer.

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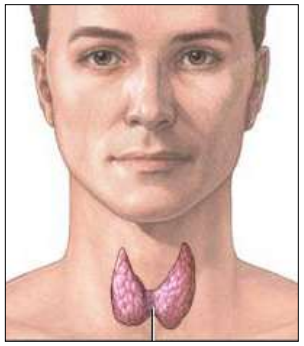
Why is it important?

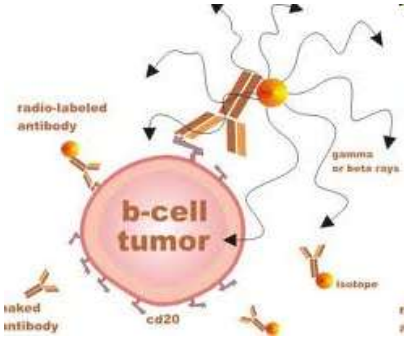
- Enables early discovery of changes in tissues since changes in function often occur before changes in anatomy
- Enables quick, personalized management of each patient.
- Can safely view and treat disease
  - Can help find and characterize diseases in practically every organ system including the heart, brain, skeleton, thyroid and kidneys—and many types of cancer.
  - Can be used to treat disease without surgery

Nuclear medicine therapy

- A unique way to kill cancer cells with minimal damage to surrounding tissue.
  - One radioactive pharmaceutical called iodine-131 can be very effective in treating thyroid disease including cancer.
  - Others are used to treat other cancers, including lymphoma, neuroblastoma and metastatic prostate cancer.

Thyroid treatment





Radioimmuno-therapy (RIT)

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How does it work?

Imaging agent given to patient

Agent goes to lungs

Patient imaged with camera

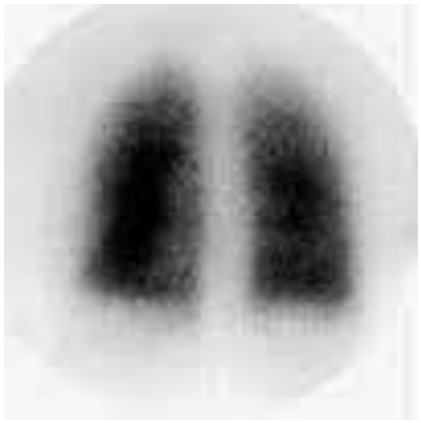

Image of lung scan

Nuclear medicine scanners

Nuclear medicine gamma camera

PET/CT camera

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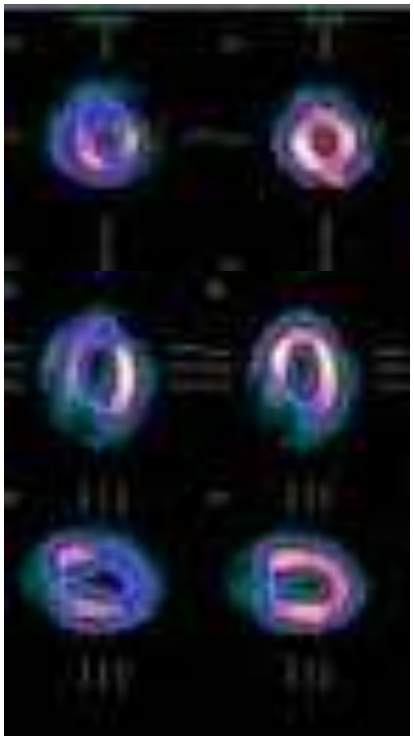
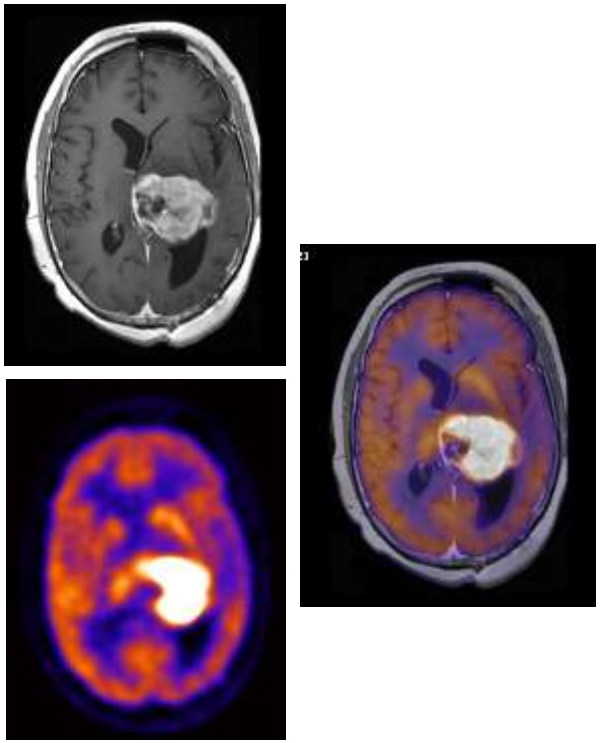
Examples of scans

Whole body
PET/CT scan



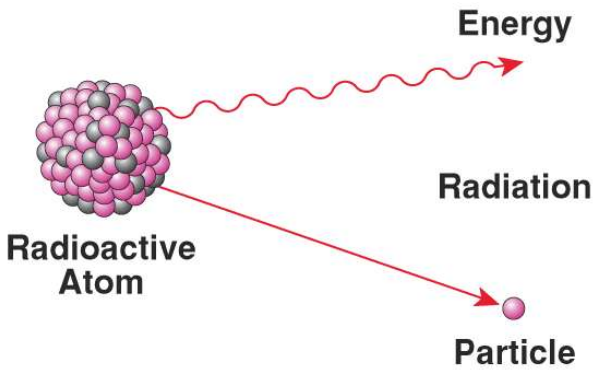
Myocardial perfusion
heart SPECT scan



Brain tumor
PET scan

What is radiation?

- Radiation is energy that is given off by particular materials and devices.
- Low-energy radiation is called non-ionizing radiation.
  - Sound waves, visible light, microwaves
- Radiation that can cause specific changes in molecules is called ionizing radiation
  - X-rays, gamma rays and particles
  - Too much ionizing radiation may damage tissues



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Do nuclear medicine tests involve ionizing radiation?

- Nuclear medicine pharmaceuticals give off gamma rays and particles that allow us to track the radioactive pharmaceuticals within the body.
  - The scanners themselves do not create radiation.
- Very small amounts are used for imaging scans.
  - The radiation disappears (decays) in a very short time.
- Larger amounts are used for therapy.
  - The radiation is targeted very precisely at the cancer cells in order to kill them.

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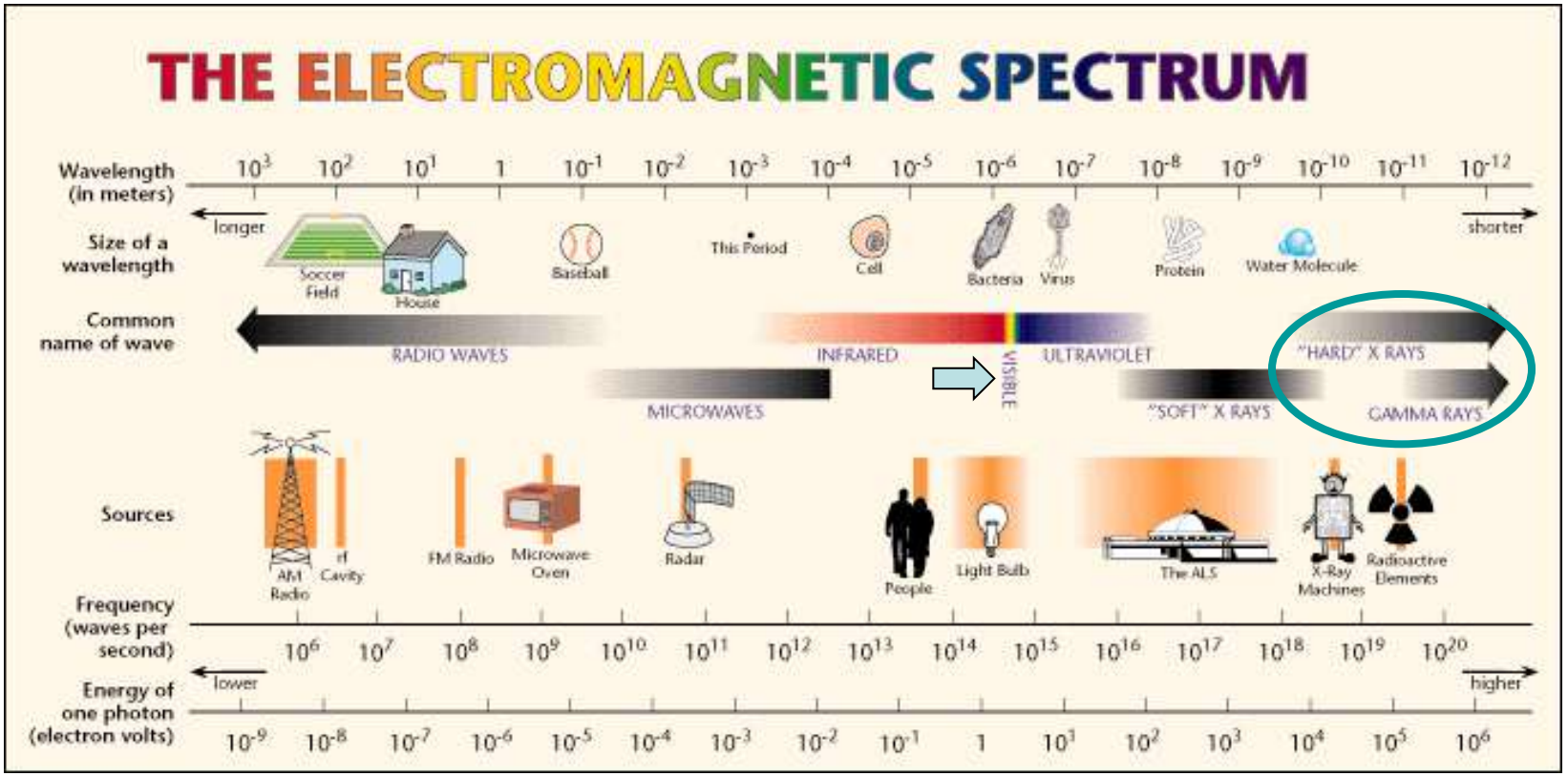
What are gamma rays?



Measuring radiation

The international unit used to measure the amount of radiation received by a patient is the “millisievert” (mSv).

Sometimes, the traditional unit, “millirem” (mrem), is used.

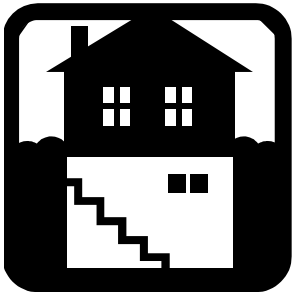
1 mSv = 100 mrem

We are exposed every day to "background radiation"

Cosmic rays
from space

Radioactivity
in the earth

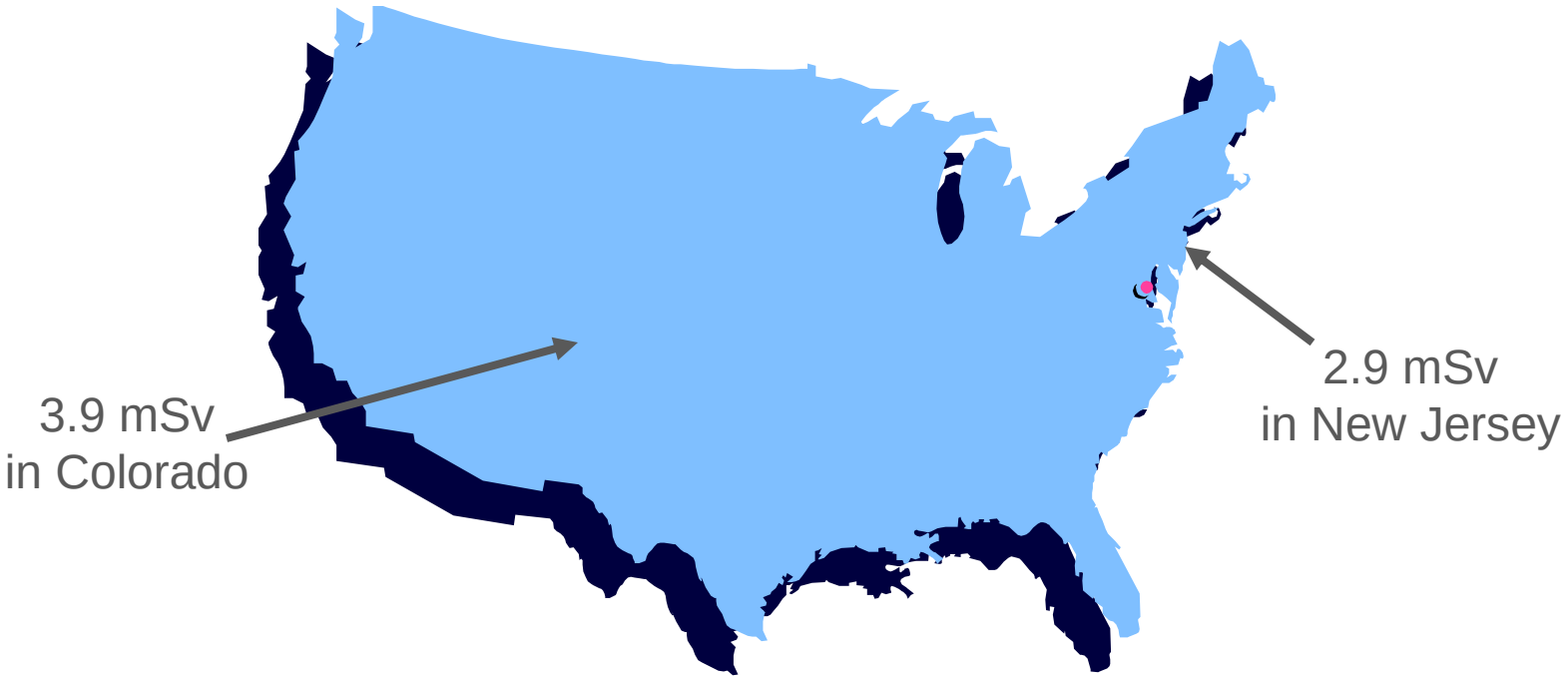
In our
bodies



Radon gas
in our houses

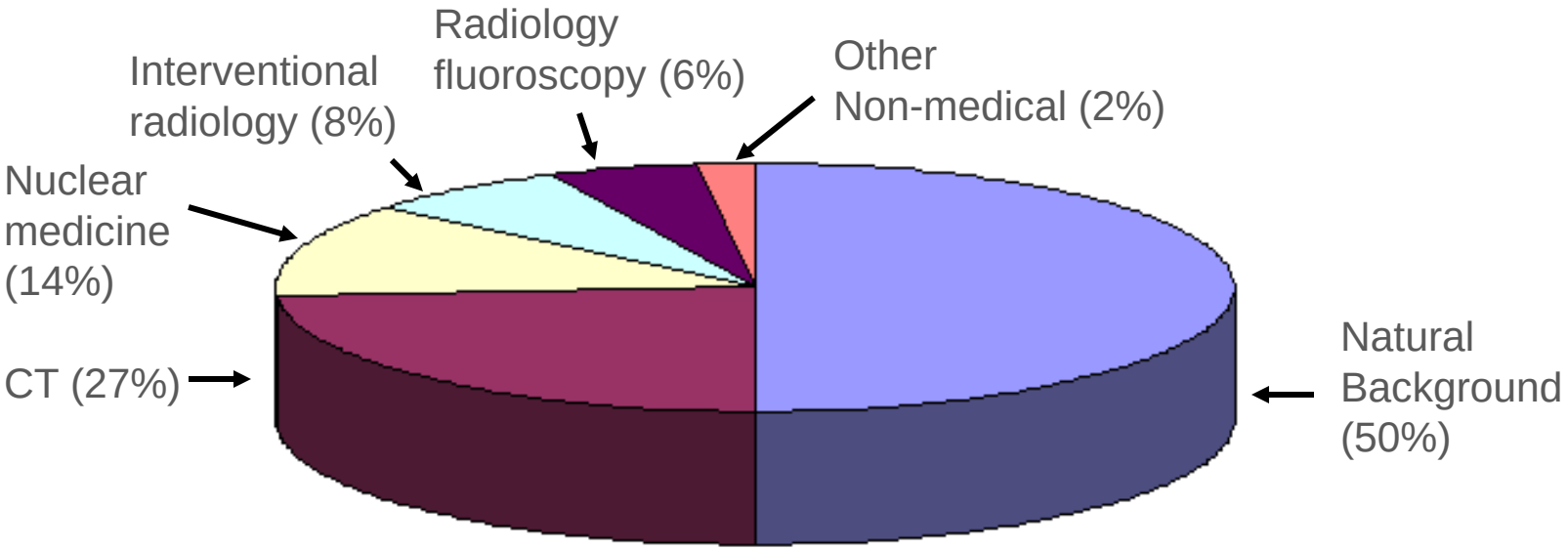
The average radiation dose in the U.S. from background radiation is 3.1 mSv, with 2.3 mSv coming from radon in our houses.

Background radiation



The average American gets about 3 mSv of background radiation each year.

How much ionizing radiation do people get?



The average annual radiation exposure in the U.S. is 6.2 mSv total, with 3.1 mSv coming from medical procedures
—NCRP Report 160

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How much ionizing radiation do people get?

Regulations allow professionals who work with ionizing radiation to receive up to 50 mSv of ionizing radiation per year (although most receive much less).

Nuclear medicine technologist

PET/CT technologist

X-ray technologist

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Putting radiation in context

Everyday Activities	Radiation Dose
Watching television	0.01 mSv/year
Air travel (roundtrip from D.C. to L.A.	0.05 mSv
Average annual exposure from breathing radon gas	2 mSv
Average annual exposure living in the United States	3 mSv/year
Annual dose limit for radiation workers in U.S.	50 mSv/year

Medical Imaging	Radiation Dose
Chest X-ray (1 film)	0.1 mSv
Nuclear med. thyroid scan	0.14 mSv
Mammogram (4 views)	0.4 mSv
Nuclear med. lung scan	2 mSv
Nuclear med. bone scan	4.2 mSv
Tc-99m cardiac diagnostic	11 mSv
Abdominal CT scan	8 mSv
F-18 FDG PET/CT study	14 mSv
Cancer treatment	50,000 mSv

* See www.discovermi.org, fact sheets, Molecular Imaging Safety for statistics sources.

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How much ionizing radiation is received from medical imaging, including nuclear medicine?

- The average effective dose from radiologic medical imaging depends on the test being performed.
- In general, radiation from nuclear medicine procedures is similar to that from other radiologic procedures and from natural background radiation.

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How much radiation is safe?

- Difficult to answer.
- Exposure to high levels of ionizing radiation can lead to unwanted health effects, including cancer.
- There is no direct evidence that the ionizing radiation routinely used in nuclear medicine and radiology leads to such effects.
- It is considered prudent for public safety to assume that every exposure to ionizing radiation, no matter how small, carries some small risk of unwanted health effects, including cancer.

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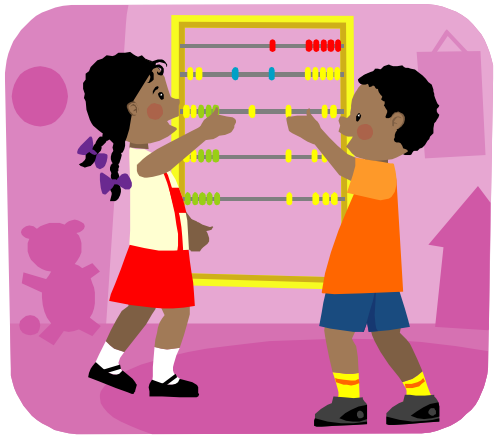
Are some populations more sensitive to ionizing radiation than others?



Children

Young women

Fetus

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Is there a risk associated with the use of nuclear medicine?

- Many medicines and medical procedures can have side effects, particularly if one uses too much.
- The same is true of nuclear medicine. When recommended, a nuclear medicine test gives your doctor important information that is well worth the very small possible risk.
- Used in the right way for the right patient at the right time, nuclear medicine is very safe.

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What is the potential risk associated with these doses?

- For effective doses from nuclear medicine procedures, say 10 mSv, only one-twentieth of a percent (0.05%) of the patients who have a test may develop a fatal cancer sometime later in life.
- Compare that to the natural prevalence of fatal cancer—which is 22%.

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Putting *risk* in context

Lifetime fatal risk from everyday activities

Activity	Lifetime Risk
Accident while riding in a car	304
Accident as a pedestrian	652
Choking	894
Accidental poisoning	1,030
Drowning	1,127
Exposure to fire or smoke	1,181
Falling down stairs	2,024
Cancer from ^{18F} PET scan	***2,700***
Accident while riding a bike	4,734
Cancer from ^{99m}Tc MDP bone scan	***4,760***
Accidental firearms discharge	6,333
Accident while riding in a plane	7,058
Hit by lightning	84,388

Decrease in Life Expectancy

Activity or risk	LLE (days)
Living in poverty	3,500
Being male (vs. female)	2,800
Cigarettes (male)	2,300
Working as a coal miner	1,100
30-lb overweight	900
Grade school dropout	800
15-lb overweight	450
Alcohol	230
Motor vehicle accidents	180
Speed limit: 65 vs. 55 miles per hour	40
Coffee: 2 cups/day	26
Radiation worker, age 18-65	25
Japanese Bomb Survivors who received less than 250 mGy	25
Birth control pills	5

How much radiation would be considered too much?

- The answer is: More than is necessary.
- Each procedure takes a certain amount of radiation to perform appropriately.
- Using too much leads to unnecessary radiation dose to the patient, and using too little may not provide enough information.
- Each procedure is optimized for the medical task at hand, the equipment being used, and the patient.

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Is this nuclear medicine test necessary?

- Patients often wonder if the test that has been ordered is necessary. What should be asked is:
  - What will my doctors learn from this procedure?
  - How will the results of my procedure affect the course of my treatment?

➔ When the procedure offers useful clinical information that will help your doctor decide on your treatment, the benefits of the procedure far outweigh its very small potential risk.

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What about nuclear medicine therapy?

- Patients receive higher amounts of radiopharmaceuticals for nuclear medicine therapy.
- These patients might have to stay in the hospital overnight or otherwise take precautions in order to keep the radiation dose to family members at a reasonable level.

- These precautions might include minimizing time spent with small children and using a separate bedroom or bathroom.

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What is the imaging community doing?

- Initiated two dose optimization campaigns
  - Image Gently (imagegently.org): Dose optimization in pediatric imaging
  - Image Wisely (imagewisely.org): Dose optimization in adult imaging

IMAGE WISELY™

- Both campaigns promote using *the appropriate procedure for the specific patient with the minimum radiation dose necessary to provide useful information*.
  - Provide information to patients and referring physicians
  - Provide guidance to imaging community for dose optimization

Useful References

- www.DiscoverMI.org (SNM)
- www.RadiologyInfo.org
- Health Physics Society Public Information Page (www.hps.org/public information)
- www.Imagegently.org
- www.Imagewisely.org
- National Institutes of Health, "An Introduction to Radiation for NIH Research Subjects" (www.drs.ors.od.nih.gov/services/rsc/pages/forms_index.htm)