APPH 226:
Scatter Reduction and Beam Restriction

Objectives: 1.5, 2.3, 5.4

MRT Program

Beam Restrictors

- Device that attaches to the x-ray tube housing to regulate the size and shape of the x-ray beam.
- Designed to control and minimize scatter by limiting the x-ray field size to only the anatomic structures of interest.

Purpose of Beam Restriction

- Benefits of restricting the beam
  - Limiting patient exposure
    - Large field size is not always needed
    - Unnecessary skin dose
  - Reducing scatter produced within patient
    - Increasing contrast on the image
    - Improved image quality

Field Size and Collimation

- Field size and collimation are synonymous
- Note the different ways to describe the same thing:
  - Increase collimation
  - "Cone in"
  - Decrease field size
- And…
  - Decrease collimation
  - "Cone out"
  - Increase field size

Off-Focus Radiation

- Ideally, all filament electrons will strike the anode at the focal spot
- But some electrons can stray, and interact on other areas of the anode
  - This creates x-rays called 'off focus radiation'
  - This type of radiation is not ideal, increases image blur, which is not ideal for image quality
    - Can also image pt tissue that was meant to be excluded (i.e. ears on a skull image)
  - 'fuzzy edge' of image – image blur/penumbra
    - "zone of unsharpness"
    - Like the blurry edge of a shadow
  - The variable aperture collimator is designed to reduce off focus radiation

Image Blur/Penumbra

- Image blur/Penumbra and off-focus radiation are reduced as the beam restrictor distance is increased from the tube port.

Beam Restrictors

- Three types
  - Aperture Diaphragm
  - Cones/Cylinders
  - Variable Aperture Collimator

Aperture Diaphragm

- Simplest
- Flat piece of lead or lead lined material that fits onto the x-ray tube head
- Commercially made or 'homemade'
- Opening is usually just less than the size of the IR used
- Field size controlled by:
  - Size of the opening
  - Shape of the opening
    - Can be circular, square or rectangular
  - SID

Aperture Diaphragm

Advantages

- Inexpensive
- Easy to use

Disadvantages

- Need multiple diaphragms to achieve different field sizes
- Larger area of unsharpness around image
  - Due to diaphragm being located closer to the focal spot

Cones and Cylinders

- Modified aperture diaphragm
- Extension cone or cylinder attached to an aperture diaphragm
- Field size determined by the size and position of the distal end
- Usually circular
- Presently used only in special circumstances

Cones

- Cone has a flared extension – upper diameter smaller than lower diameter.

Cylinders

- Cylinders have no flaring, same diameter from top to bottom

Cones and Cylinders

Advantages

- Inexpensive
- Easy to use
- Helps decrease penumbra around image (cylinder slightly more effective than cone)

Disadvantages

- Fixed field size
- Shape of field is round
- Alignment is critical between x-ray source, cone and IR
- Cones-if angle of flange is greater than angle of divergence of primary beam, not effective at restricting primary beam

Image blur/Penumbra

As the distance of the beam restrictor increases from the port the more the image blur/penumbra is reduced
- cylinder is more effective at reducing image blur because it restricts the beam for a greater distance.

Variable Aperture Collimator

- Best and most commonly used beam restrictor
- All modern general x-ray units utilize this system
- Allows the most variation and flexibility in field size adjustments

Variable Aperture Collimator

- Two sets of shutters
  - First stage - Entrance shutters
    - Located right under the tube window
    - Limits the x-ray beam like an aperture diaphragm
    - Multiple collimator blades, on top of the collimator box
    - Purpose – to control off focus radiation

Variable Aperture Collimator

- Second stage shutters
  - Located 3-7 inches below the tube
  - Longitudinal and lateral blades
  - Work in pairs that are independently controlled
    - Allows for a variety of sizes
  - Usually made of lead at least 3 mm thick

Variable Aperture Collimator

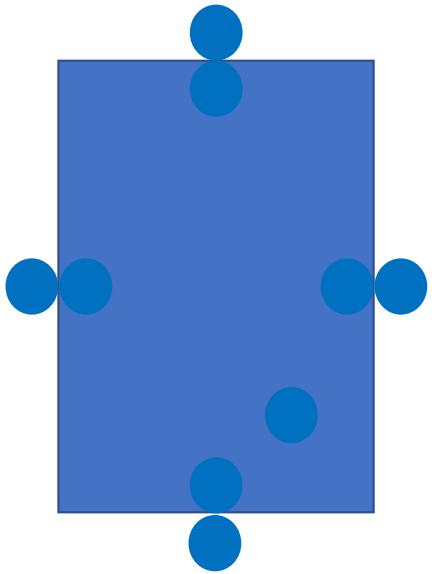
- Equipped with a light source and a mirror
- Light is intended to be an accurate representation of where the primary x-ray beam will be projected during procedure
- Mirror and light must be adjusted so that the projected light field coincides with the x-ray beam

Variable Aperture Collimator

- Collimator has a calibrated scale on the front to indicate field size
- Misalignment of the mirror can cause anatomical structures to be cut off of the image
  - Evaluated regularly with quality control program
  - Alignment of the light field and radiation field must be within acceptable limits

Alignment test – 9 penny

- Any tech can perform this if they are concerned about the alignment of the light field and radiation field



Positive Beam Limitation (PBL)

- "Automatic Collimation"
- When an IR is placed in the Bucky tray, automatic collimators mechanically adjust the size and shape of the radiation field to match that of the IR
- A way of protecting patients from overexposure, but does not replace manual collimation by technologist
- Purpose is to ensure the field size does not exceed that of the image receptor

Positive Beam Limitation (PBL)

- Still exists in digital detector system
- Can be built into the APR, so when an exam is selected, the field size will automatically change
- Can be over-ridden
- Crucial for technologists to collimate appropriately to the area of interest, and always limited to the size of the IR

Safety Code 35

- States that:

"It is not sufficient to merely collimate to limit the beam to the size of the image receptor. Care should be taken to further restrict the beam to the region of the patient's body that is of diagnostic interest."

- Safety Code 35 Section A 3.4 pg 15

Compton Scatter Interaction

- Scatter is produced during a Compton Interaction
- Scattered photons are not a part of the useful beam
- Scatter decreases the quality of the image by adding a density over the entire image that isn't related to the anatomy
  - Image fog
  - No useful information

Scatter and Image Quality

- As scatter reaching the image increases, the image loses contrast and appears grey and dull
- Only way to improve the image quality is to prevent the scatter photons from reaching the image
  - There are factors within the technologist's control that can help with this

Methods of Reduction

- Three primary factors that can influence the intensity of the scatter reaching the image
  - kVp
  - Field size
  - Patient body part thickness

kVp and Scatter - Review

- kVp controls the energy level of the x-ray photons
- When kVp is increased, the energy level is increased – this affects the interactions occurring

Beam Restriction

- As the x-ray beam is restricted through collimation, the amount of tissue being irradiated is decreased
  - Results in:
    - Improved image quality
    - Reduced patient dose

Beam Restriction

- As the field size is decreased, less scatter radiation is produced within the patient
- Less patient anatomy is being irradiated, so fewer Compton interactions are occurring
  - Less scatter reaches the IR
- "More matter, more scatter"

Field Size and Density

- When the field size is decreased, what is happening to the density on the image?
  - Decreasing because…
    - Fewer photons reaching IR
    - Scatter, although not useful, contributes to the density of the image
    - When collimating, some of the photons have been removed due to the field size – remember, the beam is not 'squeezed' when it is collimated

Compensating for Collimation

- Increase in collimation affects the number of x-rays reaching the IR to produce the latent image
- Smaller field size means fewer photons hitting patient, which results in less scatter being produced
- Therefore, exposure factors should be increased when collimation is increased

Which exposure factor?

- kVp is typically not increased
  - Will increase the proportion of scatter interactions in the patient, therefore decreasing the image contrast

- mAs should be altered to maintain the exposure
  - Will only affect density of image

Patient Thickness

- The thicker the body part is, the more scatter radiation is produced
- Cannot control patient thickness, but technologists can manage it by using proper technical factors and utilizing devices such as compression paddles
  - Also modifications in positioning can be helpful
    - PA vs AP abdomen

Readings

Bushong : Radiologic Science for Technologists 11th Edition

- Pg 116 (Off Focus Radiation)
- Pg 187- 190 (Stop before “Control of Scatter Radiation”)
- Pg 191-194 (Start at “Beam Restrictors”, and stop before “Radiographic Grids”)