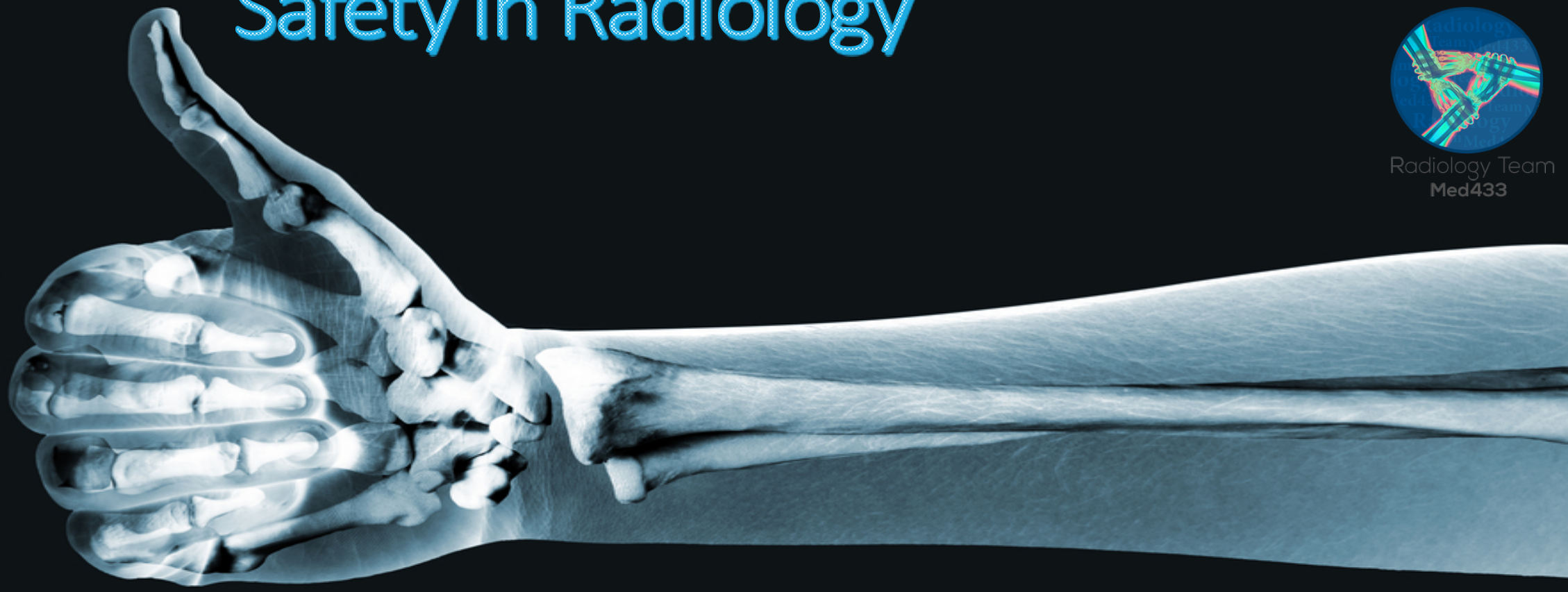
Lecture 2:

Safety in Radiology



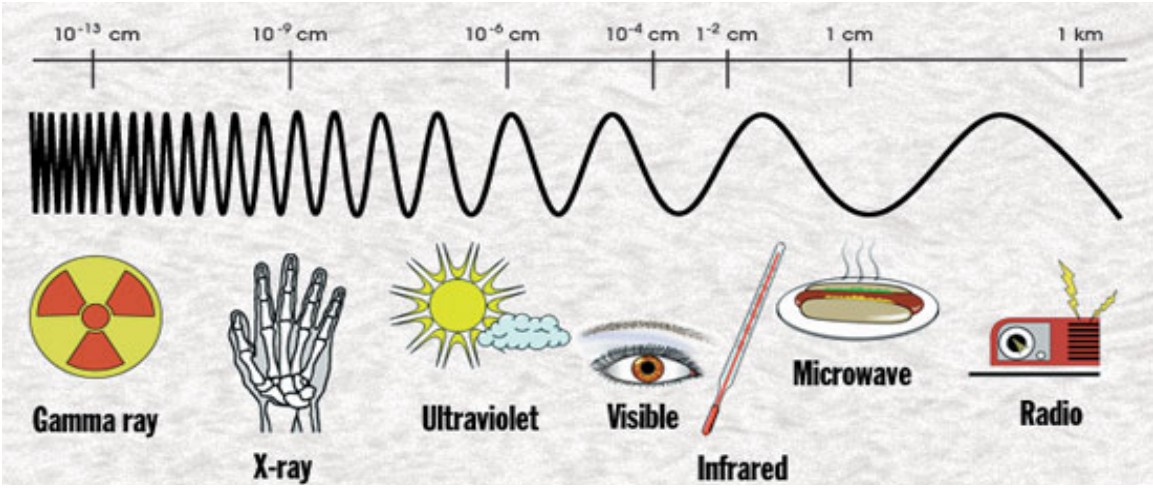
Radiology Team
Med433

● Slides ● Explanation ● Notes ● Additions ● Important

Major Sources of Risk in Radiology:

- ✓ **Radiation hazard**
- ✓ **Radioactive materials hazard**
- ✓ **Magnetic field hazard**
- ✓ **Contrast agents hazard**

Radiation is energy emitted from a substance in the form of waves.



Non-ionizing Radiation:

Does not carry enough energy to produce ions.
e.g. Microwave oven, Television, Radiowaves.

Ionizing Radiation:

Carry enough energy capable of producing ions.
e.g. alpha particles (α), beta (β), gamma (γ) and X-rays (among others).

X-ray:

- X-rays are very short wavelength (high energy) electromagnetic radiation.
- The shorter the wavelength, the greater the energy and the greater the ability to penetrate matter.
- Ionizing radiation such x-ray can be carcinogenic and, to the fetus mutagenic or even lethal.

Early Pioneers in Radioactivity:
-Rutherford: Discoverer of Alpha and Beta rays,1897.
-Becquerel: Discoverer of Radioactivity ,1896.
-The Curies: Discoverers of Radium and Polonium ,1900-1908.
-Roentgen: Discoverer of X-rays ,1895.

Deterministic effects	Stochastic (Probabilistic) effects
-These effects will occur if a minimum dose threshold is exceeded.* -Severity of damage increases with increasing dose above that threshold. ^ dose (exceeding threshold) > ^ severity of damage. *All machines are made so that the radiation does not exceed the threshold, but repeated exposure to radiation can lead to deterministic effects.	-The effect may (potentially) occur following any amount of exposure, there is no threshold. -Probability of occurrence depends on absorbed dose. ^ dose > ^ probability of occurrence of stochastic effects. -Severity of the effect is not dose related. -Even the smallest quantity of Ionizing Radiation exposure can be said to have a finite probability of causing an effect.
Examples of deterministic effects: -Cataract formation -Hair loss -Lung Fibrosis -Skin reddening (erythema) -Infertility -Bone marrow failure -Lowering of the white blood cell count	Examples of stochastic effects: -Carcinogenic effect -Genetic effect

Major organs annual dose limits for preventing deterministic effects are as follows:

Threshold for deterministic effects (Gy)			
	Effects	One single absorption (Gy)	Prolong absorption (Gy-year)
Testis	Permanent infertility	3.5 - 6.0	2
Ovary	Permanent infertility	2.5 - 6.0	> 0.2
Lens of eyes	Milky of lens cataract	0.5 - 2.0 5.0	> 0.1 > 0.15
Bone marrow	Blood forming deficiency	0.5	> 0.4

The numbers in the table represent the threshold that we should not exceed, to avoid deterministic effects.

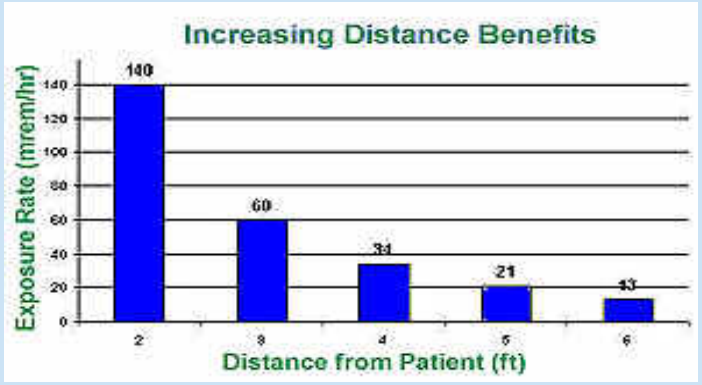
Gray (Unit):
-Gray is unit of exposure of radiation.
-One chest x-ray 0.15 mGray.
-To reach the hazardous level of 2 Gray you need 10000 chest x ray or 100 CT abdomen or 30 mins to 1hr fluoroscopy exposure.

Goals of Radiation Safety:

- **Eliminate deterministic effects.**
- **Reduce incidence of stochastic effects.**

LIMITING YOUR EXPOSURE

Three basic methods for reducing exposure of workers to X-rays:

Minimize exposure time. (Minimize time)	Maximize distance from the X-ray source. (Maximize distance)	Use shielding. (Stand behind lead protection)
	Exposure varies inversely with the square of the distance from the X-ray tube. 	Operators view the target through a leaded glass screen. -Wear lead aprons. Almost any material can act as a shield from gamma or x-rays if used in sufficient amounts. -Standard 0.5mm lead apron Protect you from 95% from radiation exposure. 

As low as reasonably achievable (ALARA):

- ✧**Reduce number of exams.**
- ✧**Reduce time of exams.**
- ✧**Use alternative (US or MRI).**

Radioactive Materials Hazard

What do we mean by Radioactivity?

- **Radioactive decay is the process in which an unstable atomic nucleus loses energy by emitting radiation in the form of particles or electromagnetic waves.**
- **An unstable nucleus releases energy to become more stable.**

Sources of Radioactivity

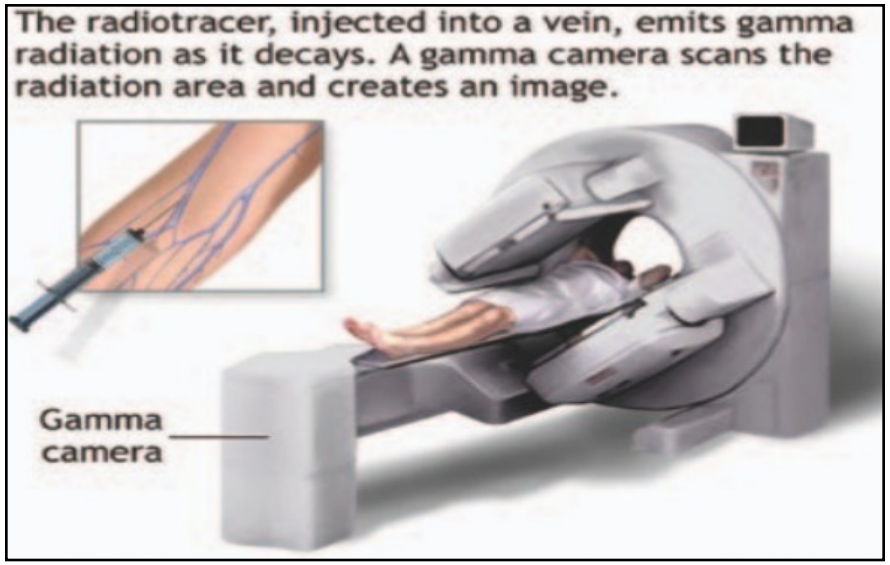
- **Naturally Occurring Sources:**
  - **Radon from the decay of Uranium and Thorium.**
  - **Potassium-40: found in minerals and in plants.**
  - **Carbon 14: found in Plants and Animal tissue.**
- **Manmade Sources:**
  - **Medical use of Radioactive Isotopes.**
  - **Certain Consumer products –(eg Smoke detectors).**
  - **Fallout from nuclear testing.**
  - **Emissions from Nuclear Power plants.**

Medical use of Radioactive Isotopes:

- Radioactive isotopes introduced into the body are distinguishable by their radiation from the atoms already present.
- This permits the relatively simple acquisition of information about the dynamics of processes of uptake, incorporation, exchange, secretion, etc.

Radiopharmaceuticals

- The most widely used radioisotope is Tc, with a half-life of six hours.
- Activity in the organ can then be studied either as a two dimensional picture or, with a special technique called tomography, as a three dimensional picture (SPECT, PET).

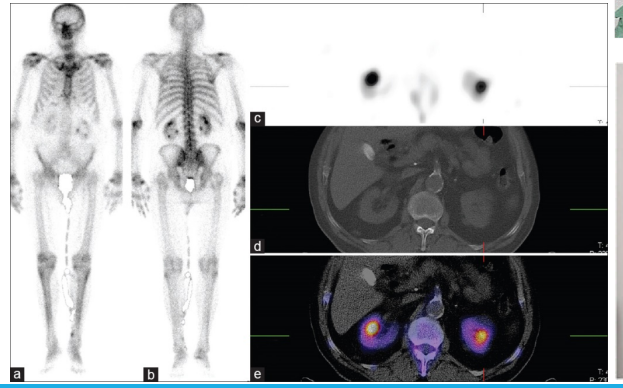


Handling Radiopharmaceuticals

- No radioactive substance should be handled with bare hands. Alpha and beta emitters can be handled using thick gloves.
- Radioactive materials must be stored in thick lead containers.
- Reactor and laboratories dealing with radioactive materials must be surrounded with thick concrete lined with lead.
- People working with radioactive isotopes must wear protective clothing which is left in the laboratory.
- The workers must be checked regularly with dosimeters, and appropriate measures should be taken in cases of overdose.
- Radioactive waste must be sealed and buried deep in the ground.

Spill Response (important)

- **On Skin:** flush completely
- **On Clothing:** remove
- **If Injury:** administer first aid
- **Radioactive Gas Release**: vacate area, shut off fans, post warning.
- Monitor all persons and define the area of contamination.



Magnetic Field Hazard

Magnetic Resonance Hazard

- **MRI is one of the imaging modality that is widely used in radiology.**
- **There is no dangerous radiation in MRI instead it uses very high magnetic field up to 3Tesla (1 Tesla = 20000 times earth gravity).**
- **This strong magnetic field produces powerful attractive force and torque which the magnet exerts on ferromagnetic objects, this is called missile effect. ***
- **The missile effect can pose a significant risk to anyone in the path of the projectile, and cause significant damage to the scanner.**
- **The effect is clearly greater for high field systems.**
- **To guard against accidents from metallic projectiles, the "5 gauss line" should be clearly demarcated and the area with that line kept free of ferromagnetic objects.**
- **It is essential that patient with ferromagnetic surgical clips, implants containing ferromagnetic components, and persons who have suffered shrapnel or steel fragment injuries, especially to the eyes, be excluded from the imager.**
- **A number of general precautions must be taken to ensure the safety of patients and personal working in the imaging suite.**
- **Access to the imaging area should be limited, and signs should be displayed to warn persons with cardiac pacemaker or neuro-stimulators not to enter the area.**
- **Credit cards and watches with mechanical parts should be left outside the imaging area to prevent magnetic tape erasure and watch malfunction.**
- **Some implants are paramagnetic, or even ferromagnetic. These implants tend to move and align with the main magnetic field.**
- **This results in a force and torque on the implant and the implant may become dislodged, resulting in severe injury to the patient.**
- **Aneurysm clips are examples of implants that can result in death if displaced.**

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- **Pacemaker and implanted cardiac defibrillator are typical examples of such devices.**

Contrast Medium Hazard

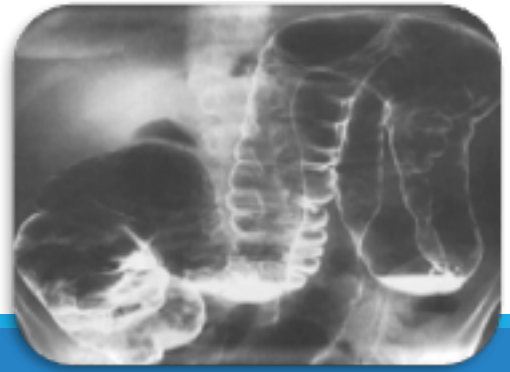
Contrast Agents

- Compounds used to improve the visibility of internal bodily structures in an image.
- Since their introduction in the 1950s, organic radiographic iodinated contrast media (ICM) have been among the most commonly prescribed drugs in the history of modern medicine.
- These contrast agents attenuate x-rays more than body soft tissues due to their high atomic weight.
- Millions of intravascular contrast media examinations are performed each year.
- Iodinated contrast media generally have a good safety record.
- Adverse effects from the intravascular administration of ICM are generally mild and self-limited; reactions that occur from the extravascular use of ICM are rare.
- Nonetheless, severe or life-threatening reactions can occur with either route of administration

Types of Contrast Agent

Negative Contrast

- Organs become more radioluscent
- X-rays penetrate more easily
- Low atomic # material
- Black on film
- E.g. air, CO_2



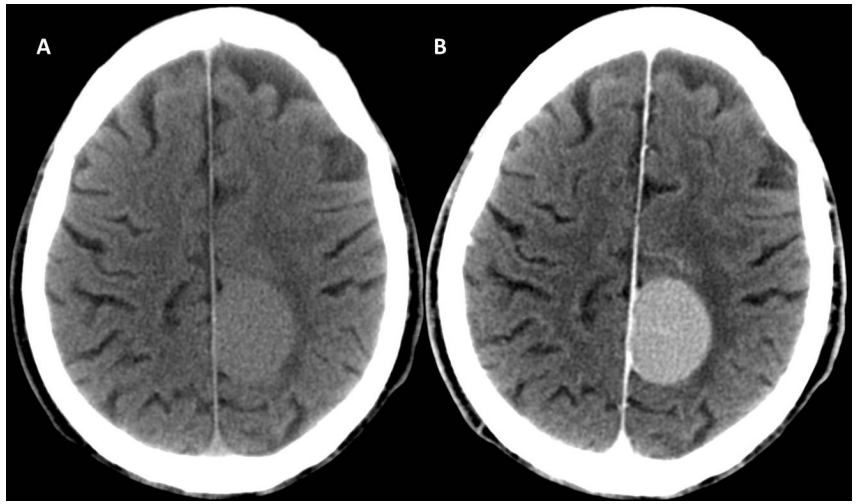
Positive Contrast

- Substance absorbs x-rays
- organ become radiopaque
- high atomic # material
- White on film
- Most common media:
  - Iodinated contrast agent
  - Barium sulphate

IODINE

Serum:	**290 mosm/kg H2O**
HOCM: Ionic monomer	**1570 mosm/kg H2O**
LOCM: Nonionic monomer	**518 mosm/kg H2O**
LOCM: Nonionic monomer	**672 mosm/kg H2O**
IOCM: Nonionic dimer	**290 mosm/kg H2O**

- IODINE (atomic wt 127) provides excellent radio-opacity.
- Higher atomic number maximizing the photo-electric effect.



Iodinated Contrast Agents

Principal classes of iodinated radiological contrast medium:

1- CONVENTIONAL High osmolar CM
   - Ionic monomer (single benzene ring)

2- Low osmolar CM
   - Ionic dimer (molecule with two benzene rings)
   - Non ionic monomer
   - Non ionic dimer

- The toxicity of contrast agents decreases as osmolality approaches that of serum.
- This has been accomplished by developing nonionizing compounds and then combining two monomers to form a dimer.
- Currently used iodinated agents are cleared almost completely by glomerular filtration.
- Circulatory half life is 1–2 hours, assuming normal renal function.

Reaction Classification

- Immediate reactions: were defined as those occurring within the department (within one hour).
- Delayed: as those occurring between the time the patients left the department and up to seven days later .
- The American College of Radiology has divided adverse reactions severity to contrast agents into the following categories:
  - Mild.
  - Moderate.
  - Severe.

Type of reaction	symptoms	Treatment
Mild	Nausea & vomiting.	Observe
Moderate	•Skin reaction. •bronchospasm.	•Anti-histamine •epinephrine
Sever	•Hypotension •Tachycardia	•Anti-histamine epinephrine •atropine

Methods of administration of contrast material:

INGESTED
- ORAL: Barium sulfate suspension

RETROGRADE
- AGAINST NORMAL FLOW: Barium Enema

INTRATHECAL
- Spinal canal

INTRAVENOUS
- Injecting into bloodstream
- (anything other than oral)

Moderate Reaction

- Reactions which require treatment but are not immediately life-threatening.

Tachycardia/bradycardia	Hypotension	Bronchospasm, wheezing
Hypertension	Dyspnea	Laryngeal edema
Pronounced cutaneous reaction	Pulmonary edema	

- **Treatment:** Prompt treatment with close observation.

Mild Reaction

- Signs and symptoms appear self-limited without evidence of progression.

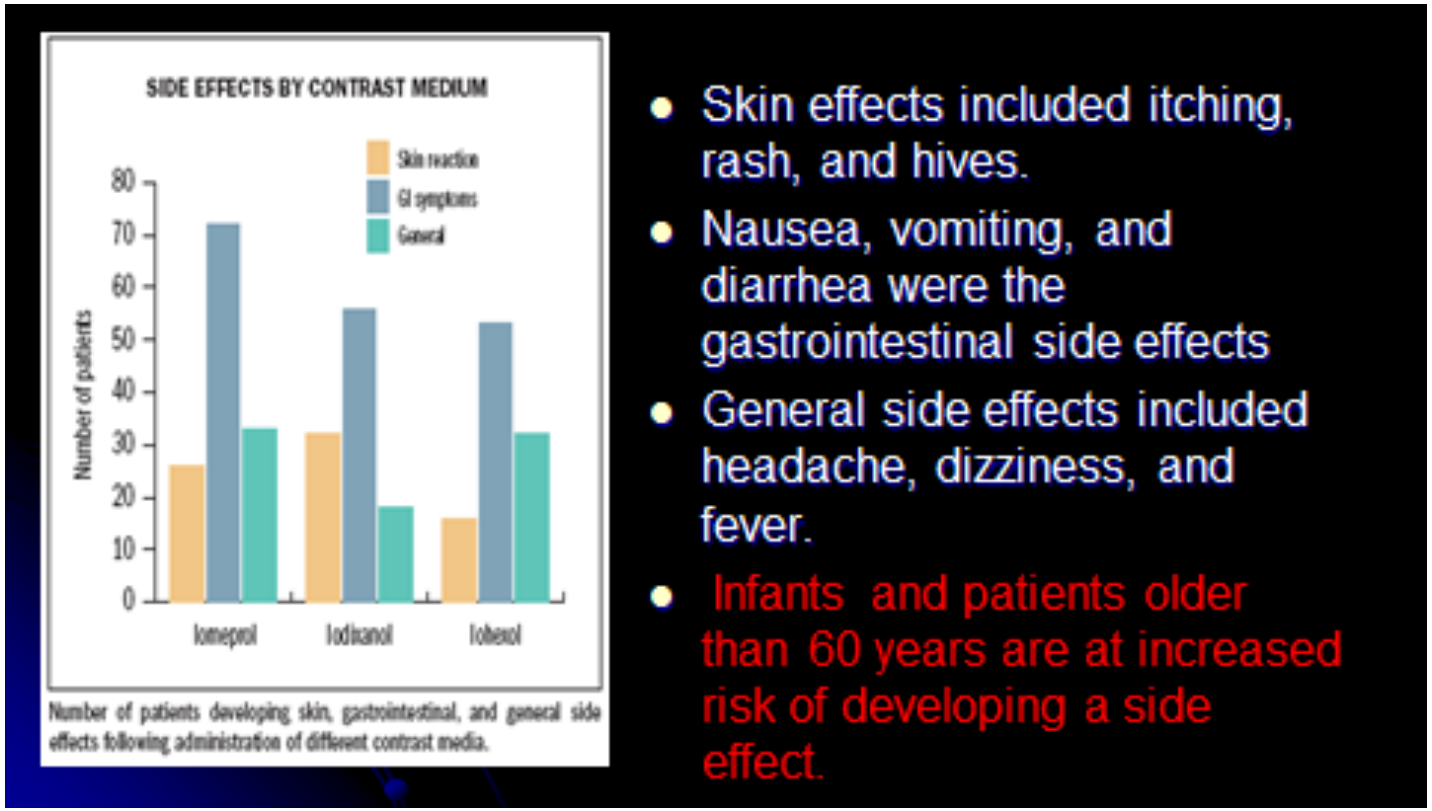
Nausea, vomiting	Altered taste	Sweats
Cough	Itching	Rash, hives
Warmth (heat)	Pallor	Nasal stuffiness
Headache	Flushing	Swelling: eyes, face
Dizziness	Chills	Anxiety
Shaking		

- **Treatment:** Observation and reassurance. Usually no intervention or medication is required; however, these reactions may progress into a more severe category.

Reaction Classification (cont.)

Delayed Contrast Reactions:

- Delayed contrast reactions can occur anywhere from 3 hours to 7 days following the administration of contrast.
- It is important for anyone administering intravenous contrast media to be aware of delayed reactions.
- The more common reactions include a cutaneous xanthem, pruritis without urticaria, nausea, vomiting, drowsiness, and headache.



Contraindications for Contrast:

- Renal Failure (Check BUN & Creatinine)
- Elevated levels could cause renal shutdown
- Anuria (no urine production)
- Asthma (possible allergies)
- Hx of Contrast Allergy / Reactions
- Diabetes - get a hx of medications taken
  glucophage must be stopped 48 hrs before contrast injection
- Multiple Myeloma
- Pregnancy (risk of fetal Thyroid toxicity).
- Allergic Reaction, Pre – medication is available.

EXTRAVASATION

- Contrast material has seeped outside of vessel.
- Apply WARM Compress 1st 24 hours.
- Cool compress for swelling.

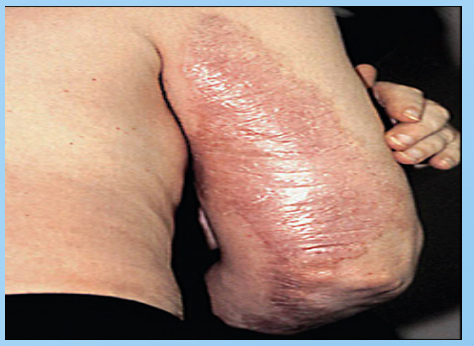
Extravasation of Contrastinto soft tissue of arm

MRI Contrast:

- The Contrast used in MRI is based on paramagnetic ions eg. Gadolinium.
- By themselves these ions are highly toxic so bound up in large molecules eg. DTPA.
- Provides a greater contrast between normal and abnormal tissues.

Gadolinium Side Effects:

- With impaired kidney function, gadolinium could lead to a serious and potentially fatal disorder called Nephorgenic Systemic Fibrosis. (NSF)



Cases from 432 Team:

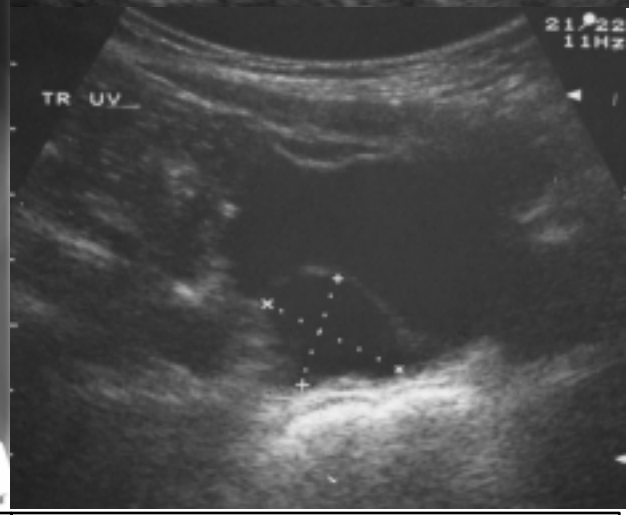
Case 1:

A 45 year old patient had the following symptoms and signs after diphasic CT of the liver:
RR= 30/min (tachypnea)
BP= 80/40 mmHg (hypotension)
Pulse = 125/min (tachycardia)
Answer: sever > Anti-histamine, epinephrine, atropine.

Case 2:

Status: Lethargic.
RR: 28/min (tachypnea)
BP: 70/40 mmHg (hypotension)
Pulse: 130/min (tachycardia)
Chest: Some expiratory wheezes
Answer: sever > Anti-histamine, epinephrine, atropine.

Case 3:



Intravenous pyelography (intravenous urography: Has filling defect could be tumor.	US: hypoechoic >cystic lesion not solid > ureterocele

The Diagnosis here is ureterocele. (A cystic out-pouching of the distal ureter into the urinary bladder)

Thank You!

We hope you found this helpful and informative.

Done by:

- Faris Alharbi
- Rayan Alowaisheq

Reviewed by:

- Abdullatif Al-hasan
- Ghaida Alawaji

You can always contact us at Radiology433@yahoo.com