Chest X-ray Taking Procedures Training for X-ray Technicians/ Radiographer

"Image Quality"

Ms. KHIN YADANAR MOE

Consultant (TB CXR Training), IDDS Project/ Myanmar

Content

Image Quality in Screen-Film Radiography

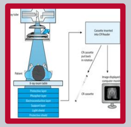


Image Quality in Digital Radiography

Technical Factors for Good Quality CXR Image

Troubleshooting

Image Quality in Screen-Film Radiography

Screen-Film Radiography

Image quality factors			
1. Density (image receptor exposure)	2. Contrast	3. Spatial Resolution	4. Distortion

Reference: John Ball ,Tony Price, Chesney's Radiographic Imaging , 5th Edition

1. Density (Image Receptor Exposure)

"Amount of blackening on the film"

Controlling factors are

i. mAs
ii. kVp
iii. Source Image Receptor Distance (SID)
iv. Grids
v. Anode heel effect
vi. Filtration

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Controlling factors (Density: Image Receptor Exposure)

i. mAs (primary controlling factor)

Controls

- The number of electrons passing from cathode to anode in the x-ray tube
- The quantity of x-rays produced at the anode
- The amount of radiation exiting the x-ray tube

** mAs controls density by controlling the quantity of x-rays emitted from the x-ray tube and the duration of the exposure.*

*** Doubling the mAs doubles the quantity or duration of x-rays emitted, thus doubling the density on the film.*

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Controlling factors (Density: Image Receptor Exposure) – Cont.

ii. kVp

Controls

The amount of energy or quality of the x-rays produced

kVp

Potential difference exists between the cathode and the anode

The electrons from the cathode strike the anode in greater numbers and with greater energy

Note: This results in an increased level of production of short-wavelength, high-energy radiation

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Adjusting Analog Image Density

**15% increase in kV will increase film density, similar to doubling the mAs*

Doubling the mAs

(2 x mAs)

When all other factors (kVp) is constant

2 x Density on radiograph

Governed by the 15% rule

(similar to doubling mAs)

e.g. 80 x .15 = 12 kv

60 x .15 = 9 kv

Increase 15% kVp = 2 x Receptor Exposure

Decrease 15% kVp = ½ x Receptor Exposure

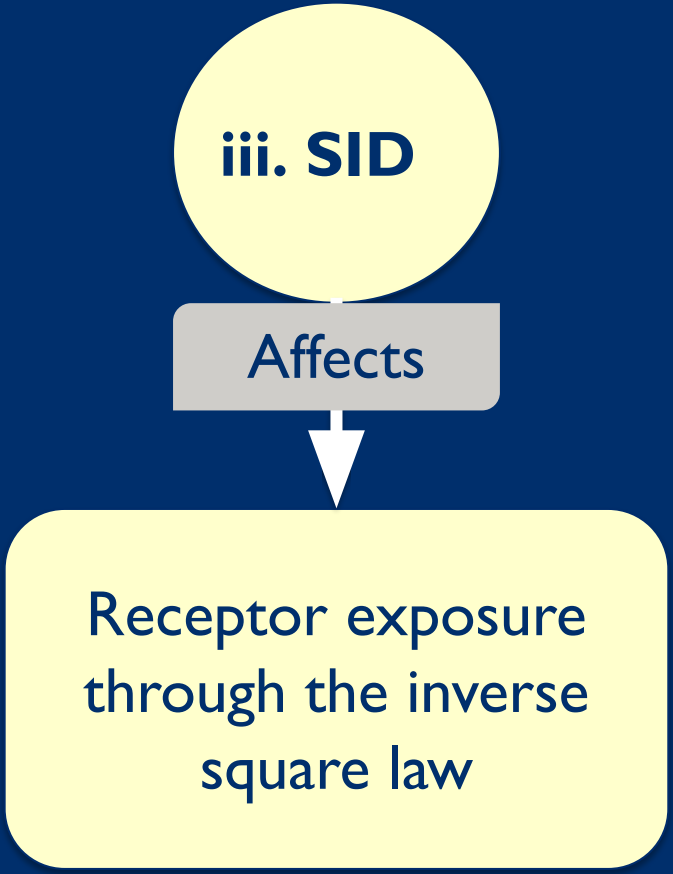
Controlling factors (Density: Image Receptor Exposure) – Cont.

2 mAs (60 kV)
underexposed

4 mAs (60 kV)
repeated, double mAs

Reference: John Ball ,Tony Price, Chesney's Radiographic Imaging , 5th Edition

Controlling factors (Density: Image Receptor Exposure) – Cont.



Inverse square law:

"Intensity of the x-ray beam is inversely proportional to the square of the distance between the source of x-rays and the image receptor."

Expressed as:

Old intensity/ New intensity = New SID2/ Old SID2

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Controlling factors (Density: Image Receptor Exposure) – Cont.

“2 x SID”

with exposure factor is constant.

=

“4 x receptor exposure (Density)”

Reference: John Ball , Tony Price, Chesney’s Radiographic Imaging , 5th Edition

Controlling factors (Density: Image Receptor Exposure) – Cont.

↓ = ↑

"1/2 x SID"

with exposure factor is constant.

"4 x receptor exposure (Density)"

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Controlling factors (Density: Image Receptor Exposure) – Cont.

Exposure maintenance formula:

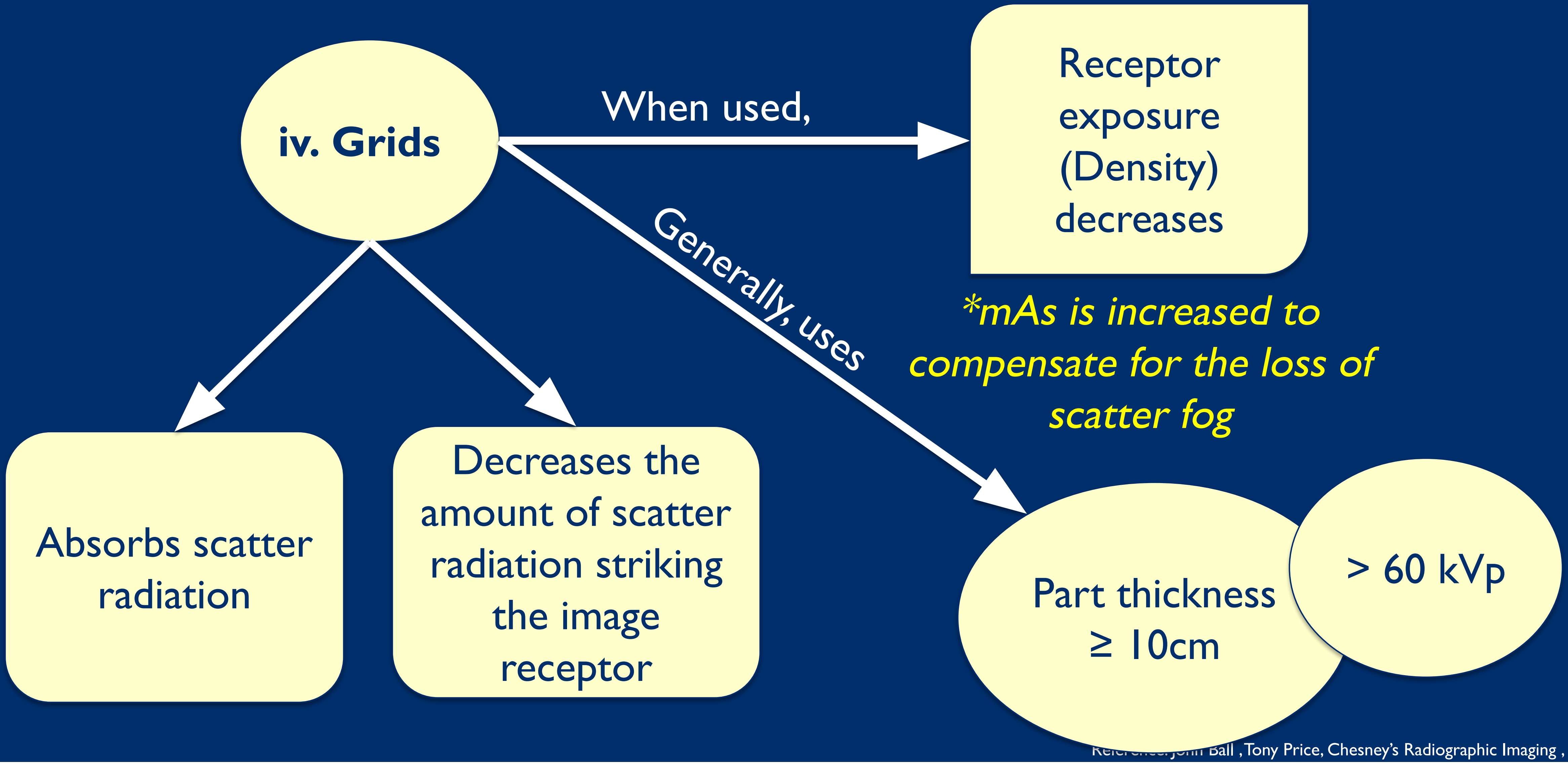
Old mAs/ New mAs = Old SID2/ New SID2

- ▲ 2 x SID = 4 x mAs ▲
- ▼1/2 SID = 4 x mAs ▼

(To maintain the same receptor exposure (Density) as that of an image taken at the old distance)

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Controlling factors (Density: Image Receptor Exposure) – Cont.



Ball ,Tony Price, Chesney’s Radiographic Imaging , 5th Edition

Grid Construction

1. Lead strips separated by aluminium interspaces
2. Grid ratio: It is the height of the lead strips divided by the distance between the lead strips

**grid ratio = H/D*

**Ratios range from 4:1 to 16:1*

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Types of Grids

Linear grids	Focused grids	Crossed grids
• Lead strips are parallel to one another • X-ray tube may be angled along the length of the grid without cut-off	• Lead strips are angled to coincide with divergence of x-ray beam • Used within specific ranges of SID • Focal range is wide for low-ratio grids • Focal range is narrow for high-ratio grids	• Consist of two linear grids placed perpendicular to each other • Superior scatter clean-up • Allow no angulation of x-ray beam • Require perfect positioning and centering

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Grid cut-off

- Decreased density along the periphery of the image caused by absorption of image- forming rays
- Used primarily with large SID or small field

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Grid Motion

1. Stationary grids
   - Do not move during the exposure
   - Grid lines may be seen
2. Moving grids
   - Reciprocate (move back and forth) during exposure
   - Eliminate the visibility of grid lines
   - Grid must begin moving just before the exposure and continue until just after the exposure to blur grid lines

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Grid Error

- Upside-down grid:

  Result is normal density in the middle of the radiograph with decreased density on the sides

- Off-level grid:

  Result is image-forming rays absorbed all across the radiographic field with cut-off (decreased density) visible over the entire radiograph

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Grid Error – Cont.

- Off-centered grid:

  Cut-off visible, more to one side of the radiograph

- Off-focused grid:

  Normal density in the middle of the radiograph with cut-off visible on the sides

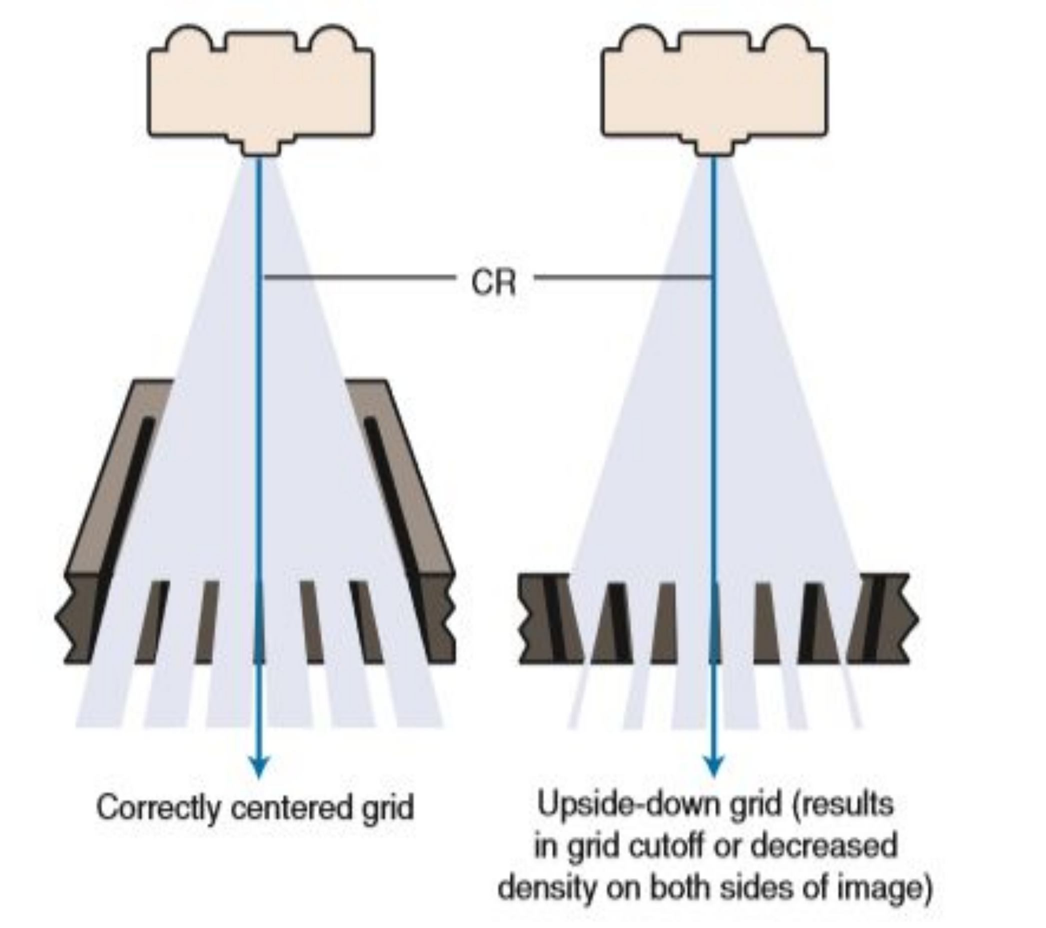
Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Radiographic quality and grids

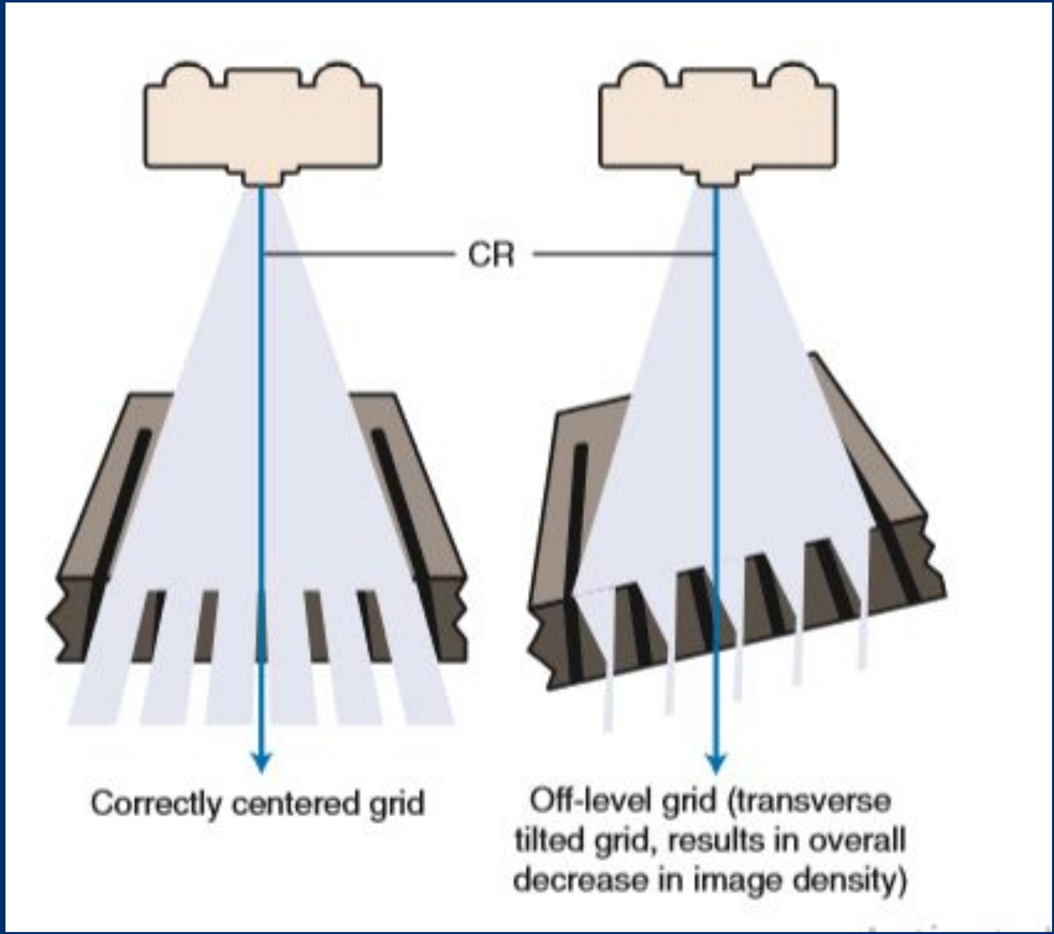
- Produce higher contrast by absorbing Compton scatter rays which produce fog if they strike the image receptor

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Controlling factors (Density: Image Receptor Exposure) – Cont.



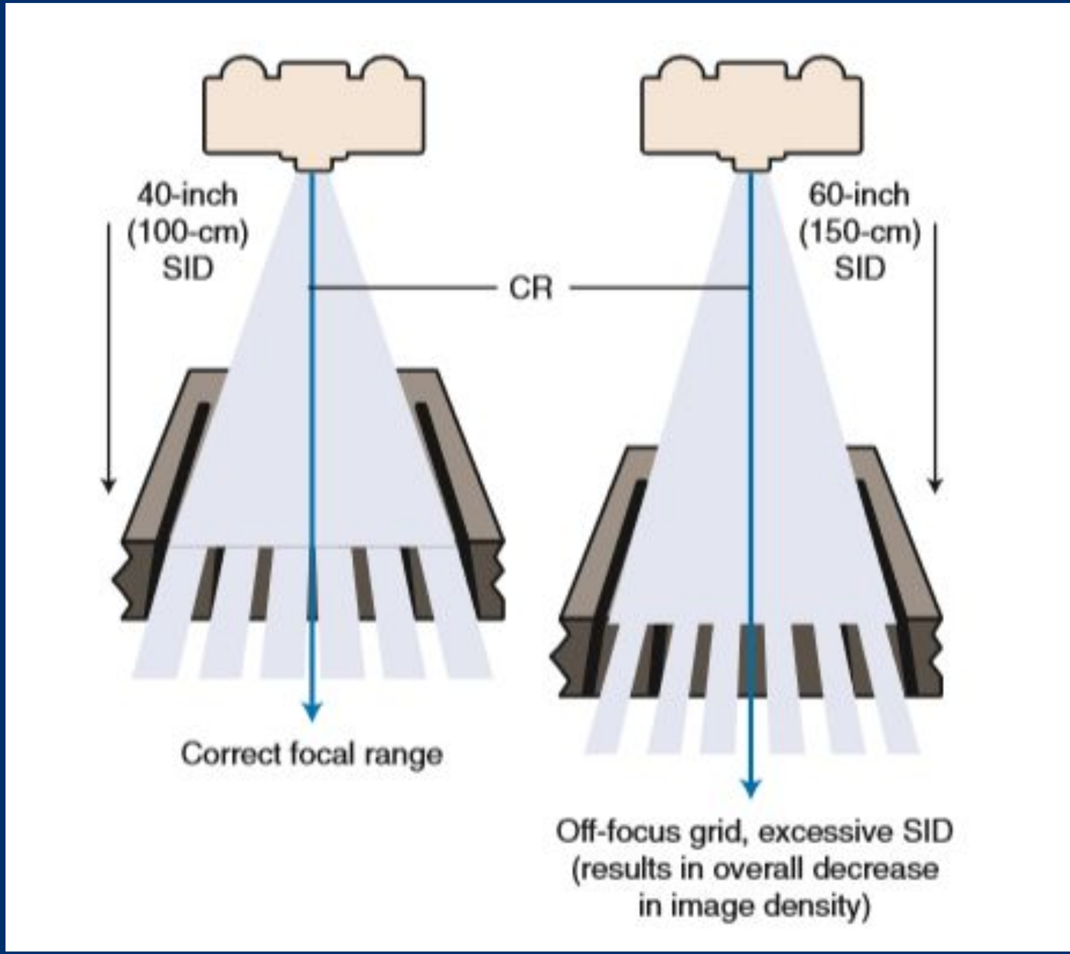
Upside-down Grid



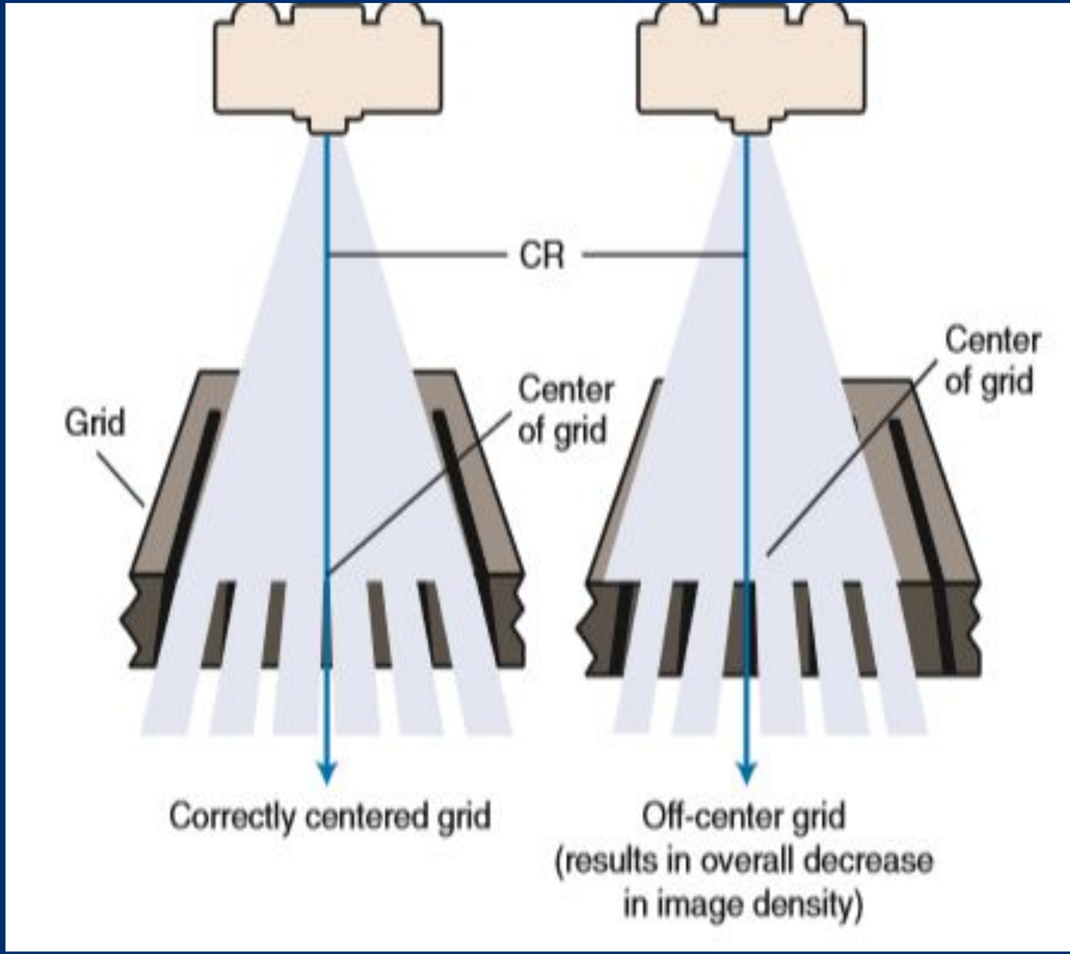
Off-level Grid

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Controlling factors (Density: Image Receptor Exposure) – Cont.



Off-focus Grid



Off-centered Grid

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Controlling factors (Density: Image Receptor Exposure) – Cont.

v. Anode heel effect

- Receptor exposure (Density) > nearer cathode end
- Receptor exposure (Density) < nearer anode end

(x-rays are absorbed by heel of anode)

X-ray intensity varies along the longitudinal axis of the x-ray beam

Can be compensated by

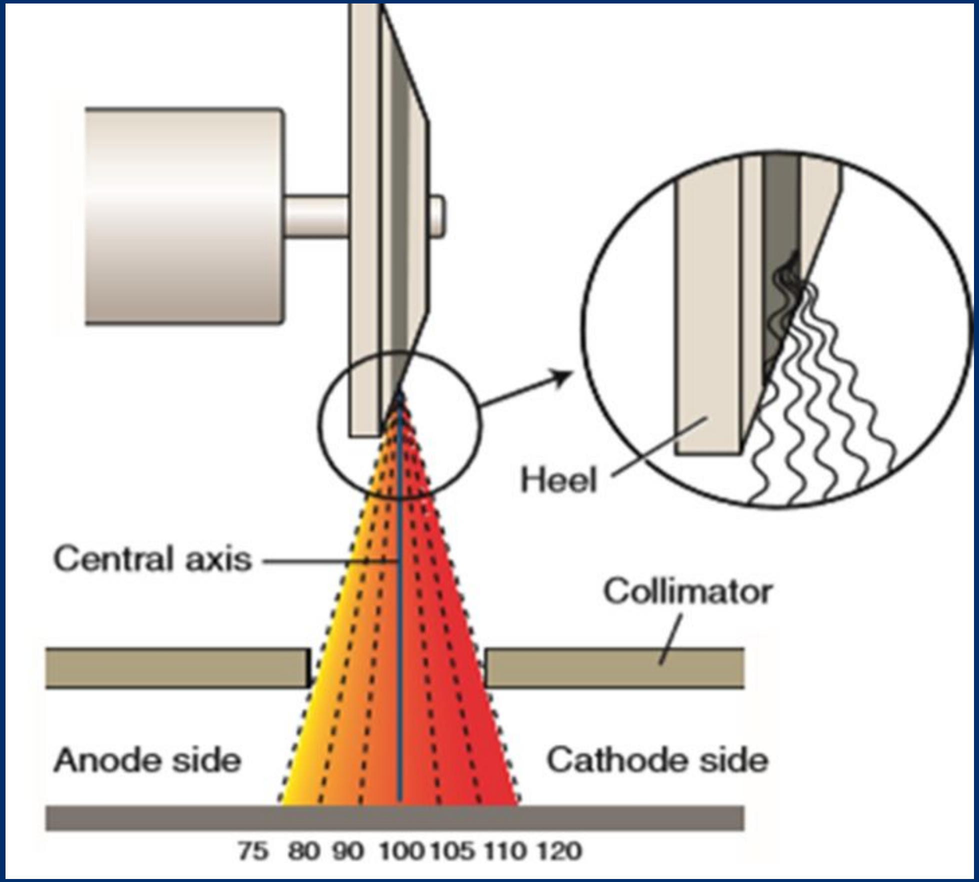
Thicker anatomy should be placed under the cathode side of the x-ray tube

Reference: John Ball ,Tony Price, Chesney's Radiographic Imaging , 5th Edition

Controlling factors (Density: Image Receptor Exposure) – Cont.

Anode heel effect

- Image Quality Increases with
  - Small focal spot
  - Shorter SID
  - Larger IR size



Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Controlling factors (Density: Image Receptor Exposure) – Cont.

vi. Filtration → Can be compensated by using →

- *Wedge filter*
- *Trough filter*
- *Boomerang filter*

Body parts of varying anatomic density → May result in → Image with partially overexposed or underexposed

because the anatomic parts attenuate the beam differently

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Controlling factors (Density: Image Receptor Exposure) – Cont.

- *Wedge filter* - mounts on the collimator

- *Trough filter* - mounts on the collimator and is used for chest imaging

**The thicker peripheral portions of the filter are placed to correspond to the anatomically less dense lungs.*

**The thinner portion of the filter corresponds to the mediastinum.*

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Controlling factors (Density: Image Receptor Exposure) – Cont.

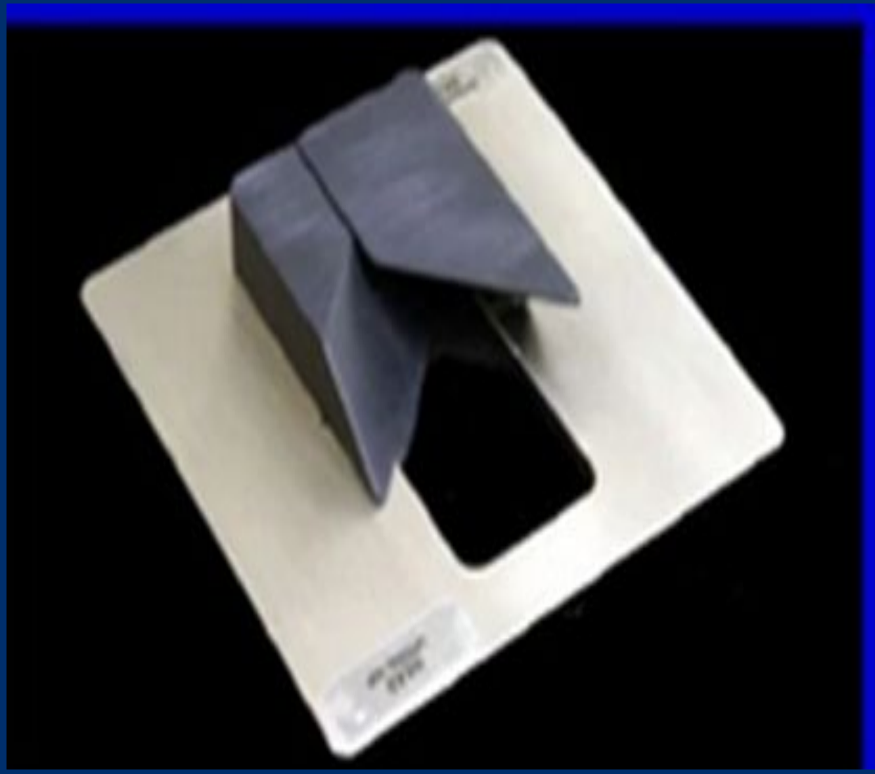
- *Boomerang filter*

  Placed behind the patient and used primarily for shoulder and upper thoracic spine radiography

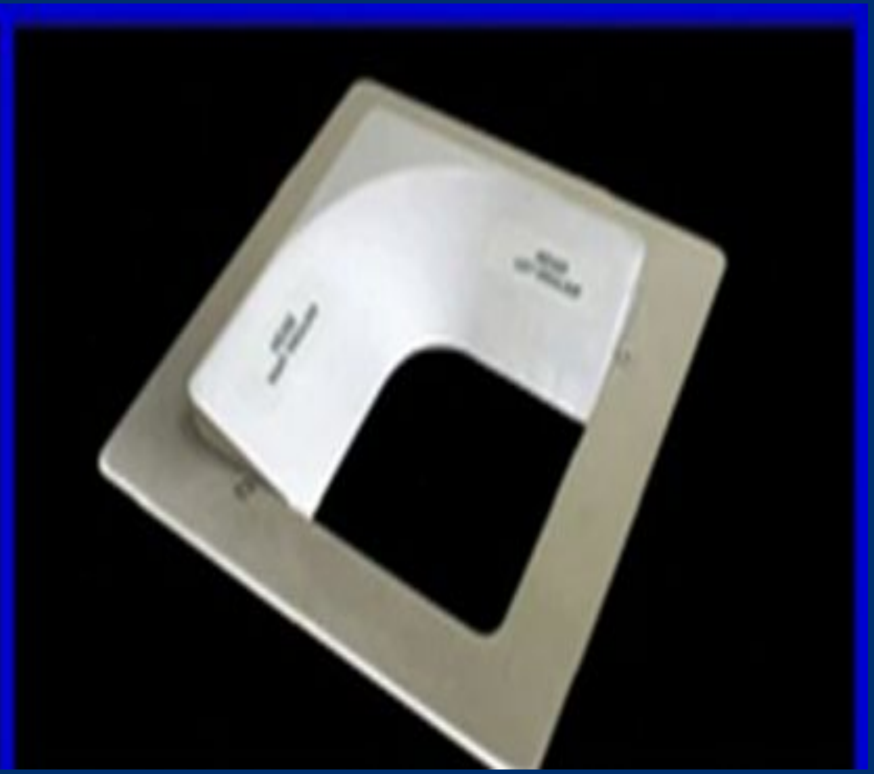
  Reduces the radiation dose

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Controlling factors (Density: Image Receptor Exposure) – Cont.



Wedge filter



Boomerang filter

John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

2. Contrast

The visible difference

between

Two selected areas of brightness

(in the displayed radiographic image)

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

2. Contrast – Cont.

Long-scale contrast

- Indicates small differences between grey shades
- Large number of grey shades present

Short-scale contrast

- Indicates much differences between grey shades
- Few grey tones present, more black- and white image

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

2. Contrast – Cont.

- ***High contrast:***
  - *Few grey tones, mainly black-and-white image*
  - *May also be referred to as short-scale contrast*
  - *Produced at lower kVp*

- ***Low contrast:***
  - *Many grey tones on image*
  - *May also be referred to as long-scale contrast*
  - *Produced at higher kVp*

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

2. Contrast – Cont.

- **Subject contrast**
  - Refers to the differences in the remnant beam secondary to the differential absorption of the x-ray beam by the structures in the body
  - Subject contrast is controlled by kVp
  - The higher the kV, the greater is the energy, and the more uniformly the x-ray beam penetrates the various mass densities of all tissues

**Higher kV produces less variation in attenuation (differential absorption), resulting in lower contrast.*

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

2. Contrast – Cont.

- Higher kV, resulting in both more numerous x-rays and greater energy x-rays, causes more x-ray energy to reach the IR, with a corresponding increase in overall density

**kV is also a secondary controlling factor of density.*

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

2. Contrast – Cont.

- Governed by the **15% rule** (similar to doubling mAs)

**(An increase in kVp of 15% doubles receptor exposure,*

a decrease in kVp of 15% halves receptor exposure)

e.g80 x .15 = 12 kv

60 x .15 = 9 kv

**15% increase in kV will increase film density, similar to doubling the mAs*

Reference: John Ball ,Tony Price, Chesney's Radiographic Imaging , 5th Edition

2. Contrast – Cont.

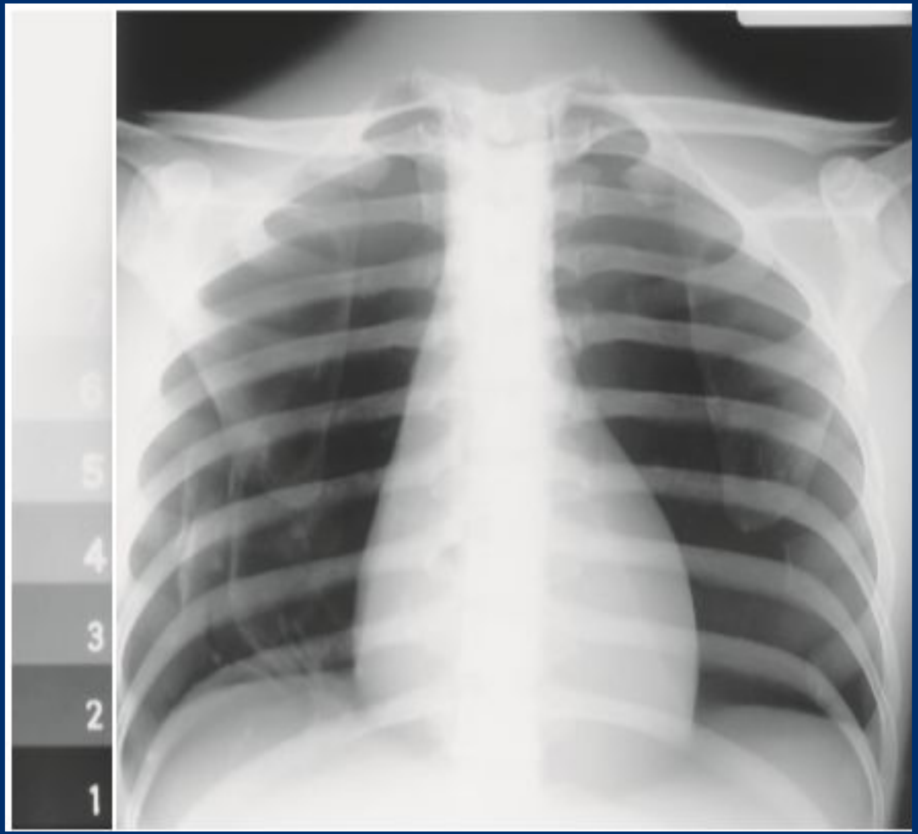
- In the lower kV range
  - 50 to 70 kV, an 8- to 10-kV increase would double the density (equivalent to doubling the mAs)

- In the 80- to 100-kV range
  - 2- to 15-kV increase is required to double the density

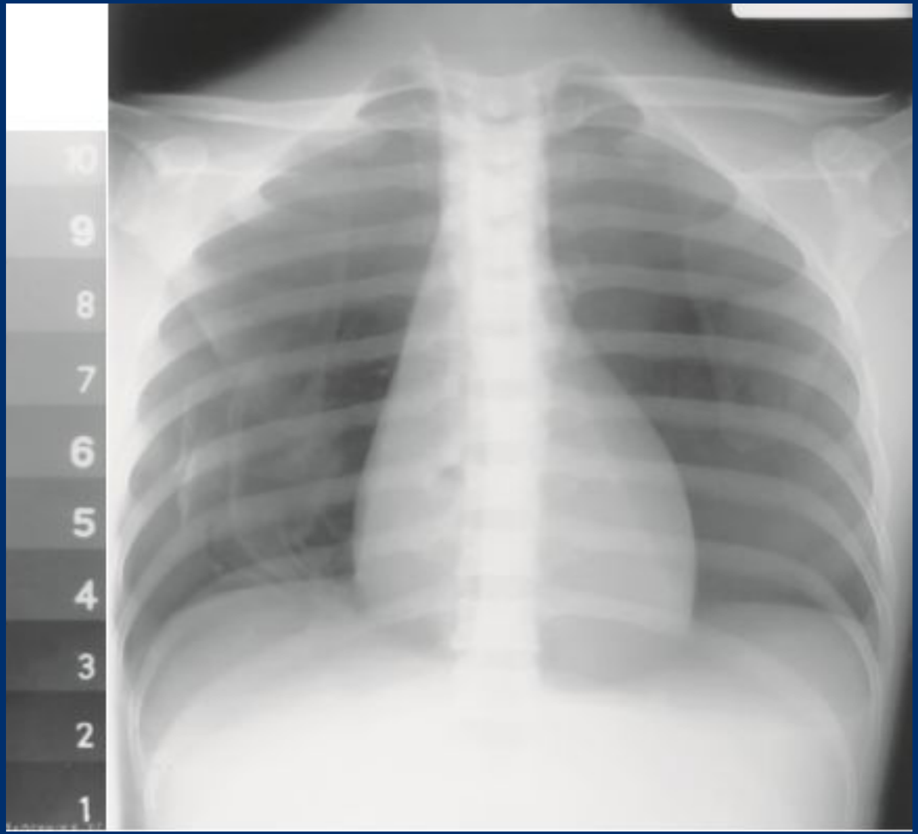
The importance of this relates to radiation protection because as kV is increased, mAs can be significantly reduced, resulting in absorption of less radiation by the patient.

Reference: John Ball, Tony Price, Chesney's Radiographic Imaging, 5th Edition

2. Contrast – Cont.



High-contrast, short-scale 50 kV, 800 mAs



Low-contrast, long-scale 110 kV, 10 mAs

Reference: John Ball ,Tony Price, Chesney's Radiographic Imaging , 5th Edition

2. Contrast – Cont.

- Collimation
  - Reduces the amount of tissue irradiated
  - Reduces the amount of scatter produced and increasing contrast
  - Reduces the radiation dose to the patient and the technologist
- Grids
  - Reduce the amount of scatter reaching the image receptor
  - Less scatter fog results in fewer grey tones which increases contrast

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

2. Contrast – Cont.

- Filtration
  - As filtration is increased, beam becomes harder (average photon striking the patient has shorter wavelength)
  - Contrast decreases as filtration increases

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

3. Spatial resolution

- Sharpness of the structural edges in the image
- Smallest detail that can be detected
- May also be referred to as detail sharpness, definition and image resolution

- Controlled by

Geometric factors	Film screen system	Motion

Reference: John Ball ,Tony Price, Chesney's Radiographic Imaging , 5th Edition

Controlling factors (Spatial resolution)

i. **Geometric Factors** consist of

Focal Spot	*Source-to-image receptor distance (SID)*	*Object-to-image receptor distance (OID)*
• The use of the small focal spot results in less geometric unsharpness	• Distance from the source of radiation to the image receptor • Longest SID should be used • Shorter SID causes magnification of the image, resulting in loss of sharpness	• Distance from the anatomic part being imaged to the image receptor • Shortest possible OID should be used • Increased OID causes magnification of the image, resulting in loss of recorded detail

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Controlling factors (Spatial resolution) – Cont.

iii. Motion

Any motion results in image blur and subsequent loss of recorded detail

---

Motion may be caused by the following:

- Patient motion (voluntary and involuntary)
- X-ray tube motion
- Excessive motion from reciprocating grid

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Controlling factors (Spatial resolution) – Cont.

Voluntary motion (breathing and body motion)
blurring of entire chest and overall unsharpness

Involuntary motion (from peristaltic action)
localized blurring in upper left abdomen

Reference: The Textbook of Radiographic Positioning & Related Anatomy, 8th Edition (ISBN 978-0-323-08388-1). Authors Kenneth L. Bontrager and John P. Lampignano.

Controlling factors (Spatial resolution) – Cont.

iii. Motion

Voluntary motion

- Minimized by controlled breathing and patient immobilization. Support blocks, sandbags, or other immobilization devices

Involuntary motion

- Minimized by decreasing in exposure time with an associated increasing in mA

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

4. Distortion

- Any geometric misrepresentation of an anatomic structure on an image receptor

- Two types of distortion:
  - Size
  - Shape

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Controlling factors (Distortion)

Size

Magnification

- Less magnification occurs at a greater SID than at a shorter SID

- This is the reason that chest radiographs are obtained at a minimum SID of 72 inches

**72-inch (183-cm) SID results in less magnification of the heart and other structures within the thorax.*

Caused by excessive OID

**The closer the object being radiographed is to the IR, the less are the magnification and shape distortion and the better is the resolution.*

Caused by insufficient SID

Causes anatomic structure to appear larger on the image than in reality

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Controlling factors (Distortion) – Cont.

Shape

Elongation

- Causes anatomic structure to appear longer than in reality
- Caused by

(a) Improper tube, part or image receptor angulation or alignment

(b) Angulation along the long axis of the part

Foreshortening

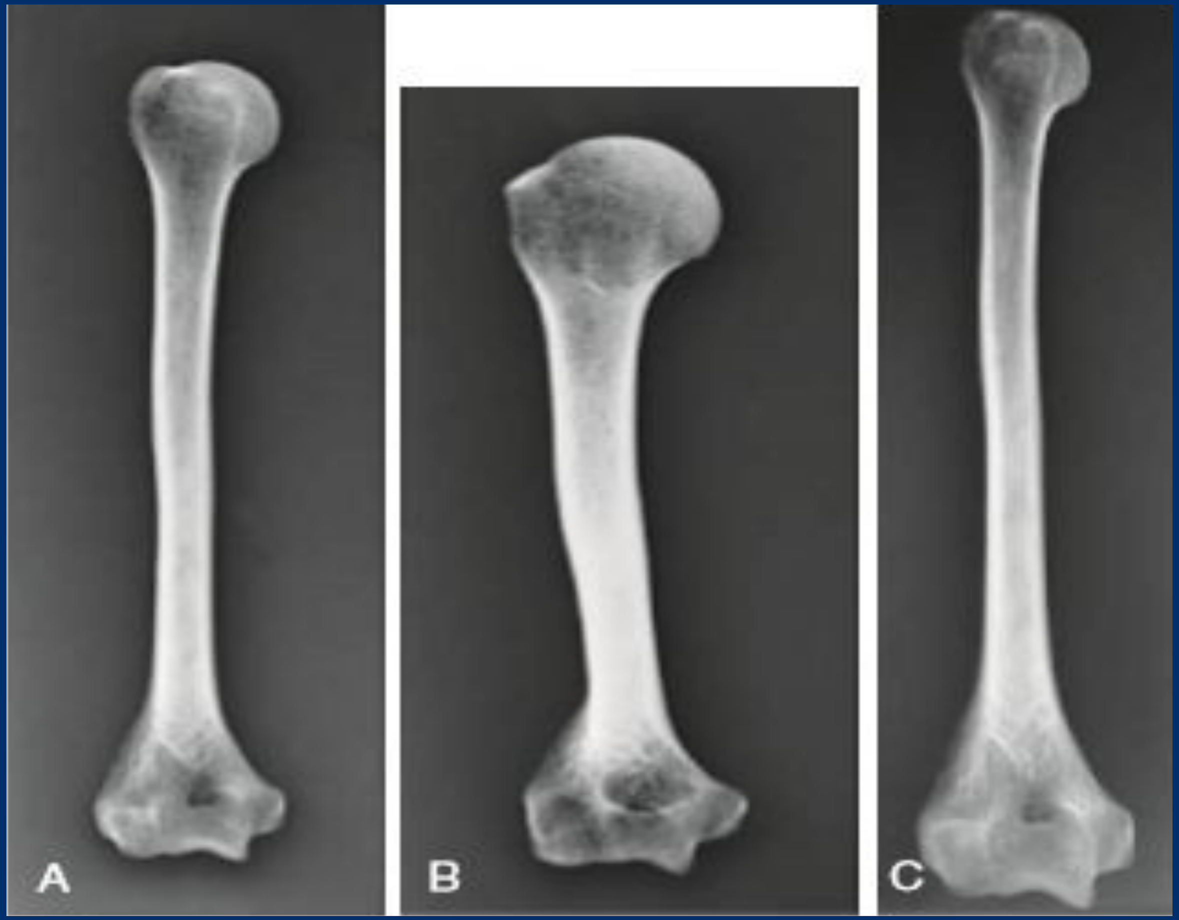
- Causes anatomic structure to appear shorter than in reality
- Caused

(a) Improper tube, part or image receptor angulation

(b) Angulation against the main axis of the part

Reference: John Ball , Tony Price, Chesney's Radiographic Imaging , 5th Edition

Controlling factors (Distortion) – Cont.



A, No distortion. B, Foreshortened. C, Elongated

Reference: John Ball ,Tony Price, Chesney's Radiographic Imaging , 5th Edition

Image Quality in Digital Radiography

Exposure Factors for Digital Imaging

Adequate kV

(to penetrate the anatomy of interest)

As kV increases,

beam penetrability increases

Higher kV can be reduced patient dose

Changes in kV can have less of a direct effect on final digital image contrast

because the resultant contrast is also a function of the digital processing

when compared to film-screen imaging

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition,

Digital Image Quality Factors

i. Brightness
ii. Contrast resolution
iii. Spatial resolution
iv. Distortion

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition,

Digital Image Quality Factors – Cont.

i. Brightness

- Is defined as the intensity of light that represents the individual pixels in the image on the monitor

**In digital imaging, the term brightness replaces the film-based term density*

- Brightness is controlled by the processing software
- Changes in mAs do not have a controlling effect on digital image brightness
- The user can adjust the brightness of the digital image after exposure

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition,

Digital Image Quality Factors – Cont.

ii. **Contrast resolution**
   - Difference in brightness between light and dark areas of an image
   - To distinguish the smallest change in exposure or signal
   - To provide visibility of small objects having similar shades of grey

- Controlling Factors:
  - Bit depth and the number of bits per pixel (the larger the bit depth, the greater the number of levels of grey possible in an image)

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition,

Digital Image Quality Factors – Cont.

iii. Spatial resolution

- Sharpness of the structural edges in the image
- Smallest detail that can be detected
- May also be referred to as detail sharpness, definition and image resolution

**general radiography have spatial resolution capabilities ranging from approximately 2.5 lp/mm to 5.0 lp/mm.*

- Controlled by- *pixel size*, *pixel pitch* and *display matrix*

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition,

Digital Image Quality Factors – Cont.

- *Pixel size* - smaller pixels provide greater spatial resolution
- *Display matrix* - monitors with a larger display matrix can display images with higher resolution.

- Influenced by SID, OID, focal-spot size and motion (same as film-screen imaging)

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition,

Digital Image Quality Factors – Cont.

iv. Distortion

- Controlled by:
  - SID and OID (same as film-screen imaging)

Reference: X-ray technician/radiographer TB Chest X-ray Training Curriculum by Prof, U Khin Hla

Technical Factors for Good Quality CXR Image

Technical factors for Good Quality CXR Images

No	Technical factors	Remarks
1	The voltage	Units of measurement, kV= kilo Voltage
2	The higher the difference in kV, the higher the speed of electron transmission (more X-ray penetration)	This causes changes in the contrast of the image
3	100-120 kV is recommended	
4	The current	Units of measurement, mA = milli Ampere

Reference: X-ray technician/radiographer TB Chest X-ray Training Curriculum by Prof, U Khin Hla

Technical factors for Good Quality CXR Images – Cont.

No	Technical factors	Remarks
5	The number of electrons depends on the amount of current applied to the filament	This can change the darkness of the image
6	More than 100mA is recommended	
7	Time	Units of measurement, s = second
8	The shorter the time, the less movement of a person and therefore a clearer image	

Reference: X-ray technician/radiographer TB Chest X-ray Training Curriculum by Prof, U Khin Hla

Technical factors for Good Quality CXR Images – Cont.

No	Technical factors	Remarks
9	Less than 0.05 seconds is recommended	
10	Distance between x-ray film and tube focus (source to image receptor distance=SID) and X-ray beam alignment	
11	Longer distance improves the image sharpness through geometric means. X-ray beam must be aligned straight with the X-ray film	
12	140-200 cm is recommended for SID	

Reference: X-ray technician/radiographer TB Chest X-ray Training Curriculum by Prof, U Khin Hla

Troubleshooting

Troubleshooting for X-ray image quality

No	Too bright image (Causes)	Too dark image (Causes)
1	Low current (Low mA)	Too much mA
2	High kV	Too long exposure time
3	Too short developing time	Long developing time
4	Low strength of developer solution	Increased strength of developer solution
5	Developer and Fixer solutions temperature lower than 68° F	Blurring of image
6		Patient cannot hold their breath properly
7		Less than cooperative patient such as children and the elderly etc.

Reference: X-ray technician/radiographer TB Chest X-ray Training Curriculum by Prof, U Khin Hla

THANK YOU !