APPH 226:
Density

Objectives: 3.1-3.4, 4.3, 5.2, 5.4

MRT Program

Latent Image

- Occurs immediately after exposure, but before processing
- Invisible
- This happens to all images, regardless of how it is acquired
  - DR – digital radiography
  - CR – computed radiography
  - Film

Image Formation

- How do we get it?
  - Result of differential absorption of the x-ray beam
- Differential absorption is:
  - Process where some of the beam is absorbed and some is transmitted
  - It's called differential because the beam is not absorbed to the same degree over the entire area exposed

Differential Absorption

- Creates an image that represents the structures of anatomy
  - Results from the variation between absorption and transmission
- When an image is created this way, several processes are required

Beam Attenuation

- When the primary x-ray beam passes through tissue and loses some of its energy
  - This reduction is known as attenuation
- Attenuation consists of
  - Absorption
  - Scattering

Absorption

- Complete absorption of x-ray photon
- Inner shell electron ejected
  - Photoelectron
- Outer shell electron drops to fill the spot
- Characteristic radiation emitted
  - Low energy – usually remains in the body
- Atom is ionized

Scattering

- Incoming x-ray photon is not absorbed
- Ejects outer shell electron
  - Compton electron, secondary electron
- X-ray photon loses energy, changes direction
  - Can go onto interact with IR (image receptor)
  - Can leave body

Scattered Photons

- Why is this an issue?
- If they reach the IR:
  - Degrade image
  - Contribute nothing useful to the image
  - Also known as image fog

kVp and Image Fog

- When kVp is increased, there are:
  - Fewer interactions in total
  - Increased amount of x-rays transmitted
  - Increased Compton scattering
- Scatter radiation creates unwanted exposure on the image called fog
  - Does not offer any useful information

Scatter and Image Fog

- Therefore when kVp is increased, the amount of fog is increased
  - How is density affected?
    - Increased fog will increase overall image density
  - How is contrast affected?
    - Increased fog leads to a decrease in contrast

Scattered Photons

- If they are absorbed:
  - Contribute to the patient's radiation exposure and increases their dose
- If they leave the body and don't reach the IR:
  - Contribute to the dose of anyone near the patient

Transmission

- Defined as: the x-ray photon passes through to the image receptor

- Amounts of absorption and transmission are varied
  - Differential absorption

On the Image…

- White
  - Areas of Absorption
  - Photoelectric Interactions
- Black
  - Transmission
  - High radiographic density
- Grey
  - Mix of both absorption and transmission

Exponential Absorption

- As x-rays pass through tissue, there is no fixed range to describe how far they go
- Attenuated photons
- For every increment of thickness, the x-rays are decreased in number, by a certain percentage
- Never reaches zero

Factors

- In order to select an optimal radiographic technique, three groups of factors must be considered:
  - Image Quality factors
  - Exposure Technique factors
  - Patient factors

Distance and Density

- SID
  - Source to Image Distance
  - Intensity changes with distance
    - Inverse Square Law

SID

- As the distance between the focal spot and the image receptor changes – the intensity of the radiation will change also
  - You'll notice as the distance is increased, the light covers a larger area

SID

- What happens to the number of photons as the area is increased?
  - The same number of photons
  - Larger area means:
    - Same number of photons covering a larger area, so less density

SID

- What happens to the image?
  - Because it is receiving less radiation, there will be less radiographic density
- What if we have a very short SID?
  - The reverse is true
  - More photons in a smaller area – increased intensity
  - More radiographic density

OID

- Object to Image Distance
- Increased OID allows less scatter to reach the IR
- Increased OID, results in decreased radiographic density

Patient Factors

- Most difficult
- Large influence on radiographic technique
- Requires experience and training on the part of the technologist

Body Habitus

- Used to classify patients when discussing patient factors
- Descriptors:
  - Aesthenic – very slender
  - Hyposthenic – between aesthenic and sthenic
  - Sthenic - average
  - Hypersthenic – larger body build

Thickness

- Calipers
- With increased thickness, how should exposure factors be adjusted?
- Must increase factors
  - Can change mAs or kVp
  - In most situations, would choose to adjust mAs

Composition

- What does the area consist of?
  - Bone?
  - Fluid?
  - Fat?
  - Muscle?
- Additional judgment required
  - Tissue thickness not linear due to many variables
  - Atomic number and density of part
- Chest vs. abdomen

General Rule of Technical Factors

- Chest
  - High kVp
- Soft tissue
  - Low kVp, high mAs
- Bony extremities
  - Low kVp

Pathology

- Another patient factor to be considered
- Radiographic technique needs to be adjusted in cases with known pathology
- We will see cases with pathologies in clinical practice

Filtration

- Three types:
  - Inherent
  - Added
  - Compensating

Inherent Filtration

- Glass or metal envelope
- Collimator usually provides some additional filtration
- Technologist has no control of this
- Built into the unit
- Designated amount by SC 35

Added Filtration

- Can be adjusted or selected
- Aluminum is the material most commonly used
- Technique charts are based on units using the lowest allowable added filtration
  - Set by the SC 35
- When filtration is added, the technique must be adjusted to compensate
  - Usually increase filtration for areas with high subject contrast
  - Can decrease dose

Compensating Filters

- Sole purpose is to balance the intensity of the x-ray beam to deliver a more uniform exposure to the IR, uniform density on image
- Can be attached at the collimator
- Can be placed on the patient, to even out the density.

More to keep in mind

- Grids
- Collimation
- Generators

Grids

- Device placed between patient and image receptor
- Purpose
  - Absorb scatter exiting the patient
- Why do we use it?
  - Improve image quality
  - High ratio grid can absorb 80-90% of scatter

Grids and Density

- How will a grid affect radiographic density?
  - It will decrease the amount of density on the image
- So then
  - mAs must be adjusted when adding, removing or changing a grid.
  - This is to maintain appropriate density.

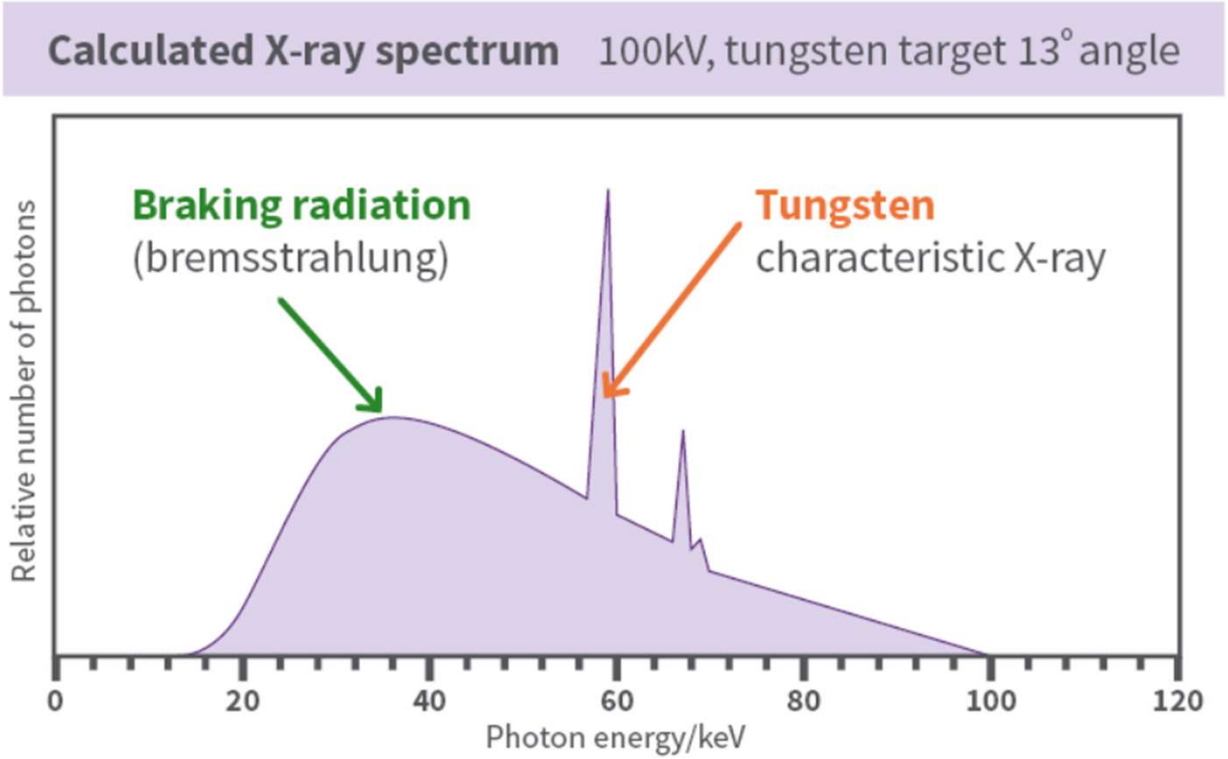
Beam Restriction - Collimation

- Collimation is
  - Adjusted by the technologist
- What does this affect?
  - The amount of tissue being irradiated
  - The amount of scatter reaching the image receptor
- What does this mean for density?
  - Less scatter reaching the image receptor results in decreased radiographic density (collimating the area of the beam)

Generators and Density

- Exposure techniques (technical factors) that we use are developed based on the type of generator in the room.
- Generator output (voltage)- efficiency of the generator

Emission Spectrum – energy distribution of the radiation produced in an x-ray exposure



https://www.arpansa.gov.au/understanding-radiation/what-is-radiation/ionising-radiation/x-ray

Emission Spectrum

- If the generator output (voltage) is more efficient, what happens to the quantity of x-ray photons?
  - there will be more x-ray photons

- With increased generator output, what will happen to the average energy of the photons?
  - the average energy will be higher

Emission Spectrum – energy distribution of the radiation produced in an x-ray exposure (generator, kVp and filtration)

- When filtration is added, low energy photons are removed
- If photons are removed, what happens to the emission spectrum?
  - The amplitude will decrease (amplitude = quantity)
- If the low energy photons are removed, what happens to the average energy of the photons?
  - The average energy will increase
- If the average energy is affected, what will the emission spectrum look like?
  - The peak will move to the right

Readings

- Bushong: Radiologic Science for Technologists, 11th ed.
  - Pg 54-55 (Inverse Square Law)
  - Pg 131 (Effect of added filtration)
  - Pg 132 (Effect of voltage waveform)
  - Pg 136-143 (don't worry about HVL)
  - Chapter 9
  - Pg 187-195 (up until Grids)
  - Pg 240-246