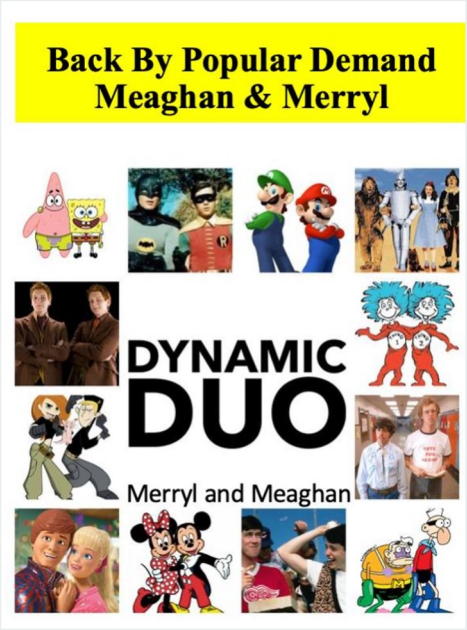
Merryl & Meaghan Tips & Tricks

Fluoroscopy Edition



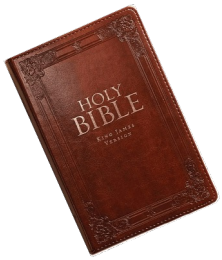
1

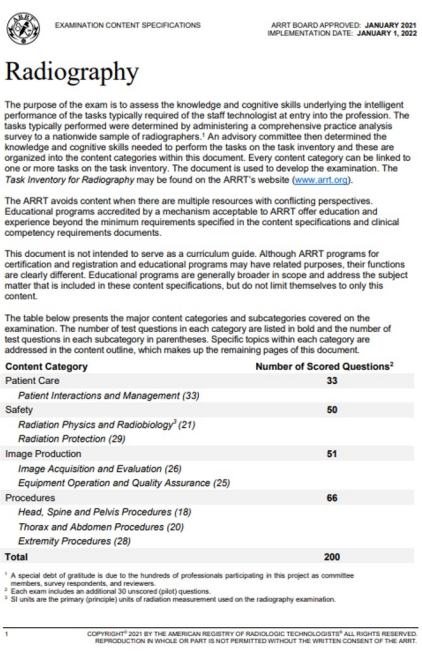
ARRT Content Specifications

The ARRT provides an examination content specification list.

It outlines the breakdown of questions in each category in addition to listing the terms and radiographic procedures included on the test.

Use it as a study guide!!





EXAMINATION CONTENT SPECIFICATIONS

ARRT BOARD APPROVED: **JANUARY 2021**
IMPLEMENTATION DATE: **JANUARY 1, 2022**

Radiography

The purpose of the exam is to assess the knowledge and cognitive skills underlying the intelligent performance of the tasks typically required of the staff technologist at entry into the profession. The tasks typically performed were determined by administering a comprehensive practice analysis survey to a nationwide sample of radiographers.[1] An advisory committee then determined the knowledge and cognitive skills needed to perform the tasks on the task inventory and these are organized into the content categories within this document. Every content category can be linked to one or more tasks on the task inventory. The document is used to develop the examination. The *Task Inventory for Radiography* may be found on the ARRT's website (www.arrt.org).

The ARRT avoids content when there are multiple resources with conflicting perspectives. Educational programs accredited by a mechanism acceptable to ARRT offer education and experience beyond the minimum requirements specified in the content specifications and clinical competency requirements documents.

This document is not intended to serve as a curriculum guide. Although ARRT programs for certification and registration and educational programs may have related purposes, their functions are clearly different. Educational programs are generally broader in scope and address the subject matter that is included in these content specifications, but do not limit themselves to only this content.

The table below presents the major content categories and subcategories covered on the examination. The number of test questions in each category are listed in bold and the number of test questions in each subcategory in parentheses. Specific topics within each category are addressed in the content outline, which makes up the remaining pages of this document.

Content Category	Number of Scored Questions[2]
Patient Care	**33**
Patient Interactions and Management (33)	
Safety	**50**
Radiation Physics and Radiobiology[3] (21)	
Radiation Protection (29)	
Image Production	**51**
Image Acquisition and Evaluation (26)	
Equipment Operation and Quality Assurance (25)	
Procedures	**66**
Head, Spine and Pelvis Procedures (18)	
Thorax and Abdomen Procedures (20)	
Extremity Procedures (28)	
Total	**200**

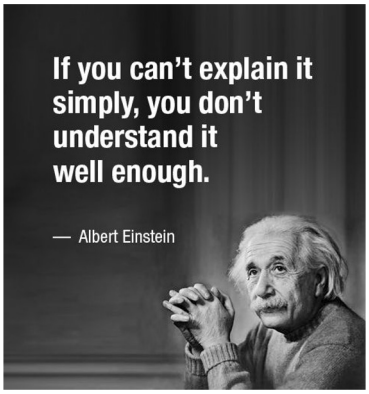
[1] A special debt of gratitude is due to the hundreds of professionals participating in this project as committee members, survey respondents, and reviewers.
[2] Each exam includes an additional 30 unscored (pilot) questions.
[3] SI units are the primary (principle) units of radiation measurement used on the radiography examination.

2

Additional Resources

Popular Resources for studying

1. Mosby Review Textbook
2. Radtech Bootcamp (Clover Learning)
3. Rad Review Easy
4. Lange Q&A
5. Lange Flashcards
6. Lange Prep
7. Corectec
8. Kettering Review
9. X-ray Coach
10. Seal Exams
11. Hesi



3

How do I organize all this information???

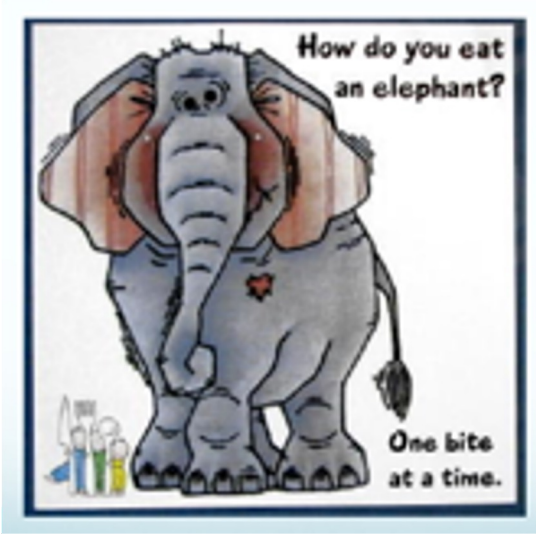
How do you eat an elephant? One Bite at a time!

How do I study all of this material? One topic at a time!

Which Bite of the Elephant (Topic)?

- ❑1. Ethics & Legal
- ❑2. Interpersonal Communications
- ❑3. Physical Assistance & Monitoring
- ❑4. Medical Emergencies
- ❑5. Infection Control
- ❑6. Handling & Disposal of Toxic Matter
- ❑7. Pharmacology
- ❑8. Principles of Radiation Physics (3)
- ❑9. Biological Aspects of Radiation (3)
- ❑10. Minimizing Patient Exposure (3)
- ❑11. Personnel Protection (3)
- ❑12. Image Acquisition & Technical (4)
- ❑13. Imaging Equipment (5)
- ❑14. Image Processing & Display (4)
- ❑15. Criteria for Image Evaluation (4)
- ❑16. Quality Control (5)
- ❑17. Head
- ❑18. Spine & Pelvis
- ❑19. Thorax
- ❑20. Abdomen, GI & GU
- ❑21. Upper Extremities
- ❑22. Lower Extremities
- ❑23. Other

https://www.merrylfulmer.com/



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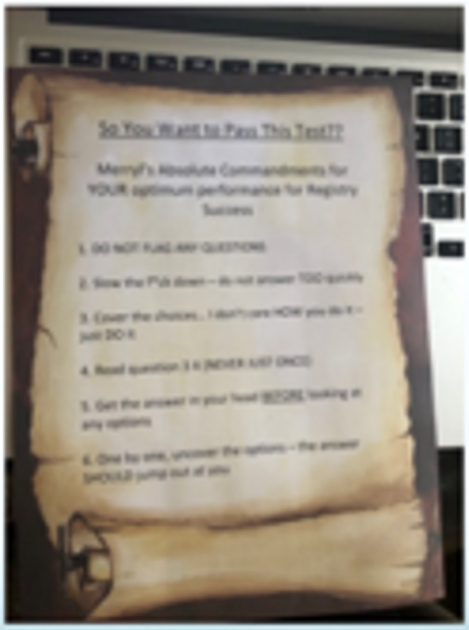
Want to Pass this Test?

Merryl Fulmer's Absolute Commandments for success!

1. DO NOT FLAG!
2. Slow the f*uck down
3. Read the question 3x
4. Cover the choices (don't look)
5. Answer the question in your head first
6. One by one uncover the options

Go with your first gut instinct

Don't change your answers!!



5

The benefit of tutoring

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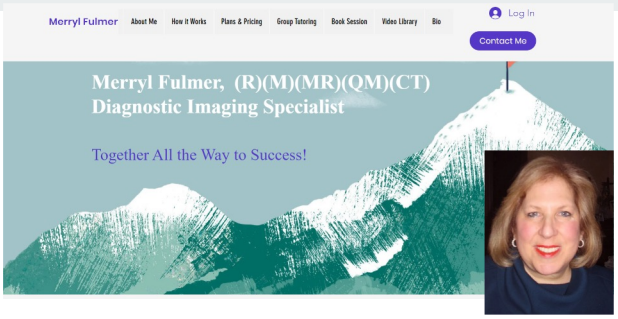
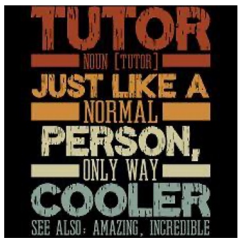
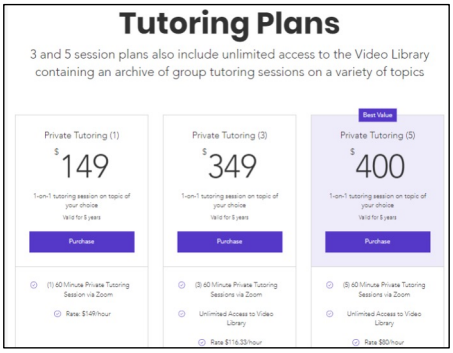


Most students learn better and find more enjoyment in their studies when they receive the kind of personalized attention that a tutor can offer.

A good tutor will learn about the student's interests, strengths, and weaknesses, what motivates and discourages them, and their personal goals





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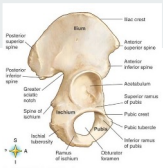
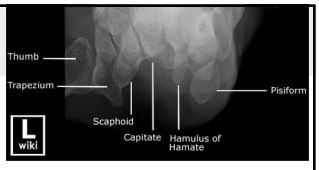
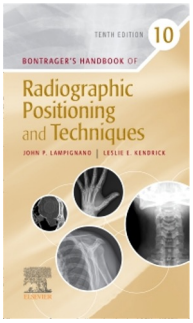
Procedures & Anatomy





- **Radiographic procedures category comprises the biggest area of all the questions on the exam. 66 out of 200 questions**
  - *Success on the registry can be substantially improved by prioritizing this section and giving it sufficient time and effort in your study plans.*
- **Go TEXTBOOK and Make procedures a part of every study session**
  - *If you set aside 2 hours to study, take 20-30 minutes and review an area of anatomy and procedures.*
- **Divide material into sections** – *Keep in mind **28 questions of 66 will be extremities*! Follow the Specs!!!**
  - *Fingers to elbow*
  - *Humerus & Shoulder*
  - *Toes to knee*
  - *Femur & Pelvis*
  - *Spine*
  - *Cranium & Facial Bones*
  - *GI & Urology studies*
  - *Other – arthrograms, myelogram, HSG etc.*
- **ANATOMY!**
  - *Know anatomy!*
  - *Even the exams that are not common ex: carpal tunnel, Judet, Holmblad*



7

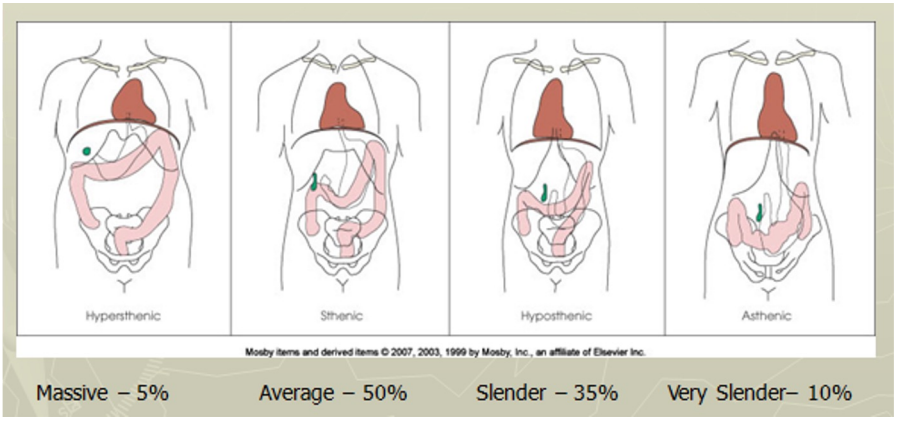
Body Habitus! Key words!

Sthenic - Average body type = 50%

Hyposthenic - Below average body type = 35%

Asthenic - Extremely small build = 10%

Hypersthenic - Above average or massive = 5%

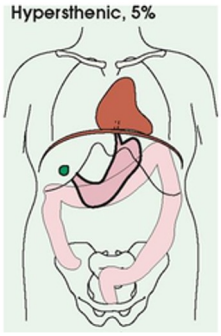


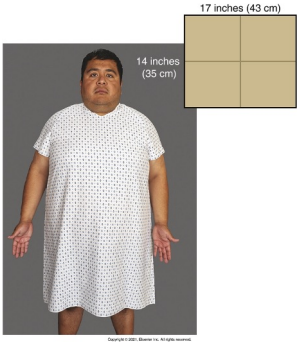
8

Body Habitus - Hypersthenic

Hypersthenic

- 5 %
- Very “stocky”
- Dome of the diaphragm is high
- **Gallbladder**
  - **High and Transverse** and to the right
  - **Level T10-T11**
  - 1” caudal to xiphoid
- **Stomach**
  - **High and more transverse**
  - **Level T9-T12**
  - **Duodenal Bulb level of T11 - T12**
- **Large Intestine**
  - Extends to periphery
  - Transverse colon and left colic flexure located high in the abdomen





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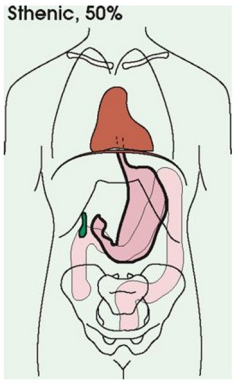
Body Habitus - Sthenic

Hypersthenic

- 50 %
- Average - slightly heavy set
- **Gallbladder**
  - **Level T12-L1**
  - 2-3” caudal to xiphoid
- **Stomach**
  - **J shaped - more vertical and primarily left of midline**
  - **Level T10/11-L2**
  - **Duodenal Bulb level of L1-L2**
- **Large Intestine**
  - left colic flexure located high in the abdomen
  - Transverse colon lower to mid abdomen

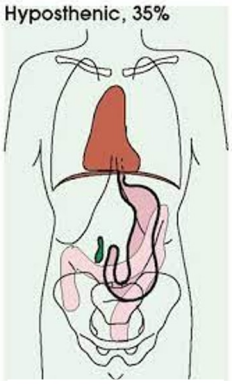


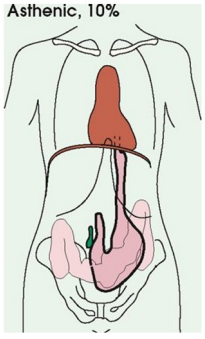
10

Body Habitus - Hyposthenic / Asthenic

Hyposthenic = 35% **Asthenic = 10%**

- 45% combined - similar anatomy location
- Slender build
- Long, narrow, slender thorax
- **Gallbladder**
  - **Level L3-L4 (just above crest)**
  - Near midline
- **Stomach**
  - **Elongated, vertical and low**
  - **Level T11-L5**
  - **Duodenal Bulb level of L3-L4**
- **Large Intestine**
  - left colic flexure and transverse colon located low in the abdomen.





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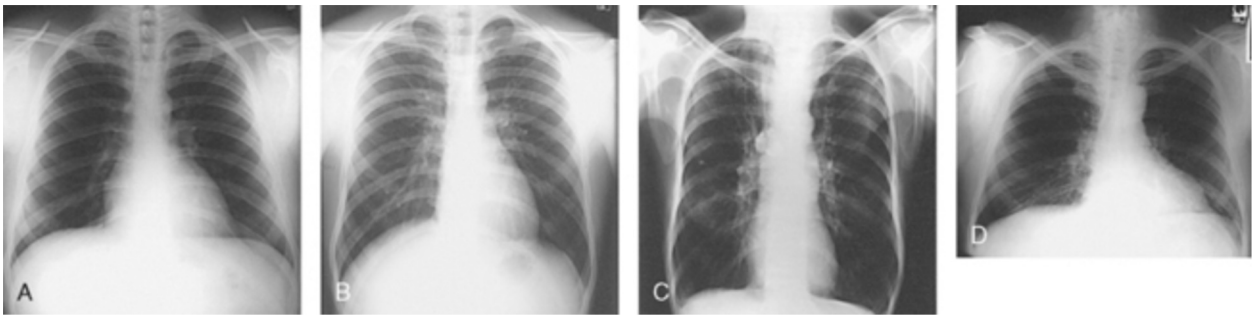
Body Habitus - Chest images



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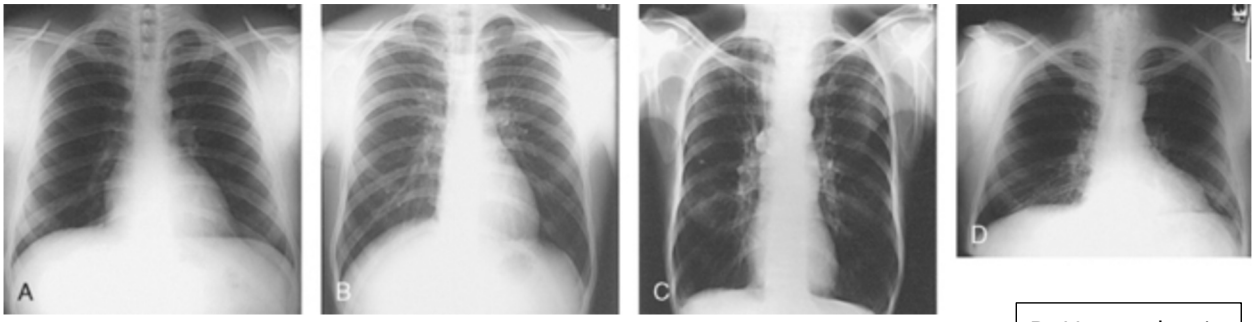

A. Sthenic

B. Hyposthenic

C. Asthenic

D. Hypersthenic

Placement, shape and size of lungs heart and diaphragm will help you determine body habitus.

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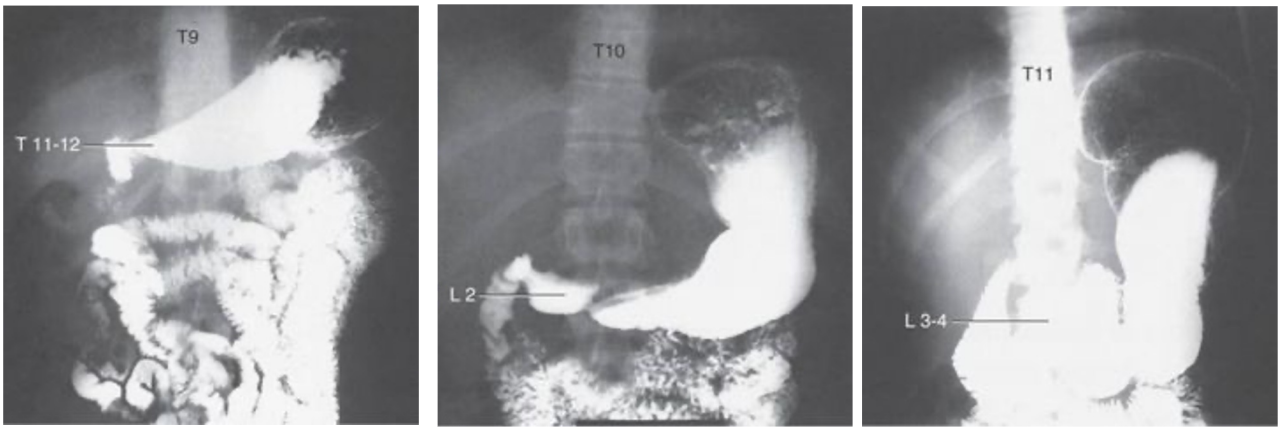
Body Habitus - Abdomen Imaging
Stomach & Duodenal Bulb location



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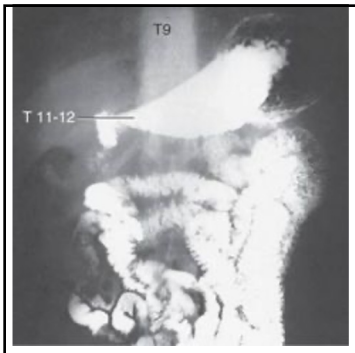
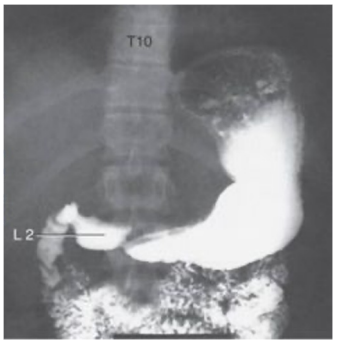
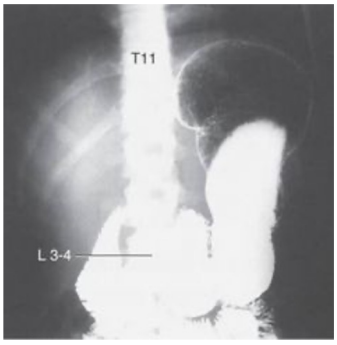


Hypersthenic - Massive
Stomach high and transverse
Gallbladder high and transverse
Duodenal bulb T11-T12



Sthenic - Average
Stomach long and Low - J shape
Gallbladder T 12- L1
Duodenal bulb L1-L2



Hyposthenic/Asthenic- Thin
Stomach long and Low - J shape
Gallbladder low and midline
Duodenal bulb L3-L4

15

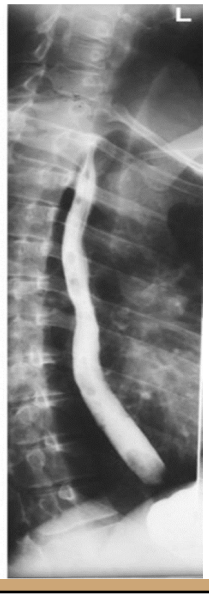
Fluoroscopy Procedures

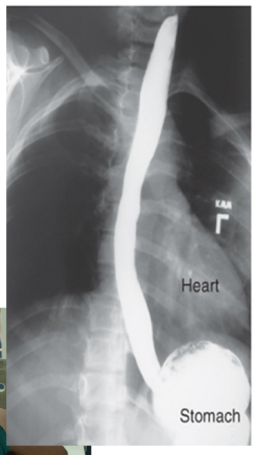
1. Esophagus
2. Swallowing dysfunction study
3. Upper GI series (single & double)
4. Small Bowel Series
5. Contrast Enema (single & double)
6. Hysterosalpingogram
7. Arthrogram
8. Myelogram
9. Cystography
10. Cystourethrography
11. Intravenous Urography (IVU)
12. Retrograde Urography
13. ERCP
14. Surgical Cholangiogram

16

Esophagus Barium Swallow

1. **Right Anterior Oblique (RAO) Esophagus**
   a. **"RAO Drinking"**
   b. Patient will be drinking barium from a cup with a straw during exposure
   c. **Oblique degree = 35-40 degrees**
   d. CR = T5/T6
      i. 2-3" or 5-7.5 cm below jugular notch
   e. Esophagus should be **between the vertebrae and the heart**
      i. Under rotated = esophagus over spine





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Swallowing Dysfunction study (CINE)

Modified Barium Swallow

- Speech pathologist involved
- Uses video fluoroscopy
- ?aspiration
- Stroke patients

18

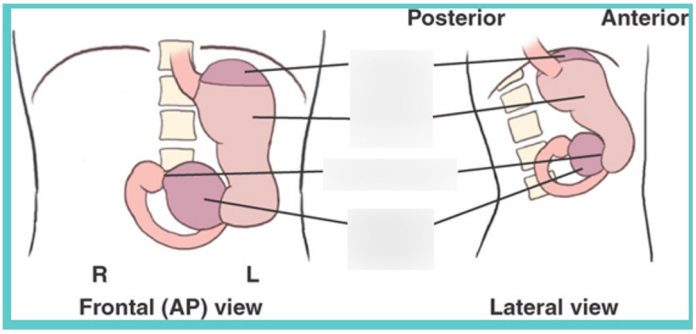
Stomach Anatomy

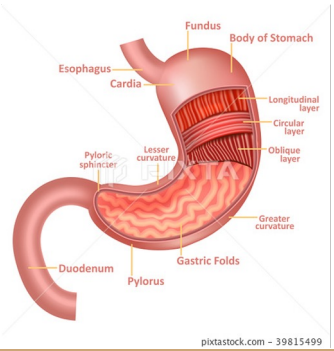
Fundus sits posterior

- Fundus is positioned closer to the spine.

Body and Pyloric regions are more anterior to the fundus

- Body and Pyloris are positioned closer to the anterior border of the abdomen.





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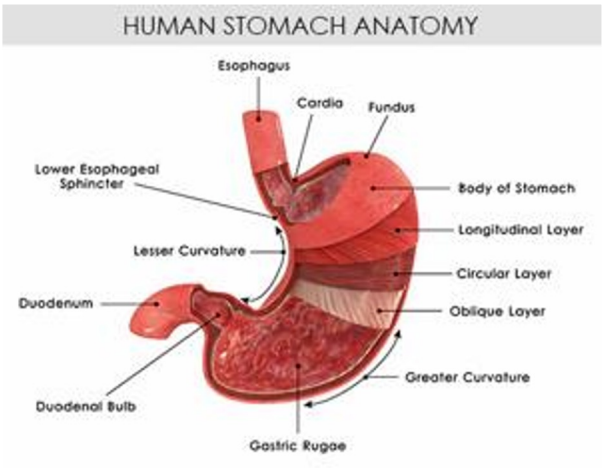
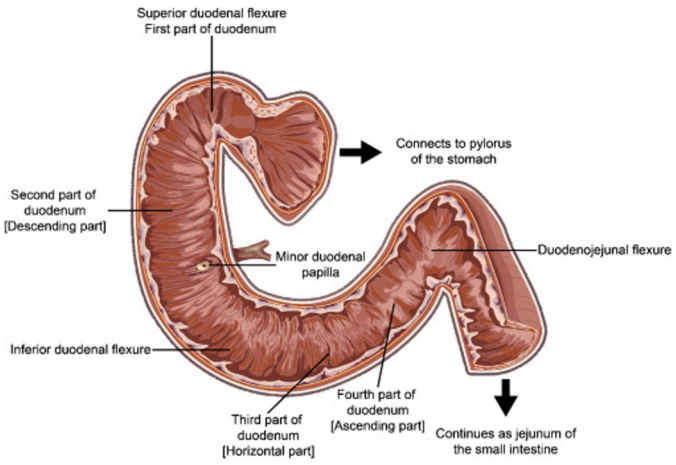
Stomach and Duodenum - Review anatomy





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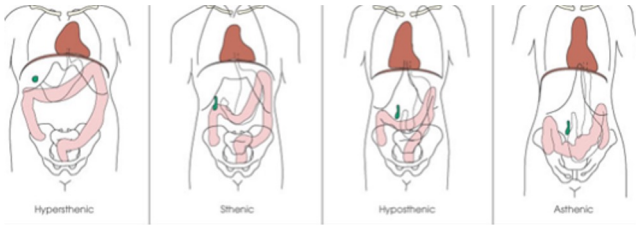
What Positions Should I know for Upper GI?

1. **AP Supine**
2. **PA Prone**
3. **Right Anterior Oblique RAO**
   a. **40-70 degree oblique**
      - Sthenic = 45 - 55 degree oblique
      - Asthenic = 40 degree oblique
      - Hypersthenic = 70 degree oblique
4. **Left Posterior Oblique LPO**
   a. **30-60 degree oblique**
      - Sthenic = 45 degrees
      - Asthenic = 30 degrees
      - Hyper = 60 degrees
5. **Right Lateral**
   a. Central Ray Sthenic = L1 & 1-1 ½ inches anterior to midcoronal plane
   b. Asthenic 2" below L1 & Hypersthenic 2" above L1
   c. **Retrogastric Space** - Space behind the stomach

Single UGI = Contrast Only
Double = Contrast + CO2 effervescent granules (fizzies)

General Central Ray Location
Sthenic = L1
Asthenic = 2" below L1 (long stomach)
Hypersthenic = 2" above L1 (High and transverse)



Short & Stout = Up & Out
Tall & Thin = Down & In

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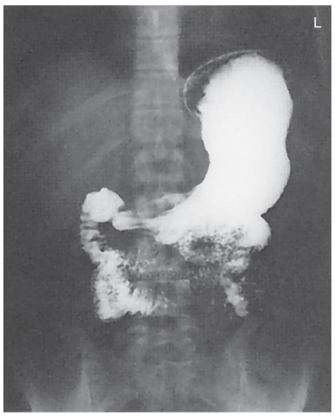
Prone (PA)



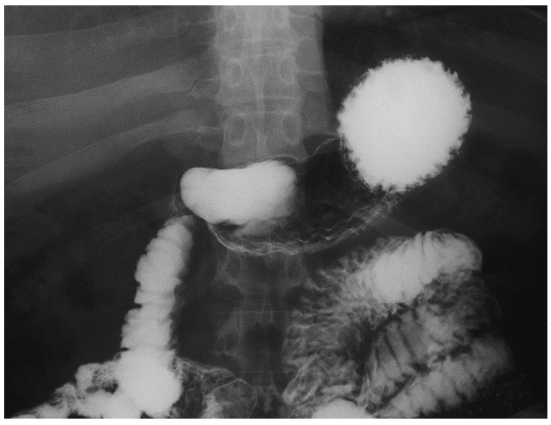
"ABS"
A = Air
B= Barium
S = Spine

Spinous Processes Midline

Air in the Fundus

Barium in the Body & Pyloris

Supine (AP)



Spinous processes midline

Barium in the Fundus

Air in the Body & Pyloris

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RAO

"ABS"
A = Air
B= Barium
S = Spine

LPO

Scotty Dogs! = Oblique Spine

Air in the Fundus (prone oblique)

Barium in the Body & Pyloris

Scotty Dogs! = Oblique Spine
Barium in the Fundus (Anterior oblique)
Air in the Body & Pyloris
Demonstrates the duodenal bulb!

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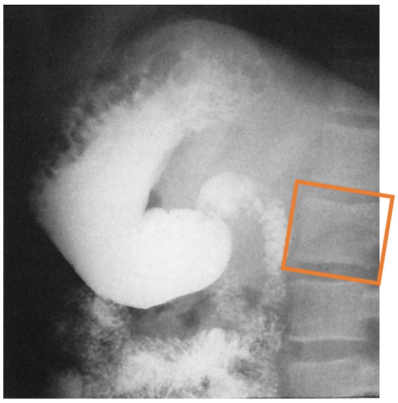
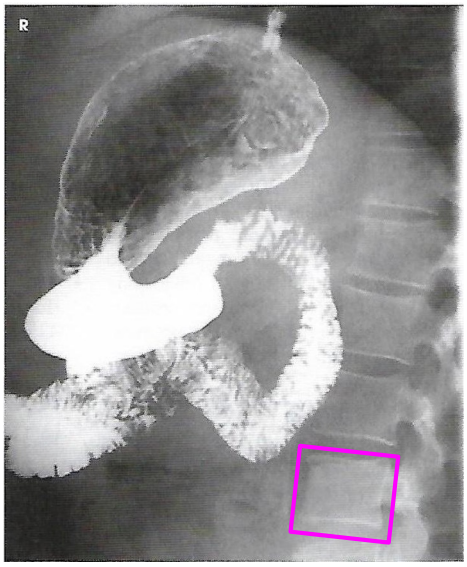
RIGHT LATERAL STOMACH





Lateral Vertebra = Lateral Stomach

Retrogastric Space - space between stomach and spine

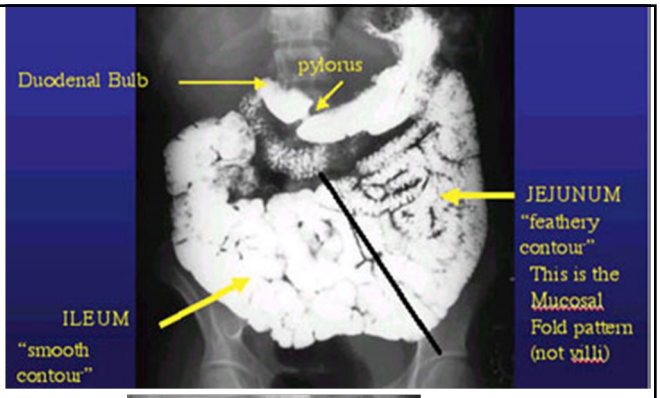
"ABS"
A = Air
B= Barium
S = Spine

24

Small Intestine

3 parts

1. **Duodenum**
   a. 1st part of the small intestine
   b. C-shaped
   c. Shortest section
   d. Contains the **major papilla and minor duodenal papilla**
2. **Jejunum**
   a. 2nd segment
   b. Contains mucosal folds
   c. "Feathery appearance"
3. **Ileum**
   a. Longest segment
   b. Connects to the large intestine via the **ileocecal valve**



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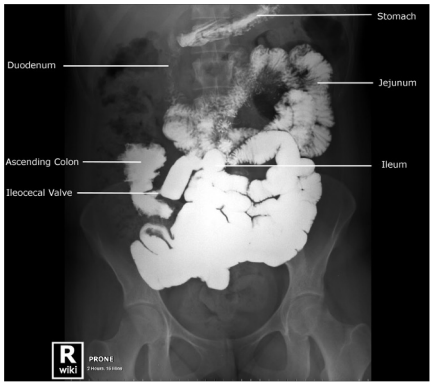
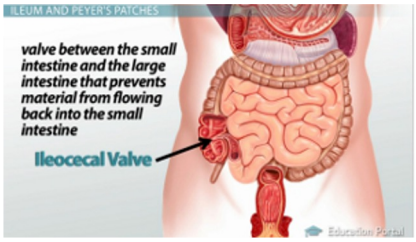
SMALL BOWEL SERIES

"Timed Sequence Study"

- Evaluates the **form and function** of the **small intestine.**
- Can be combined with UGI or performed as SBFT only
- **Timing begins when the patient starts ingesting the contrast**
- Images are performed at time intervals (Ex. 30 mins)
- **Prone abdomen imaging is performed to compress the bowel**
- Once the contrast reaches the terminal ileum the patient is brought into a fluoroscopy room for "TI" imaging.
- Spot imaging is done to visualize the **ileocecal valve, terminal ileum, and cecum.**





26

Large Intestine Anatomy

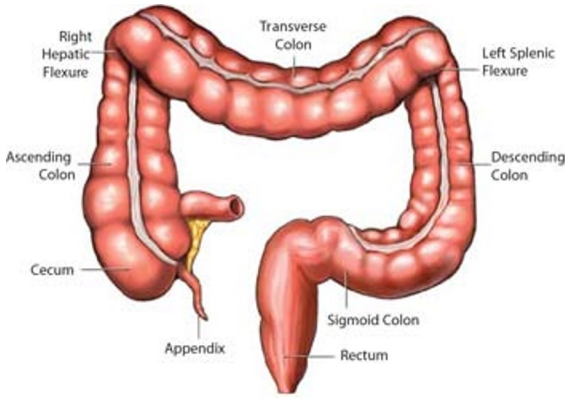
The **transverse colon sits anteriorly** to the flexures.

- The flexures are "folded" in appearance, this will appear superimposed on AP/PA images.

Oblique positions will open up the flexures.

It is important to know which flexures is found on the right side of the body and which is found on the left!

The **Left Flexure is usually higher!**



Anatomy of Large Intestine

27

Contrast Enema

Single vs. Double contrast

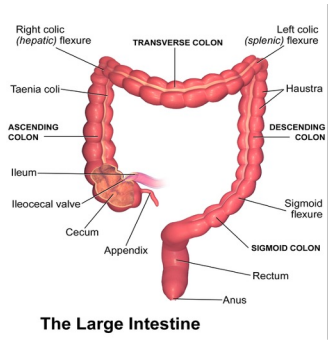
- Single has Ba only
- Shows anatomy and muscle contractions

Double uses gas also

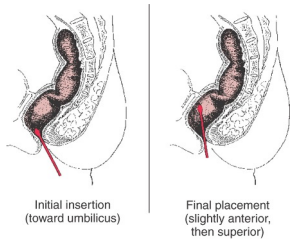
- Shows defects in **mucosal lining** and intraluminal lesions
- Focus is on the anatomy with **Air (side up)**

Max enema bag height above table 24"

Review BE tip insertion and SIMS position!



The Large Intestine



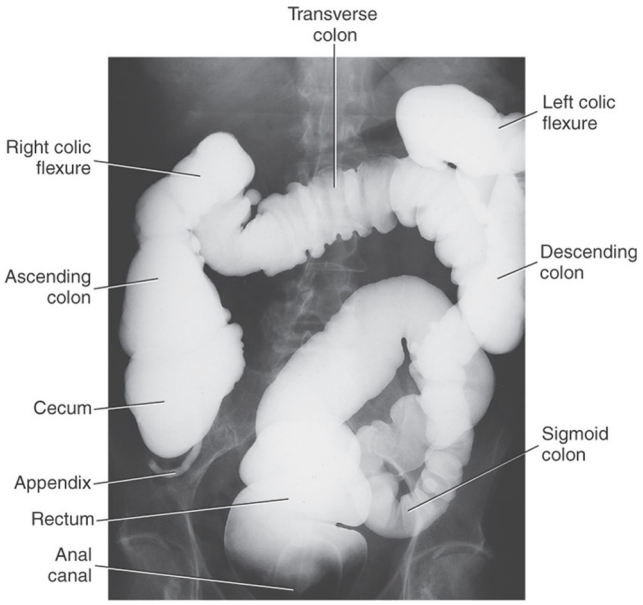
28

Supine AP & Prone - Single Contrast

When air is not present the entire colon will be filled with contrast.

The flexures are superimposed with the transverse colon.

Hypersthenic patients may require a 2 crosswise approach to include the entire anatomy.

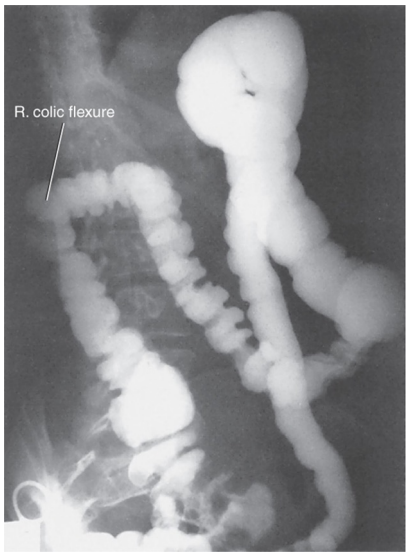


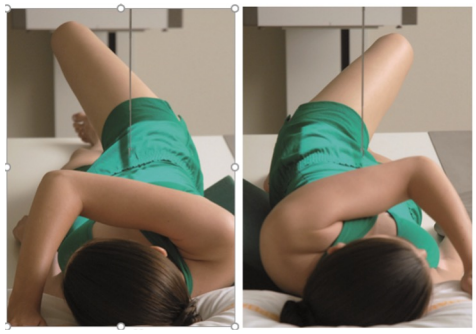
29

Single Contrast = Obliques
2 Posterior Oblique Positions - Open the Flexures

Posterior Obliques (PO) will demonstrate the **flexure that is away (Farthest)** from the IR.

LPO = Right (Hepatic) Flexure
RPO = Left (Splenic) Flexure





30

2 Anterior Oblique Positions - Open the Flexures

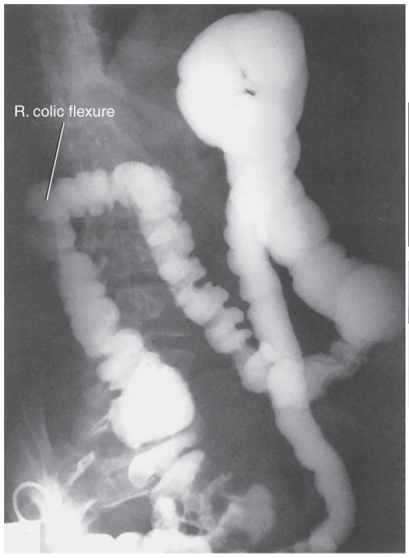
Anterior Obliques (AO) will demonstrate the **flexure that is closest** to the IR (side down).

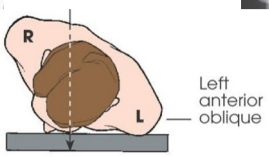
LAO = Left (Splenic) Flexure

LAO = "Left always open"

RAO = Right (Hepatic) Flexure

RAO = "Right always open"

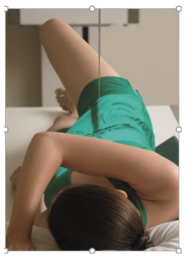


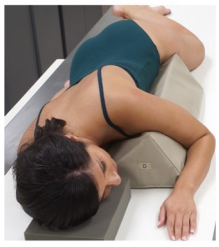


31

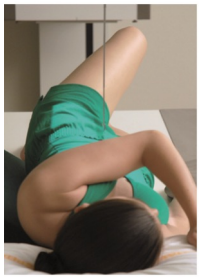
Oblique Pairs!

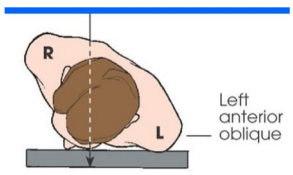
RAO & LPO will both demonstrate the Right Hepatic Flexure





LAO & RPO will both demonstrate the Left Splenic Flexure





32

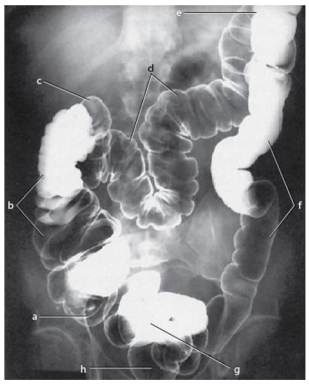
Supine AP & Prone - Double Contrast (Air)

Supine = Air in the transverse colon

Air Rises!

Prone = Contrast in the transverse colon

Fluid Drops!



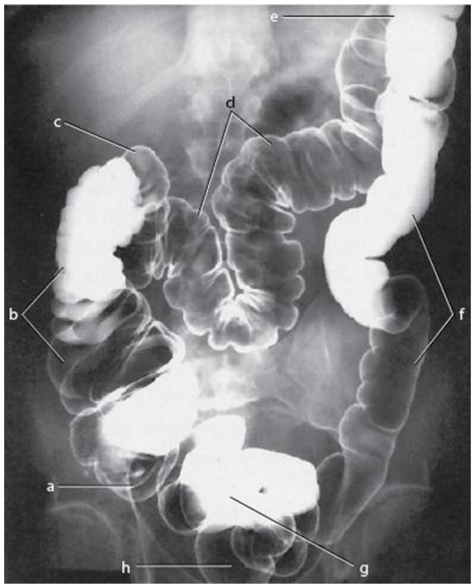
Remember that the **Transverse colon sits anterior** to the flexures.

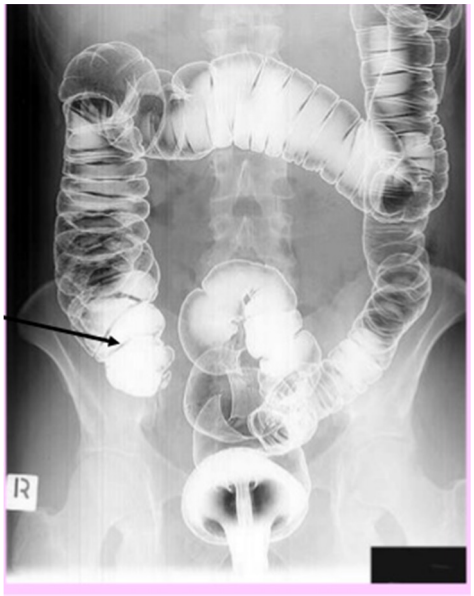
When the patient is supine, the transverse colon will sit higher and fill with air.
Supine = Air Rises

When the patient is prone, the transverse colon is down close to the table and will fill with barium.
Prone = Barium Fills

33

Prone Or Supine?

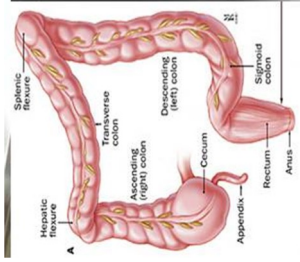




34

Double Contrast (Air) = Decub = Air/Fluid Levels!

Right Lateral Decubitus



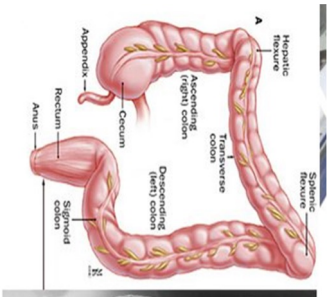
Decubitus Contrast Imaging Demonstrates the "upside" or the side with Air.

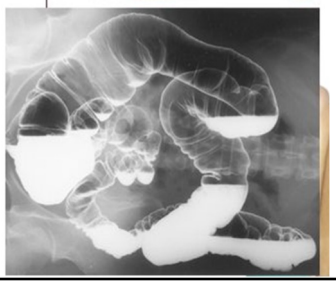
The Barium is fluid which is heavier than air, it will drop to the lowest point.

Air will rise to the side up!

Left Splenic Flexure is usually always higher, when looking at an image.

Left Lateral Decubitus





35

Left Lateral Decubitus

Left Side Down Decubitus

"Horizontal Beam

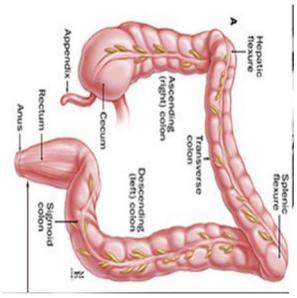
Demonstrates **Air Sides:**

- **Medial Descending**
- **Lateral Ascending**

Air will rise to the side of the body and side of the intestine that is up.

Barium will fill the lowest points.

Air fluid levels clearly demonstrated.



36

Right Lateral Decubitus

Right Side Down Decubitus

"Horizontal Beam"

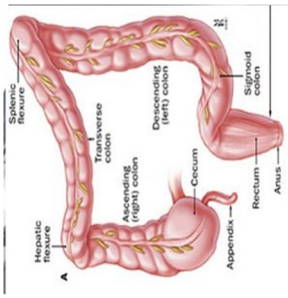
Demonstrates **Air Sides:**

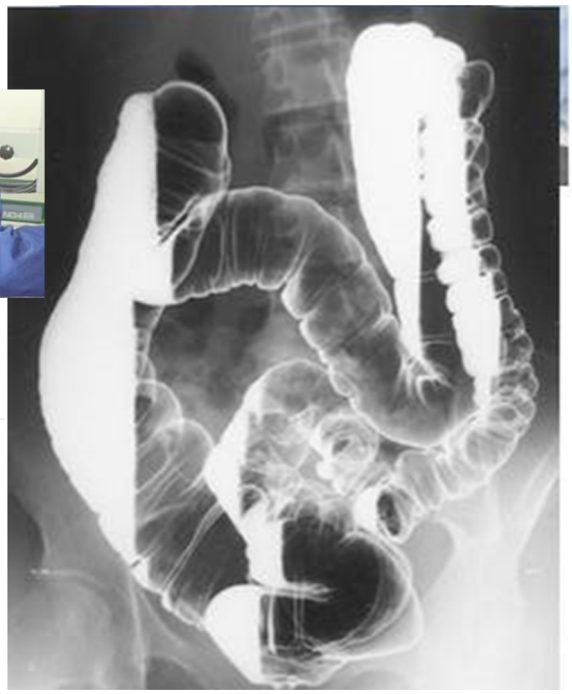
- **Medial Ascending**
- **Lateral Descending**

Air will rise to the side of the body and side of the intestine that is up.

Barium will fill the lowest points.

Air fluid levels clearly demonstrated.





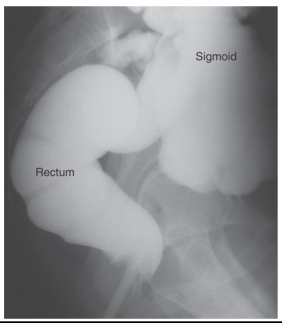
37

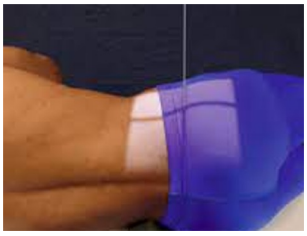
Lateral Rectum (single) or X-table Lateral Rectum (Air)

Single Contrast Enema uses a true lateral rectum.

Patient is in Lateral Position with femoral heads superimposed.

Focus is on the rectosigmoid region.





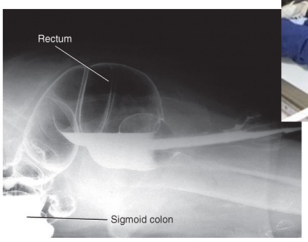
Double Contrast Enema (air) uses a X-table lateral rectum.

- Ventral Decubitus Lateral Rectum

Patient is prone.

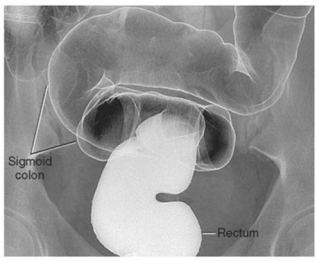
Air/Fluid levels demonstrated

Focus is on the rectosigmoid region.



38

AP Axial Sigmoid Or PA Axial Sigmoid



AP Axial Sigmoid

- Pt Supine
- Tube Angle - **30-40 cephalad**
- CR 2" inferior to ASIS

PA Axial Sigmoid

- Pt Prone
- Tube Angle - **30-40 Caudad**

Elongated Rectosigmoid

"Toes up" = Angle up!

Axial sigmoid tip = Pelvis will look elongated and distorted

39

SCOUT

Abdomen taken prior to the start of any fluoroscopy study involving contrast.

Annotation on the Image:

- Scout

Post Evacuation

Abdomen image (PA or AP) taken after a fluoroscopy study with contrast.

The patient should try to evacuate as much contrast as possible prior to taking exposure.

Annotation on the image:

- Post-evac

40

Hysterosalpingogram

Water Soluble iodinated Contrast media is used to demonstrate **patency of the fallopian tubes**

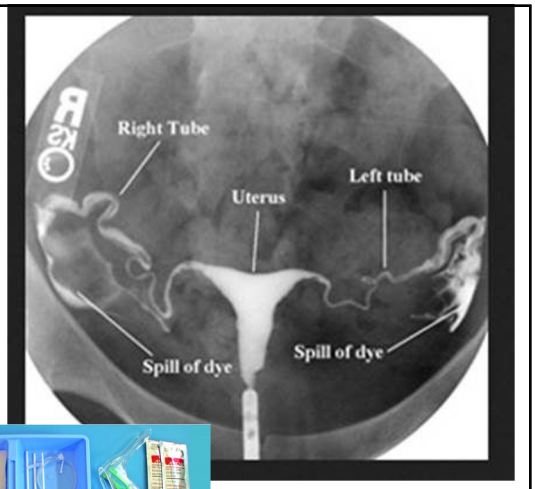
May be **diagnostic or therapeutic**

Performed between day 7-10 of menstrual cycle

Primary indication is infertility.

Performed in conjunction with OBGYN

Contraindications = pregnancy, acute pelvic inflammatory disease, contrast media allergy.



Tenaculum

41

Myelography

Contrast media is administered via a spinal puncture into the **subarachnoid space- intrathecal injection**

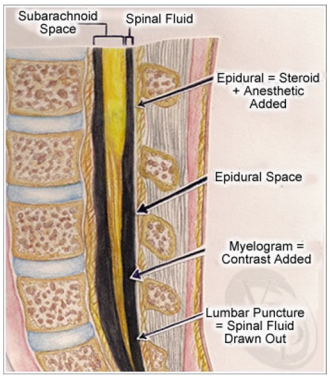
Preferred site for spinal puncture **L3-L4**, although other disc spaces may be used including cervical puncture (C1-C2)

Conus medullaris - lower border of L1 - must inject lower than this level

Cisternal puncture- between atlanto-occipital joint space

Water soluble contrast is deposited into the subarachnoid space

Primary pathology - **Herniated Nucleus pulposus (HNP)**



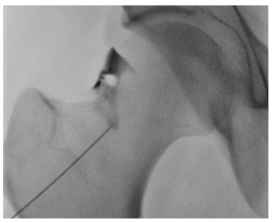
42

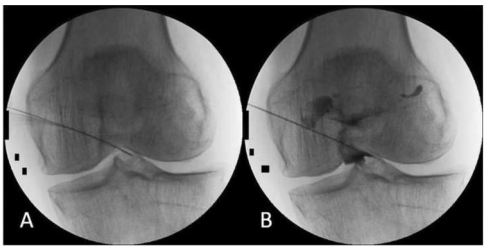
Arthrography

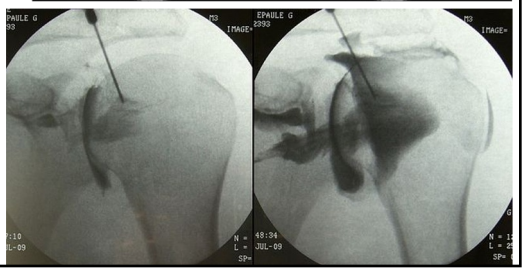
Study of Synovial joints and surrounding tissues with contrast media. Contraindications are known allergy to contrast media or allergy to local anesthetics

- **Hip**
  - Hip pain - ? Labral tear
- **Knee**
  - Indications - tear of the joint capsule, menisci, collateral, cruciate ligaments. Non trauma - baker's cyst
  - Positive contrast agent - water soluble
  - Negative agent - air
- **Shoulder**
  - Demonstrate joint capsule, rotator cuff, long tendon of the biceps muscle, and articular cartilage.
  - Chronic pain or weakness - rotator cuff

Informed & Written consent, Patient history, medications, blood thinners, allergies, Sterile technique







43

Arthrography - Review Joints - SAD

S:Synarthroses (immovable). These are f**ixed or fibrous joints**. They're defined as two or more bones in close contact that have **no movement**.

- The **bones of the skull** are an example.
- The immovable joints between the plates of the skull are known as sutures.

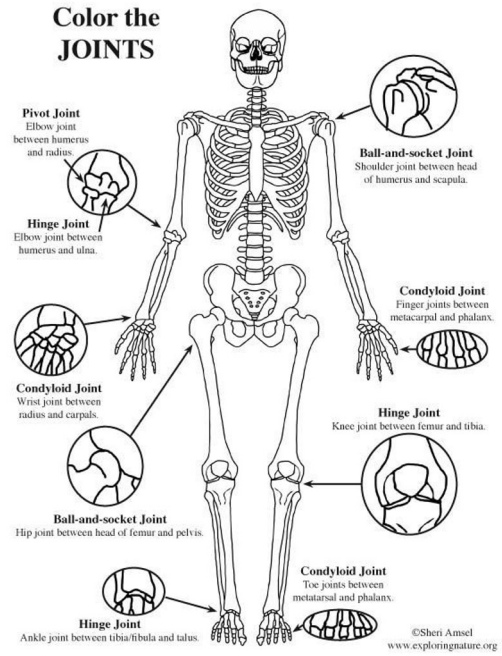
A:Amphiarthrosis (slightly movable). Also known as **cartilaginous joints**, these joints are defined as two or more bones held so tightly together that only **limited movement** can take place.

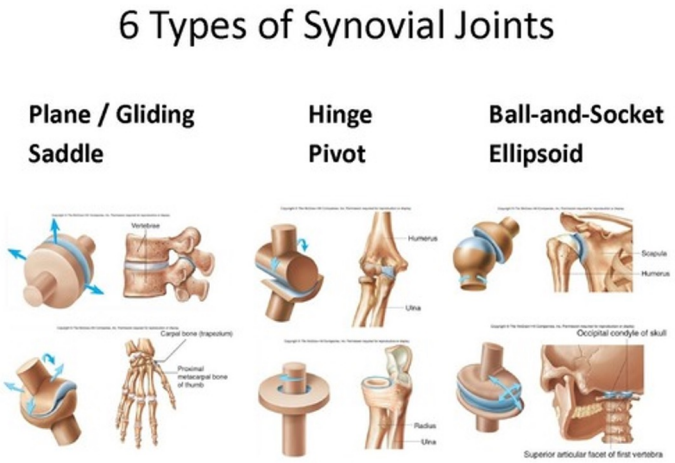
- The **vertebrae of the spine** are good examples.

D:Diarthroses (freely movable). Also known as **synovial joints**, these joints have **synovial fluid** enabling all parts of the joint to **smoothly move** against each other. These are the most prevalent joints in your body.

- Examples include joints like the **knee and shoulder**.

44





45

Intravenous (IV) Urography - IVU

Involves water soluble contrast injected via an IV.

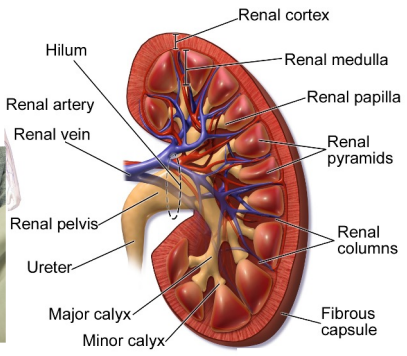
Visualizes the urinary system

- Major and minor calyces
- Renal Pelvis
- Ureters
- Urinary bladder

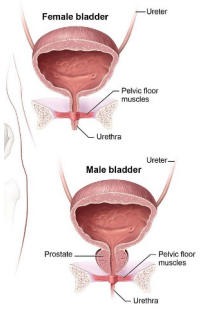
IVU is a **functional test** - **Antegrade** Contrast method

Demonstrates the collecting portion of the urinary system, **functional ability** of the Kidneys, and evaluates for pathology or abnormalities.

- Visualize collecting portion of the urinary system
- Assess the functional ability of the kidneys
- Evaluate the urinary system for pathology or anatomical abnormalities.



Kidney Anatomy



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IVU - Scout & AP

Pt should **empty Bladder** prior to injection

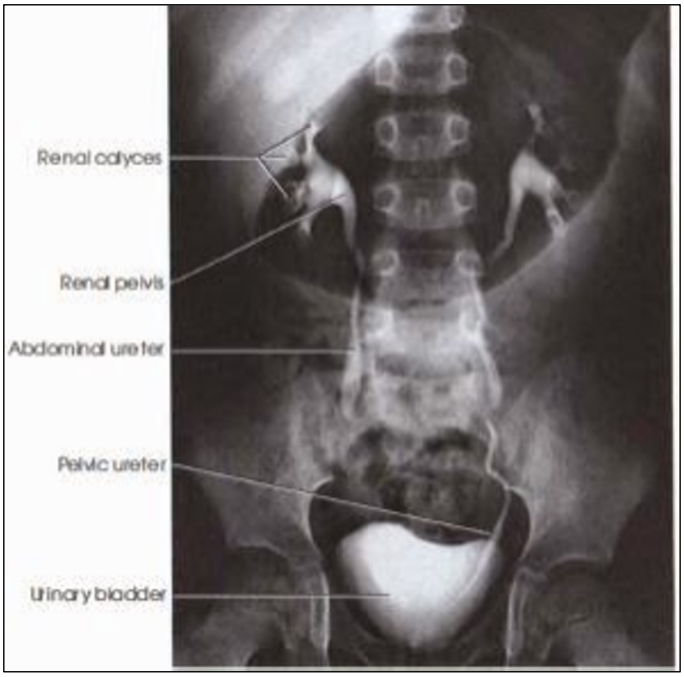
- Urine will dilute the contrast in the bladder.

Scout - taken prior to contrast injection

- Annotate Image - "Scout"

AP - Central Ray at iliac crest - same as KUB

- Include Kidneys, ureters & Bladder
- Expiration



47

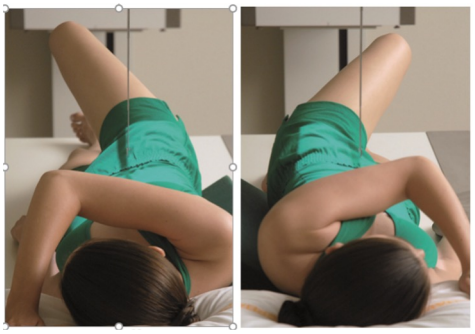
IVU Obliques - RPO & LPO

30 degree posterior obliques

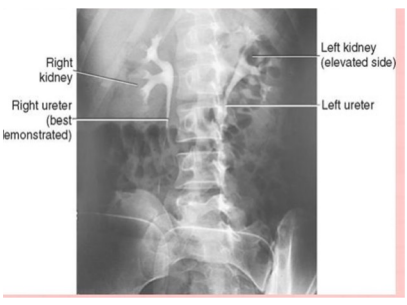
Demonstrate "Upside" Kidney - Kidney farthest from IR

Demonstrates "Downside" Ureter - Ureter closes to IR

LPO
- Right Kidney Parallel
- Left Ureter



RPO
- Left Kidney Parallel
- Right Ureter



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Cystography

Examination of **the Bladder** via a **urethral catheter**

- Pt should **empty bladder** prior to the start.
- When **catheter is placed** any urine remaining should be drained.
- If a catheter is already present, clamp and remove tubing.

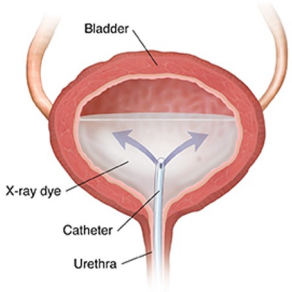
Contrast is administered retrograde

Contrast is placed on an **IV pole, use gravity to flow into the bladder.**

Run contrast through tubing to avoid air bubbles

Routine Cystography Imaging

- AP
- AP Axial
- RPO & LPO
- Lateral



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AP & AP Axial

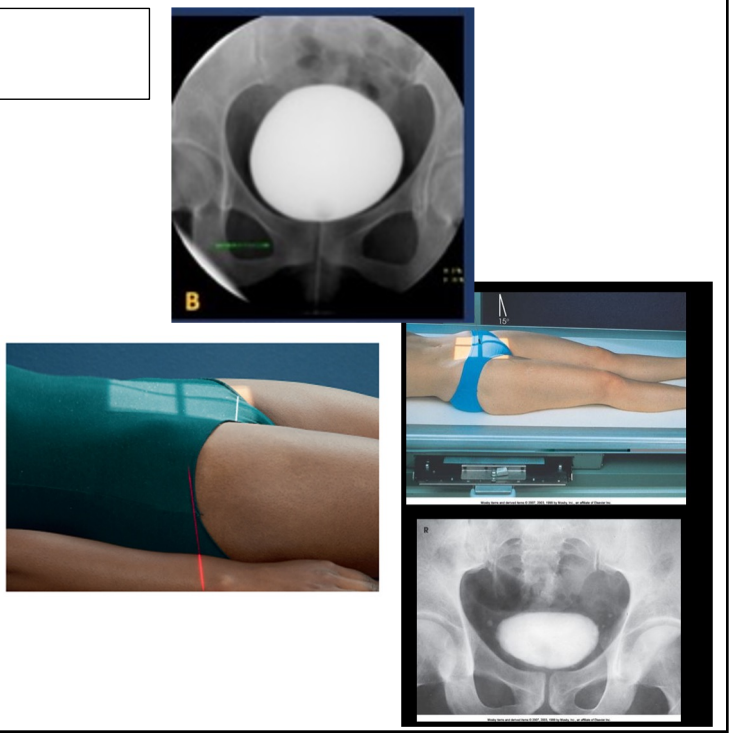
AP - pt supine

- **CR 2" superior to symphysis**

AP Axial - pt supine

- Tube angle **10-15 degrees caudad**
- **CR - same**
- Projects pubic symphysis inferior to bladder
- *Similar to AP coccyx*

Urinary bladder should not be superimposed by pubic bones.



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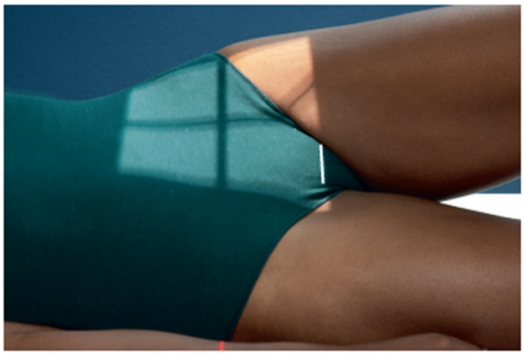
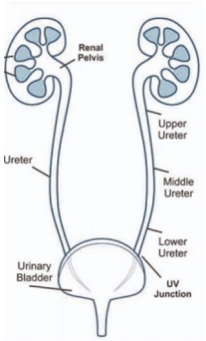
Oblique Bladder

RPO & LPO

Steep Oblique - 45-60 degree oblique

- **Visualize the posterior aspect of the bladder.**
- **Ureterovesical junction (UV)** attaches posteriorly.
- **CR - 2" Superior to pubic symphysis**
- Avoid superimposition of the bladder over the lower limbs
  - *Don't flex leg*
- *Obturator foramen closed on side down.*





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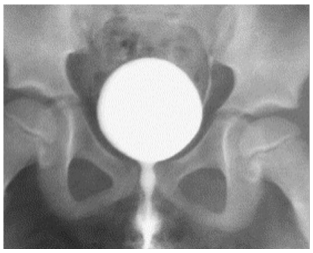
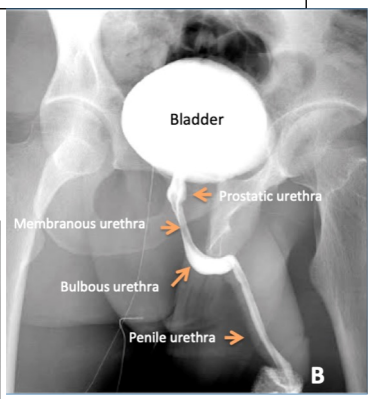
Voiding Cystourethrography - Voiding positions

VCUG - V = Imaging during voiding

Males

- **30 degree RPO**
- Superimpose urethra over soft tissue
- Move femur out of the way





Female

- **AP Position**

Catheter:

Catheter will be removed during voiding in pediatrics.

- Pediatrics under 1 year = 3 fills.
- Loosen tape when ready.

Adult catheter removal time may vary. One fill only.

- Have urinal ready.

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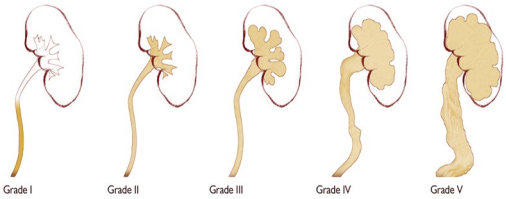
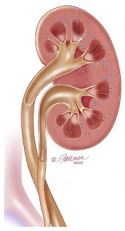


Urinary Reflux

Double collecting system

Horseshoe Kidney



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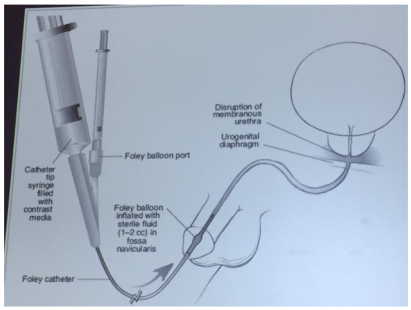
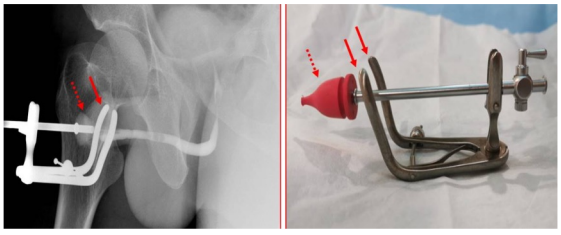
Retrograde Urethrography (RUG)

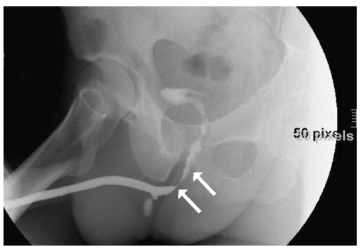
Evaluation of the **male urethra**

- Contrast is injected via a **catheter retrograde** (against normal flow).
- Catheter placed into urethra - **clamp may be used.**
  - *Brodney Clamp*

Contrast is injected into the urethra looking for **strictures** or abnormalities.







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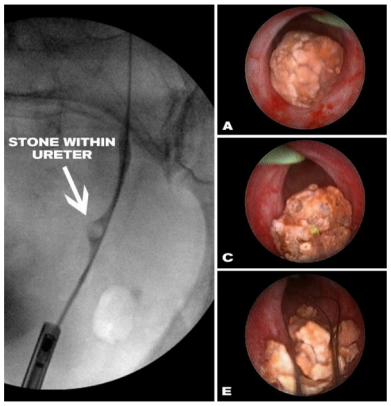
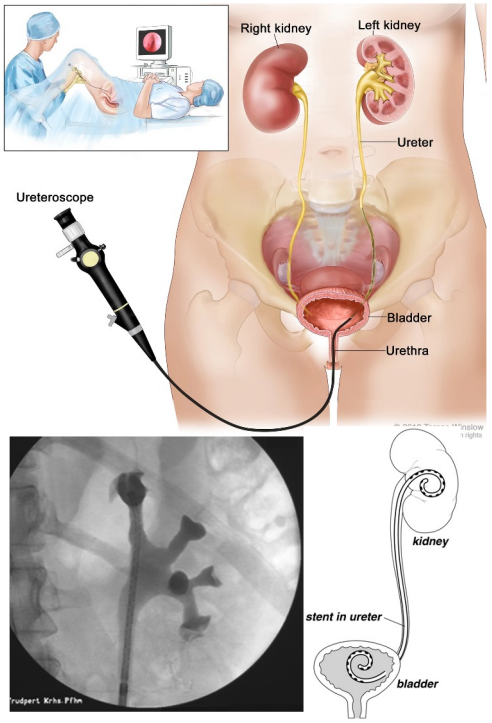
Ureteroscopy

Procedure to address **kidney stones**

Involves the passage of a **ureteroscope**, through the urethra and bladder and up the ureter to the point where the stone is located.

- **Operating room with a urologist**
- Sterile environment
- C-arm used for imaging
- Contrast used
- Stent may be placed





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Body Habitus - Gallbladder Location

Hypersthenic

- High & Transverse
- T10- T11

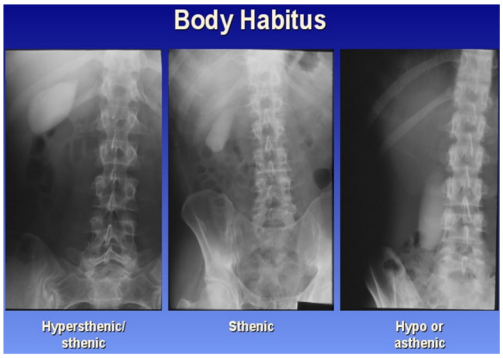
Sthenic

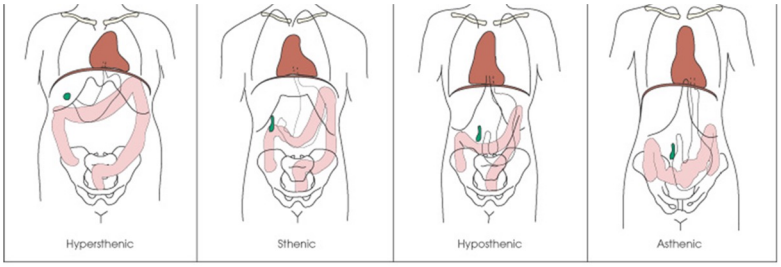
- T12-L1

Hyposthenic/Asthenic

- L3-L4

- *Tall and thin = down and in*
- *Short and stout = up and out*





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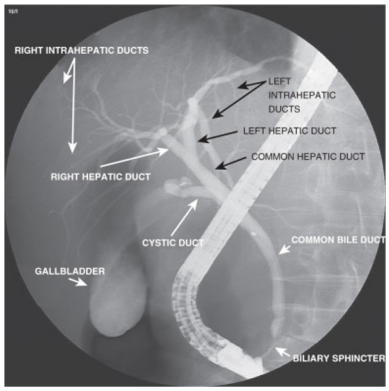
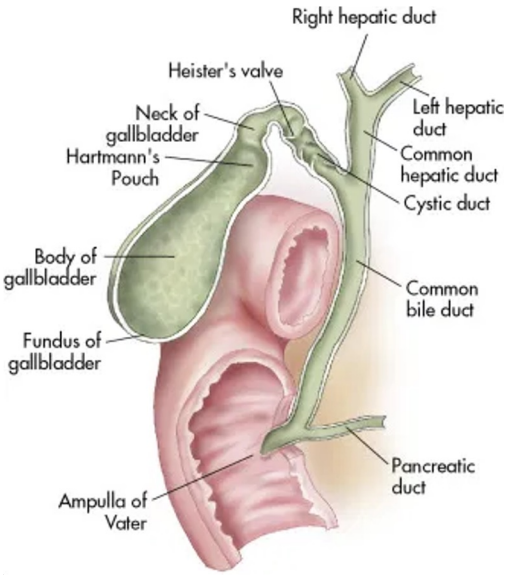
Hepatic System

3 important ducts

- **Cystic duct** - duct that connects gallbladder
- **Hepatic duct** - Duct that connects liver
- **Common bile duct** - Cystic and hepatic duct combine to form this duct
  - Terminates at the duodenum where it connects with pancreatic duct





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Biliary Ducts

Consists of bile ducts and the gallbladder

Two main hepatic ducts in liver – Right & Left

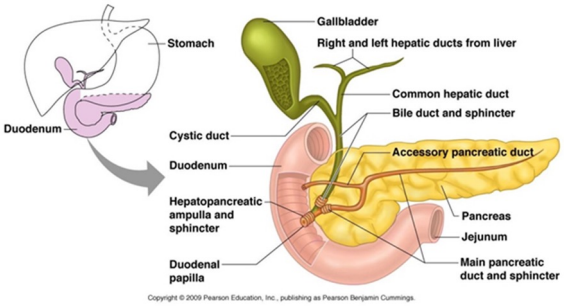
- Right and left hepatic ducts join to form **common hepatic duct**

Common hepatic duct unites with cystic duct to form common bile duct

Common bile duct joins the pancreatic duct (Duct of Wirsung)

Together they empty into the duodenum via the **hepatopancreatic ampulla (ampulla of Vater)**

Ampulla controlled by hepatopancreatic sphincter (sphincter of Oddi)



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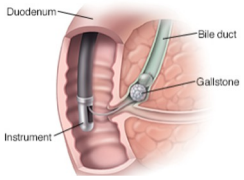
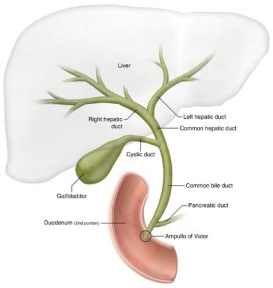
ERCP - Endoscopic Retrograde Cholangiopancreatography

Duodenoscope with a camera enters **duodenum** and places a wire through the **papilla.**

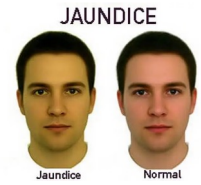


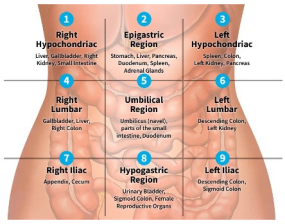


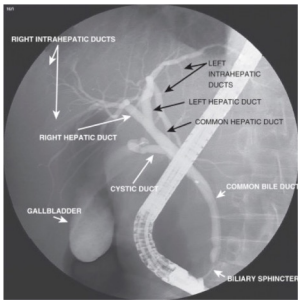
Evaluates common bile duct, cystic duct, and pancreatic duct.

- **Cholelithiasis-**Gallstones
- **Pancreatitis** - inflammation of the pancreas
- **Jaundice** - yellow coloring

Biliary Stent placement







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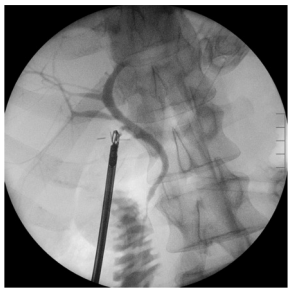
Surgical (Operative) Cholangiogram



Injection of contrast dye into common bile duct during surgical procedure

C-arm is used for imaging in the OR

Sterile Procedure (in OR!)

Fowler's Position - Reverse Trendelenburg

- Feet lower than head

Cholecystectomy- Surgical Removal of Gallbladder

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Contrast Media

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Positive Vs. Negative Contrast

Positive Contrast

- Composed of higher–atomic number elements
- Appears **radiopaque** on image
  - Barium sulfate
    - Atomic no. 56
  - Water soluble iodinated
    - Aqueous contrast
    - Atomic no. 53
    - Ionic or Non ionic

Negative Contrast

- Composed of low–atomic number elements
- Appears **radiolucent** on image
  - Air
  - CO_2 fizzies
    - Average Atomic no. 8

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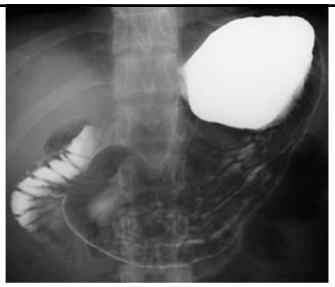
Air and Gases



Negative contrast agents:

- Cause affected structures to be darker than surrounding structures
- Nontoxic
- **Double Contrast UGI**
  - *Fizzies - CO_2 gas crystals*

- **Double Contrast BE**
  - *Room air*
- Double Contrast Arthrography
- Myelography

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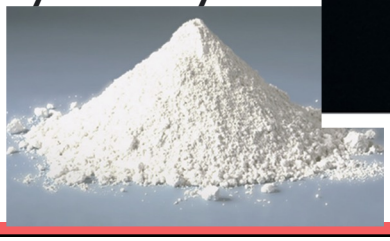
Barium Sulfate

- Positive Contrast
- Radiopaque
- Chalk-like substance
- Absorbs more x-rays
- **Colloidal Suspension**
- **Never dissolves in water**
- Inert physiologic activity within human body - **reaction very unlikely.**
- $BaSO_4$
- Atomic Number 56



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Elimination of barium

- Barium can cause **constipation and dehydration**.
  - Patients should **drink plenty of fluids** for the next 24-48 hours.
- Following an imaging exam with barium, the material is **eliminated through bowel movements.**
  - Stool may appear white
- The majority within **24 hours**

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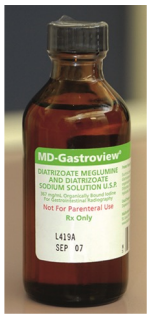
Water-Soluble Iodinated Contrast Media

- **Indications**
  - **Perforated** viscus
  - Presurgical procedure
- **Contraindications**
  - **Hypersensitivity to iodine**
  - Previous reaction



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Elimination of Iodinated Contrast

- Iodinated Contrast is **water based.**
- The contrast material is **absorbed by the body or eliminated through urine.**
- The majority within **24 hours** in a patient with normal renal function.

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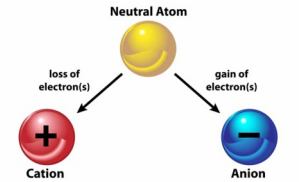
To major types: Ionic & Nonionic

Ionics

- Dissociates into two ions:
  - Anion
  - Cation



- Disrupts homeostasis - In biology, homeostasis is the state of steady internal, physical, and chemical conditions maintained by living systems.
- Associated with high rates of adverse events and fell out of favor in the 1990s.

Nonionics

- Do not dissociate into anions and cations
- Lower osmolality
- Less toxic at cellular level
- Less likely to cause patient reaction
- More tolerable by patients
- Disadvantage = Cost $$$

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Viscosity vs. Osmolality

Osmolality: This is the **concentration of iodine particles** in the solution.

- **High osmolality = it has a higher concentration of particles than blood**
- **Higher iodine concentration equals high osmolality. Higher Iodine concentration = higher risk of reaction.**

Viscosity: The **thickness or stickiness of the suspension**. Viscosity influences the solution's ability to flow through the needle used for the injection as well as its ability to flow through blood vessels.

- **Highly viscous solutions are harder to inject.**
- One thing that can be done to **make thick solutions easier to inject is to warm the material** to body temperature prior to making the injection.
  - Commercial contrast warmers are available for this purpose.
- Highly viscous materials tend to cause the patient more burning or stinging pain as it travels through vessels, making the patient feel hot.
- **A greater concentration of iodine means higher viscosity.**

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Fluoroscopy Equipment

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Fluoroscopy Equipment

Stationary vs. Mobile Fluoroscopy

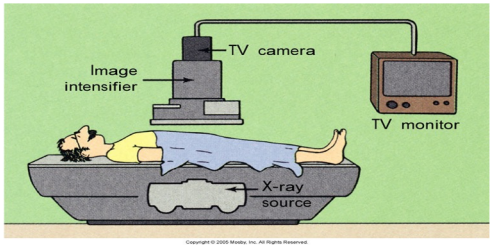
- **Fluoroscopy room = Stationary Fluoroscopy**
- **C-arm = Mobile Fluoroscopy**

Unlike diagnostic x-ray tubes, the source is under the patient.

The **fluoroscopic x-ray tube** is located **under the fluoroscopic table,** and the **C-arm x-ray source** is **under the patient and/or surgical table.**

The **Image Intensifier (II) is located over the patient.**

The Image Intensifier(II) works similar to the Imaging plate by collecting the remnant or exit radiation after passing through the patient to create the radiographic image.



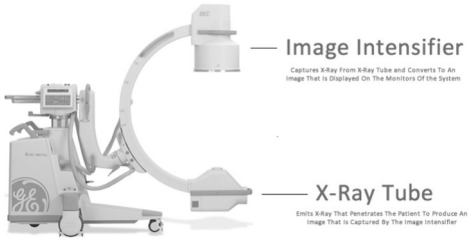


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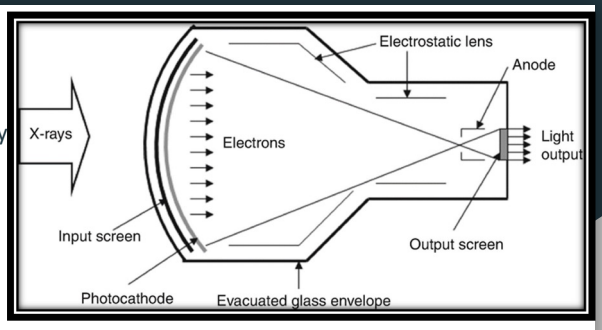
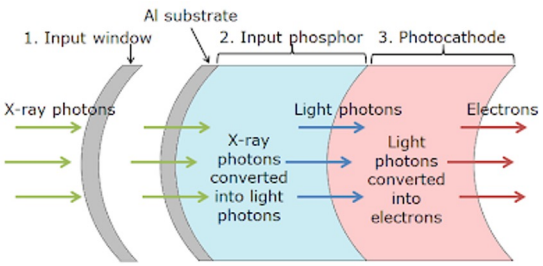
Image Intensifier

The image intensifier is found above the patient for either stationary (fluoro room) or mobile (C-arm) fluoroscopy.

Parts:

1. **Input phosphor**
   a. **Made of cesium iodide**
   b. **Takes remnant beam and converts x-ray photons into light photons**
2. **Photocathode**
   a. **Takes the light photons and converts them into electrons**
   b. **Photoemission = emitting electrons from light source**
   c. **Made of alloy of antimony & Cesium**
3. **Electrostatic lenses**
   a. **Focus the electrons toward the anode**
4. **Anode**
   a. **Donut shape - hole in the middle**
   b. **Sends to output phosphor**
   c. **Made of Tungsten**
5. **Output**
   a. **Made of Zinc Cadmium Sulfide**
   b. **Converts the electrons into light photons**





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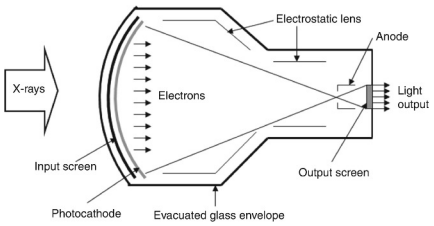
Hint for Image Intensifier (XLELM)

Can you drag and drop in order and/or location?

1. **Input Phosphor =Cesium Iodide** crystal
   a. (X-L) Turns **X**-rays into **L**ight
2. **Photocathode** - (L-E) converts **l**ight photons into **e**lectrons
3. **Electrostatic lenses** - **"Focuses"** electrons
   a. no conversion - similar to focusing cup in x-ray tube
4. **Anode** (donut shape) - **Accelerates** electrons - Tungsten
5. **Output phosphor** = **Zinc Cadmium Sulfide**
   a. Converts **e**lectrons into **l**ight photons
   b. Sends information to a CCD
6. **Charged Coupled Device (CCD) 2 jobs**
   a. Converts light back to electrical signal
   b. Collects electrical signal and sends it to the ADC
7. **Analog to digital converter (ADC)** converts to digital signal.
8. **M = Monitor** - see image on monitor screen



Materials Hint = Think alphabet! C before Z!
Input phosphor = Cesium Iodide
Anode = Target = Tungsten
Output phosphor = Zinc Cadmium Sulfide

Hint It never turns back into x-ray photons!!!*

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Illumination

The **principal advantage of image-intensified fluoroscopy** over earlier types of fluoroscopy is **increased image brightness.** Just as it is much more difficult to read a book in dim illumination than in bright illumination, it is much harder to interpret a dim fluoroscopic image than a bright one.

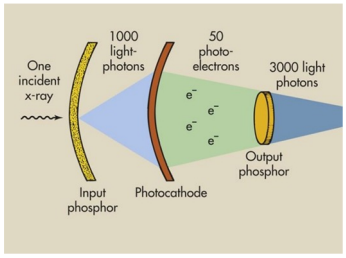
The increased illumination of the image is attributed to the multiplication of light photons at the output phosphor compared with x-rays at the input phosphor.

- The ratio of **light photons at the output phosphor** divided by the number of **input x-ray photons** is the **Flux gain.**
- **Flux Gain = total number of light photons produced by each electron**

The ability of the image intensifier to increase the illumination level of the image is called its BRIGHTNESS GAIN.

- The brightness gain is simply the product of the **minification gain X the flux gain**.
- Total brightness gain ranges from 5,000 - 20,000 and decreases as the tube ages.

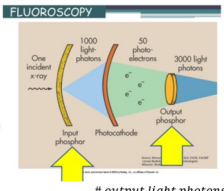
The **minification gain** is a ratio of the size of the input phosphor compared to the size of the output phosphor. The output phosphor is smaller than the input, increasing brightness



$$\text{Minification Gain} = \left(\frac{\textit{input phosphor diameter}}{\textit{output phosphor diamater}}\right)^2$$

Large input phosphor and small output phosphor.

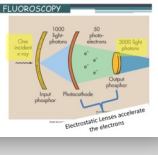
There's more electrons concentrated into a smaller area striking output phosphor.



$$\text{Flux Gain} = \frac{\#\ \textit{output light photons}}{\#\ \textit{input xray photons}}$$

One x-ray in = 3000 light photons out!

Due to electrostatic lenses accelerating electrons towards output phosphor.



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Gains

Flux Gain

$$\frac{\text{\# of light photons (output)}}{\text{\# of x-rays (input)}}$$

Minification Gain

$$\left(\frac{\text{input phosphor diameter}}{\text{output phosphor diameter}}\right)^2$$

Brightness Gain = Minification Gain x Flux Gain

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Automatic Brightness Control (ABC)

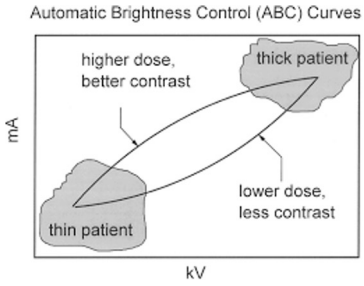
Fluoroscopy uses a technology referred to as **Automatic Brightness Control (ABC) to control the kVp and mA**

ABC regulates the kVp and mA for fluoroscopy depending on the part being examined. It will adjust as the radiologist moves the II over different areas of the body, as well as areas with or without contrast.

- **Maximum mA station for fluoroscopy is 5 mA**
- This will also determine the Brightness of the image

kVp will vary by **body part, thickness of the body part, and type of contrast.** This also may vary per equipment type / manufacturer.

- Barium work = 100 range
- Air contrast = 90 range
- Water soluble contrast = 70-80 range



kVp DEPENDS ON THE BODY PART BEING EXAMINED

Examination	kVp
Gallbladder	65–75
Nephrostogram	70–80
Myelogram	70–80
Barium enema (air contrast)	80–90
Upper gastrointestinal	100–110
Small bowel	110–120
Barium enema	110–120

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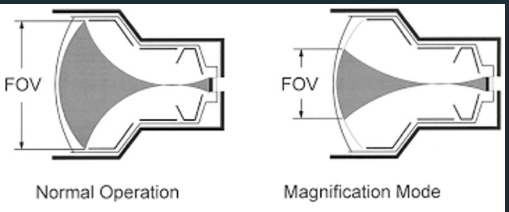
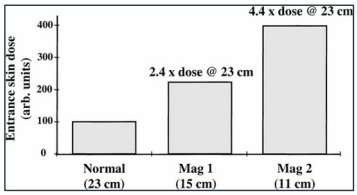
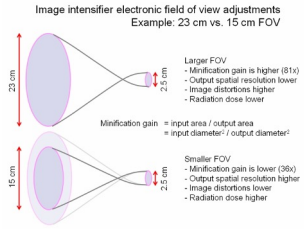
II Magnification Mode

Increases Magnification electronically

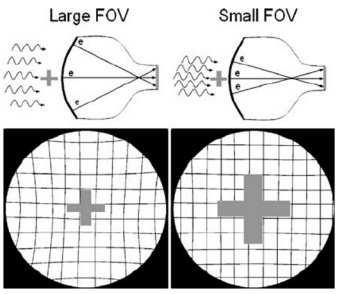


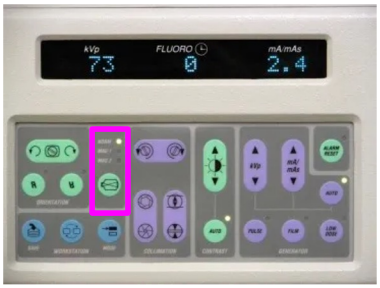
- Results in a **smaller field of view**
  - **Decreased Input Phosphor size**
  - Moves the focal point forward in the II
- **Increases Spatial Resolution**
- **Increases Contrast Resolution**
- Lowers image brightness
- ABC compensates for the decreased brightness by **increasing the x-ray output**
- **Increases Patient Dose**
  - **Smaller input size = increased dose**
  - 23 cm Input phosphor size = less dose
  - 15 cm phosphor size = increased dose

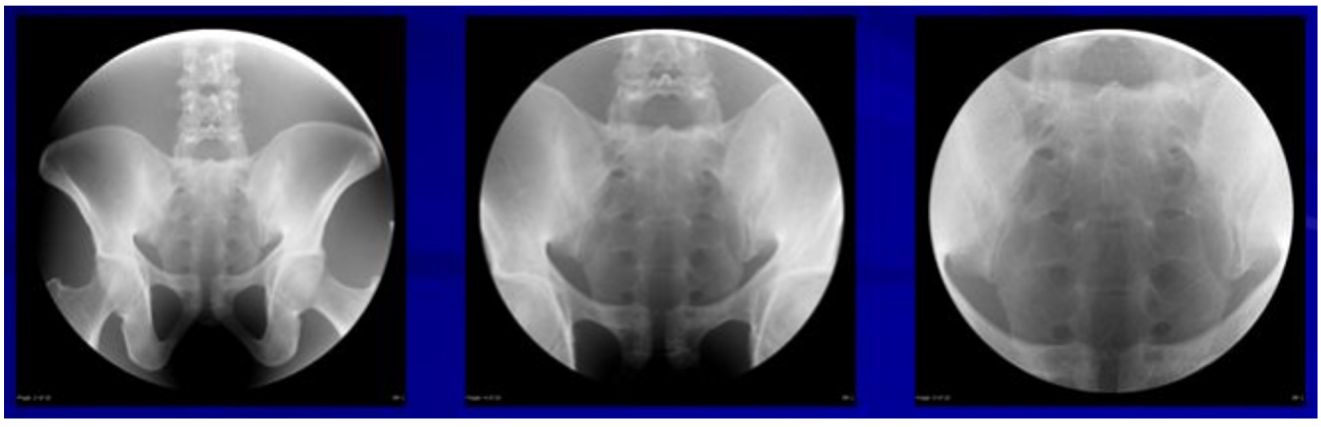




77







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Magnification - SID

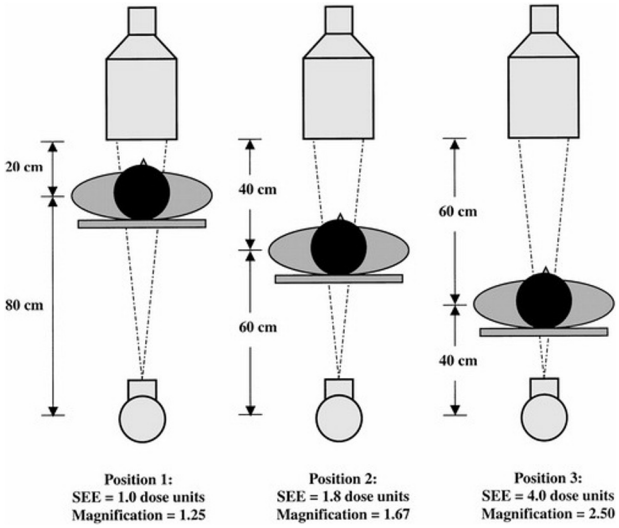
Mobile fluoroscopy (c-arm) x-ray source is most often below the patient or in lateral position.

Increasing the SID - moving the patient away from the x-ray source, **closer to the II reduces dose**.

- Decreases Magnification
- Decreased OID from II

Decreasing SID - moving the patient **closer to the x-ray source increases dose.**

- Increases Magnification
- Increased OID from II



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Digital fluoroscopy Advances

Newer C-arms are a Flat Panel Detector (FPD) model.

Compared with traditional circle FOV, FPD matrix FOV extends the imaging area of the detector. It has a wider FOV of 43×43cm.

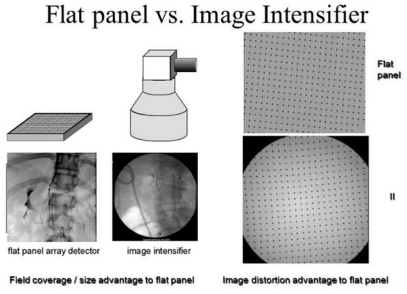
More importantly, flat panel detector has linear surface. Each pixel has the same character, and the resolution and contrast in each area is same.

FPD's improve image quality

FPD's reduce patient dose

Less cumbersome to move

Reduces sterile field contamination



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Flat Panel Detectors (FPD) = Indirect Conversion

X-rays Exit the patient

Cesium Iodide Scintillator converts x-rays to light.

Amorphous Silicon Photodiode converts light to electrons.

TFT collects electrical signal

- **Matrix (Array)**
- **Filled with DEL's**
  - **Smaller DEL's = increased Spatial Resolution**

Scintillator
- Cesium Iodide
- X-rays to light

Photodiode
- Amorphous Silicon
- Light to Electrical signal

TFT
- Collects Electrical Signal

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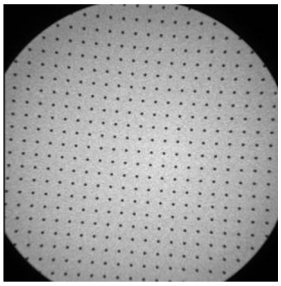
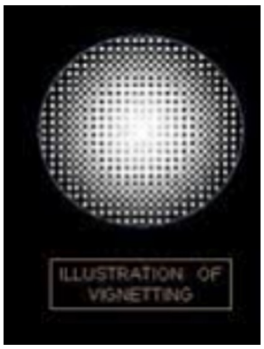
Errors

Vignetting - is a reduction of an image's brightness or saturation toward the periphery compared to the image center

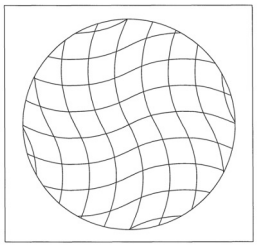
Pincushion Artifact - The loss of shape at the edges of the fluoro image.





S Shape Distortion - image in a fluoroscopic system to distort with an "S shape

FIG. 2



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Radiation Protection Fluoroscopy

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PT Dose Reduction Techniques

Intermittent Fluoroscopy- Most radiologists are trained to control the fluoroscope intermittently, that is, keeping the x rays on only a few seconds at a time, long enough to view the area of anatomy.

Removal of Grid - The presence of grids in x-ray systems primarily increases the contrast and hence the image quality; however, they increase the dose to the patient and staff by a factor of two or more. **In pediatric cases, removal of the grid has resulted in dose reduction of up to one-third to one-half** with little or no loss in contrast and image quality.

Last Image Hold - The last image is digitally "frozen" on the monitor after x-ray exposure is terminated. Last image hold is a dose-saving feature by not taking a formal exposure. **Think "Screenshot"**

Electronic Collimation - Modern systems have electronic collimation, which overlays a collimator blade on the last image hold so that one can adjust field dimensions without exposing the patient.

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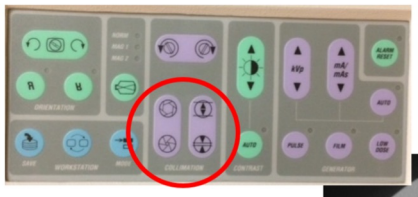
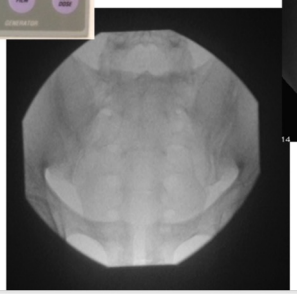
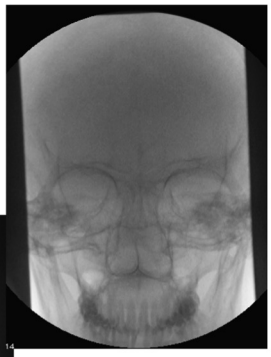
C-arm Collimation

Collimation



- 2 options on C-arm
  - Iris
  - Leaves
- Collimating improves your image by removing the excess scatter radiation





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Low dose, Pulse, Boost

Fluoro = eye
Boost = eye +
High dose exposure

Low Dose reduces exposure by 50%

Pulse reduces exposure by 75-90%

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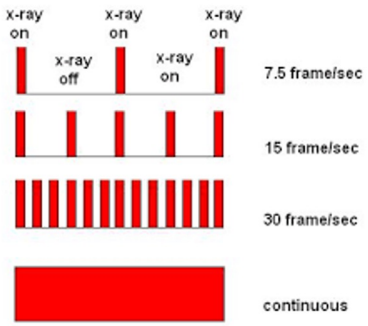
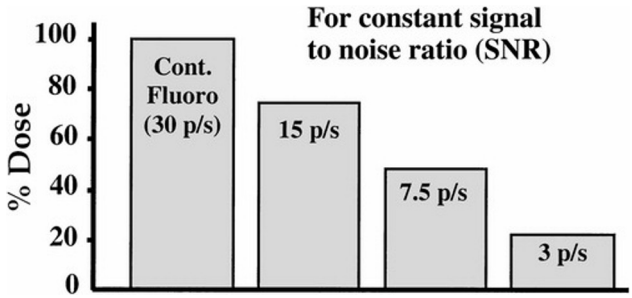
Pulse setting during Fluoroscopy

The x-ray beam is emitted as a series of short pulses rather than continuously.

At reduced frame rates, pulsed fluoroscopy can provide substantial dose savings.





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Source to Skin Distance (SSD)

Source to skin distance (SSD) is the distance between the tube and the patient during fluoroscopy.

Mobile Fluoroscopy (c-arm) = 12" or 30 cm

- *hint = Take lunch at 12:30 in the OR*

Stationary fluoroscopy (fluoro room) = 15" or 38 cm

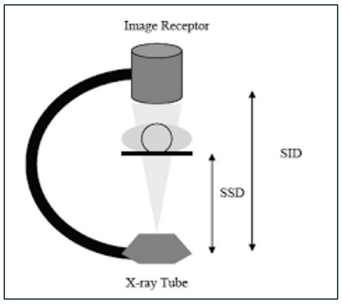

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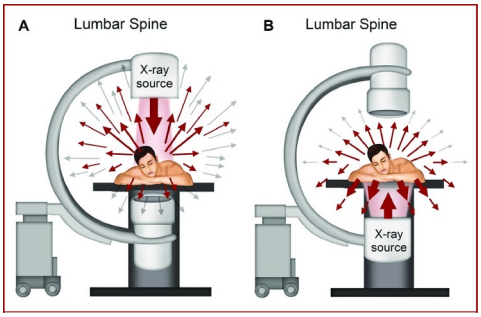
Image Intensifier Placement

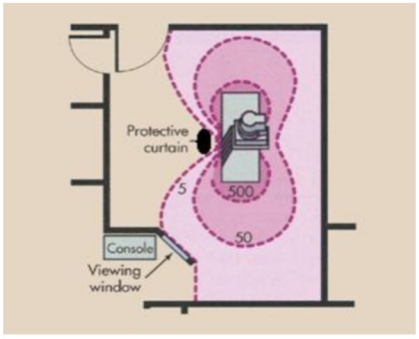
The largest amount of scatter produced is located where the x-ray beam enters the patient.

Try to have the x-ray source underneath the patient whenever possible when using a C-arm.

In Fluoroscopy keep the OID minimized when possible. The radiologist should keep the II close to the patient.

The least scatter location is **90 degrees** to the patient where the II is placed over them.





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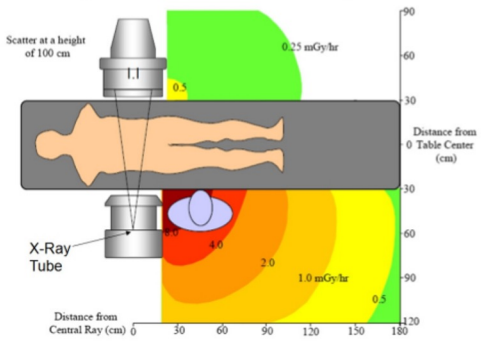
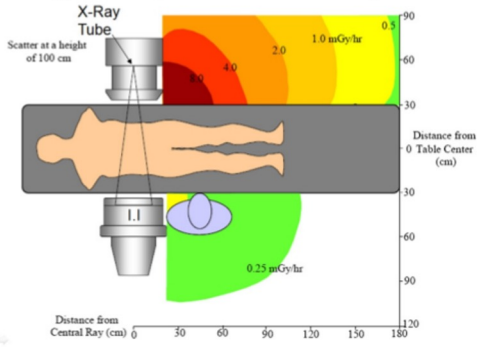
The highest operator exposure is near the x-ray tube side of the patient.

Lateral Beam Orientation With the X-ray Source Near the Operator



Lateral Beam Orientation With the Image Receptor Near the Operator



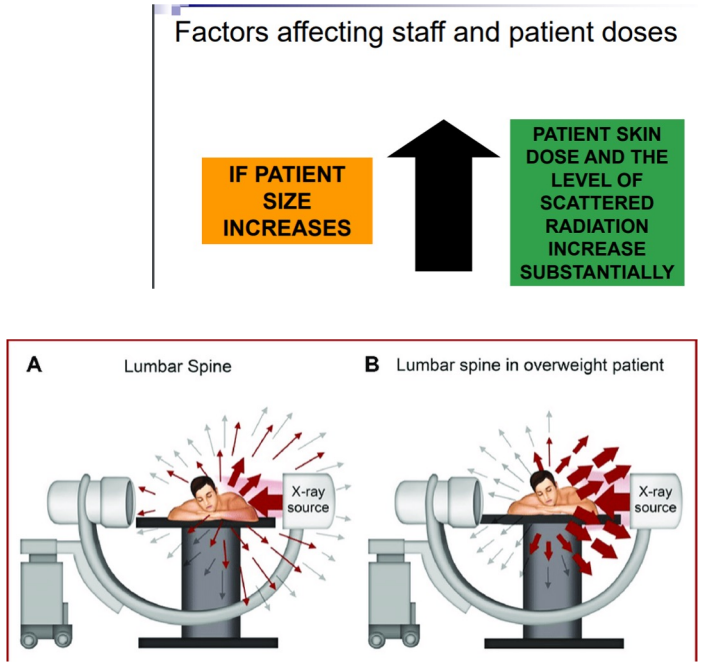
90

Patient Thickness

When patient size increases, scatter radiation also increases.

The increase in scatter radiation will impact both the radiographer and the patient.

Patient skin dose will also increase



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Portable & Fluoroscopy protection

1. Exposure switch on portable must be on a cord at least **6 ft. (2 m)** long and the **dead-man type.**
2. Fluoroscopic exposure control should be the dead-man type.
3. X- rays are only generated when someone is **actively pressing the switch** (either a button or a foot pedal).
4. If the switch is not being pressed, the equipment is in standby and not generating x rays.

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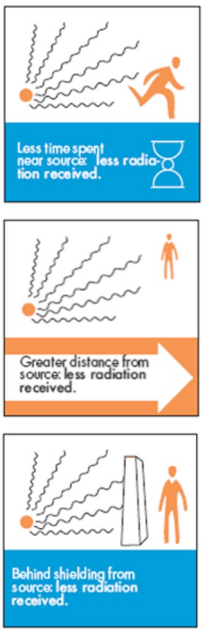
Cardinal Rules of Radiation Protection

As an occupational radiology worker it is important to keep radiation exposure to yourself to a minimum.

1. **Time - Keep your time exposed to radiation as short as possible**
2. **Distance - Try to increase your distance from the source (patient) as much as possible. Primary!**
3. **Shielding - Protect yourself with shielding whenever possible. Wear the shielding correctly and place radiation badge outside of the lead. Try to find lead that fits properly and has been tested yearly.**



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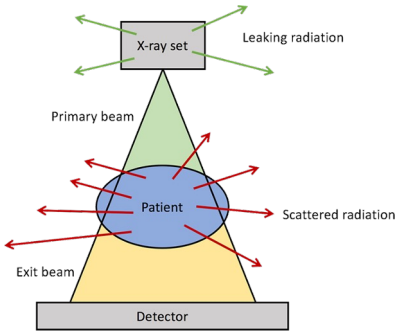
Sources of Radiation Review

Primary Radiation:

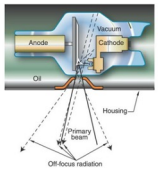
- **Primary Beam:** This refers to the **x-ray beam prior to any interaction** with the patient, grid, table or image intensifier.
- **Exit Beam:** The **beam that interacts with the detector** is termed the exit beam and will have been significantly attenuated.

Secondary Radiation:

- **Scattered Radiation:** This is a direct result of the **Compton effect** in the patient and **contributes the most to staff radiation dose.**



- **Leakage Radiation:** This is **leakage from the x-ray tube housing**. However, this is limited to a maximum of **1 mGya/hr at 1 meter** from the focus and, in practice, is usually much less. **Rare!**
- **Off Focus Radiation:** off-focus radiation refers to the **emission of x-ray photons which originate outside of the anode focal spot**. Essentially a form of scatter, photons produced in this manner **may result in blurring** and are of no use for diagnostic purposes



OFF FOCUS RADIATION

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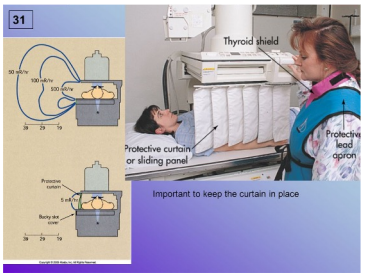
Shielding & Protective Devices NCRP # 102

Shield Type	Thickness of Lead
Aprons	**0.50 mm PB**
Thyroid Shields	**0.50 mm PB**
Glasses	0.35 mm Pb
Gloves	0.25 mm Pb
Protective Curtain (Fluoro)	0.25 mm Pb
Bucky slot cover (fluoro)	0.25 mm Pb



mm Pb	75 kVp	100 kVp
0.25mm	66%	51%
0.50mm	88%	75%

*.25 mm PB required, **.50 mm PB recommended** for fluoroscopy*

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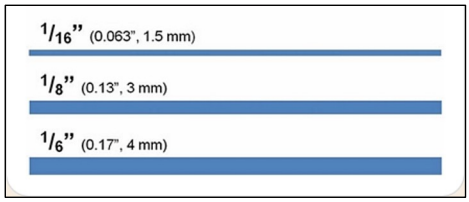
Room Design with Shielding

Shielding

Primary Barrier = 1/16 inch Pb

Secondary Barrier = 1/32 inch Pb

1" = 25.4 mm

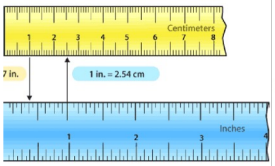


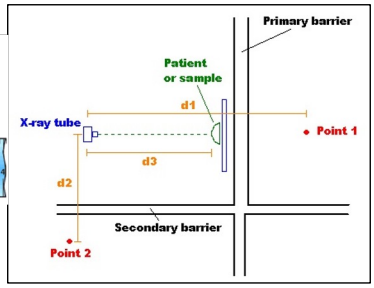
Primary Barrier

- **Primary beam is directed**
- **Wall behind wall bucky and floor below table bucky.**
- Floor to a **height of 7 feet (2.1 m)**
- **1/16" Lead (1.6 mm)**

Secondary Barrier

- Located wherever **leakage or scatter** radiation may strike.
- Doors to xray room
- **X-ray control booth**
  - *Primary beam will not be directed.*
- ***1/32" of Lead (0.8 mm)***
- **Lead window in control booth 1.5 mm**
- Extends from primary barrier (7feet) to the ceiling
  - **½" overlap required.**





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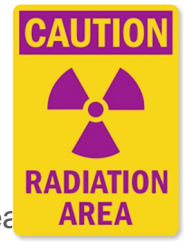
Determinants of barrier thickness



1. **Distance:** Between the source of radiation and the barrier.
2. **Occupancy:** Who occupies a given area. Controlled vs. Uncontrolled area
    a. **Uncontrolled area: Areas where personnel are not provided radiation exposure monitors (dosimeters)** or radiation safety training. **Public**
        - Should be shielded to ensure an effective dose limit to the general public of **20 µSv per week**
    a. **Controlled area:** Occupied by persons trained in radiation safety and wearing personnel monitoring devices. **Technologists**
        - Shielded to keep exposure **under 1 mSv per week**
3. **Workload:** Measured in **mA minutes per week** (mA min/wk); takes into account **the volume and types of exams performed in the room.**
4. **Use factor: Amount of time the beam is on and directed at a particular barrier.**

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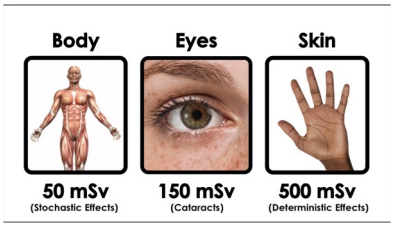
Radiation Dose and Monitoring



Dose Equivalent Limits (DEL)

- Set by **NCRP # 116**
- **Annual whole body dose 50 mSv**
    - No Age!
- **Lens of the eye = 150 mSv**
- **Everything else(Thyroid, skin, hands, feet) = 500 mSv**
- **Cumulative** Effective limit/lifetime = **10 mSv x age**
- General population (infrequent exposure)
    - **5 mSv**
    - **10% of occupational** dose
- Embryo/fetus = **5 mSv total, 0.5 mSv per month**
- **Student Radiographer yearly = 1 mSv**

Exposure Type	Dose Levels
Occupational Exposure (Annual)	
Whole Body Effective Dose Limits (Stochastic Effects)	50 mSv
Dose Equivalent Limits for organs (Non Stochastic Effects)	
Lens of Eye	150 mSv
All others	500 mSv
Public Exposure (annual)	
Effective dose euivalent limit, continous exposure	1 mSv
Effective dose euivalent limit, infrequent exposure	5 mSv
Dose Equivalent Limits for lens, skin and extremities	50 mSv
Embryo Fetus Exposures	
Total dose equivalent limit	5 mSv
Dose Equivalent in a **month**	0.5 mSv
Annual effective **education and training exposure**	1 mSv
Dose Equivalent Limits for lens, skin and extremities	50 mSv

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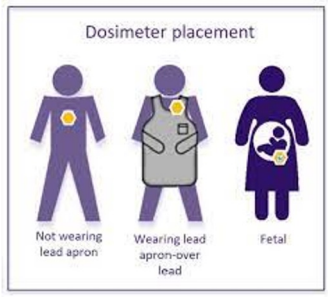
Personal Dosimeters

Radiation monitor should be worn on the **collar, OUTSIDE the apron at chest level.**

The position of the radiation monitor should remain consistent from day to day

Make sure to wear the dosimeter facing out toward the exposure

Pregnant technologists should wear an additional dosimeter placed **at waist level UNDER lead apron.**



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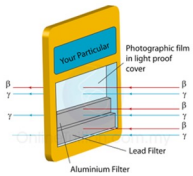
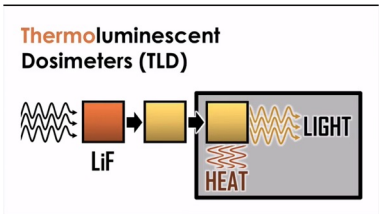
Dosimeters



Film Badge Dosimeter



Film Badge

- Contains a small piece of **radiographic film**
- Density of film indicates exposure
- **Cheap** and can be used for long periods of time
- Provides a **permanent record**

Thermoluminescent Dosimeter (TLD)

- Contains **Lithium Fluoride**
- **Heated and releases light** in proportion to exposure
- **More expensive**
- **No permanent record**
- Not exchanged but every 90 days usually.

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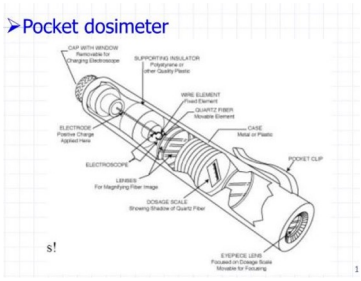
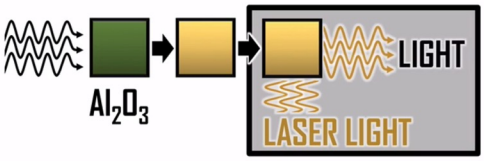
Dosimetry

➢Pocket dosimeter



Optically Stimulable Luminescent Dosimeter



Pocket Dosimeter

- **Immediate Reading**
- False-positive/false negative concern
- **NO permanent record of dose**

Optically stimulated luminescence dosimeter (OSL)

- **Aluminum oxide** is exposed to a **laser** **& emits visible light** in proportion to radiation exposure
- Filters allow determination of deep, shallow and eye exposure
- **Offers permanent record of dose**

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Dosimetry - Control Badge

Each batch of OSL dosimeters sent to a facility includes a control badge to protect against false readings. It should never be worn by a technologist!

The purpose of control dosimeters is to accurately distinguish an individual's occupational radiation exposure from variations in background radiation levels such as potential exposure to radiation where dosimeters are stored when not worn.

Any dose recorded on the control dosimeters will be subtracted from the badge readings to obtain the most accurate individualized occupational dose reports

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Dosimetry Reports

- Reviewed by physicist
- Reviewed by staff (quarterly)

M = Minimal dose to even report (below 1 mrem)

Dose listed in mrem

- **1 mSv = 100 mrem**
- **50 mSv (yearly) = 5,000 mrem**
- **1 mSv (yearly) = 100 mrem**

https://www.youtube.com/watch?v=--81zHv-nOI

Dose Report

Quarter (mSv)			Year-to-Date (mSv)			Lifetime Total (mSv)		
Deep Dose	Eye Dose	Shallow Dose	Deep Dose	Eye Dose	Shallow Dose	Deep Dose	Eye Dose	Shallow Dose
M	4	4	13	20	54	121	54	87

*M = Minimal, below reportable level

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Record of Accumulated Dose

Using a monitoring Device

- Required if might receive 10% of allowed dose equivalent limit of 50 mSv
  - 5 mSv

Content

- Whole body, deep, shallow and eye
- Monthly, quarterly, yearly lifetime
- **"M"= minimal**
- **Occupational exposure records must be kept how long? lifetime**
- **Length of record keeping? 3 yrs**
- What is supposed to happen if you change jobs? Transfer records

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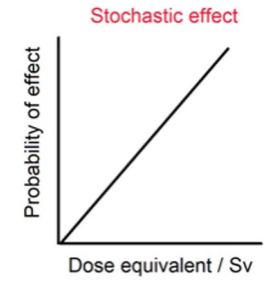
Stochastic Vs. Deterministic

Stochastic Effects (Random)

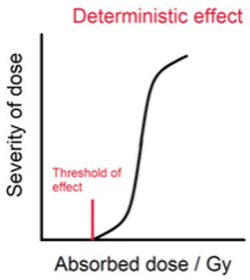
- Also known as **probabilistic**
- Dose determines **the chance** of getting the effect but not the severity of the effect
  - Like winning the lottery (random/non-threshold)
- **Linear Non-Threshold - X-ray**
- Examples: **Cancer, genetic effects**



Linear Non Threshold

Deterministic Effects (Not Random)

- Also known as **tissue reactions**
- Dose determines **the severity** of the effect rather than the chance of getting the effect
  - Like putting money into a bank account (not random)
- **Non-Linear Threshold**
- Examples: **Skin Erythema, Acute Radiation Syndrome, Cataracts**



Non Linear Threshold

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Units Of Measurement

Tips
The A's have Grays!
The E's have V's (sievert SV)
Q = Multiply 2
T = Multiply 3

Except Exposure = C/kg

Quantity	SI Unit	Notes	Calculation
Exposure In Air			
Exposure		Number of ionizations in air	Coulomb/Kg
Air Kerma	**Gray (Gy)**	Energy of ionizations in air	1 Gy = 1 J/kg
Exposure In Tissue			
Absorbed Dose	**Gray (Gy)**	Energy absorbed in matter	1 Gy = 1 J/kg
Equivalent Dose	**Sievert (SV)**	Radiation weighting factor	Gy x Wr = Sv
Effective Dose	**Sievert (SV)**	Tissue weighting factor risk of cancer	Gy x Wr x Wt = SV

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Thank you for joining us!

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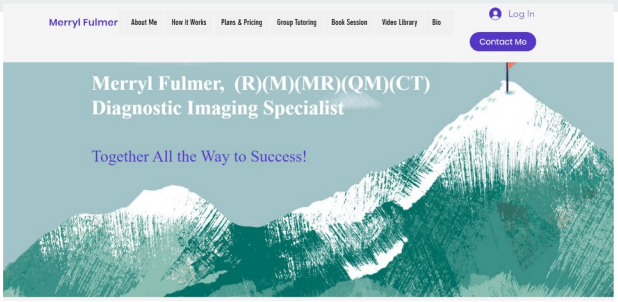

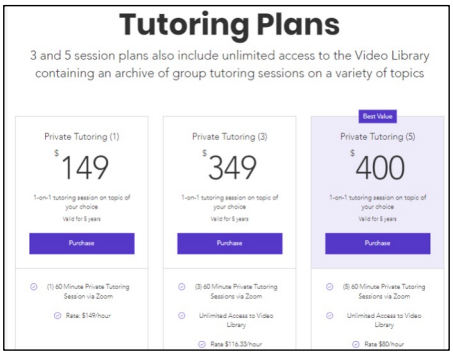

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