Radiological Equipment Techniques (Lec 6)

Effect of scatter radiation on image contrast

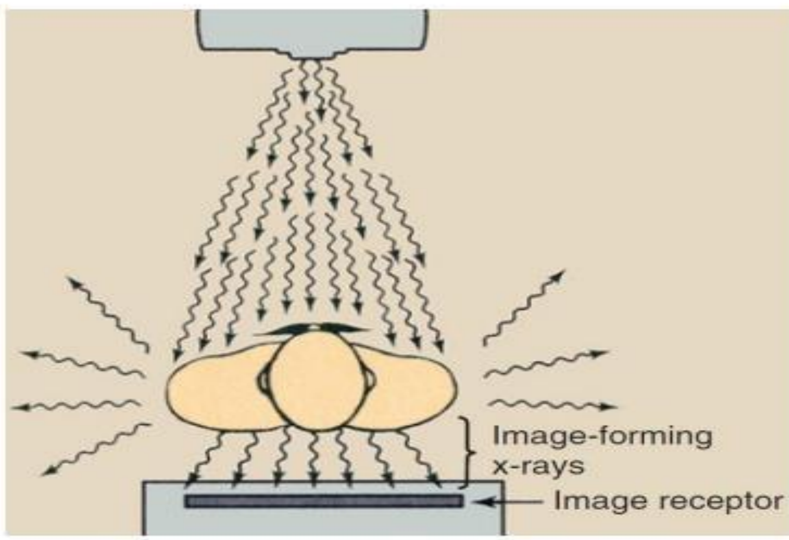
1. Production of Scatter Radiation

When primary x-rays interact with the patient, x-rays are scattered from the patient in all directions.

Two types of x-rays are responsible for the optical density and contrast on a radiograph:

1-Those that transmitted through the patient without interacting.

2-Those that are scattered within the patient through Compton scatter interaction.

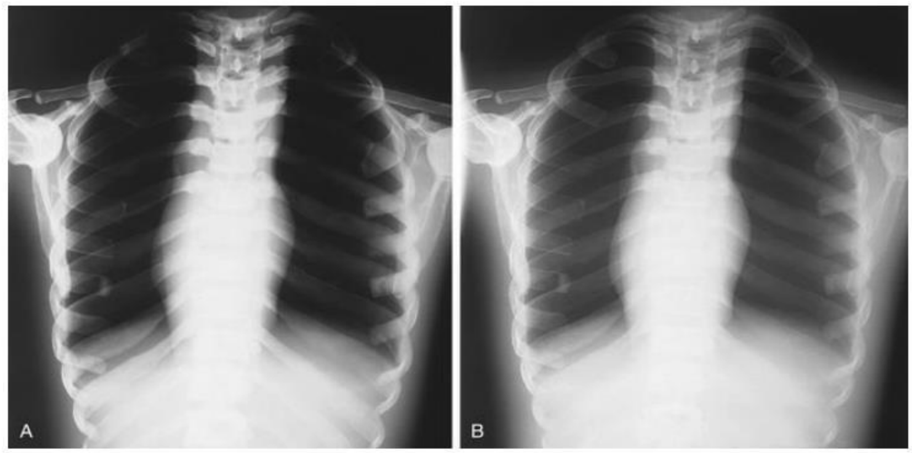


2. Scatter and contrast

One of the most important characteristics of image quality is contrast.

Image contrast is the degree of difference in optical density between (black and white) areas of a radiographic image.

Contrast resolution is the ability to image and distinguish soft tissues.



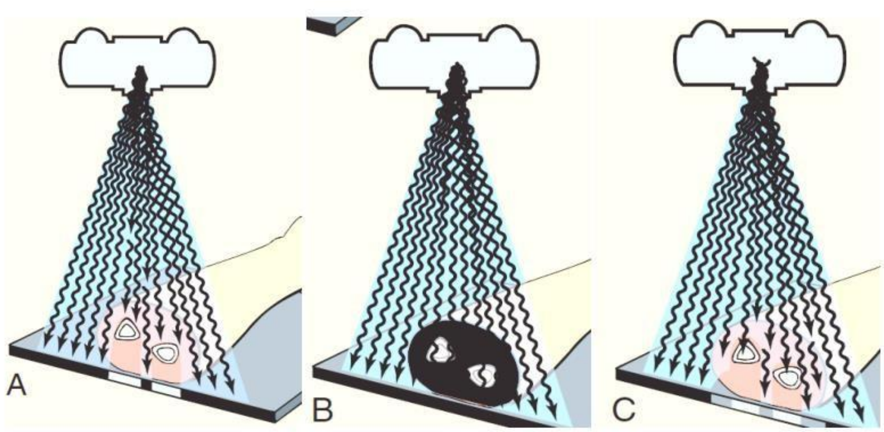
If there are only transmitted x-rays (no scattered x-rays) the image would be very sharp (figure A below). Then, the change in optical density from dark to light, that represents the bone–soft tissue interface, would be very clear (abrupt). Therefore, image contrast would be high.

If there is only scatter radiation (no transmitted x-rays) reached the image receptor, the image would be dull gray (see figure B below). Therefore, the radiographic contrast would be very low.

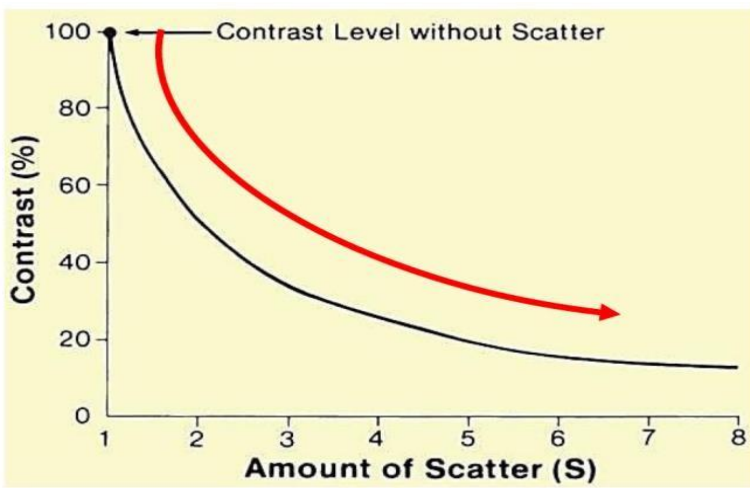
In the normal situation, however, image-forming x-rays consist of both transmitted and scattered x-rays (see figure C below). Therefore, this image has moderate contrast.

The loss of contrast results from the presence of scattered x-rays.

Two types of devices reduce the amount of scatter radiation that reaches the image receptor: beam restrictors and grids.



As scatter radiation increases, the radiographic image loses contrast and appears gray and dull.



3. Factors affecting scatter radiation

Three primary factors influence the relative intensity of scatter radiation that reaches the image receptor: 1-kVp 2-field size 3-patient thickness

3.1 kVp

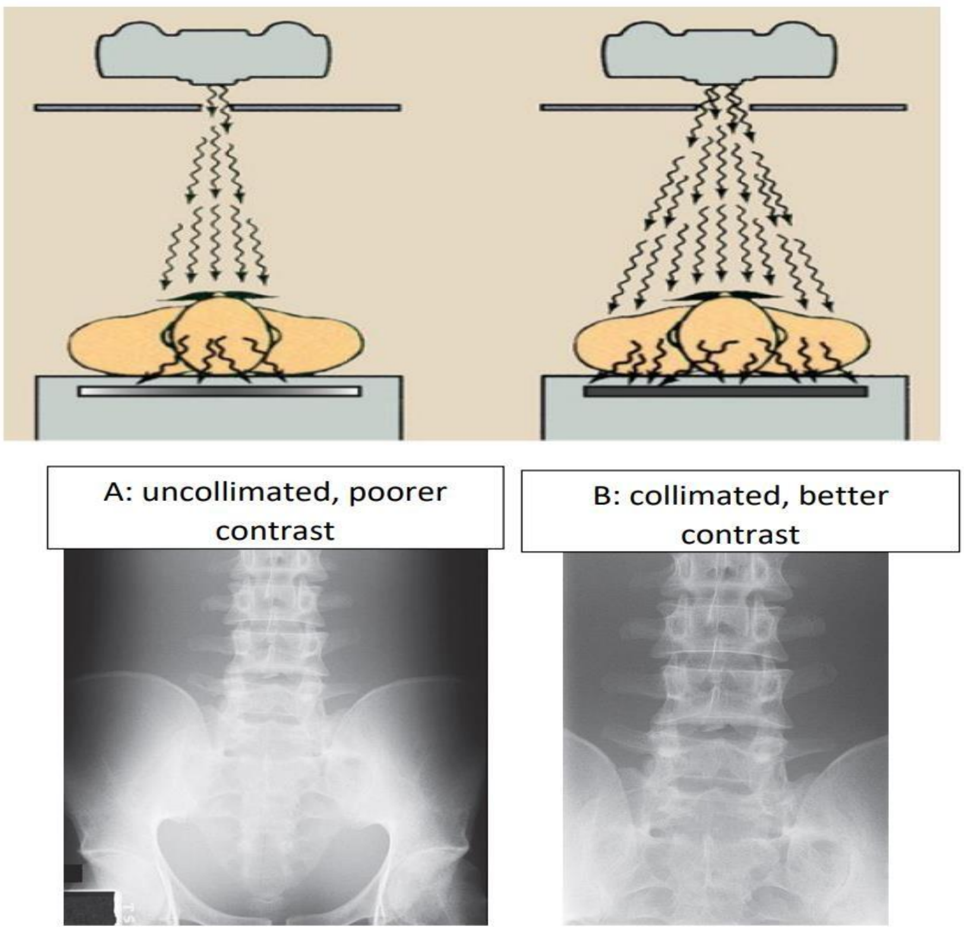
As x-ray energy is increased, the absolute number of Compton (scatter) interactions decreases, but the number of photoelectric interactions decrease much more rapidly.

Therefore, the relative number of x-rays that undergo Compton (scatter) interaction increases.

Thus, increasing kVp will increase scatter ratio/level then image blur increases which reduces image contrast.

3.2 Field Size

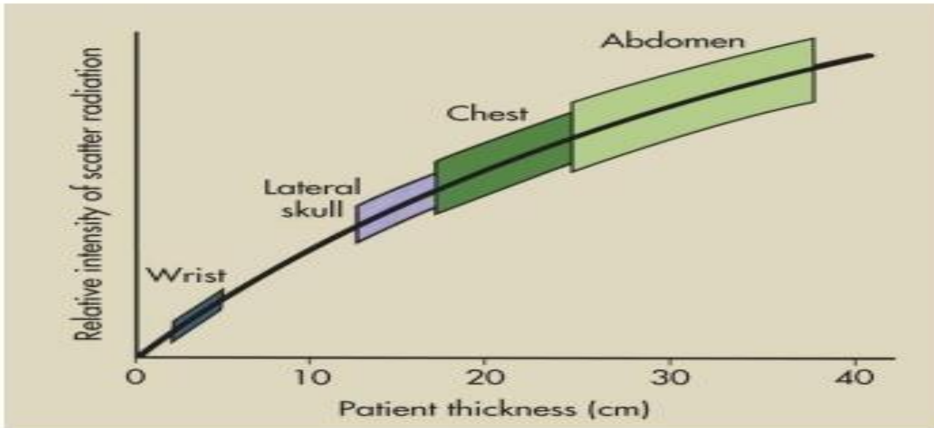
x-ray beam field size affects the level of scatter radiation. Increasing field size leads to increased scatter radiation.

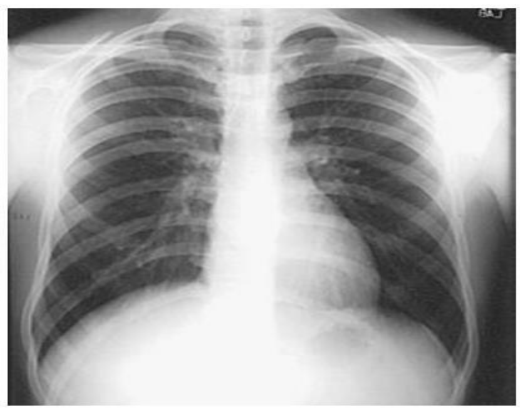


3.3 Patient Thickness

Imaging thick parts of the body results in more scatter radiation than imaging thin parts.

The extremity (hand) radiograph will be much sharper than of the chest or pelvis because of the less thickness and reduced amount of scatter radiation.





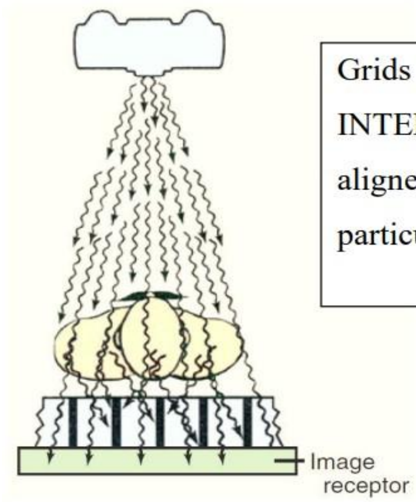
The Grids

The radiographic grid was invented in 1913 by Gustave Bucky.

It is effective mean for reducing the amount of scatter radiation that reaches the image receptor.

A radiographic grid is a device that is placed between the anatomic area of interest and the image receptor to absorb scatter radiation from the patient, and hence, improves the image contrast.

The grid is designed to transmit only x-rays in a straight line direction from the x-ray tube target to the image receptor. Scatter radiation is not in straight line so it is absorbed in the grid material.



Grids basically made of LEAD INTERSPACING (ALUMINIUM) which is aligned with the geometry of x-ray beam of a particular tube.

1. Grid Construction

Grids contain thin lead strips or lines that have a precise height, thickness, and space between them. Radiolucent interspace material separates the lead lines. Interspace material typically is made of aluminum.

The lead lines and interspace material of the grid are covered by an aluminum front and back panel.

Grid construction can be described by: 1-grid frequency 2-grid ratio.

1.1 Grid frequency

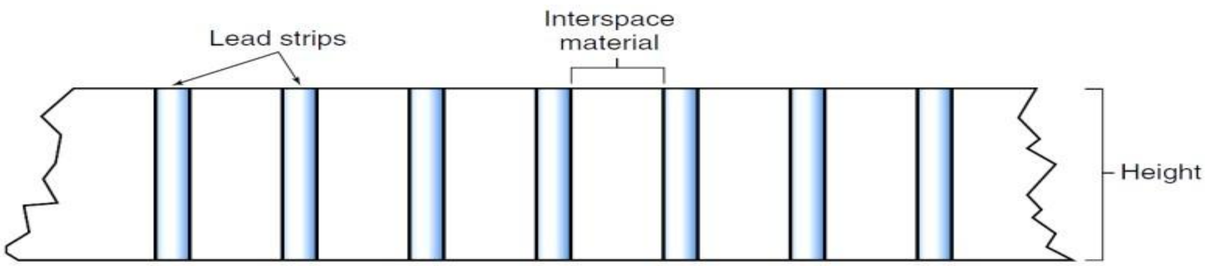
Grid frequency: expresses the number of lead lines per unit length, in inches, centimeters, or both. Grid frequencies can range in value from 25 to 80 lines/cm (63 to 200 lines/in).

A typical value for grid frequency might be 40 lines/cm (100 lines/in).

If grid strip width is held constant, the higher the frequency of a grid, the thinner its interspace must be and the higher the grid ratio.

1.2 Grid ratio

Grid ratio is defined as the ratio of the height of the lead strips to the distance between them (Figure below). Grid ratios range from 4:1 to 16:1.



Grid ratio can also be mathematically expressed as follows:

$$\textbf{Grid ratio} = h / D$$

where h is the height of the lead strips and D is the distance.

Example: What is the grid ratio when the lead strips are 2.4 mm high and separated by 0.2 mm?

Solution:

Grid ratio = h / D

Grid ratio = 2.4 / 0.2 = 12 or 12:1

High-ratio grids are more effective in reducing scatter radiation than are low-ratio grids.

This is because the angle of scatter allowed by high-ratio grids is less than that permitted by low-ratio grids (see figure below).

The disadvantage of high-ratio grids is that it increases the patient radiation dose.