Chapter

2

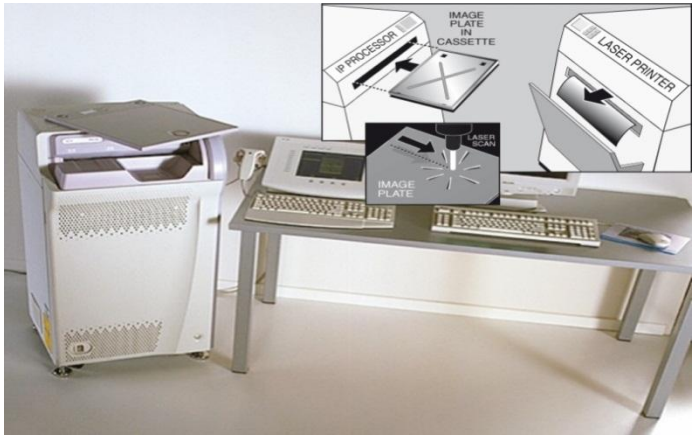


Image Quality, Digital Technology, and Radiation Protection

Kenneth L. Bontrager

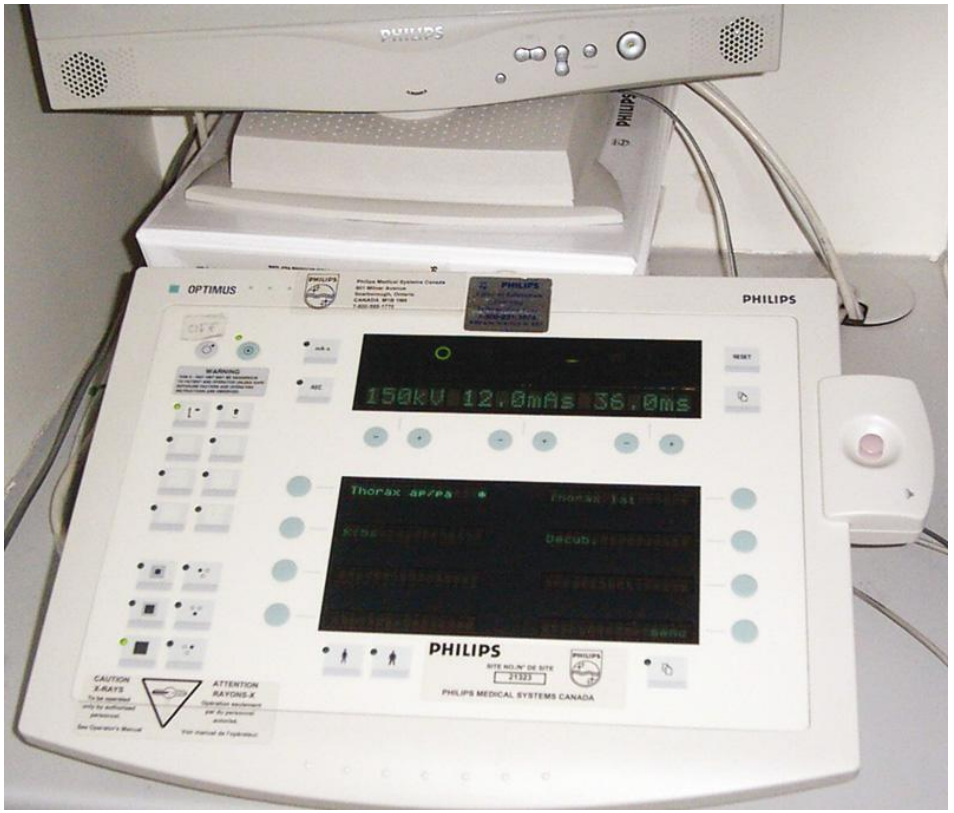
John P. Lampignano

Image Quality Factors—Film-Screen Systems

1. Density
2. Contrast
3. Resolution
4. Distortion

Exposure Factors (Technique)

1. Kilovoltage (kV)
2. Milliamperage (mA)
3. Exposure time (seconds)
   - mAs (milliampere-seconds)



Density

- Amount of blackness
- Controlling factors:
  - mAs (mA × time)
  - kV
- Influencing factors:
  - Source image receptor distance (SID)
  - Screen and IR speed

Density Change Rule

- 15% change in kV
  (similar to doubling mAs)

- Examples:
  80 kV × .15 = 12 kV
  60 kV × .15 = 9 kV

Density Change Rules

Density adjustment rule:

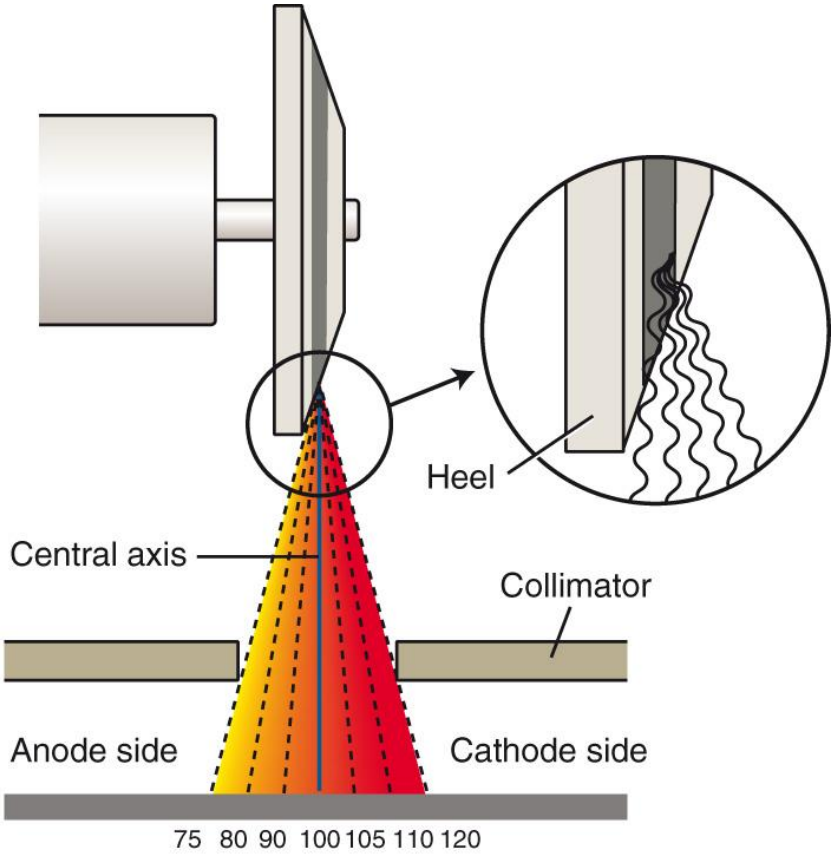
- 25% to 30% increase in mAs (minimum change)

Density repeat rule:

- Doubling mAs (to correct density on repeats)

Anode Heel Effect

- More intense under cathode
- Increase with
  - Small focal spot
  - Shorter SID
  - Larger IR size
- Application
  - Thicker parts at cathode



Percent intensity of x-ray beam
(more pronounced at shorter SID and larger IR)

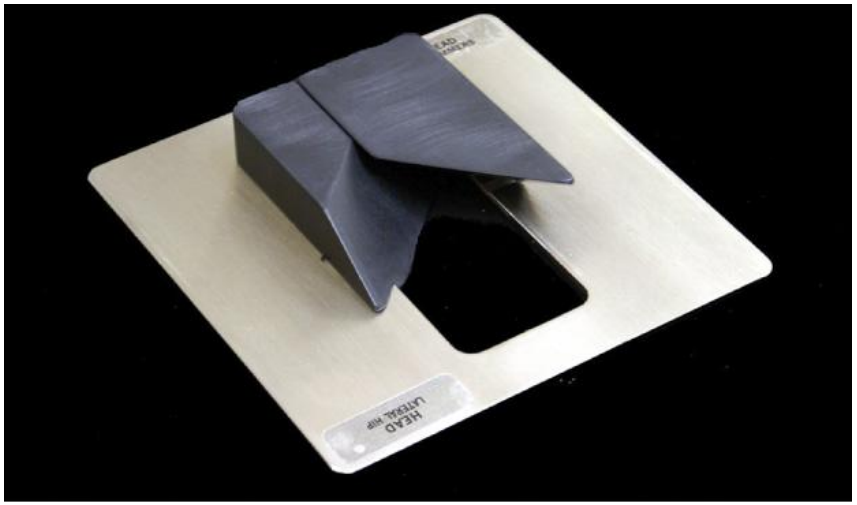
Compensating Filters

Compensating filters filter out a portion of the primary beam toward the thin or less dense part of the body that is being imaged.

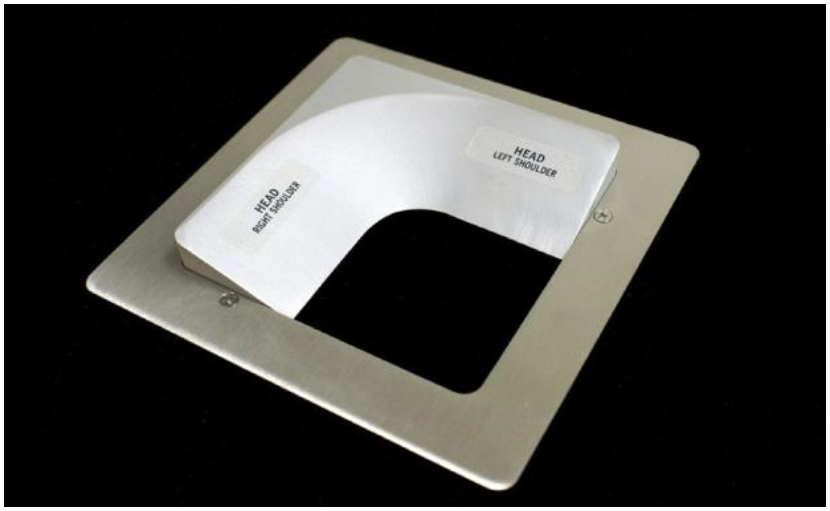
Types of compensating filters include the following:

- Wedge filter
- Trough
- Boomerang

Compensating Filters



Wedge filter

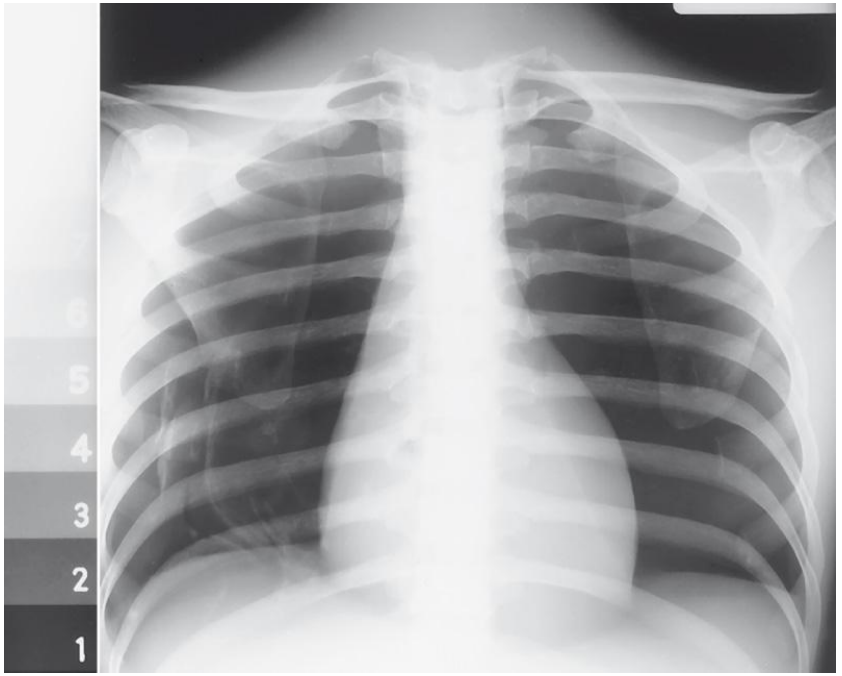


Boomerang filter

Benefits of Compensating Filter

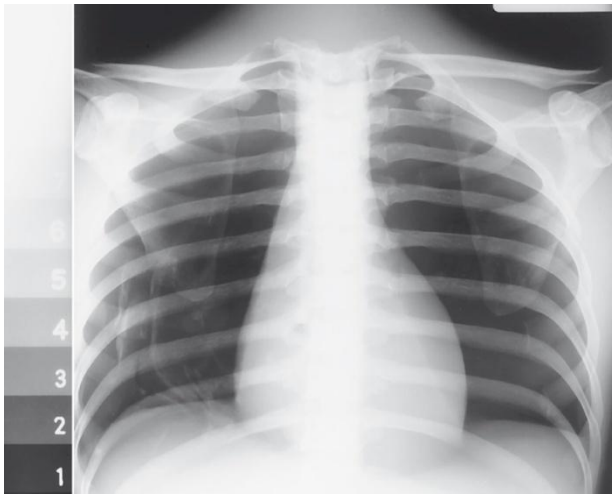
Radiographic Contrast

- Differences (variation) in density
- Controlling factor—kV

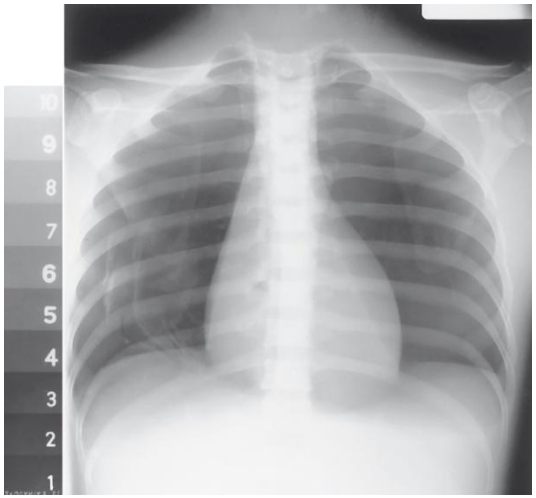


High vs. Low Contrast

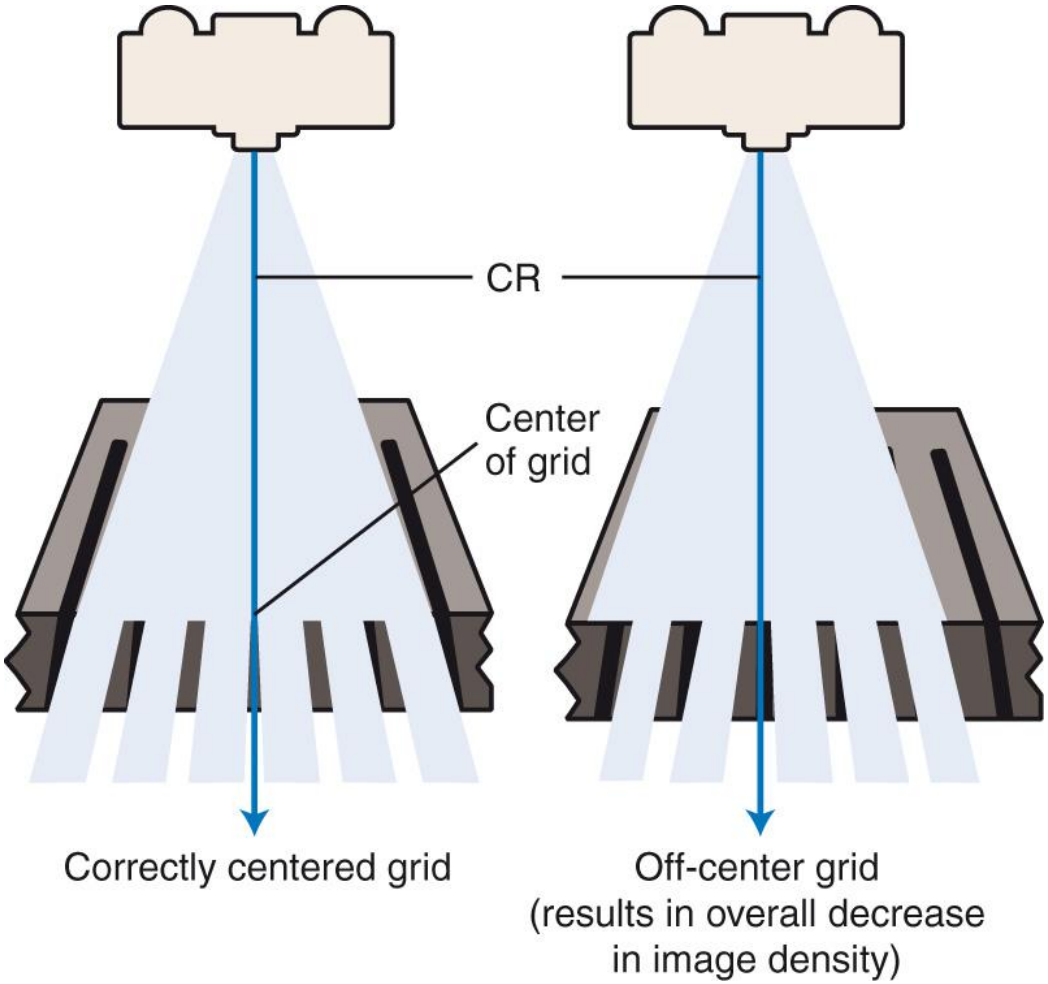
- High contrast:
  - Short scale
  - 50 kV (800 mAs)



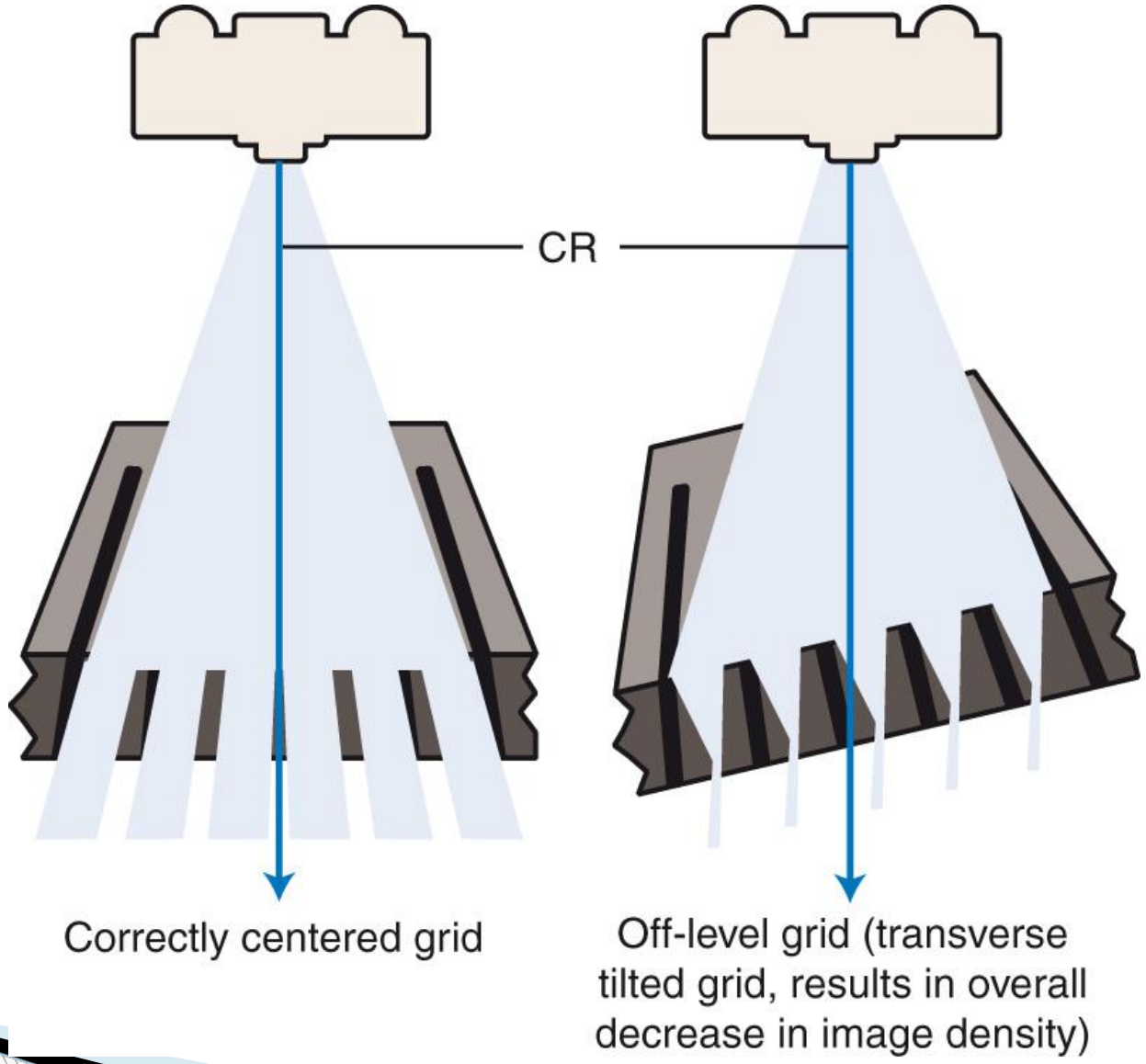
- Low contrast:
  - Long scale
  - 110 kV (20 mAs)



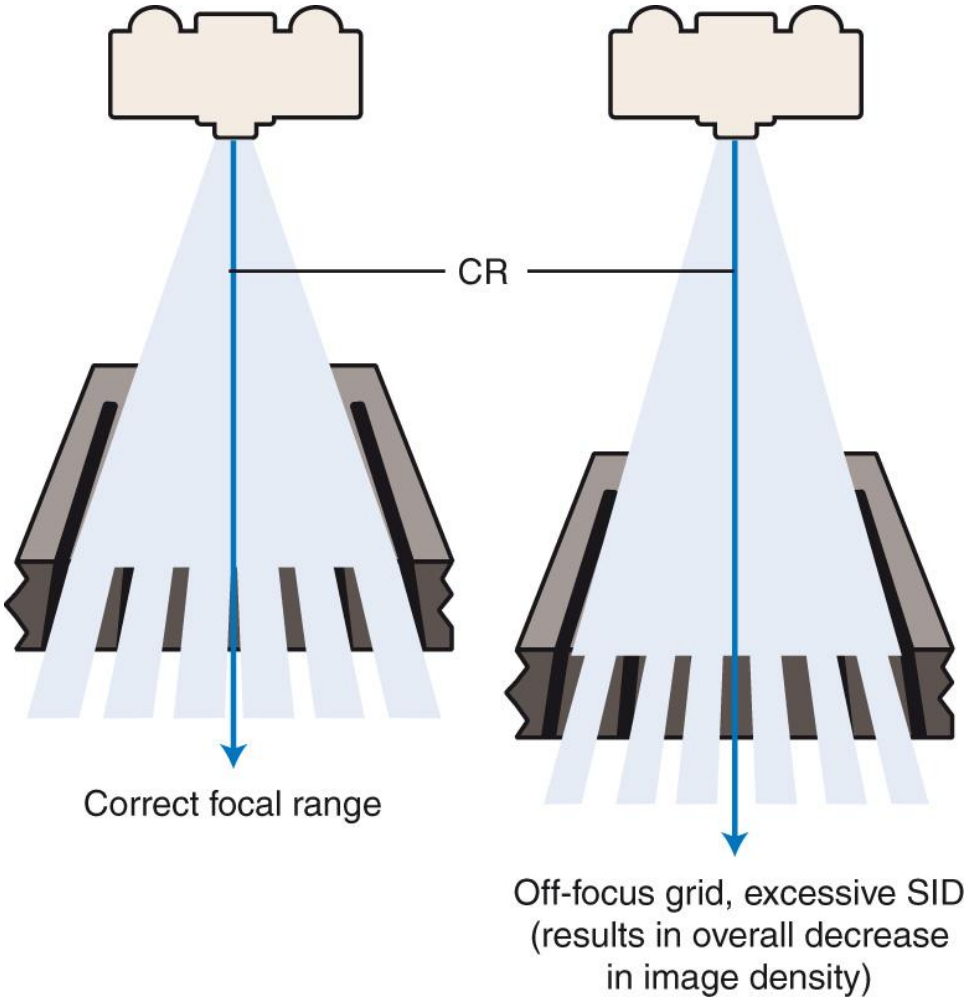
Off-Center Grid Cutoff



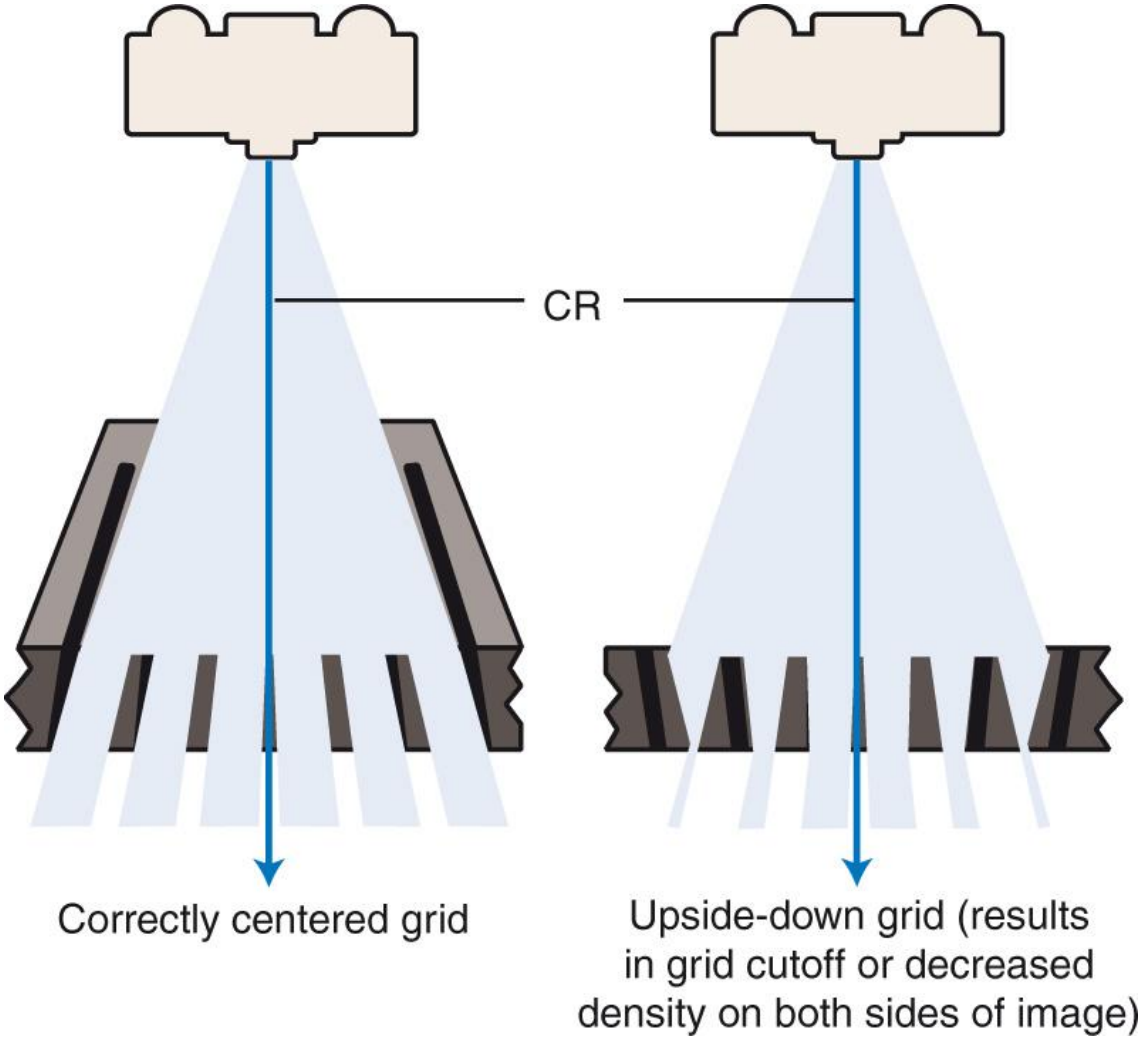
Off-Level Grid Cutoff



Off-Focus Grid Cutoff



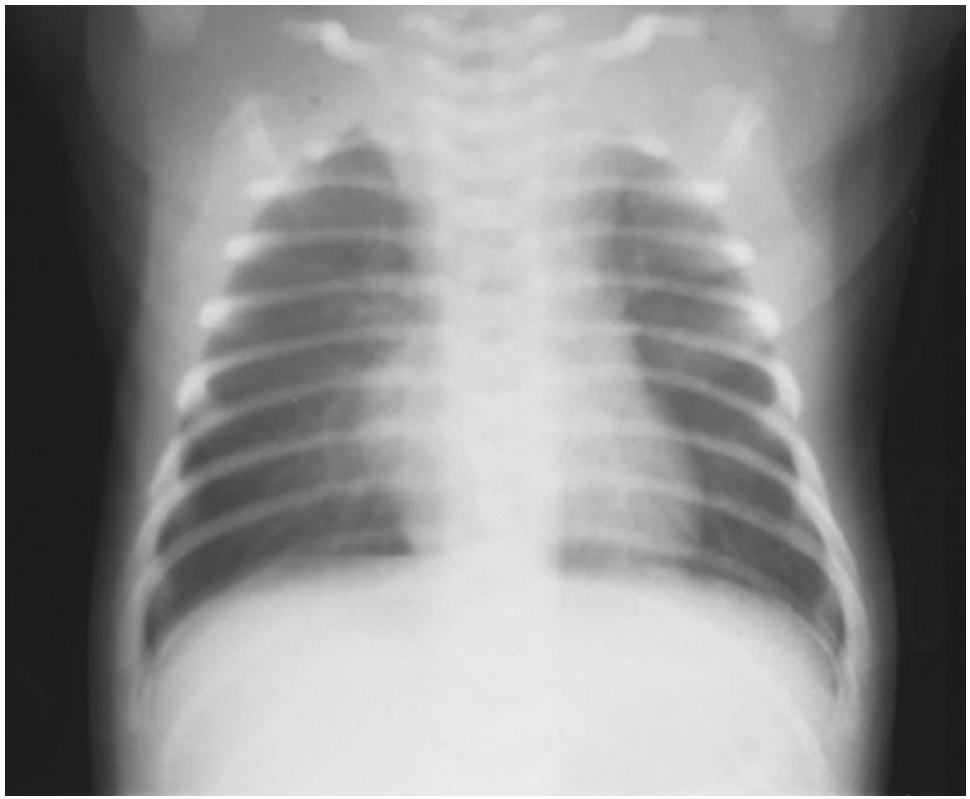
Upside-Down Grid Cutoff



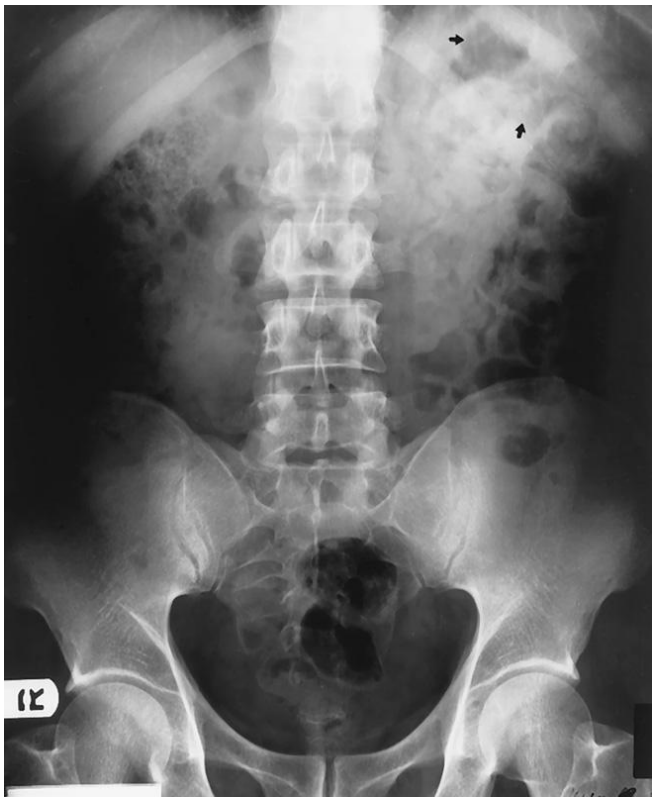
Resolution (Definition)

- Recorded sharpness of structures
- Lack of definition is blur or unsharpness.
- Motion is greatest deterrent (two types).

Motion



Voluntary motion (breathing)

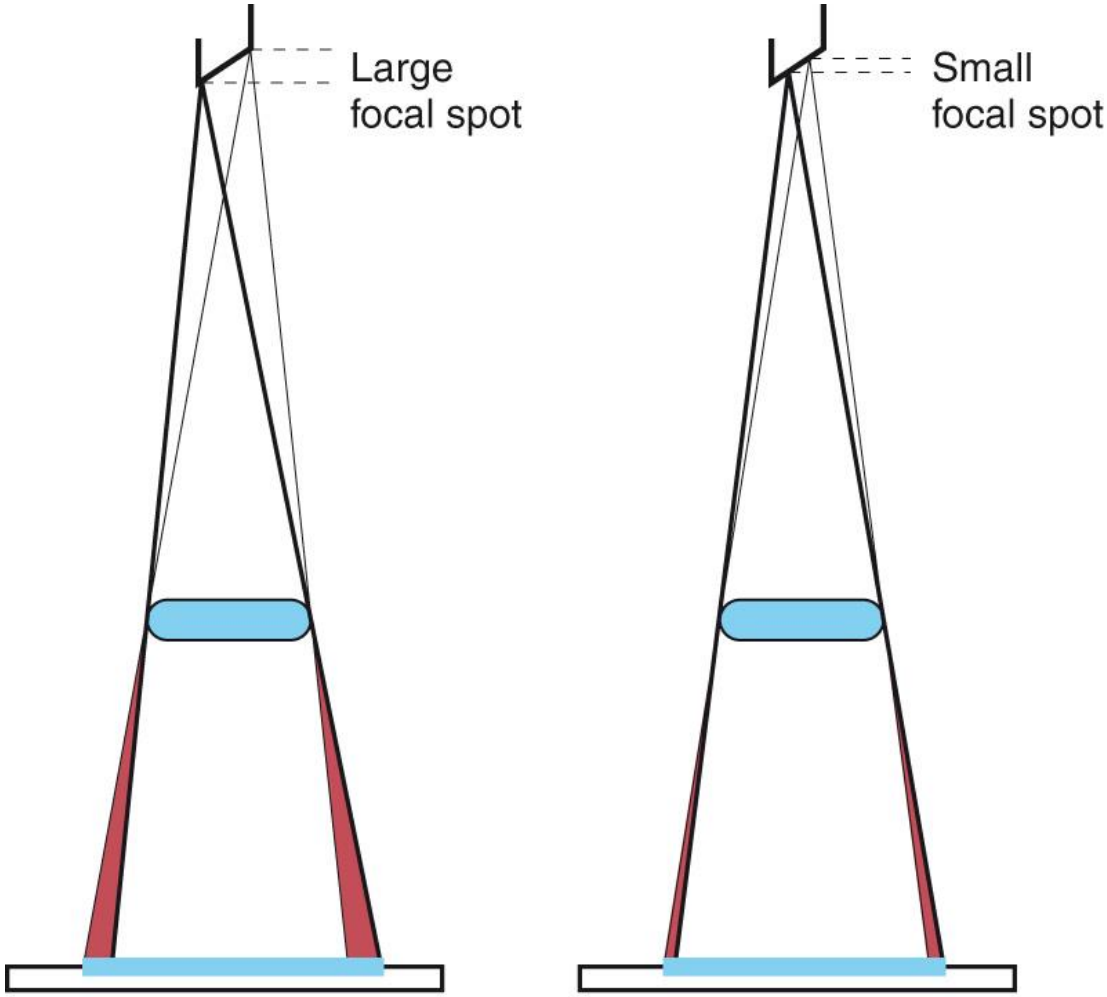


Involuntary motion (peristalsis)

Image Quality Summary Chart

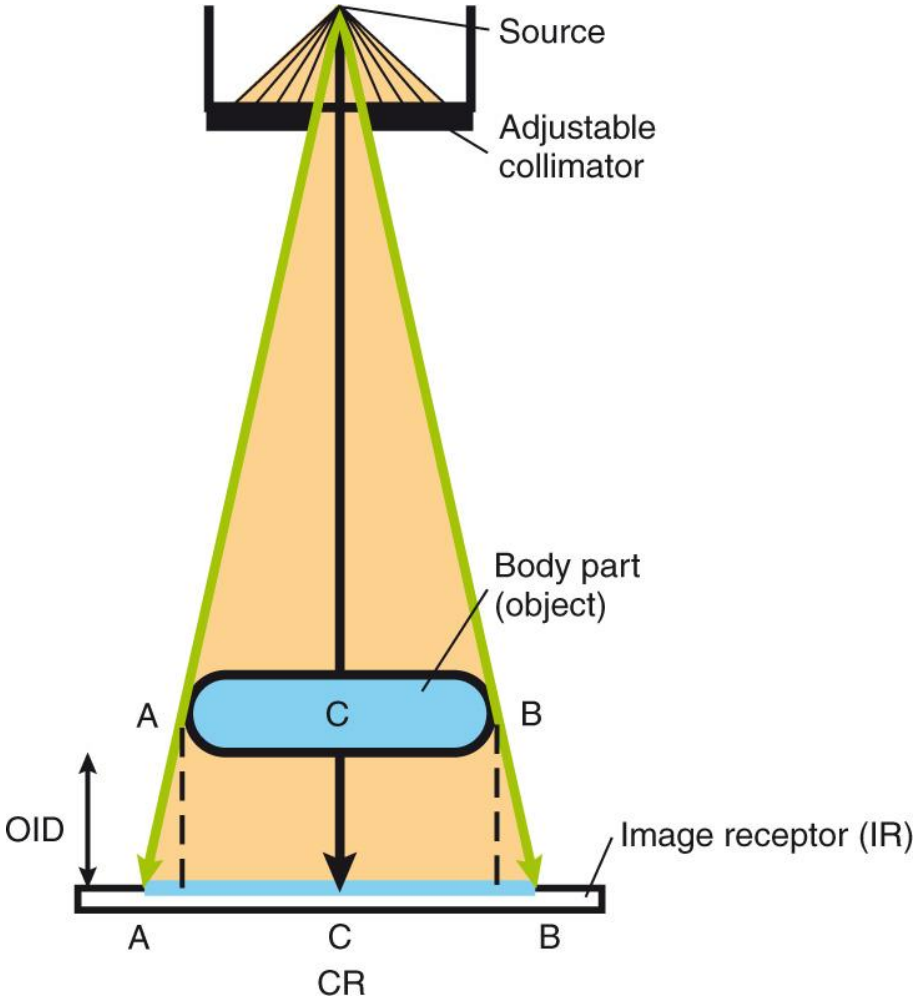
1. Small focal spot—Use small focal spot whenever possible to improve detail.
2. Shorter exposure time—Use shortest exposure time possible to control voluntary and involuntary motion.
3. Film-screen speed—Use faster film-screen speed to control voluntary and involuntary motion.
4. SID—Use longer SID to improve detail.
5. OID—Use shorter OID to improve detail.

Focal Spot Size



Distortion (Magnification)

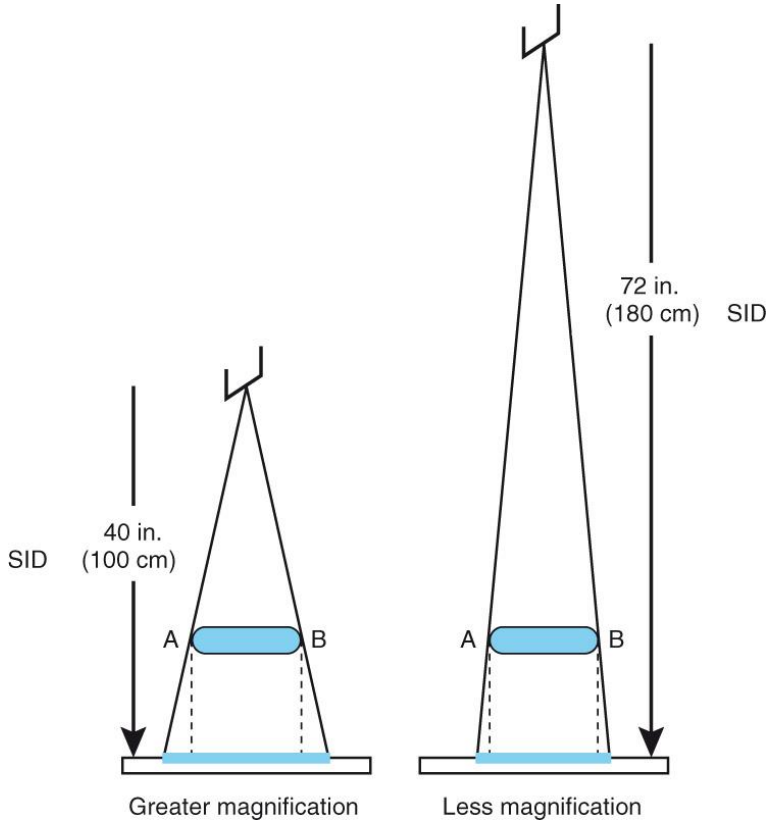
- Misrepresentation of object size or shape
- X-ray beam divergence



Distortion

Controlling factors

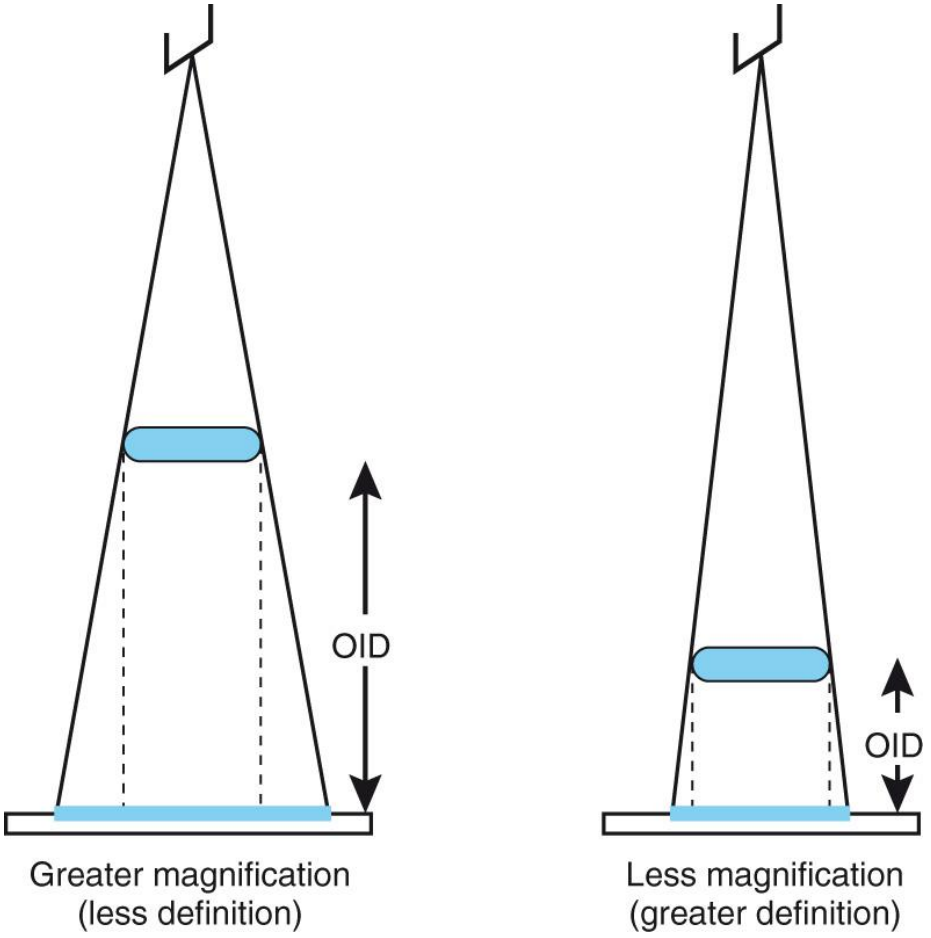
- SID (source image receptor distance)
- OID
- Object IR alignment
- CR alignment



Distortion

Controlling factors

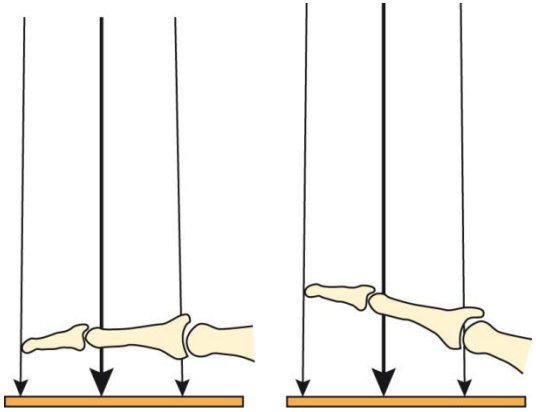
- SID
- OID (object image receptor distance)

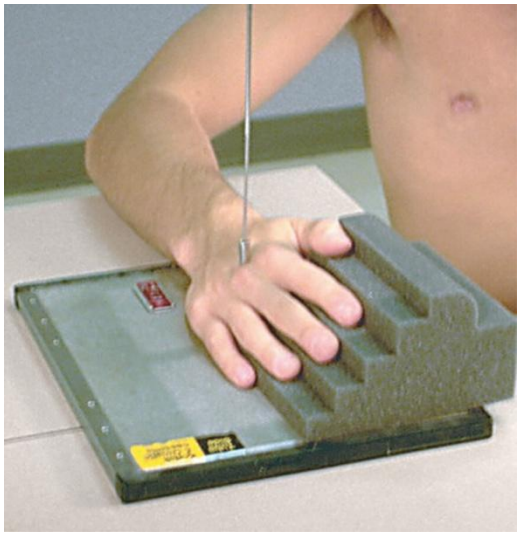


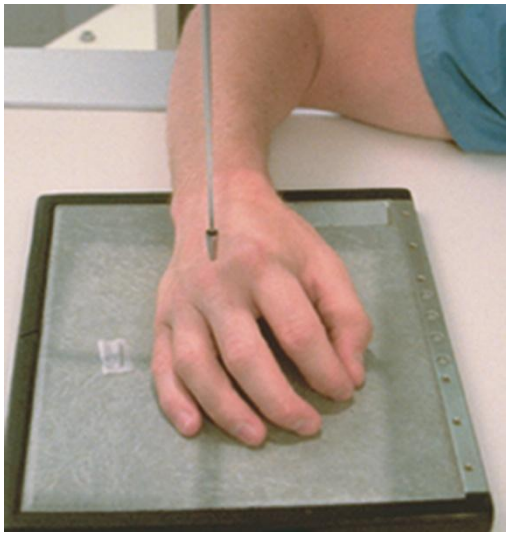
Distortion

Controlling factors

- SID
- OID
- Object IR alignment







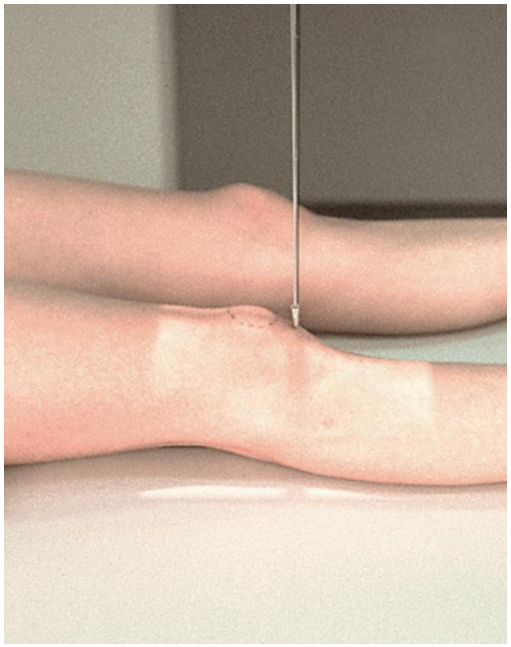
Digits parallel—joint open

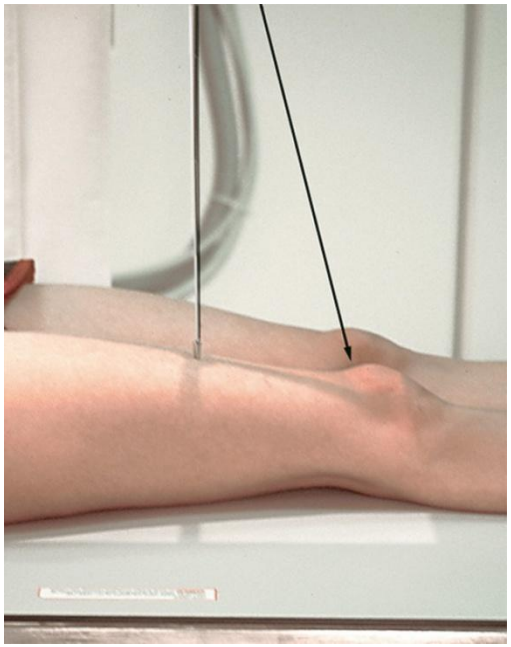
Digits not parallel—joints not open

Distortion

Controlling factors

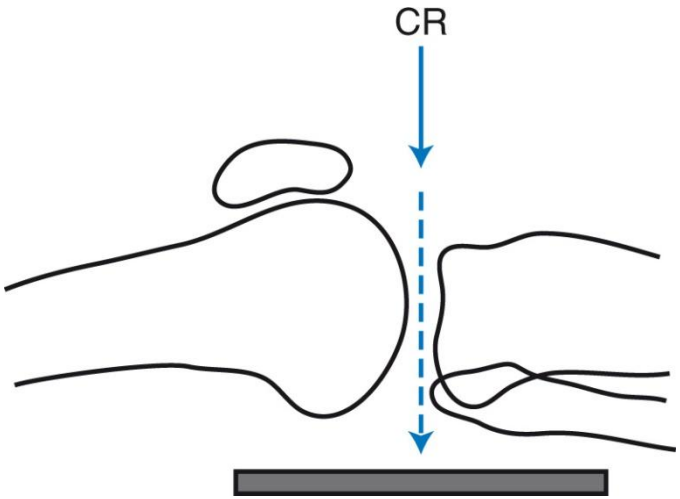
- SID
- OID
- Object IR alignment
- CR alignment



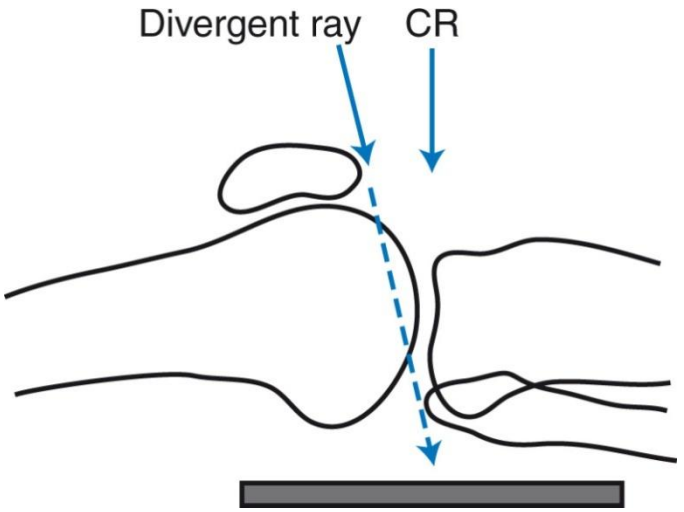


CR Alignment

- CR parallel to joint



- CR not parallel to joint



Quiz Me

Which of the following is ***NOT*** a quality factor for film-based radiography?

A. Density
B. Focal spot size
C. Contrast
D. Distortion
E. Resolution

Quiz Me

The primary controlling factor for density is

A. mAs
B. kV
C. SID
D. OID

Quiz Me

When the **anode heel rule** is applied, the thicker aspect of the anatomy should be placed under the cathode end of the x-ray tube.

A. True
B. False

Quiz Me

Which of the following is ***not*** a type of compensating filter?

A. Wedge
B. Boomerang
C. Slotted
D. Trough

Quiz Me

What is the primary controlling factor for radiographic contrast?

A. mAs
B. kV
C. SID
D. Focal spot size

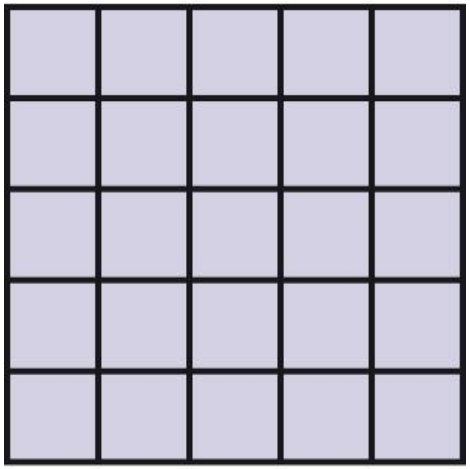
Quiz Me

What type of grid cutoff will occur if a shorter SID is used than what is specified for a particular grid?

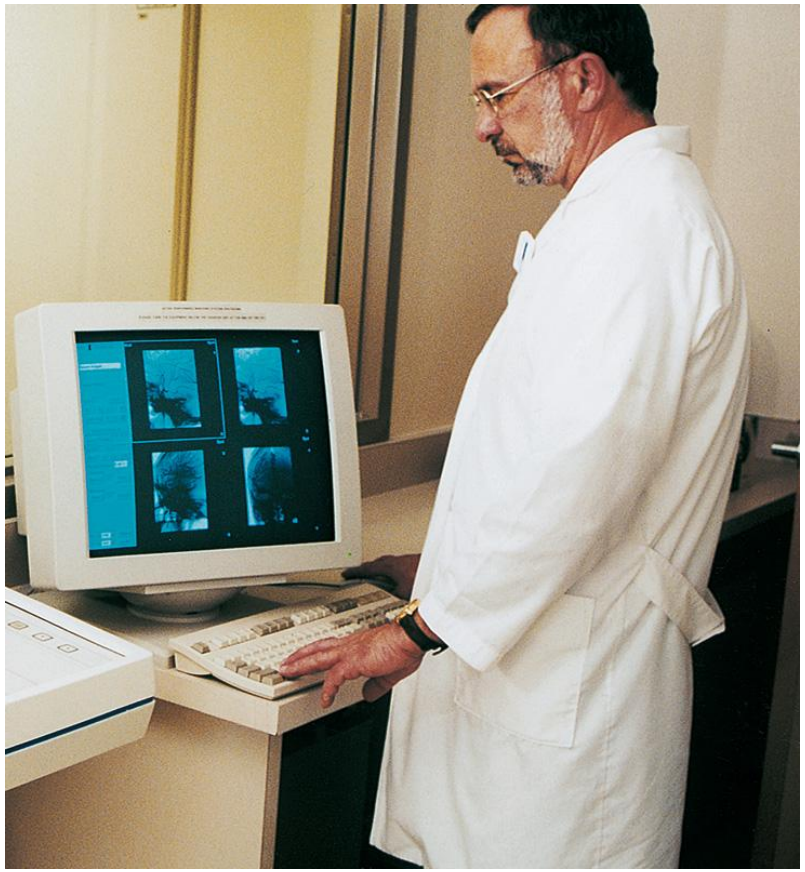
A. Off-center
B. Off-level
C. Off-focus
D. Off-distance

Image Quality in Digital Radiography

Display matrix



Pixel



Processing digital image

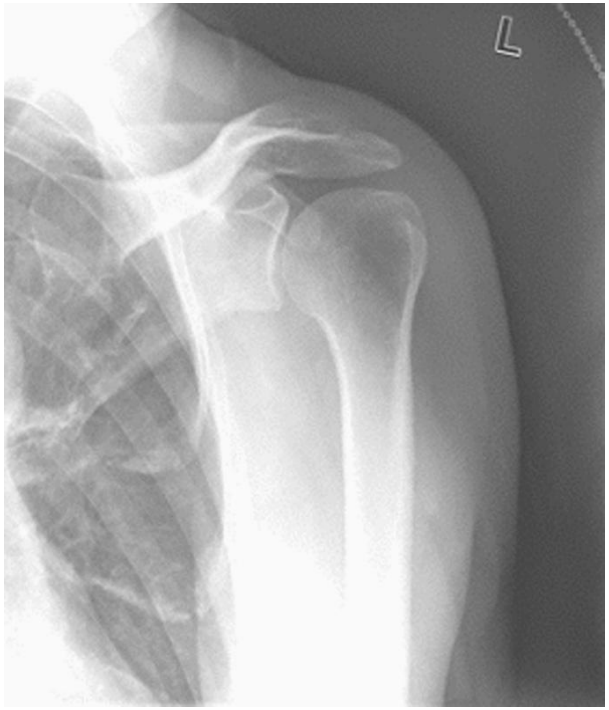
Exposure controls—kV, mAs, and time

Image Quality in Digital Radiography

- Brightness
- Contrast
- Resolution
- Distortion
- Exposure index
- Noise

Brightness

Intensity of light representing individual pixels in image



AP shoulder—high brightness

AP shoulder—less brightness

Contrast

Differences in brightness between light and dark areas of image

AP shoulder—higher contrast

AP shoulder—lower contrast

Resolution

Recorded Sharpness of Structures on Image

Controlling factors:

- Acquisition pixel size
  - Inherent to the digital imaging detector
- Display matrix
  - Dependent on capabilities of the display monitor

Distortion

Misrepresentation of Object Size or Shape

Controlling factors:

- SID
- OID
- CR alignment

Exposure Index
(referred to by some manufacturers as sensitivity "S" numbers)

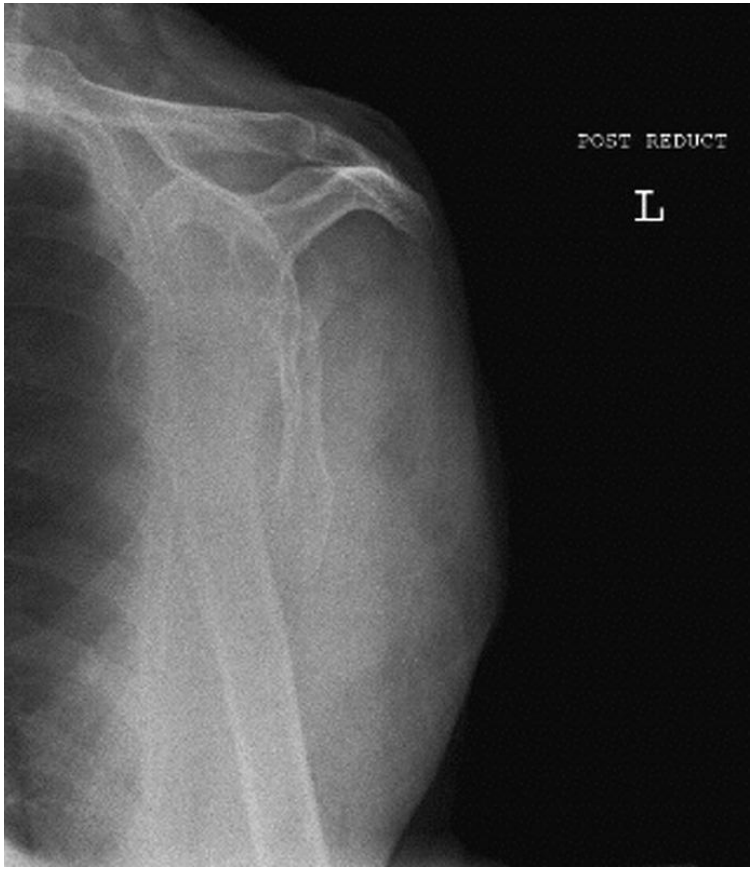
A numeric value that is representative of the exposure the image receptor received

- May be inversely or directly proportional to radiation striking the image receptor
- Key in verifying optimal digital image is obtained with least dose to patient

Exposure Index

Dependent on the intensity of the radiation striking the detector, which is the effect of

- mAs
- kV
- Total detector area irradiated
- Objects exposed (air, metal implants, patient anatomy)



Low exposure index (high “S” number)—Underexposed

Acceptable exposure index

High exposure index (low “S” number)

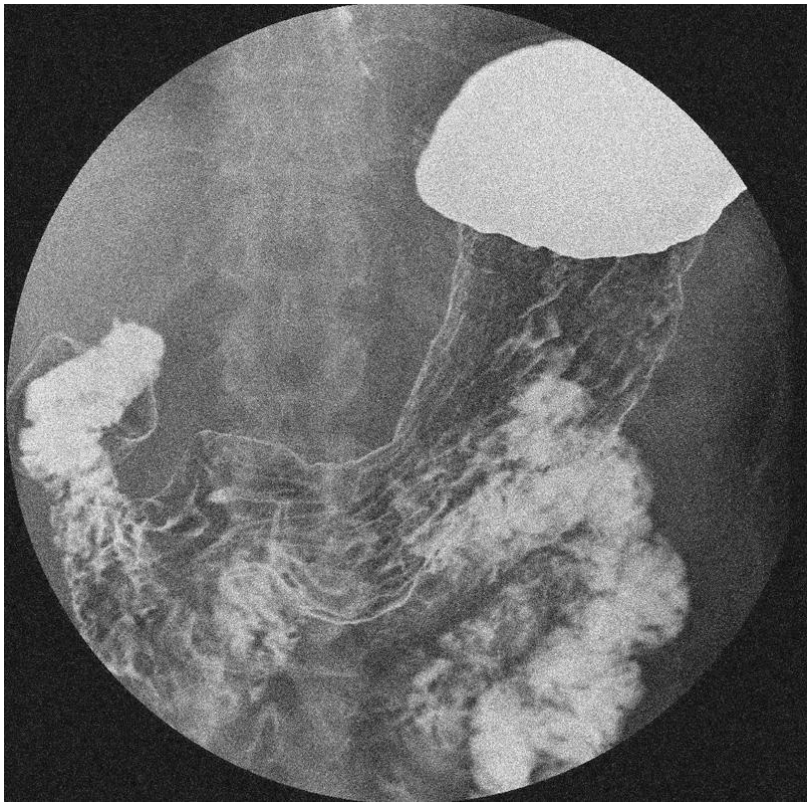
Acceptable exposure index

Noise

Random disturbance that obscures image clarity

- High signal-to-noise ratio (SNR) is desirable.
- Low signal-to-noise ratio (SNR) is undesirable.

Acceptable SNR
(good image quality)



Low SNR
(poor image quality)

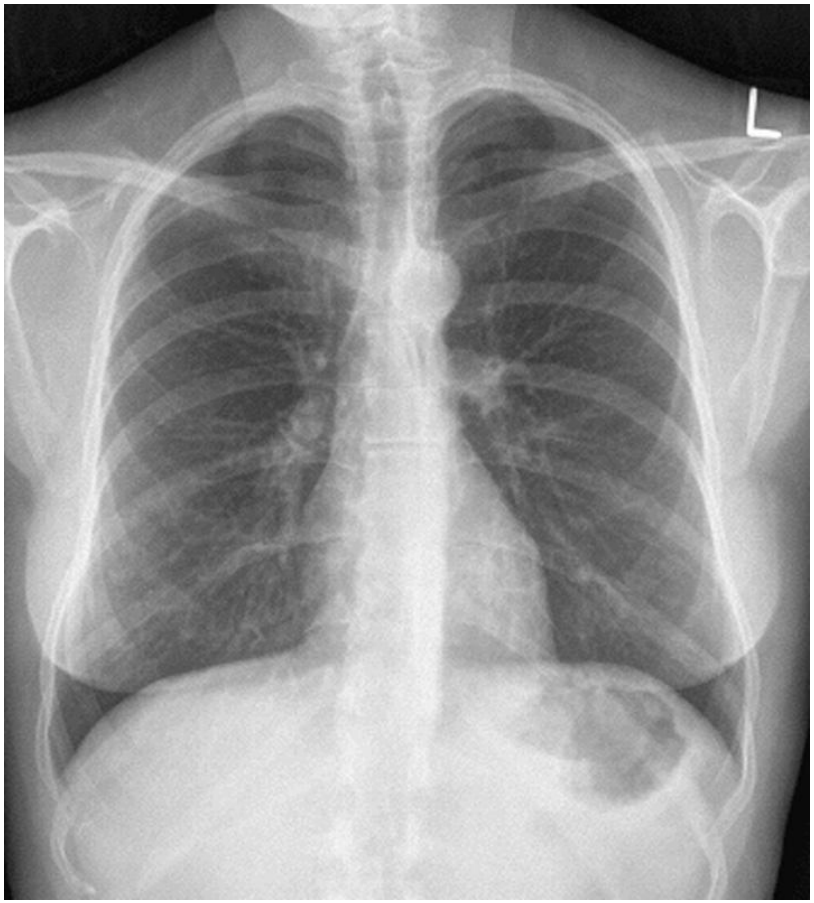
Post-processing

Changing or enhancing the electronic image to improve diagnostic quality

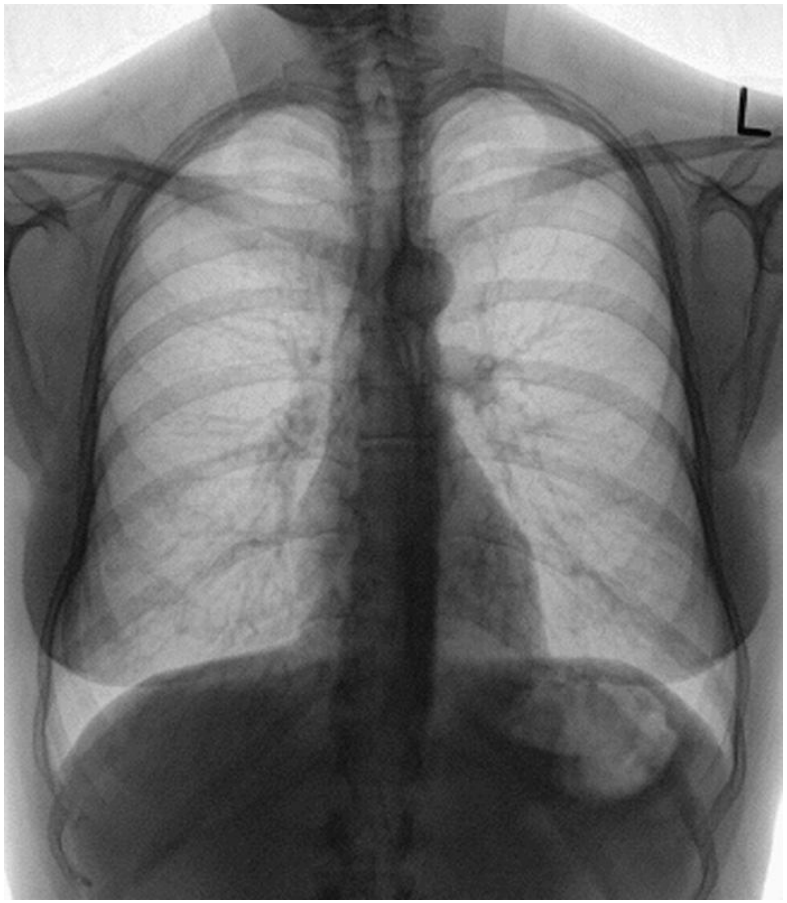
- Algorithms applied to improve diagnostic quality of image
- Post-processing cannot improve low SNR image.

Post-processing Options

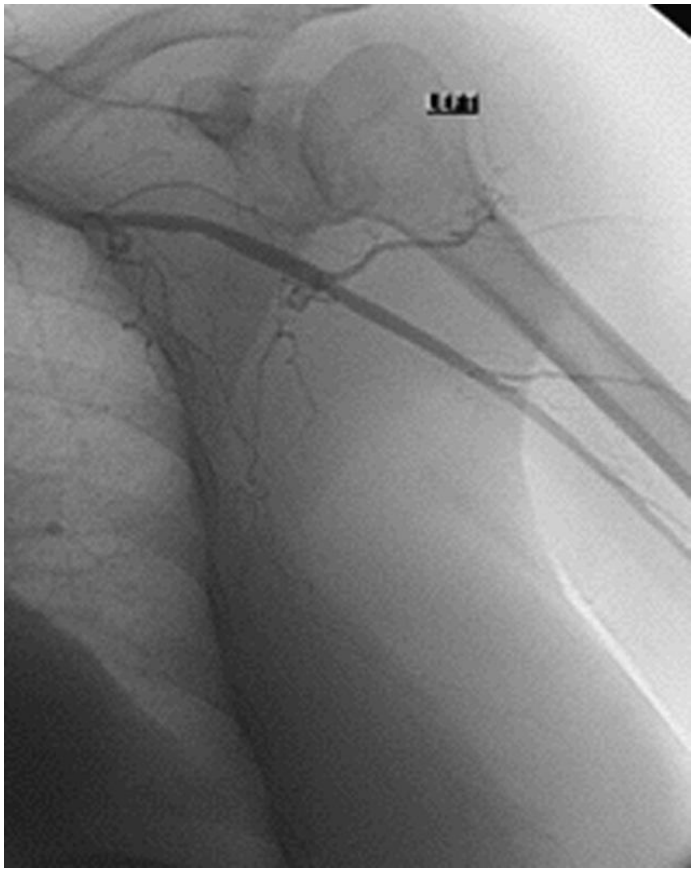
- Windowing
- Smoothing
- Magnification
- Edge enhancement
- Subtraction
- Image reversal
- Annotation



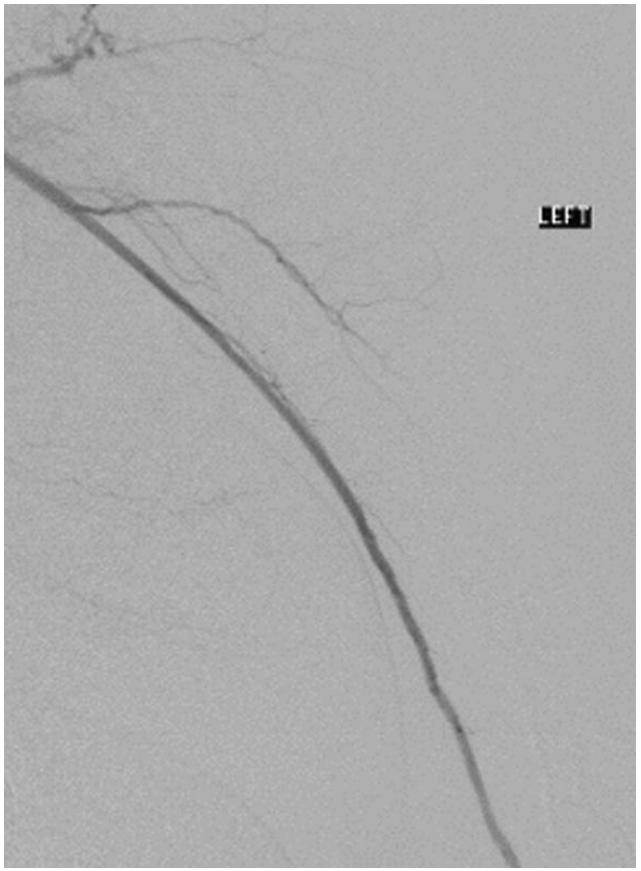
Chest without any post-processing



Chest with image reversal



Nonsubtracted AP shoulder



Subtracted and magnified shoulder angiogram

Quiz Me

Highly complex mathematical formulas are called

A. Binary codes
B. Exposure indices
C. Equalization filters
D. Algorithms

Quiz Me

The intensity of light that represents the individual pixels in the digital image on the monitor is the definition for

A. Brightness
B. Contrast
C. Density
D. Noise

Quiz Me

Random disturbance that obscures or reduces clarity is the definition for

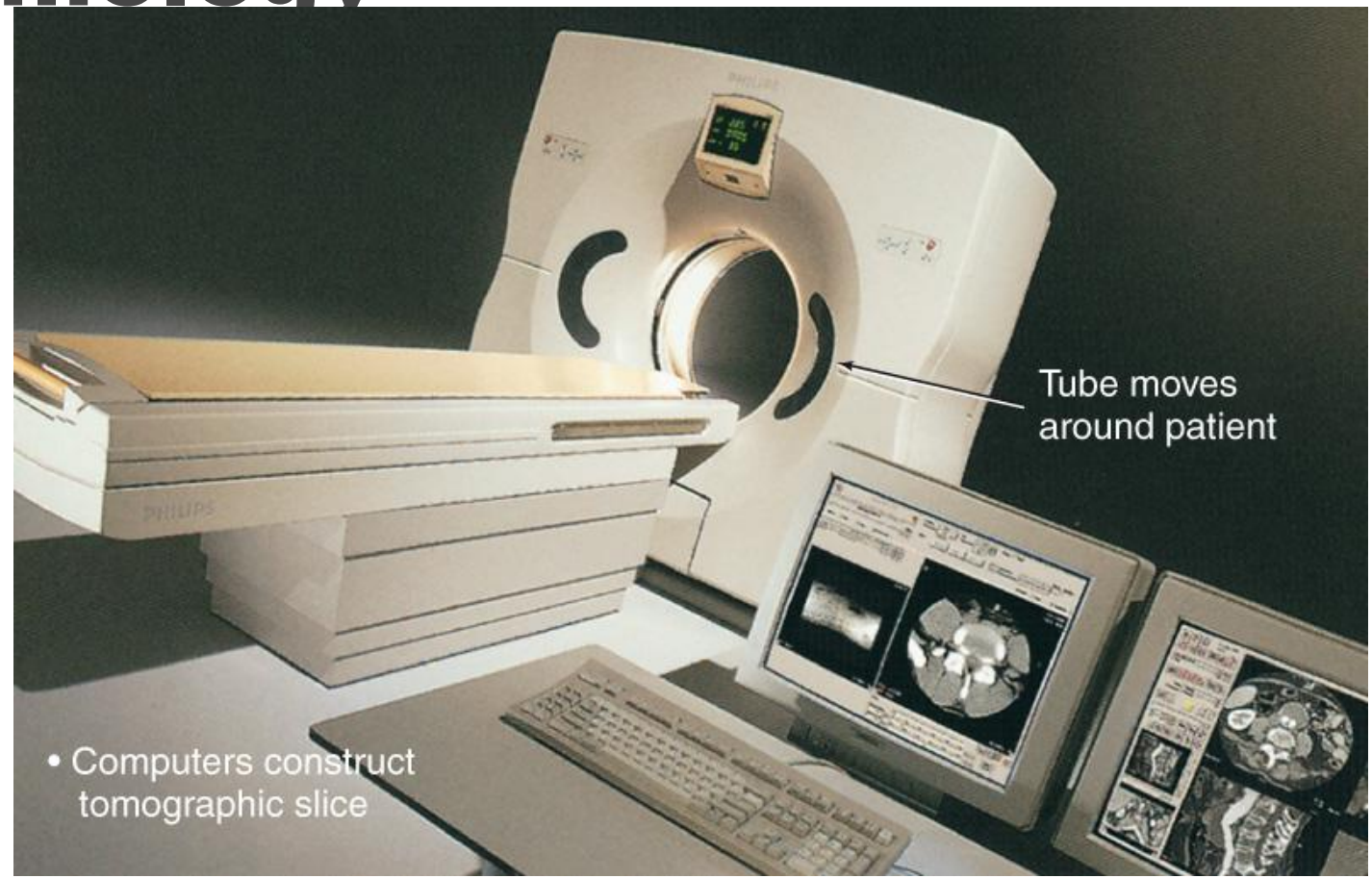
A. Noise
B. Resolution
C. SNR
D. Distortion

Quiz Me

A low SNR digital image can be enhanced through post-processing techniques.

A. True
B. False

Applications of Digital Technology



- Computed tomography (CT), one of the first applications of computers in radiography

Computed Radiography (CR)

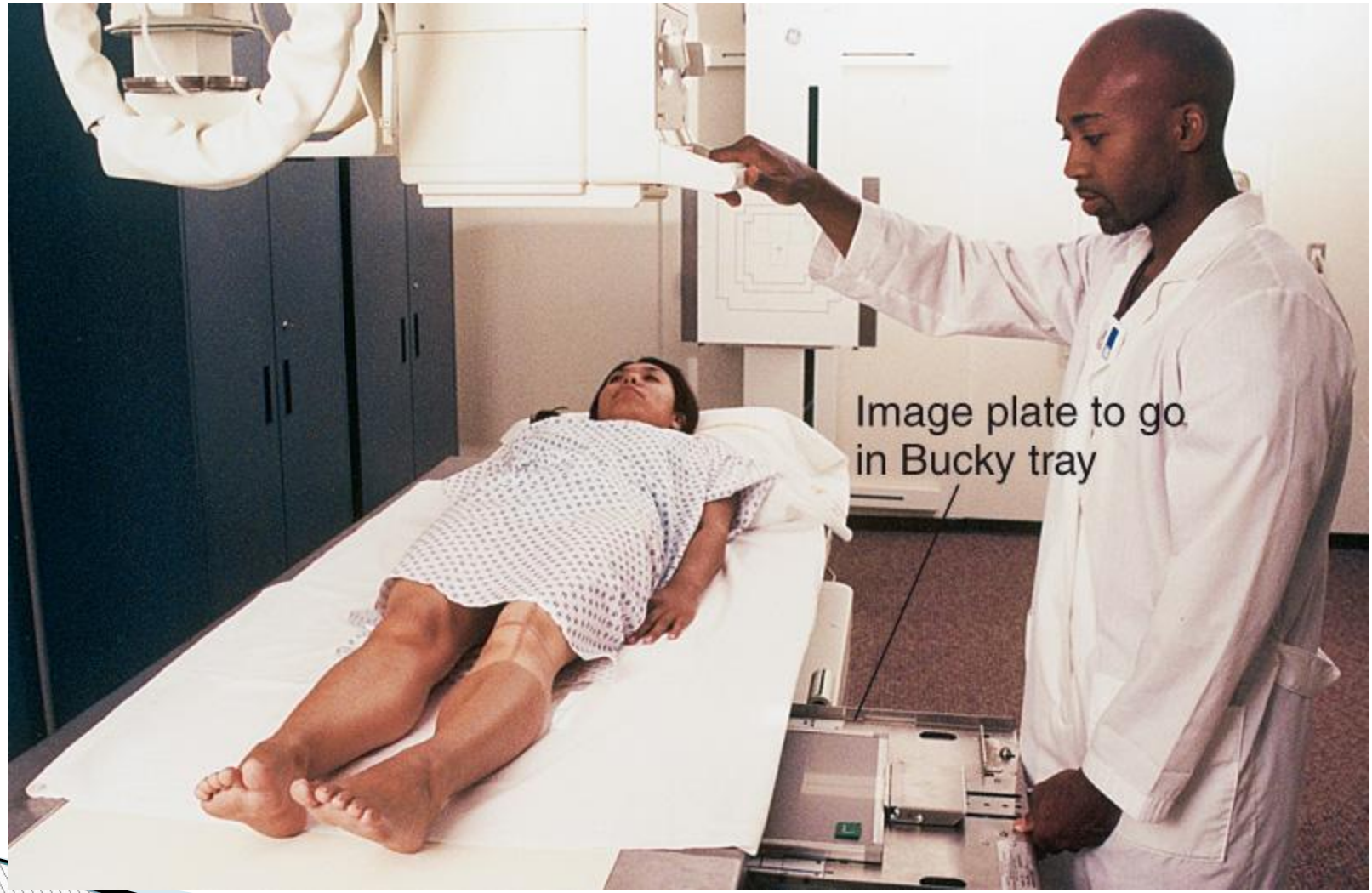
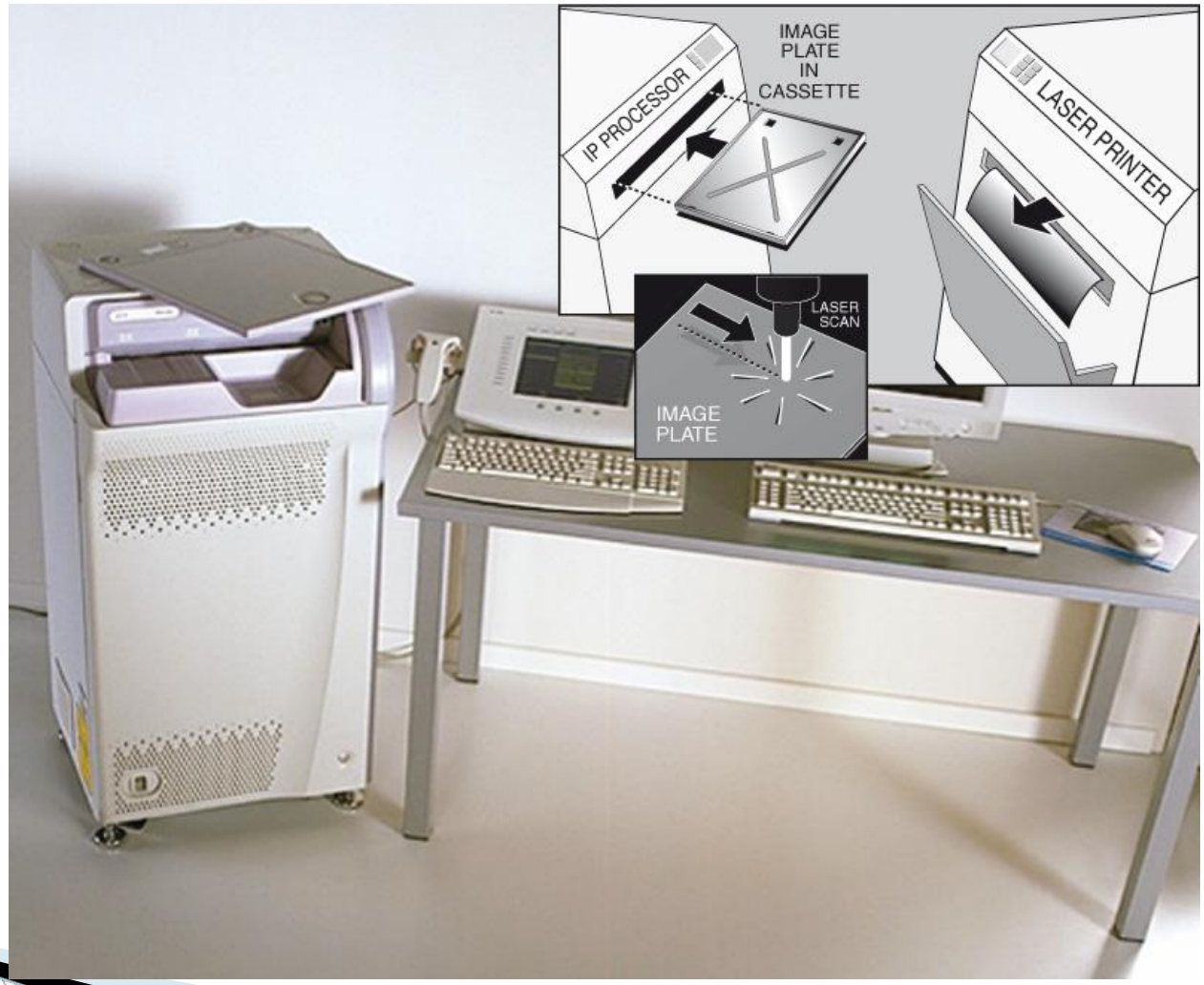
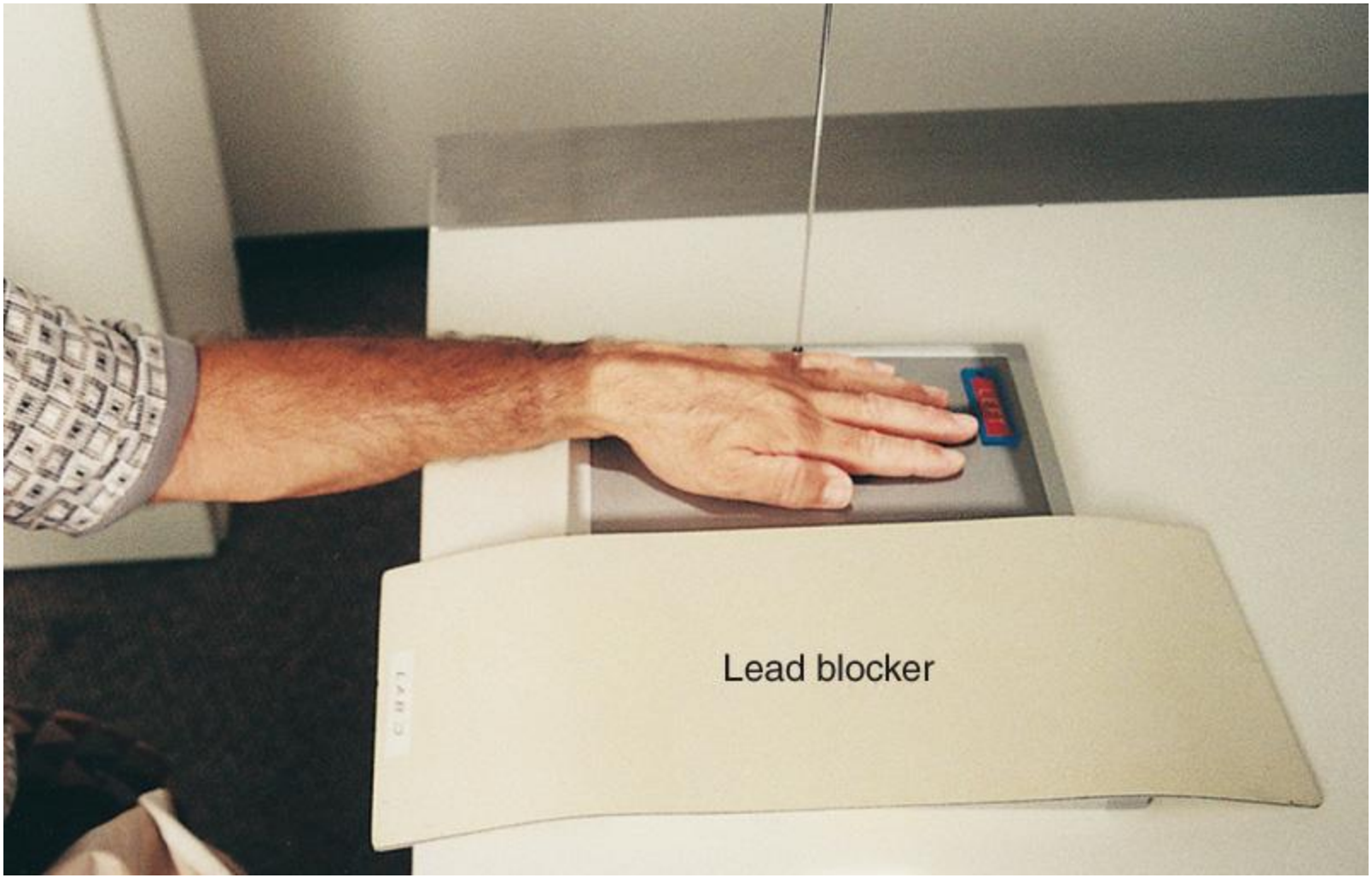


Image Plate Reader/Processor and Workstation





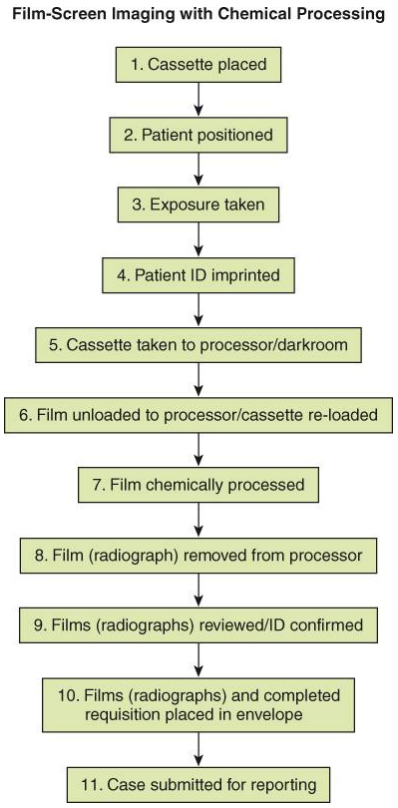
Why is it important to collimate and use lead blockers with CR?

Direct Digital Radiography (DR)

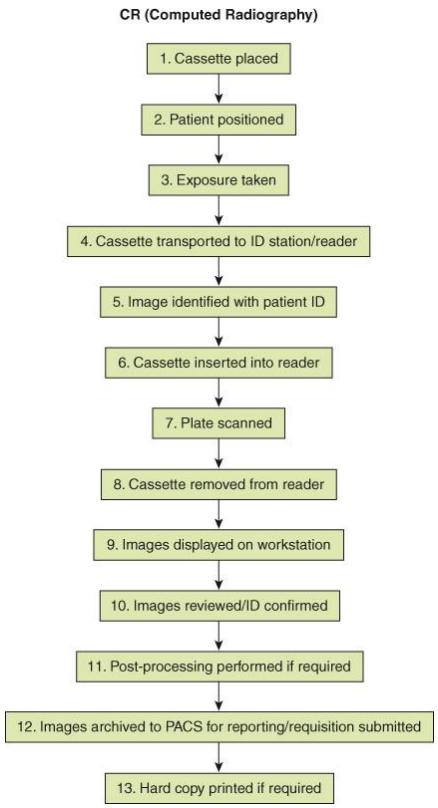
DR Chest Imaging System

DR Mammography Unit

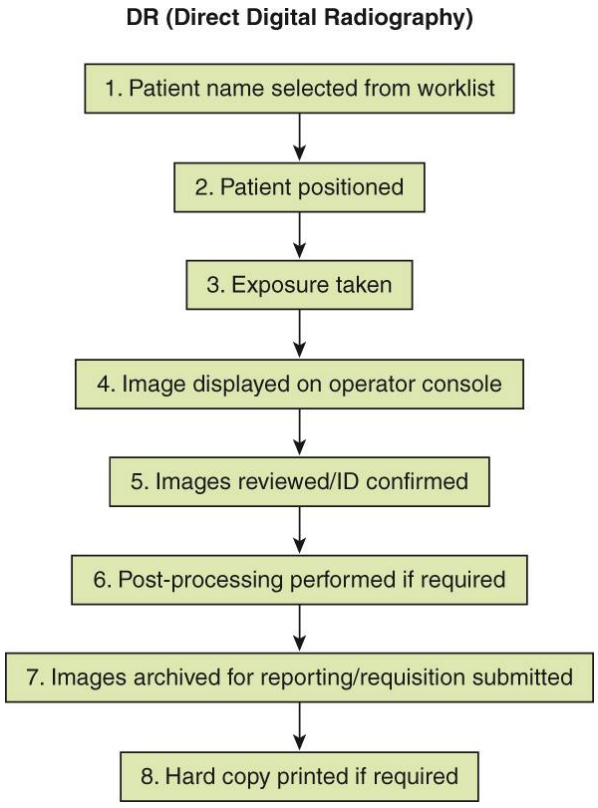
Steps of Image Production Comparison



Film-screen

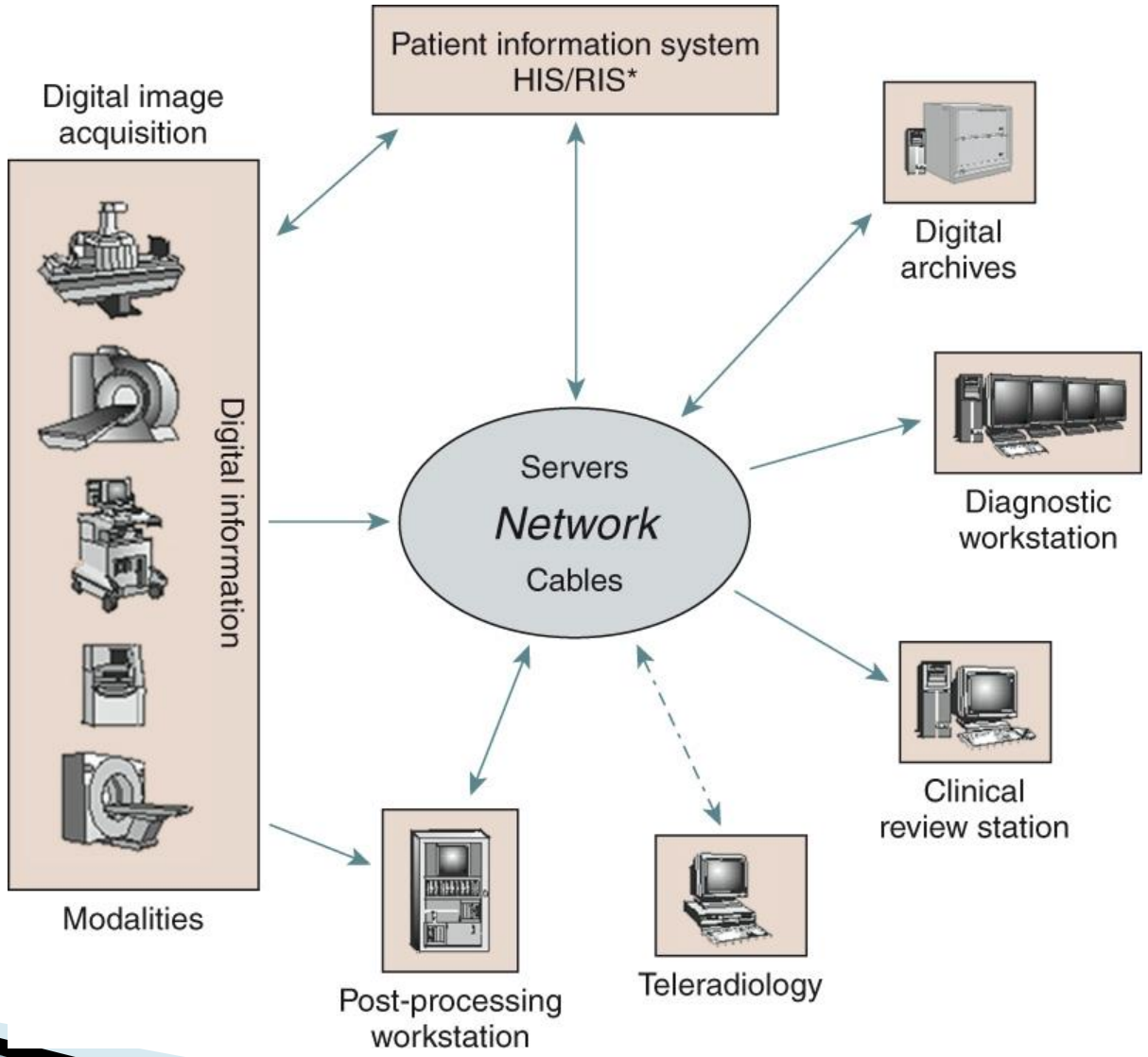


Computed radiography (CR)



Direct digital radiography (DR)

PACS Network



Provide Definitions for the Following Digital-Related Acronyms:

- PACS
- RIS
- HIS
- HL7
- DICOM
- IP
- IR
- SNR

Review

- What is the difference between “window level” and “window width”?
- What is the difference between “density” and “brightness”?
- Define the term “noise.”

Radiation Protection

- Patient
- Fellow workers
- Self

Units of Radiation

- Roentgen (R)

used for measurements in air

- Rad (radiation absorbed dose)

used for patient dose purposes

- Rem (radiation equivalent man)

used for worker protection purposes

Units of Radiation
(traditional and SI units)

Traditional	SI Units
• Roentgen	Coulombs/kg of air
• Rad	Gray (Gy)
• Rem	Sievert (Sv)

Dose-Limiting Recommendations

Replaced MPD (maximum permissible dose) in 1994

- Occupationally exposed workers

  Annual: 5 rem (50 mSv) per year (ED)

  Cumulative: 1 rem (10 mSv) times years of age

- General population

  – .1 rem (1 mSv) per year

Pregnant Technologists

- What is the dose limit for a pregnant technologist per month?
- What is it for the entire gestational period?

Personnel Monitoring

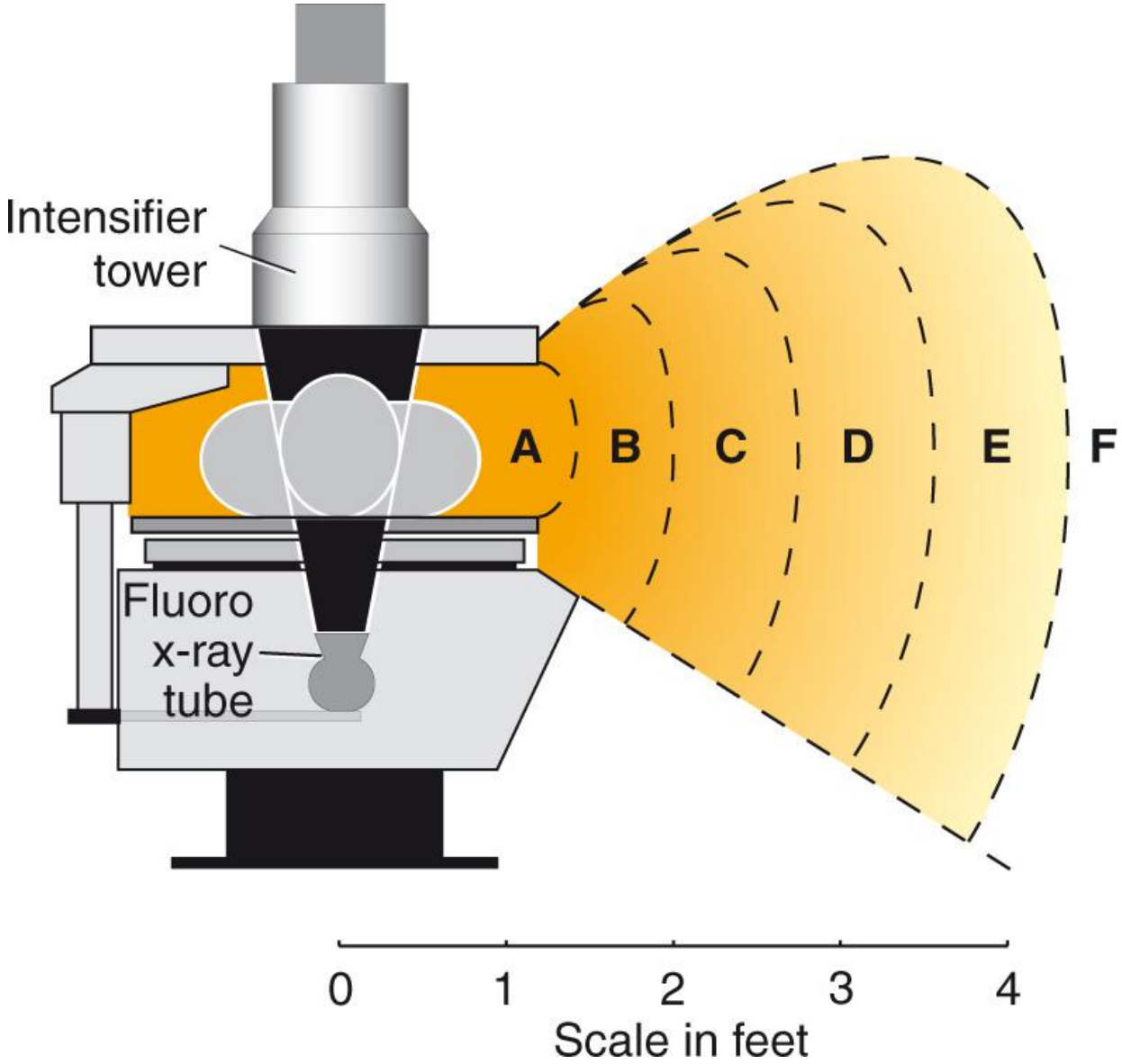
- Film badge
- TLD (thermoluminescent dosimeter)
- OSL (optically stimulated luminescence)
- *Worn at waist or chest level
  or
  on collar during fluoroscopy

* Consult RSO.

ALARA Principles

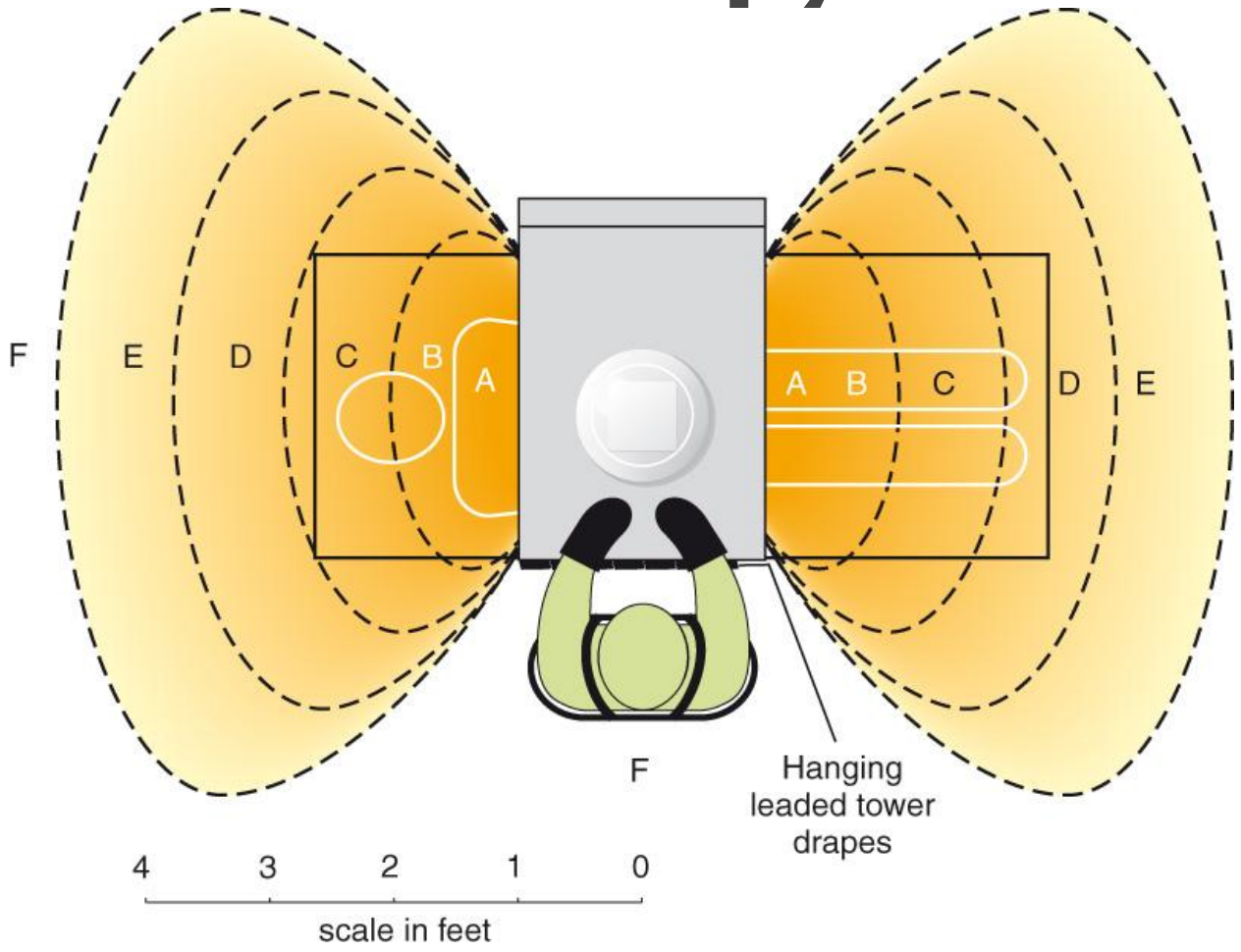
1. Always wear a personnel monitor.
2. Radiology personnel should not restrain patients.
3. Sound radiographic exposure factors
4. Cardinal rules of radiation protection:
   - Time
   - Distance
   - Shielding

Mobile fluoroscopy or C-arm



Fluoroscopy exposure patterns (without tower drape shields in place)

Worker Protection During Fluoroscopy



Fluoroscopy exposure patterns (with tower drape shields in place)

Fluoroscopy Safety Practices

- Bucky slot cover
- Lead drape
- .5 mm lead apron
- Exposure limit: 10 R/min

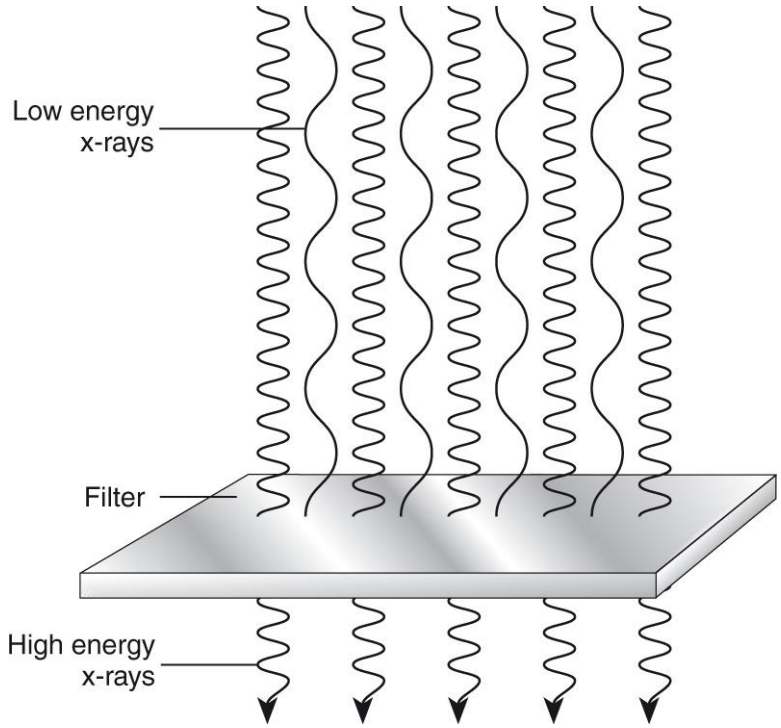
Thyroid shield with protective apron

Patient Protection

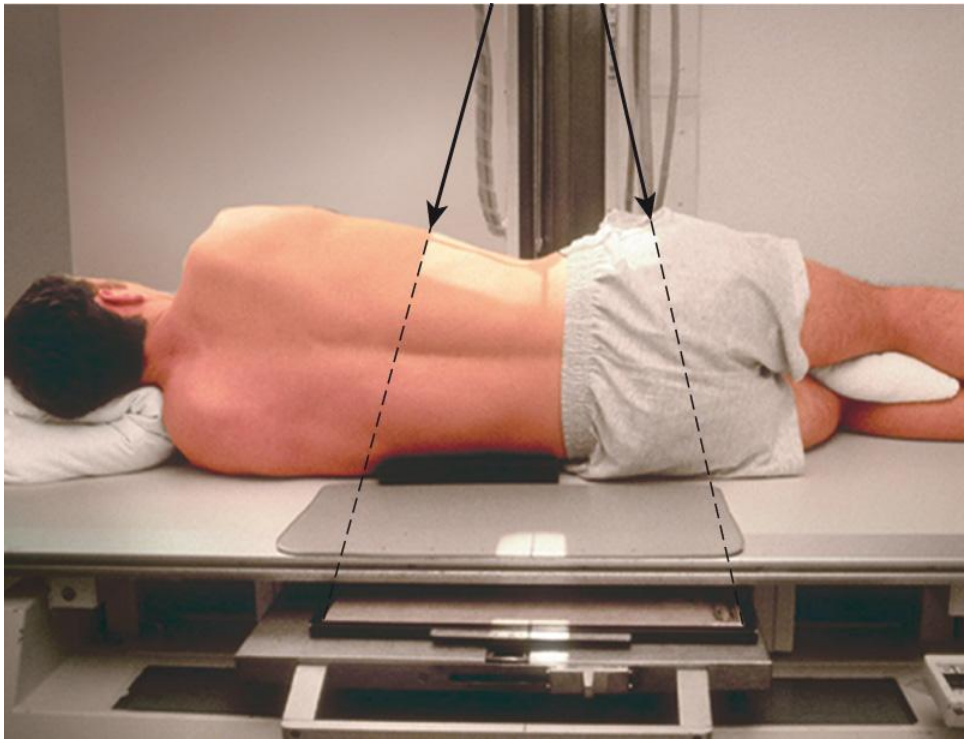
1. Minimum repeat radiographs
   - Clear instructions
   - Positioning and exposure factors

Radiation Protection Practices

1. Minimum repeat radiographs
2. Correct filtration
   - Inherent and added
   - 2.5 mm Al total

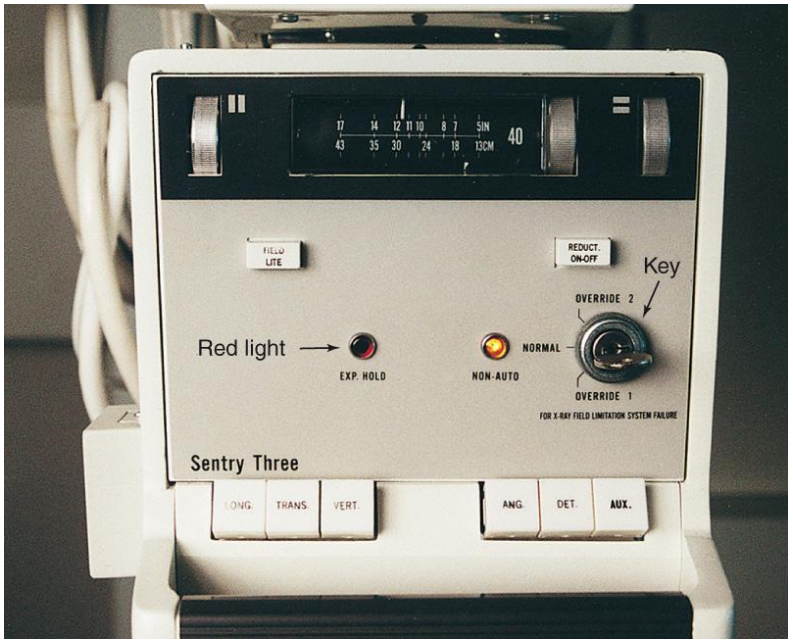


- Close four-sided collimation: One of the best ways of reducing patient exposure! (Remember divergence of x-ray beam.)



Radiation Protection Practices

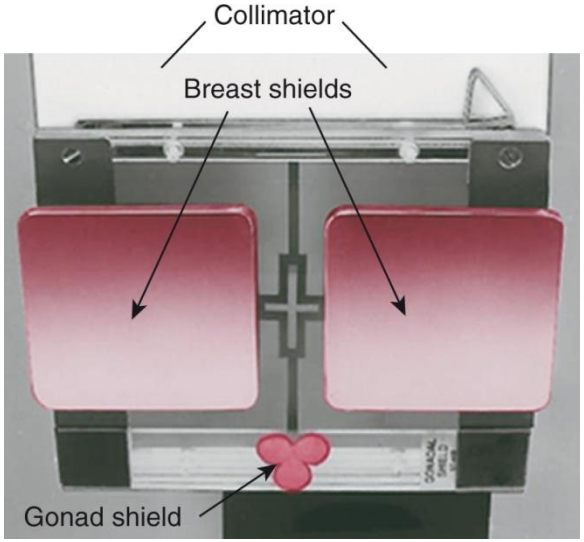
1. Minimum repeat radiographs
2. Correct filtration
3. Accurate collimation

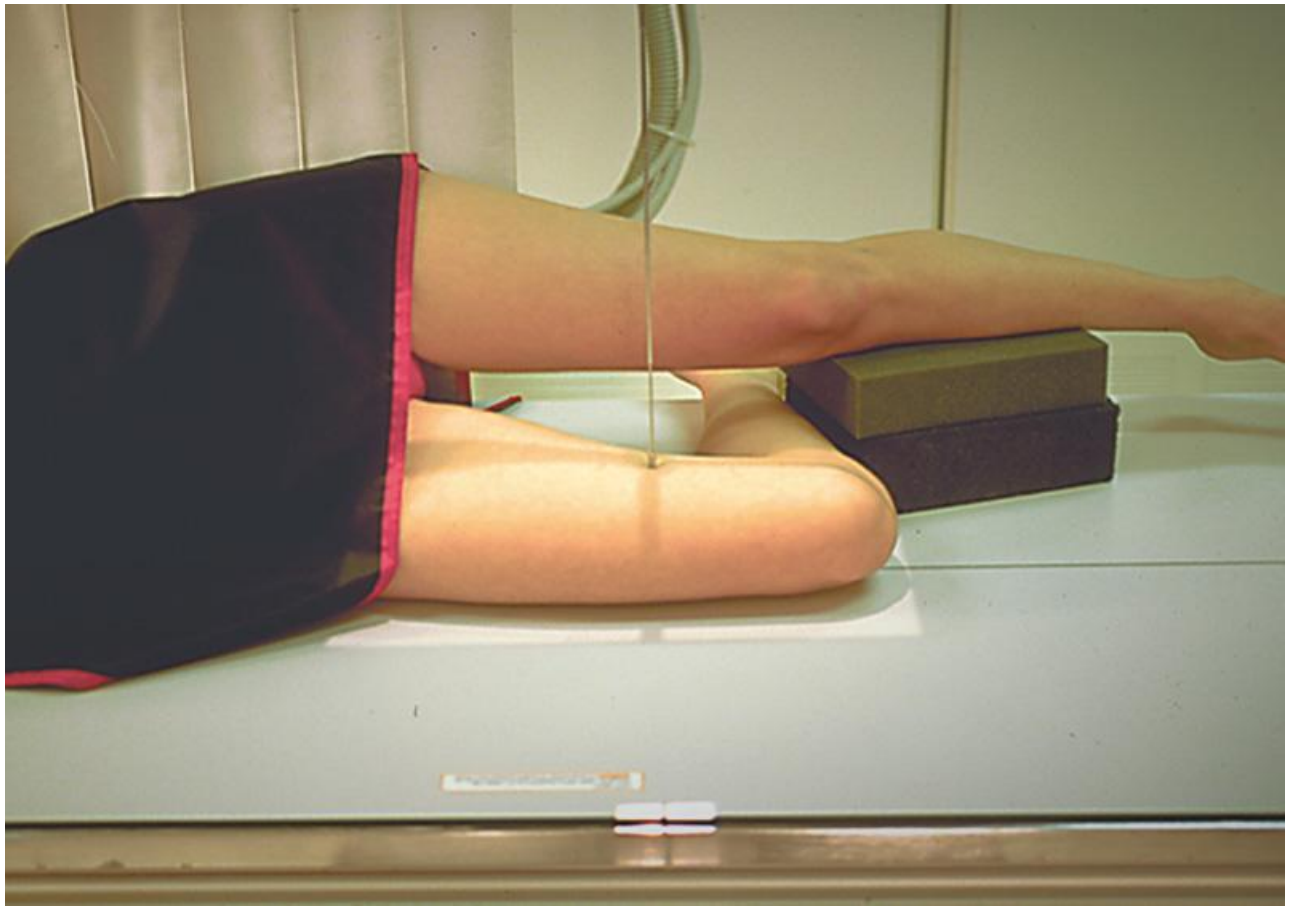


- Types of collimators
  - Manual type
  - Positive-beam limitation (PBL)

Radiation Protection

1. Minimum repeat radiographs
2. Correct filtration
3. Accurate collimation
4. Specific area shielding
   - Shadow shields
   - Contact shields

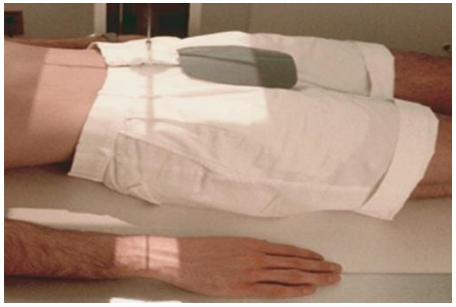




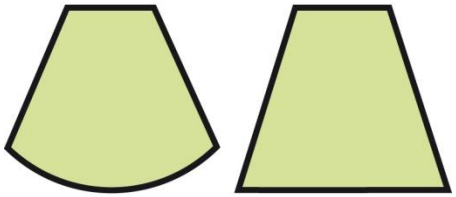
Vinyl-covered lead shield

Radiation Protection

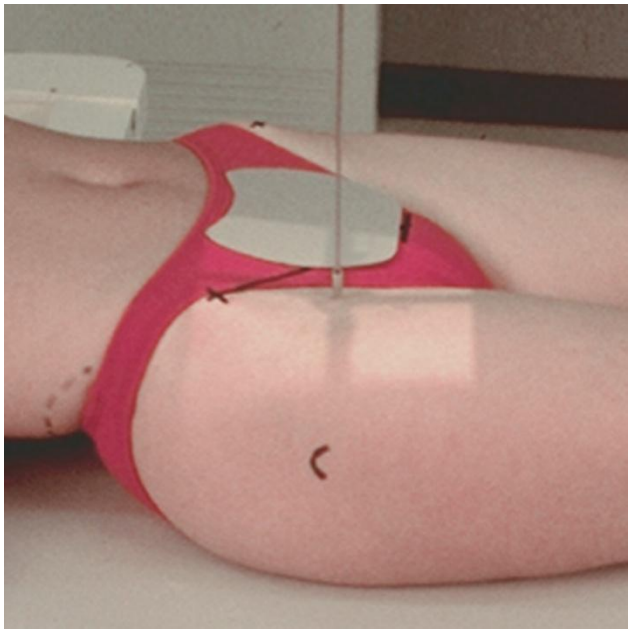
- Gonadal contact shields
  - 1 mm lead equivalent
  - Reduces dose 50% to 90%



–Male gonadal shield



Possible shapes

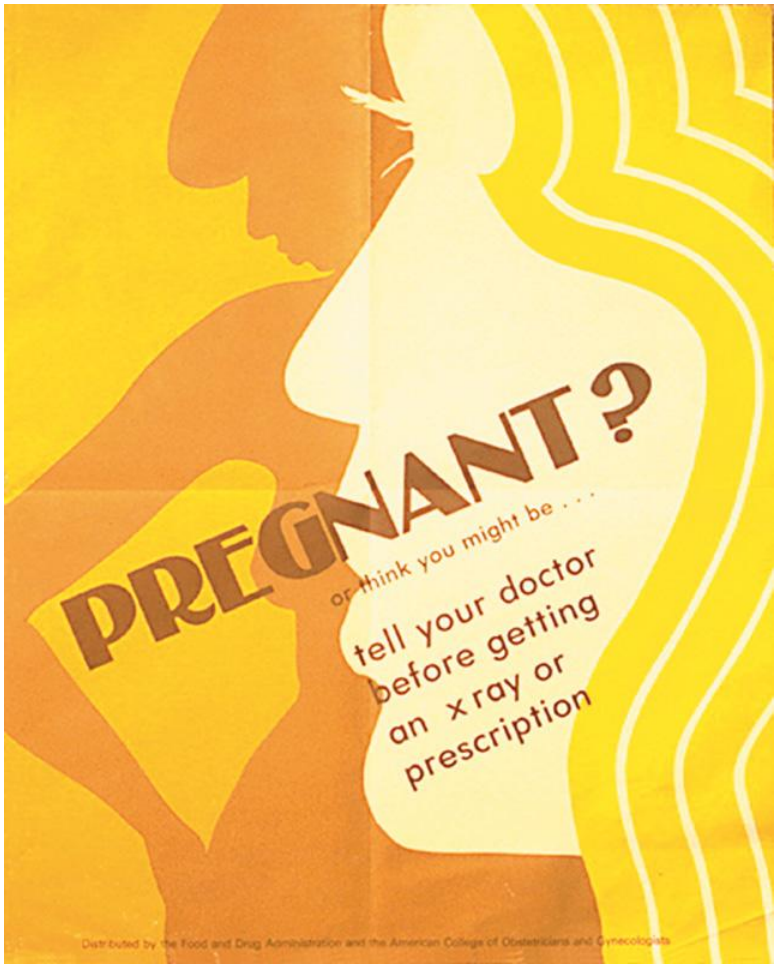


–Female ovarian shield

Possible shapes

Radiation Protection

1. Minimum repeat radiographs
2. Correct filtration
3. Accurate collimation
4. Specific area shielding
5. Protection for pregnancies



Quiz Me

The SI unit equivalent for Rad is

A. Coulombs/kg of air
B. Gray
C. Sievert
D. Curie

Quiz Me

What is the annual dose limit for a technologist per year?

A. 5 mSv
B. 15 mSv
C. 50 mSv
D. 500 mSv

Quiz Me

What minimum lead thickness or equivalency must a protective apron possess when worn for a fluoroscopy procedure?

A. .5 mm Pb/Eq
B. 1.0 mm Pb/Eq
C. 1.5 mm Pb/Eq
D. 2.5 mm Pb/Eq

Quiz Me

What is the most effective way to reduce patient dose?

A. Use of high kV
B. Increase in added filtration in x-ray tube
C. Use of gonadal shielding
D. Close four-sided collimation

Chapter 2
Image Quality, Digital Technology, and Radiation Protection

- The End -

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- The End -

Reference Page

- Bontrager, K. L., Lampignano, J. P. **Textbook of Positioning and Related Anatomy,** 7th Edition, Copyright 2010 : Mosby/Elsevier Inc., ISBN 978-0-323-05410-2