Beam Restriction

- Methods employed or devices used to keep scatter radiation production to a minimum
- Purpose is to control and decrease scatter radiation production
- Results in:
  - Decreased patient radiation dose
  - Improved radiographic contrast due to decreased fog

Control of Scatter

Using Beam-Restricting Devices

- Ideally, beam restrictors decrease field size (FS) to anatomy of interest
- Unnecessary tissue exposure decreases
- Scatter decreases
- Scale of contrast shortens
- Visibility of detail increases
X-ray Photons

Some x-rays interact with the patient and are scattered away from the film (a). Others interact with the patient and are absorbed (b). X-rays that arrive at the image receptor are those transmitted through the patient without interacting (c) and those scattered in the patient (d). X-rays of type c and d are called image-forming x-rays.

Collimation

Collimation of the x-ray beam results in less scatter radiation, reduced dose, and improved contrast resolution.

Field Size (FS)

- Increased FS increases volume of tissue irradiated
- Results in increased scatter
- Decreased FS decreases beam quantity
- Decreases scatter
- Shortens scale of contrast in image
Collimation

The relative intensity of scatter radiation increases with increasing field size.

Trade Off

- By decreasing FS, fewer photons reach image receptor
  - Image receptor exposure decreased
  - Increase in mAs must accompany significant reduction in FS to maintain image receptor exposure

Scatter Radiation Production

- Increases with:
  - Higher kVp
  - Increased Compton scatter
  - Decreased Photoelectric absorption
  - Compensate by using lower kVp, yet results in increased patient absorbed dose
kVp

- Affects the energy (penetrability) of the x-ray beam
- Increasing kVp affect on interactions:
  - Increased transmission
  - Decreased photoelectric absorption
  - Increased Compton scatter

Increase kVp

- Affect on patient dose:
  - Decreased dose
    - Decreased photoelectric absorption
    - Increase in kVp typically accompanied by reduction in mAs
  - Affect on image quality:
    - Longer scale of contrast

Decrease kVp

- Affect on interactions:
  - Decreased transmission
  - Increased photoelectric absorption
  - Decreased Compton scatter
Decrease kVp

- Affect on patient dose:
  - Increased dose
    - Increased photoelectric absorption
    - Decrease in kVp usually accompanied by increase in mAs
  - Which increases dose even more

Decrease kVp

- Affect on image quality
  - Shorter scale of contrast

Patient Thickness

- Thicker body parts produce more scatter
- Denser body parts produce more scatter
- Both of these factors increase number of interactions x-ray beam undergoes as it passes through the body
Patient Thickness

- Denser body parts produce more scatter
- Higher electron density $e^-$ present in thicker/denser tissues
- Increased likelihood of interaction occurring

Scatter Radiation Production

- Increases with:
  - Greater patient or anatomical part thickness
    - Abdomen results in increased scatter production as compared to an extremity
  - Hypersthenic patients produce more scatter as compared to the sthenic, hyposthenic, and asthenic patients

Relative intensity of scatter radiation increases with increasing thickness of anatomy

Compression

- Compensate by using compression as applicable
- Scatter radiation is reduced, resulting in lower dose and improved contrast resolution.
Decreasing Part Thickness

- Compression devices used to improve spatial resolution and contrast
- Decreases patient thickness
- Results in lower patient dose
- Brings tissue closer to film
- Utilized in mammography

Scatter Radiation Production

- Increases with:
  - Larger x-ray field size (decreased collimation)
  - Intensity of scatter increases with larger IR field size

Scatter Radiation Control

- The radiographer must strive to minimize the quantity of scatter that reaches the IR
- Restrict the x-ray beam size to the size of the anatomical structures required to demonstrate in the image
- No reason to leave collimators open to extend beyond the IR size
- Objective is to decrease patient radiation dose, and achieve optimum contrast
Beam Restricting Devices

- Aperture Diaphragm
  - Thin sheet of lead with opening attached to x-ray tube head (Protective housing exit portal)
  - Specific diaphragm used for anatomical parts that reflect the IR size
  - Often used:
    - In a dedicated Chest Radiography Room
    - With a cylinder or cone

- Cylinder & Cone
  - Comprised of lead, attached to the collimator
  - Used to produce circular images with a decreased field size
  - Primarily used in dental radiography

Collimator

- Modern equipment
- Light localizing
- Two sets of shutters that permits infinite number of field sizes
  - Length and width of field independently controlled
Beam Restricting Devices

- Variable Aperture Collimator
  - Most commonly employed device
- Components:
  - First-stage entrance shutter
    - Limits off-focus radiation
  - Second-stage shutters
    - @3mm lead for a variety of field sizes
  - Bulb
  - Mirror
  - PBL

Collimator and Penumbra

- Bottom shutters reduce penumbra
- Geometric unsharpness around periphery of image
  - Also known as edge unsharpness
- Improves sharpness of recorded image edge

Collimator and Off-Focus Radiation

- Upper shutters reduce off-focus radiation reaching IR
- Off-focus radiation produces images beyond exposed field of radiation
  - Ghosting effect
Light Field

- Uses light reflected off mirror to project coverage of x-ray beam
- Proper adjustment of mirror necessary to accurately display location of exposure field
- Light field/x-ray beam coincidence testing should be part of quality control (QC) program
- Needs to be accurate within +/- 2% of SID

Features of Collimator Housing

- Central ray must be marked
- Some units project location of phototimer sensors in light field
- Alignment light helps center beam with image receptor

Positive Beam Limitation (PBL) Devices

- Automatically collimates beam to size of cassette
- Possible to override PBL
  - Can reduce beam to smaller field than cassette size
Pathology and Radiation Absorption

- Patients are radiographers greatest variables
- Beam attenuation
  - Dependent on thickness and composition of patient’s tissues

Pathology and Radiation Absorption

- Pathology can alter thickness and composition of patient’s tissue density

Pathology and Radiation Absorption

- Small, localized pathology does not require change in technical factors
Radiographer’s Responsibilities

- Read requisition
- Take accurate patient history
- Observe patient closely
- Adjust technical factors when necessary

Additive Conditions

- Increase tissue thickness, effective atomic number, and/or tissue density
  - Increase attenuation
  - Inversely related to image receptor exposure

Additive Conditions

- Require increase in technical factors to properly expose image receptor
- Thicker, denser part requires more penetration
  - General compensation
    - Increase in kVp
Increased Attenuation (Additive) Conditions

- Multiple systems
- Abscess
- Edema
- Tumors

Increased Attenuation (Additive) Conditions

- Chest
  - Atelectasis
  - Bronchiectasis
  - Cardiomegaly
  - Congestive heart failure (CHF)
  - Empyema
  - Pleural effusions
    - Hemothorax and hydrothorax

Increased Attenuation (Additive) Conditions

- Chest
  - Pneumoconiosis
  - Pneumonia (pneumonitis)
  - Pneumonecetomy
  - Pulmonary edema
  - Tuberculosis
    - Advanced and miliary
Increased Attenuation (Additive) Conditions

- Abdomen
  - Aortic aneurysm
  - Ascites
  - Cirrhosis
  - Calcified stones

Increased Attenuation (Additive) Conditions

- Extremities and skull
  - Acromegaly
  - Chronic osteomyelitis
  - Hydrocephalus
  - Osteoblastic metastases
  - Osteochondroma
  - Paget’s disease
  - Sclerosis
**Destructive Conditions**
- Decrease tissue thickness, effective atomic number, and/or tissue density
  - Decrease attenuation
  - Directly related to image receptor exposure

**Destructive Conditions**
- Require decrease in technical factors to properly expose image receptor
  - General compensation
  - Decrease kVp

**Decreased Attenuation (Destructive) Conditions**
- Chest
  - Emphysema
  - Pneumothorax
Decreased Attenuation (Destructive) Conditions

- Abdomen
  - Aerophagia
  - Bowel obstruction

- Extremities and skull
  - Active osteomyelitis
  - Aseptic necrosis
  - Carcinoma
  - Degenerative arthritis
  - Fibrosarcoma
  - Gout

- Hyperparathyroidism
- Multiple myeloma
- Osteolytic metastases
- Osteomalacia
- Osteoporosis
Basic Pathology

- Definition
- Beam attenuation
  - Increased vs Decreased absorption
  - Exposure factor change

- Additive conditions
  - Increase body tissue thickness, Z#, and/or density
  - Atelectasis
  - Pleural Effusion
  - Tuberculosis
  - Ascites
  - Osteoblastic Mets

- Destructive conditions
  - Decrease body tissue thickness, Z#, and/or density
  - Emphysema
  - Pneumothorax
  - SB Obstruction
  - Osteoporosis
  - Osteolytic Mets

Respiratory System Pathology

- Primary tuberculosis. Consolidation of right upper lobe.
- Calcified tuberculoma. Large soft tissue mass in left lung (arrows) that contains dense central calcification.
Respiratory System Pathology

Emphysema.

Platelike atelectasis. Horizontal linear streaks of opacity (arrows) can be seen in lower portions of both lungs.

Respiratory System Pathology

Pleural effusion. B, Left lateral decubitus projection shows that retrocardiac density represents large amount of free pleural fluid.

Spontaneous pneumothorax. Complete collapse of right lung.

Respiratory System Pathology

Skeletal System Pathology

Disuse osteoporosis. Severe periarticular demineralization after prolonged immobilization of the hand.

Skeletal System Pathology

Osteoblastic metastases. Multiple areas of increased density involving pelvis and proximal femurs representing metastases from carcinoma of urinary bladder.

GI System Pathology

Ascites. A. Plain radiograph shows general abdominal haziness

Small bowel obstruction.