General Radiographic Image Quality

Radiographic image is the final product of imaging department and it passes through many steps before viewing. To achieve the ideal images with high quality and lowest possible radiation dose to the patient, one should take care during each stage of image formation which isn’t only practiced by one person who is designated to do that, It is the responsibility of everybody in the facility to improve quality on a regular basis.

And in our presentation we will discuss the imaging chain components which affect the image quality including:

1. X-ray Tube
2. Patient
3. Receptors
4. Post-processing

X-Ray Tube Related Artifacts

1- Overexposure (too much mAs), or Underexposure (too little mAs):

**Cause:** By increasing or decreasing the x-ray beam current mAs which influence the amount of darkness on the image. Low (mAs) produces too light (underexposure) film.

2- Overpenetrated (too much kVp), or Underpenetrated (too little kVp):

**Cause:** The higher the energy (kVp), the greater the penetrating power of X Rays so at very high energy levels, the difference between bone and soft tissue decreases and both become equally transparent which result in loss of contrast (overpenetration)

The over- or underexposed radiograph may result from equipment failure such as in case of reduced x-ray tube output, e.g. when the tube is near the end of its working life.

**Artifact remedies:** The selection of the exposure factors depends on the anatomical structure under investigation and the level of contrast and resolution needed e.g. higher kVp is required when the subject contrast is high (chest) while for breast since the contrast is low we need low kVp with high mAs to enhance the resolution by reducing the noise.

3- Noise: is the random fluctuation on the optical density of the image, more photons give less noise and it affected by many other factors that we will talk about them later on.

**Remedy:** By increasing the mAs the image noise will be reduced.

4- Unsharpness (blurring)

**Causes:**

a) Geometric unsharpness: the loss of definition which results from using large focal spot size (wide X-ray beam) due to penumbra effect and short SID.
b) Motion unsharpness: due to x-ray tube movement is suggestive of poor equipment design or failure to activate the tube suspension locks. In rare cases, the whole tube assembly may oscillate or drift during the exposure and possibly cause motional unsharpness.

**Artifact remedies:**

a) The selection of the small focal spot on a dual-focus x-ray tube will result in less blurring or unsharpness and longer SID will produce a sharper image.
b) By insuring that tube is well centered and locked in its place.

5- Distortion (size)

Magnification (size): decreasing the SID will result in magnification of the body part under examination.

6- Inadequate collimation

**Causes:** which could be opened collimation resulting in increase the scattered radiation and thus the level of random background noise on the film which degrades the visibility of low contrast details making the image looks grainy and lacks of detail, or over collimation resulting in cutting parts of the area of interest.

**Artifact remedies:** Adequate care may be taken to avoid creating these artifacts; Good collimation will both minimize the dose to the patient and improve image quality, Determine if light is functioning and is clearly defined under normal operating conditions, without visible dust or foreign matter shadows and determine that they are functioning correctly and smoothly.

7- Double exposure artifact

**Cause:** The wide dynamic range of the CR system allows the bone and soft tissue to be visualized on the workstation with a single exposure. On occasion, two radiographs taken on the same imaging plate may create a double exposure artifact. With the conventional film-screen system, most double exposures result in a blackened unreadable image.

**Artifact remedy:** Care therefore should be taken when reading these films as this artifact may sometimes mimic pathology.

**Patient related artifacts**

1- unsharpness (blurring)

a) Obesity & shape of the body part:

**Cause:** increasing the thickness of the part of the body to be imaged or of the patient will affect many things, firstly the exposure will need to be increased resulting in poorer contrast and tends to produce more scatter, secondly since the x-ray beam must travel more distant results in increased exposure time and introduces motion artifact. Thirdly the penumbra also increases resulting in more geometric unsharpness which is also affected by the shape of the body part.
Artifact remedies: Some of the solutions that can help in imaging obese patients before acquisition includes using a grid and increasing the kVp and mAs and after acquisition increasing the film development speed and adjusting window and level settings.

b) Patient motion
Cause: Patient motion due to their age or physical and mental status or because the position they have been asked to adopt is uncomfortable, painful, and unstable or failure to hold breathing, all these consider as voluntary movement while the involuntary include motion of internal organs, such as the heart or abdominal viscera.
Artifact remedies: Voluntary motion can be reduced by use of careful instructions to the patient, reassuring the patient to reduce anxiety and tension, ask the patient to hold breathing during exposure, Immobilization devices, and various accessories can be used including non-opaque pads and sandbags to immobilize the extremities, let the patient to sit rather than stand, Involuntary by employing shortest possible exposure time and use faster film-screen combination.

2- Distortion
a) Shape
Cause: the object and film are not parallel to each other. It can be seen that if the centre of the x-ray beam is directed at right angles to the object but the object is not parallel to the image receptor, then a distorted, elongated image is produced. If the centre of the beam is directed at right angles to the image receptor but is angled in relation to the object, then a distorted, foreshortened image will be produced.
Artifact remedies: in cases, when the object and film cannot be parallel to each other, a compromise can be made by directing the central ray at right angles to an imaginary line bisecting the angle between the object and the film. Although a distortion does occur, the net effect is neither elongation no foreshortening of the image. This technique may required if a patient is unable to straighten a limb to bring it parallel to the film when imaging a long bone.

b) Size
Cause: increasing the distance between the image receptor and body part under examination or the patient will result in magnification.
Artifact remedy: by placing the body part under examination as close as possible to the IR like in chest examination where we put the patient in PA position to avoid magnification of the heart.

3- Radiopaque or radiolucent artifacts.
Causes: Presence of radio-opaque items (e.g. collar, cast, mattress, jewellery, dentures, trace of contrast media on patient's gown...etc) or radiolucent e.g. gasses in path of x-ray produces annoying image opacities (artifacts) which may obscure or confuse vital anatomical detail.
Artifact remedy: The radiographer should clear the patient from any objects that may encounter the path of the x-ray beam except for the collars, fixation and any other medical accessories, the radiographer must inform the patient's physician before removing, adjusting the technique to maximize the visualization the area of interest e.g. increasing the exposure factors in the presence of cast, or by using tomography technique as in KUB to remove the effect of gasses.

Receptors related artifact
1- Grid (Grid cut-off)
Cause: Due to angulations across the grid, off-centering of the beam or using the wrong focus-film distance (SID) or up-side down position is called grid cut-off or edge cut-off. It produces a loss of image density.
Artifact remedy:
1. Ensure that the grid is not tilted transversely.
2. Grid should not be off-level.
3. Using recommended focal range of focused-grid.
4. Tube side of focused grid is facing x-ray tube.
5. Grid should be checked periodically for any damaged.
6. Ensure the tube angle is parallel to the grid lines.

2- Computed radiography (CR) corduroy or aliasing/moiré artifact
Cause: This is likely to be caused by incompatibility of the CR system with the grid frequency of the wall Bucky this is because the grid frequency (the number of grid strips or lines per inch or per centimeter) is lower than the scan frequency.
Remedy: the grid frequency should be slightly higher than the scan frequency.

3- Image blurring or "photographic unsharpness"
   a) Cross over and parallax effect
   Cause: In duplitized film when emulsion does not completely absorb the light from the intensifying screen, the unabsorbed light from one side can pass through the film base and expose the emulsion on the other side. As the light passes through the film base, it diverges and produces image slightly larger than the opposite side so that they are not exactly superimposed "parallax effect" resulting in slight blurring of edges, such effects tend to become more noticeable in situations where high speed (sensitivity), low dose techniques are required.
   Artifact remedy: this effect can be eliminated by using digital systems otherwise it can be decreased by placing a light-absorbing layer between the film emulsion and film base or using a slower, high-resolution, single screen or non screen system.

   b) Poor film screen contact & Incorrect screen film match
   Cause: 1 - poor film screen contact which exhibits a characteristic diffuse effect over a limited area of the image associated with badly design or damaged cassettes.
2- Incorrect screen film match which appear as insufficient density (decreased film contrast) failure to achieve correct spectral matching by using a film in the wrong type of cassette would result in requiring an X-ray exposure of higher magnitude.

Artifact remedies: 1- ensures that the films are placed properly; screens are fitted and attached to cassettes and cassette latches are not broken. Cassettes and screens should be replaced if necessary.

2- By ensuring that the film light sensitivity is corresponding to the light emitted by the screen.

4- Image noise (graininess)

Cause: As we mentioned earlier there are other factors related to IR that affect the noise. The use of very fast intensifying screens (large Phosphor size & thicker screen) and not enough mAs or kVp.

Artifact remedies: by using of low-speed intensifying screen or increasing the exposure factors.

5- Static marks

Cause: low humidity or improper handling in the darkroom prior to processing generate static electrical charges which triggers chemical changes in the emulsion and result in characteristic black static marks on the film.

Remedy: Preventing static artifacts was at times difficult. Grounding your hand on a metal object before you remove the film from the cassette would probably avoid the static discharge.

6- Screen mark Artifacts

Cause: white sharply defined artifact produced by scratches, stains, and foreign objects (deposits), such as hair, dust, and cigarette ashes, on the screen surface which interrupt light in its passage from screen phosphor to film emulsion.

Artifact remedies: Intensifying screens should be cleaned periodically according to the manufacturer's instructions.

7- CR imaging plate artifacts

a) Light spot

Cause: Any debris blocking the IP’s emission of light when scanned by the laser in the plate reader will cause a white artifact when viewed using a normal grey scale presentation e.g. Residue from adhesive tape used to attach lead markers to the outside of the cassette has caused artifacts when the tape came in contact with the IP, Static caused a hair to cling to the IP which can be seen on the skull image.

Artifact remedy: IPs must be cleaned regularly or when artifacts such as these are noted.

b) Scratches artifacts
**Cause:** Imaging plates (IPs) that must bend as they pass through the plate reader are susceptible to cracking. These cracks usually first become visible on the edges of the IP, where generally they do not interfere with the clinical image. As the deterioration progresses, cracks appear closer to the central area of the IP.

**Artifact remedy:** An IP must be replaced when cracks occur in clinically useful areas.

8- Backscatter artifact

**Cause:** appears as a dark line along the lateral portion of the film and is caused by backscatter transmitted through the back of the conventional film/screen cassette. The line corresponds to the cassette hinge where the lead coating is weakened or cracked.

**Artifact remedy:** to reduce backscatter, the radiographer should take care when dealing with these types of cassettes, always should be checked for any damaged and replaced if necessary.

9- Reversed cassette

**Cause:** unusual superimposed pattern on the anatomy will appear if cassette is reversed where the tube side of cassette is pointed away from the x-ray tube source.

**Artifact remedy:** when placing the cassette be sure that the tube side is facing the x-tube to avoid repeating x-ray.

10- CR plate discoloration

**Cause:** improper cleaning of the cassettes by using too much water without proper drying will result in a stain image.

**Remedy:**

11- Monitor artifacts

**Cause:** applying strong pressure on the screen of digital systems may result in damaged screen's crystals and creates artifacts that are not related to the original image.

**Remedy:** taking care of the screen and apply light pressure on it when required as in CR monitors to avoid this type of artifact.

**Post-processing related artifacts**

a) Chemical manual/automatic processor/daylight artifacts

1- Over or underdevelopment: If the concentration of the developer is too high or too low or if the temperature of the developer is too low. Excessive or reduced density will occur respectively. the film will appear lack of contrast.

2- Chemical staining: Inadequate fixing or washing during film processing leads to eventual yellow or brown staining of the image.
4- Water spots: Water spots can occur on the film if the replenishment rates are incorrect, if the squeegee mechanism that the film passes through after the wash tank is defective, or if the dryer is malfunctioning.

6- Guide shoe marks: results when the film rubs against the guide shoes during transport. The artifact manifests as a series of evenly spaced lines parallel the direction of film transport. Plus density shoe marks are caused by the guide shoes in the developer tank. Minus density often occur in the fixer to washer crossover.

5- Clumping of silver halide granules: excessive processing temperature, the silver grains may clump together to form particles which may be coarse enough to give the image a grainy appearance.

**Remedies:** Chemicals should be changed regularly (using appropriate concentration and replenishment rate), and the processing conditions, such as temperature, and development time should be carefully optimized.

7- Finger print or pressure marks most common (Kink “nail” marks or crescent-shaped crimp mark)

**Cause:** due to inappropriate handling during processing.

**Remedy:** Automatic 'daylight' film-handling systems eliminate this fault.

6- Fog (loss of radiographic contrast): it could be from safelight in dark room which affects the whole film (general increase in image density) or from white light whether from daylight or artificial source, it produces total blanking of the affected area (leakage at edges of cassette or penetrate to center of film). It may also result from temperature or humidity, contact with any chemicals or gases such as polished metal surfaces and mercury vapors….etc, or if the films out of expiry date.

**Remedies:** The radiographer should develop the films in the dark room as fast as possible to avoid prolonged film exposure to safelight. If film is found to be outside the expiry date, the box must be withdrawn from stock. The oldest box is used first (stock rotation). Be sure that the area where films are processed is clear and clean from any chemical fumes or vapors. Store boxes away from strong sunlight because of its heating effect, ideally storeroom should not have any window, to keep standard level of humidity the room should not have any hot water or steam pipes running through it, it should be well ventilated.

b) Digital Radiography
- Computed radiography
- DDR (Direct Digital Radiography)

1- Vertical or horizontal patterns of hyperintense signal.

**Cause:** caused by dirt on the light guide in the plate reader which block the light emitted from the imaging plate when it’s scanned by the laser.
**Remedy:** the light guide of the photomultiplier tube was checked and cleaned.

2- Plate reader electronics artifact  
3- Incomplete or incorrect erasure setting  
**Cause:** IPs are automatically erased after they are read. They must be manually erased if they are not used for a period of time, or to erase an incorrect exposure.  
**Remedies:** the correct erasure setting must be used when a manufacturer provides more than one erasure option. For an incorrect radiographic exposure, the erasure cycle should be longer and should expose the plate to a more intense light than is needed for an IP that has been unused for a few hours. Incomplete erasure may produce an image artifact.  
- This bilateral knee image was spoiled when the incorrect erasure setting was used to eliminate a previous femur image. Evidence of this is the residual image of the lead marker in the top corner of the image, the tissue line from the previous image (upper arrow) and the additional line of collimation along the bottom of the image (lower arrow).

4- Inappropriate image processing selection  
**Cause:** an image with loss of contrast as a result of improper selection of image processing.  
**Remedy:** the same image repeated showing acceptable image quality as a result of proper selection of image processing.

5- Insufficient collimation  
**Cause:** the failure of the operator to follow collimation rules results in inability of the software to determine collimation boundaries and alteration of the histogram so that it was outside the normal range for that body part selection due to increase amount of unattenuated radiation striking the imaging plate.  
**Remedy:** matching the positioning and collimation with the image processing parameters.

6- Excessive edge enhancement artifact  
**Cause:** improper enhancement selection may produce artifacts that interfere with diagnosis particularly where two structures of markedly different attenuation meet in which it can simulate pathologic lesions. In some cases it leads to a darkened band along any dense prosthesis which can simulate loosening or infective changes.  
**Remedy:** images displaying this type of artifact can be reprocessed and do not have to be repeated.

7- Laser printer artifacts
**Cause:** A common laser printer artifact is caused by dirt on the polygon mirror that directs the laser across the film. This presents as a white line running perpendicular to the printer's laser scan lines. The appearance of this artifact is very similar to lines caused by dirt on the plate reader's light guide. To determine whether the artifact is caused by the laser in the printer or the laser in the plate reader, consider the orientation of the line with respect to the laser scanning direction. Alternatively, if the artifact is caused by the laser printer, it will not appear on the soft copy version of the image.

**Remedy:** the mirror should be cleaned.

Artifacts such as those described above can result in an image being repeated. An awareness of common artifact appearances can assist in finding a timely diagnosis and remedy. Minimizing the number of repeat images from artifacts will improve efficiency and reduce patient radiation dose.

**References:**


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