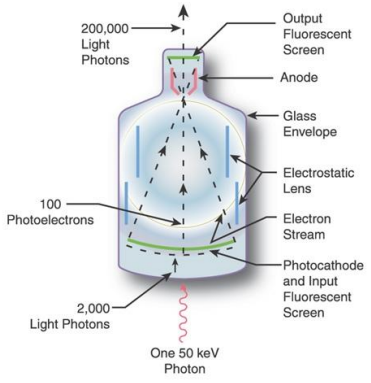
Fluoroscopy Operation and Safety: Influence on Patient Dose

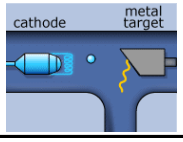
Fluoroscopy

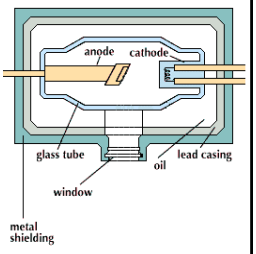
- High dose procedures
- Last resort **after** routine radiography
- 100-500 mA for routine studies vs. an average of 3mA for fluoroscopy*
- Dynamic studies
- Transient structures
- Fluorescence



Standard X-Ray Tube

- Rotating anode
- Small focal spot
- Operates in the range of 0.5 to 5 mA





Milliamperage (mA)

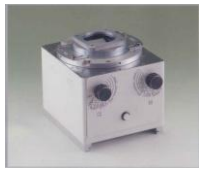
- mA controls density and photon quantity
- Directly proportional to dose
- Typical mA's:
  - Average of 3 mA
  - Spot imaging > 100 mA

Kilovoltage Peak (kVp)

- Contrast
- Differential absorption
- Quality
- Peak kVp

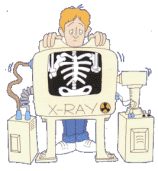
Collimation

- Principle method to reduce patient dose
- Image will NOT be brighter if collimation is open wider



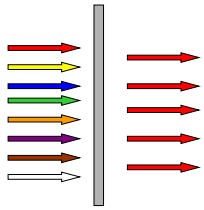
Collimation and Title 17

- With automatic collimating devices on a fluoroscopic unit, an unexposed border must be visible at all heights above the table
- With manual collimation: 14 inches above table



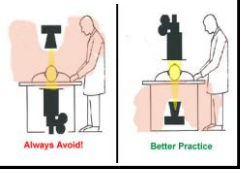
Filtration

- Hardens the beam
- Inherent = 0.5mm AL
- Added = 2.0mm AL
- Total ***minimum*** filtration is 2.5 mm/AL



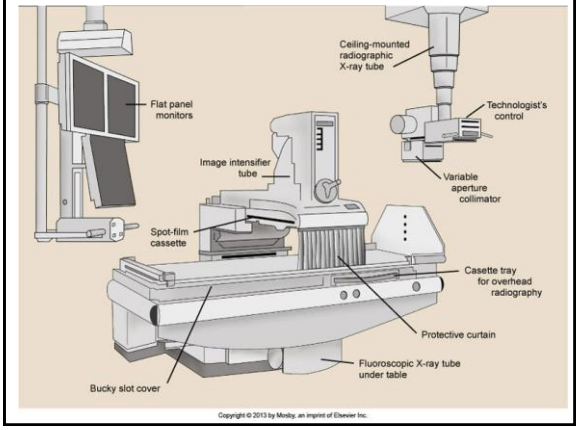
Source to Table Top Distance (STTD)

- Should be 18”
- Shall be no less than 12”
- Also called target-to-panel distance (TPD)



Object to Image Distance

- OID in fluoroscopy refers to the distance between the patient and the image intensifier
- Minimize at all times
- Ultimately reduces patient dose (to be discussed later)



Low Absorption Table Tops

- Made of composite materials like Bakelite, fiberglass, polycarbonate, carbon fiber, etc.
- Table cannot excessively absorb the primary beam
- Shall be no more than 1 mm Al (aluminum equivalent) at 100 kVp

Exposure Switch

- Must be of the dead-man type
- Exposure is discontinued when pressure is released

Primary Protective Barrier

- Refers to the image intensifier tube housing
- 2 mm Pb at 125 kVp
- Primary barrier for room
  - 1/16” Pb at 6’8”
- Secondary barrier for room
  - 1/32” Pb at 6’8”

Bucky Slot Cover

- 0.25 mm Pb or equivalent
- For operator protection

Protective Drapes

- 0.25 mm Pb or equivalent
- Prevents scatter from reaching the operator
- Theoretically, one could receive 500 mR / hr at 1 foot from the table
- The technologist/operator only gets 1/1000 of what the patient receives

Exposure Time

- Fluoroscopy exposure is pulsed rather than continuous
- System must have *last image hold* (LIH)
- Want to limit the "beam on" time

Exposure Rates

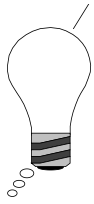
- Air Kerma Rate (AKR)
- For normal operation, up to 5 R / min OR 2.2 R/mA to Max 5 mA
- 10 R / min with a coupled recording device
- 44 mGy/min = 5 R/min
- 88 mGy/min = 10 R/min

Reset Timer

- Preset to 5 minutes
- Does NOT terminate exposure
- Alerts fluoroscopist to accumulated fluoroscopy time
- If an alarm sounds, it must be for a minimum of 2 seconds

Illumination (Room)

- Room must have <u>low illumination</u>
- Enhances black and white vision
- <u>Indirectly</u> impacts patient dose



Quantum Mottle

- Too few incident photons at the input phosphor
- Appears as noise or “snow”
- Poor image quality
- ***More evident using high contrast or magnification modes***

Resolution

- Pertains to detail of small objects adjacent to each other
- Line pair tester
- Line pair / mm (lp/mm)
- Modulation Transfer Function (MTF)
- Ideal value = 1
- In reality, MTF < 1

Contrast

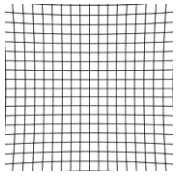
- Subject contrast
- Controlled by kVp
- Short and long scale
- Detector contrast ratio 15:1
- Decreases with age

Contrast

- The brightness ratio of the periphery of the output screen to the center of the output screen is referred to as **contrast**

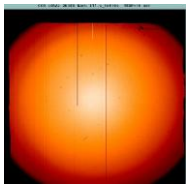
Distortion

- Size distortion
- OID
- Shape distortion
- Geometric differences between input and output phosphors
- Pincushion effect



Vignetting

- Also due to geometric differences between input and output phosphors
- Fall-off of brightness at the periphery of the image

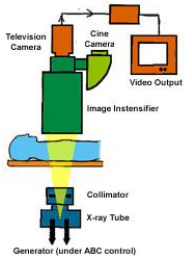


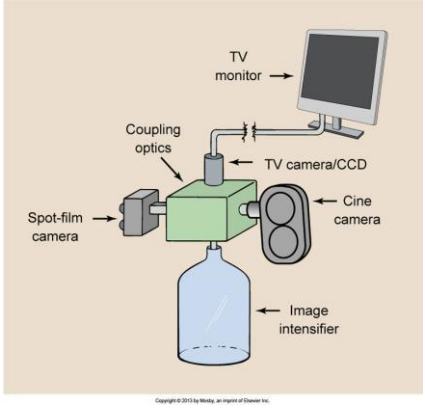
Cameras & Lag

- Image build-up and decay in the TV camera
- Vidicon camera:
  - high lag, low dose
- Plumbicon camera:
  - Low lag, high dose
- **Cameras** are attached at the output phosphor
- NOTE: TV cameras are NOT used with CCD or flat panel detectors

Synchronization of Coupled Device

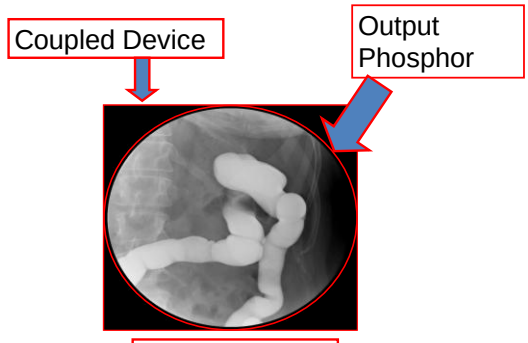
- A coupled device is a camera or similar
- Operates at the same frequency of x-ray pulses
- Shutters closed when film is transported





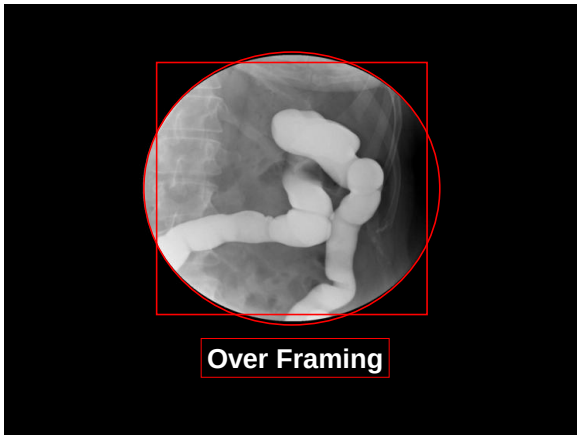
Framing (Pulse) Frequency

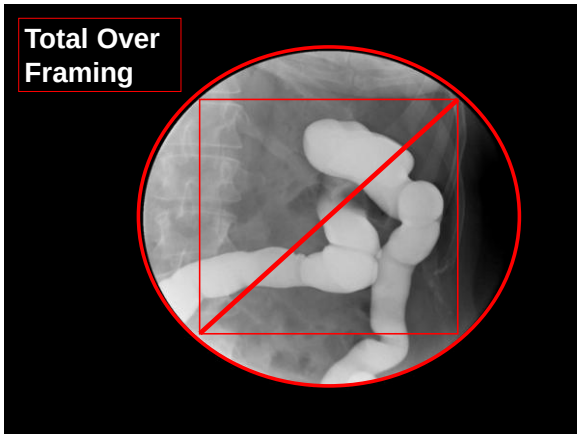
- Always in division of 60
- Typically 30 frames/pulses per second
- Higher framing frequency means higher dose to the patient



Exact Framing

Under Framing





F Number

- References the speed of a given camera
- The lower the number, the faster the camera
- Low number will reduce patient dose
- F= Focal length / diameter of lens

Recording Devices

- Conventional spot film
  - **Highest dose & best quality**
- Spot film camera (photospot, digital photospot)
  - Low dose with lower quality
- Video Tape
  - **Lowest dose with poor quality**
- Digital recording
  - Lower dose and good quality

Gonadal Shielding

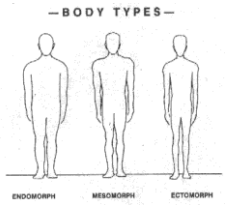
- Mandated by law
- California requires a minimum of 0.5 mm Pb
- "Shall be no less than 0.5 mm Pb"

Grids

- Use always increases patient dose
- Most fluoroscopy systems have low ratio grids
- Avoid using grids in pediatric patients

Body Habitus

- Tissue density
- Additive conditions
- Destructive conditions
- High atomic number and attenuation



Scatter and Absorption

- High kVp
- Large field size
- Thick body habitus
- Extended source of radiation

X-Ray Generators

- Common generators include single phase, three-phase, medium, and high frequency
- Three-phase and high frequency have certain advantages such as constant potential and high mA resulting in unlimited exposure times

Contrast Media

Contrast Media

- The purpose of contrast media is to alter the characteristics of the patient's body
- Many structures will not be apparent unless contrast media has been introduced
- Contrast media will either be positive or negative

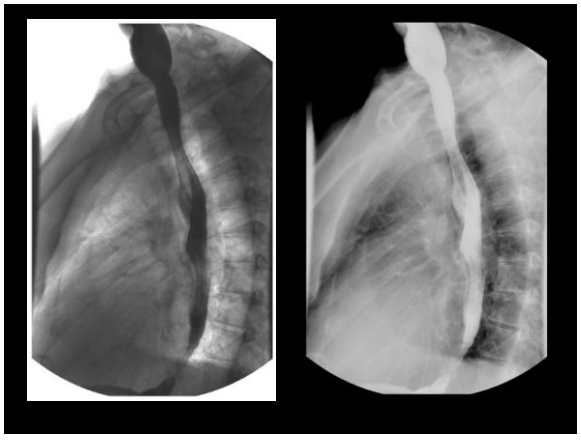
Contrast Media (cont)

- Negative contrast media are those which are considered radiolucent
  - These media would consist of room air, CO_2, or something similar
- Positive media absorb x-rays and are considered radiopaque
  - Barium, iodine, or something with a higher atomic number
- Must be non-toxic

$BaSO_4$

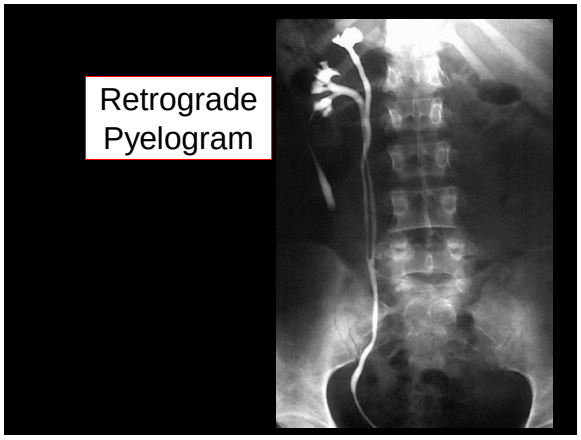
- Most frequently chosen contrast
- White, crystalline powder that is mixed with water to make a **suspension**
- Can be administered by mouth, rectum, and tube insertion
- Relatively nontoxic, however, if there is a leakage into the peritoneal cavity or blood stream, an adverse reaction can occur
- Can be constipating

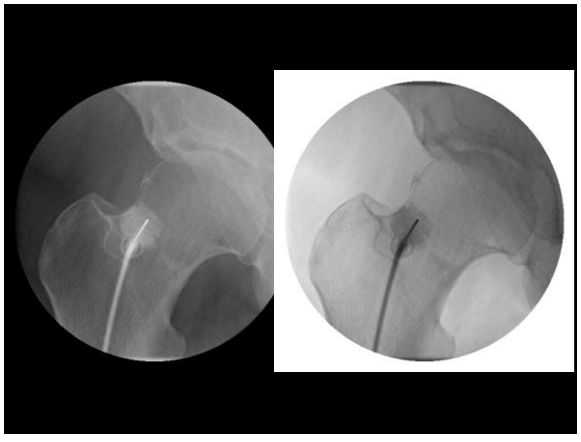
Barium Preparation

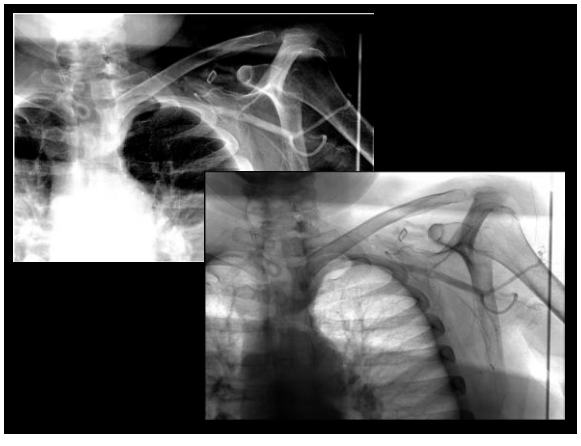


Iodinated Contrast

- Iodine has an atomic number of 53
  - Absorbs photons through photoelectric interactions
- Most are water-based (in solution)
- Can be ingested (for GI studies) and injected (venous, arterial, joint spaces, thecal sac, etc.)


Retrograde
Pyelogram





Ionic Media

- All iodinated contrast media are composed of a cation (+) and an anion (-)
- The cation is either the sodium or meglumine compound in ionic media
- The ions dissociate (ionize) completely once inside the body

Ionic Media

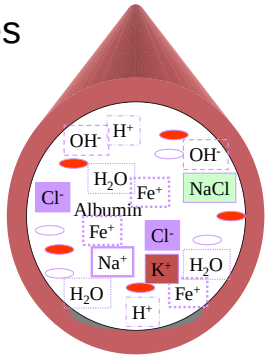
- Most are higher-osmolality contrast media (**HOCM**)
- Osmolality is a measure of the total number of particles in solution per kilogram of water
- Osmotic pressure controls fluid movement in the body

Ionic Media (cont)

- HOCM changes the blood plasma
- Pulls water from the tissue into the blood stream causing an electrolyte imbalance
- Movement also causes **hypervolemia** and blood vessel dilatation

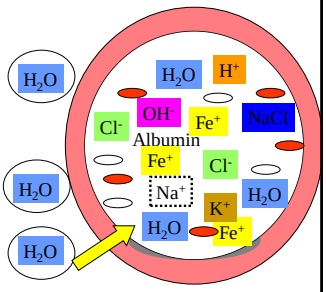
Electrolytes

- Anion
  - Negatively charged constituent
- Cation
  - Positively charged constituent



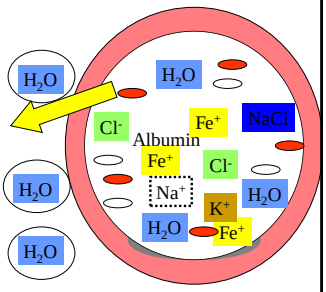
Effects of Hypertonic Contrast Media

- Water moves into lumen to dilute environment
- Net effect an increase in the volume of fluid in the lumen, but homeostasis is restored



Effects of Hypotonic Contrast Media

- Water moves out to equalize concentration
- Net reduction in intracellular volume
- Edema in surrounding tissue



Non-ionic Media

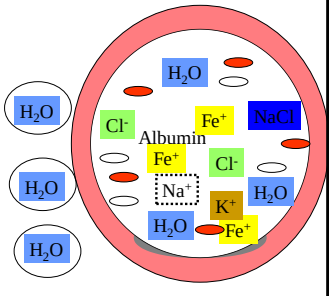
- Contrast media was developed over time to reduce side effects
- Some media do not dissociate into cations and anions
- Others are still ionic but with large molecules which do not cause osmotic effects

Non-ionic Media (cont)

- Lower-osmolality contrast media (**LOCM**)
- Cations were removed without any loss of diagnostic information
- Replaced with compounds that do not dissociate
- Osmolality closer to human plasma
- **LOCM** are more water soluble, may be less likely to trigger allergic effects

Effects with Non-Ionic Contrast Media

- Less net movement of ions in either direction
- Less change in electrolyte balance
- Minimal fluid shift through kidneys



All Iodinated Contrasts

- Iodine in its natural state is chemically reactive and can be toxic in the body
- Both types of iodinated media contain additives (citrate, calcium disodium edetate)
- Prevent iodine atoms from being removed from the contrast molecules

Patient Assessment

- Patient history must be taken for information pertinent to contrast injection and anything that may predict an allergic reaction
- Prevention of serious adverse effects
- Correct medical treatment must be initiated immediately in the event of a reaction

Effects of Iodinated Contrast

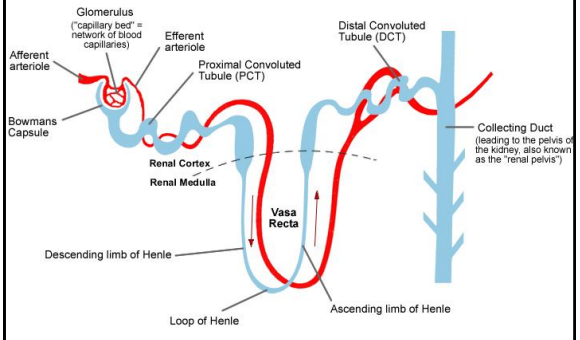
- General effects
  - HOCM show greater effects and adverse reactions
  - Viscosity is influenced by concentration and size of the molecule
  - Affects ability to inject

Renal Effects

- HOCM cause arteries of the kidneys to expand because of the osmotic effect
- Expansion results in release of vasoconstrictors to constrict the renal arteries
- End result is diminished blood supply to the kidneys

Renal Effects (cont)

- Osmotic effects presumed to increase the amount of molecular substances reabsorbed by the renal tubules
- Osmotic diuresis and dehydration
- BUN and creatinine are good indicators for possible contrast media-induced renal effects



http://www.ivy-rose.co.uk/Topics/Urinary_System_Nephron_Diagram.htm

Patient Reactions

- Expected side effects
- Mild (minor)
- Moderate
- Severe
- Vasovagal

Expected Side Effects

- A feeling of flushing or warmth
- Nausea and / or vomiting
- Headache
- Pain at the injection site
  - Check for extravasation
- Altered taste, may be metallic

Mild Adverse Reaction

- Nausea / vomiting
- Cough
- Feeling of warmth
- Headache
- Dizziness
- Shaking
- Itching
- Pallor

Moderate Adverse Reaction

- Tachy- or bradycardia
- Hyper- or hypotension
- Dyspnea
- Bronchspasm or wheezing
- Patient complaint of feeling of throat closing (laryngeal edema)

Severe Anaphylactic Reaction

- Dyspnea related to laryngeal edema
- Hypotension
- Seizures
- Cardiac arrythmia
- Lack of patient response
- Cardiac / respiratory arrest

Vasovagal Response

- Reaction to the procedure itself than the contrast
- Due to high anxiety on the part of the patient
- Pallor (paleness), cold sweats, rapid pulse, syncope (or complaining of feeling faint), bradycardia, hypotension
- Stop contrast, place patient flat or in Trendelenberg position, notify supervising physician, stay with the patient

Your Role

- Responsibility of patient comfort throughout the duration of the procedure
- Identify signs and symptoms of adverse reactions
- Obtain a thorough patient history that can indicate contrast media contraindications or increased possibility of adverse reactions