Artifacts in Digital Radiography (DDR & CR)

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1. Introduction of DDR & CR
2. Digital Radiography (DDR) System and Artifact
3. Computed Radiography (CR) System and Artifact
4. Laser Printer Artifact
Introduction of DDR & CR

-Dynamic range is the range of X-ray exposure over which a meaningful image can be obtained.

-Detective Quantum Efficiency (DQE) is the efficiency of a detector/IP in converting incident X-ray energy into an image signal.

-High DQE values indicates that less radiation is needed to achieve identical image.
Introduction of DDR & CR

- DR & CR have wider and linear dynamic range on Imaging Plate (IP) & detector, they can display both soft tissue and bone on one image due to difference in specific tissue absorption, decrease number of exposure if additional images is required
- Patient radiation dosage is reduced due to lower the number of exposures to fulfill different requests
- Lower the repeated rate due to overexposure or underexposure
Definition

Artifacts are any undesirable objects or structures recorded on the radiograph
1. Digital Radiography (DDR) System
2. Digital Radiography (DDR) Artifact
Direct Digital Radiography (DDR)

- Flat-panel detector (~70% cost of system)
- Photoconductor (most commonly is selenium) convert x-ray photons into electrical charges by setting electron free
- The dynamic range is wider than CR
- The DQE is higher than CR
Digital Radiography (DDR) System

1. Is a cassette-less system
2. Use a flat panel detector.
3. Detector provides direct digital output
4. No processor and reader required
5. Images available in below 10 seconds
6. Need new equipment installation

Note: But for the Carestream DRX wireless series, the flat panel detector such like a heavy cassette which can also use in the conventional system by a suitable accessory and DR system
Digital Radiography (DDR) System

For the image display
1. Unprocessed image as read from receptor
2. Not a readable diagnostic image
3. Requires computer processing before presentation as finished radiography
**Digital Radiography (DDR) System**

**Computer processing**
1. Establish location of collimated
2. Define anatomic region
3. A histogram is generated by dividing a scanned area into pixel and determining the signal for each pixel
4. Produce look-up table based on histogram from anatomical area
5. Final display image
**Noisy Detector Power supply**

Vertical lines, which are symmetrical around the center of the image, are caused by a noisy detector power supply.

Solution:
Replace power supply
Digital Radiography (DDR) Artifact

**Noisy Detector Power supply**

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Solution:
Replace power supply
Digital Radiography (DDR) Artifact

Tomo Bar Artifact

This artifact is caused by a bad pixel

Solution:
Perform detector bad pixel calibration to map out the bad pixel
Digital Radiography (DDR) Artifact

Fibre Optic Cable malfunction

Dots or vertical lines in the image can be caused by a bad optic cable.

Solution:
Replace fibre optic cable.
Digital Radiography (DDR) Artifact

Latent Image

Latent image which is caused by over exposure.

Solution:
Wait and the latent image will disappear.
Digital Radiography (DDR) Artifact

**Loose Cone**

Cone has fallen out of the x-ray tube port and is blocking the collimator from opening.

Solution:
Remove the collimator and re-attach the cone to the tube port
Bar code artifact

Bar code artifact can be caused by a failure in a data module or the detector.

Solution:
Perform bad pixel calibration, if calibration fail then replace detector.
Bar artifact

Bar artifact can be caused by a failure in a data module

Solution:
Replace detector
1. Computed Radiography (CR) system

2. Computed Radiography (CR) Artifact
Computed Radiography (CR) system

CR Imaging Plate (IP)

- Life is around 10000 exposures
- Very sensitive to scattered radiation
- The dynamic range is lower than DR
- The DQE is lower than DR
Computed Radiography (CR) system

- X-ray unit
- CR workstation
- Image plates
- CR reader
Computed Radiography (CR) system

Structure of the Imaging Plate
There have different layers for different function

Protective layer
- Insulates IP from handling trauma

Phosphor layer
- Holds the photostimulable phosphor (PSP)

Support layer made of polyester
- The base on which the other layers are coated

Conductor layer
- Grounds the IP eliminating electrostatic problems

Light shield layer
- Prevents light from erasing data on the IP
Computed Radiography (CR) system

Computed radiography Image acquisition

Image plate cycle:
1. When the exposure is taking, latent image will create in the image plate
2. CR reader will extract the latent image from the image plate
3. After readout the image, the image plate will erase the residual signal by the erasing light. And the plate can reuse again.
1. The cassette is opened in the CR reader with release of the imaging plate from the cassette
2. The image plate is moved by the rollers for scanning by the laser beam
3. The laser light stimulates the trapped electrons to become free and release of light photons
4. The light released from the imaging plate is collected by the fiber-optic light guide and strikes a photomultiplier tube (PMT) where it produces an electronic signal
5. The electronic signal is digitized and stored in a display monitor
6. The image plate is then exposed to a high-intensity halogen lamp which erases any residual energy remaining from a prior exposure
7. The image plate is returned to the cassette which is ready for reuse
CR artifacts are broadly classified into:
1. Image acquisition artifacts
2. Image processing artifacts
1. Image acquisition artifacts
Computed Radiography (CR) Artifact

1. **Image Acquisition Artifacts**
   1. Twin Artifacts (Double Exposure)
   2. Uncollimated Images
   3. Delayed Scanning
   4. Exposure Though the Back of the Cassette
   5. Inappropriate Exposure Factors
   6. Improper grid usage
   7. Scatter Radiation
   8. Care and Carelessness
   9. Light Bulb Effect
Postprocedure radiography of KUB with double-J stent shows two double-J stents (arrows) resulting from double exposure, one during inspiration and other during expiration.

Shetty C M et al. AJR 2011;196:W37-W47
Repeat radiography taken to reconfirm shows single double-J (arrows)

Shetty C M et al. AJR 2011;196:W37-W47
Image Acquisition Artifact

Twin artifact (Double Exposure)

Chest radiography show double exposure due to IP unloading
Twin artifacts (double exposure)

Causes
Two subsequent exposure on same imaging plate

Appearance
Duplication of images

Remedy
Proper knowledge of using of X-ray equipment
Uncollimated images

Uncollimated image resulting from lack of primary beam collimation. Radiograph of pelvis shows increased density over midportion and to right side of pelvis because of improper collimation.

Shetty c M et al. AJR 2011;196:W37-W47
Subsequent pelvis radiograph with proper collimation shows uniform density over pelvis.

Shetty C M et al. AJR 2011;196:W37-W47
Uncollimated images

Causes
Improper collimation

Appearance
Unsharp images

Remedy
Proper collimation in accordance with cassette size and body part
Delayed Scanning

Neck radiographs was subject to delayed readout (after 48 hours). It show decreased density in periphery as compared with center of images, as fading of image starts from periphery (arrows).

Shetty c M et al. AJR 2011;196:W37-W47
Abdomen radiographs were also subject to delayed readout. It shows decreased subject contrast.
Delayed scanning

**Causes**
Delayed between acquisition and processing of image

**Appearance**
Fading of image

**Remedy**
Proper knowledge of radiographers to check that no delay occurs between acquisition and processing.
Exposure through the Back of the Cassette

Radiograph of neck shows rounded radiopaque ring shadow (arrow) on the right lower part of the neck, which if overlooked, can be wrongly diagnosed as tracheostomy tube.

Shetty c M et al. AJR 2011;196:W37-W47
Exposure through the Back of the Cassette

This axillary shoulder was exposed through the back of a cassette. A different pattern to the prevision radiography because of different design of the cassette.

Exposure through back of cassette

**Causes**
Poor basic knowledge of construction of cassettes

**Appearance**
Various patterns of image according to cassette design

**Remedy**
Proper education of radiographers in handling of cassettes
Image Acquisition Artifacts

Inappropriate exposure factors
Overexposure

Radiograph of hands shows darkening of image that obscures image details. Artifact is result of overexposure. It over the latitude of the image plate.

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Overexposure

Causes
Improper exposure setting

Appearance
Darkening of image

Remedy
Proper exposure factors to be used based on body part and patient size
Inappropriate exposure factor
underexposure

Image shows underexposed grainy radiograph of KUB in which quantum mottle is evident and image quality is degraded.
Inappropriate exposure factor
Proper exposure

Control radiograph of same patient as in previous slide using proper exposure factors.

Shetty c M et al. AJR 2011;196:W37-W47
Inapropriate exposure factor
underexposure

Lumbar spine image shows underexposed in which very noise of the whole image and the diagnostic value also decrease.
Underexposure

**Causes**
Improper exposure setting

**Appearance**
Grainy image owing to quantum mottle

**Remedy**
Knowledge of dynamic range and its limitation in CR system
Improper Grid usage: Moire Pattern

Radiograph of pelvis shows wavy radiolucent lines, resulting in suboptimal image, that were caused by usage of grid with frequency of 33 lines/cm.

Shetty C M et al. AJR 2011;196:W37-W47

Moiré patterns can easily be caused by low frequency grids in a digital image, because of the very high contrast signal that the grid-strips project onto the detector.
The moire pattern seen in this knee image was caused by using a grid with a frequency of 33 lines/cm, which was oriented with the grid lines parallel to the plate reader's scan lines.

Improper grid usage

**Causes**
Usage of grids with low grid frequencies

**Appearance**
Different types of moire pattern

**Remedy**
Usage of grids with 60 lines/cm or more; grid lines should run perpendicular to plate reader’s laser scan lines
Scatter Radiation

Cassette was kept accidentally in radiograph with pen over it for some time. Radiograph of abdomen shows fading of image of pen overly lumbar spine.

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Scatter Radiation

No erasure of long storage Image plate. The image plate had put in the examination room for a long period without used.
Scatter radiation

**Causes**
Cassette placed in too close the primary beam or no erasure of long storage Image plate

**Appearance**
Deterioration of quality of image and imprints of objects placed over cassette.

**Remedy**
Protect cassette from any unwanted radiation and erase cassette before using
Kink artifact due to bucking of imaging plate. IVU radiograph shows curvilinear marks (arrows) adjacent to right upper and lower pole of right kidney, which can misdiagnose contrast extravasations. Other kink marks are seen in course of left ureter, which can be mistaken for calcified stone.
Care and carelessness

Causes
Mishandling of imaging plate during cleaning process

Appearance
Kink marks on the image

Remedy
Cassettes and image plates should be handled with care
Chest radiographs show darkening (arrows) in lower and outer portions of radiograph, obscuring details of image. Darkening occurs because of either high kV used in obese patients, scatter radiation or improper collimation.

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Image Acquisition Artifacts

**Light bulb effect**

The light bulb effect most occur in chest radiography for the obese patient

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Light bulb effect

**Causes**
High exposure, back scattered radiation entering imaging plate from patient’s bed due to increased exposure for obese patients or due to uncollimated x-ray

**Appearance**
Darkening of lower and outer portions of an image

**Remedy**
Reduce back scatter by lowering the KV or proper collimation.
2. Image Processing Artifacts
Image Processing Artifacts

**Hardware induced artifacts**

Image plate:
- Artifacts due to cracks on imaging plate
- Artifacts due to dust particles on imaging plate

Roller artifacts:
- Disparity artifact
- Damage of imaging plate due to rollers
- Dust over rollers
- Malfunctioning rollers

Plate reader artifact

Cassette-related artifact

**Software induced artifacts**

Image transmission errors
- Communication error artifact
- Data cable malfunctioning artifact

Artifact due to improper erasure setting
Hardware induced artifacts
Hardware Induced Artifacts

**Artifacts due to cracks on imaging plate**

Chest radiograph shows curvilinear opacity overlying left clavicle (arrow), which suggests cracks due to mechanical stress. Opacity can be misdiagnosed as parasitic calcification.

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Hardware Induced Artifacts

Artifacts due to cracks on imaging plate

Thumb radiograph showing cracks (white arrow) that usually first become visible on the IP edges. As deterioration progresses, cracks appear closer to the clinically used areas of the IP (black arrow).

In some instances, early cracking along the edge of the IP does not occur. This crack appears as a lucency near the radius, which could be confused with a foreign body.

Artifacts due to cracks on imaging plate

Causes
Damaged imaging plates during frequent transportation

Appearance
Cracks

Remedy
Change imaging plate
Hardware Induced Artifacts

Artifacts due to dust particles on image plate

Radiographs of right elbow joint show radiopacities (arrows) overlying soft tissues, which like soft-tissue calcification or foreign bodies but are actually due to dust over imaging plate.

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Hardware Induced Artifacts

Artifacts due to dust particles on image plate

left thigh show radiopacities (arrows) overlying soft tissues

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Artifacts due to dust particles on imaging plate

**Causes**
Dust particles wedged over imaging plate

**Appearance**
Focal radiopacities

**Remedy**
Regular cleaning of imaging plates with proper cleaner (ethyl alcohol). Paper towels or gauze should not be used because they leave fibers on the plate, the use of lint-free cloth is advisable.
Disparity artifact

This artifact occurs because of malfunction of roller in CR reader, causing defective scanning and resulting in alteration in image contrast (arrows) in upper and lower half of chest radiograph. Lower half of it was exposed to laser beam for longer time, which resulted in brighter image output that suboptimal image.
Disparity artifact

Causes
Malfunctioning of rollers in CR reader

Appearance
Defective scanning resulting in alteration in image contrast

Remedy
Periodic cleaning of roller in CR reader by the supplier
Damage of imaging plate due to rollers

Chest radiograph shows radiopacities (arrows) along right lateral chest wall. One can easily misdiagnose opacities as calcified granulomas in lung.
Damage of imaging plate due to rollers

**Causes**
Mechanical damaging of IP during transport through rollers

**Appearance**
Focal linear radiopacities

**Remedy**
Replace that part of roller
Hardware Induced Artifacts

Dust over rollers

Radiograph of pelvis shows horizontal radiopaque line (arrows) that can be traced outside margins of pelvis
Hardware Induced Artifacts

Dust over rollers

Chest radiograph shows multiple scattered radiopacities (white arrows) overlying soft tissues of left upper abdomen due to dirt over localized area on rollers. These can be misdiagnosed as soft-tissue calcification. There is another radiopacity (black arrow) look like a gallstone in right upper of the abdomen, which is actually caused by roller damage.

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Dust over rollers

**Causes**
Dust deposited over IP during transport through rollers

**Appearance**
Multiple localized radiopacities

**Remedy**
PM the CR reader periodically by the supplier
Hardware Induced Artifacts

Malfunctioning rollers

Anterior half of lateral skull radiograph is not visualized because slipping of feed rollers, resulting image being half read (black arrow). Radiopaque line (white arrow) is plate reader artifact resulting from dirt in the light guide.

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Malfunctioning rollers

**Causes**
Slipping of feed rollers from transport

**Appearance**
Half-read image

**Remedy**
Periodic cleaning and recalibration of feed rollers by the supplier
Plate reader artifact

The horizontal white line (arrow) shown on this chest radiograph was caused by dirt on the light guide in the plate reader. The light guide collects light emitted from the imaging plate when it is scanned by the laser.

Hardware Induced Artifacts

**Plate reader artifact**

Lateral knee radiograph shows horizontal thin radiopaque line (arrow) overlying supracondylar region. Artifact is attributed to dirt in light guide in CR reader.

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Hardware Induced Artifacts

Plate reader artifact

Lateral shoulder radiograph shows vertical thin radiopaque line (arrow) overlying scapular region.
Hardware Induced Artifacts

**Plate reader artifact**

Chest radiograph shows vertical radiopaque line (arrow) cross the right lung region. It is a common artifact occur in CR system.
Plate reader artifact

Causes
Dirt over light guide

Appearance
Linear radiopaque line

Remedy
Periodic cleaning of light guide by supplier. For the A&E shift, sometimes we have not enough time to wait the supplier technical staff to clean the light guide. We may do it by ourselves.
Cleaning CR reader

We can open the CR reader by open the lock (blue arrow) which below the display LCD of the CR reader. And then pull the door (red arrow) to each sides. We can see a metal wire (green arrow) in the lower part of the CR reader.
Plate reader artifact

Cleaning CR reader

We can pull the wire out and push it back for several times to reduce the dust particle. After that reset the CR reader.
The dark line along the lateral portion of this upper abdomen is caused by backscatter transmitted through the back of the cassette. The line corresponds to the cassette hinge where the lead coating was weakened or cracked.

Hardware Induced Artifacts

**Cassette related Artifact**
Vertical linear radiolucent line (white arrows) seen over head of first metacarpal simulates linear fracture (black arrow) unless traced beyond margins of bone. Artifact is cause by cracks in lead foil in the back of cassette.

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Cassette related artifact

**Causes**
Cracked or weakened lead coating on back of cassette

**Appearance**
Linear radiolucent line

**Remedy**
Replace of cassette
Software Induced Artifacts
Software Induced Artifacts

Communication error artifact

Lower part of radiograph (arrow) of knee joint was not visualized because of missing lines of pixels. Transmission of image was truncated because of sudden power failure.
Communication error artifact

**Causes**
Power failure during image transmission

**Appearance**
Missing line or pixels in resulting image

**Remedy**
Do not process the IP during electric supply check and the power supply should connect to essential socket
Software Induced Artifacts

Data cable malfunctioning artifact

Lateral view of lumbar spine radiograph shows alternating radiopaque and radiolucent line obscuring image detail. Problem was narrowed down to malfunctioning data cable in CR reader.

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Data cable malfunctioning artifact

**Causes**
Failure of data cables in the power unit of CR reader

**Appearance**
Alternating radiopaque and radiolucent lines

**Remedy**
Replace data cables
Software Induced Artifacts

Artifact due to improper erasure setting

KUB radiograph shows superimposed residual chest radiograph image, which is seen in form of ribs and clavicle shadows (black arrows). Also note two side marker (white arrows) in the radiograph. Artifact was due to improper erasure setting for the chest radiograph.

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Artifact due to improper erasure setting

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).
Artifact due to improper erasure setting

• Causes
  • Malfunctioning of the erasure light

• Appearance
  • Residual image is left in IP

• Remedy
  • Replace the erasure light
Dry Laser Printer Artifact

a. Common Artifact
b. Agfa printer system in QEH
c. Handling Method

Note: Although most hospitals are working in filmless, but for the some special cases e.g. Patient for OT. They also need to print film. So I also mention it.
Most common artifact of dry Laser Printer

The chest radiograph shows a radiopaque line in the central region, it is not the imaging plate artifact or plate reader artifact because the artifact only appear in the film, but not in the monitor image. And for the solve this artifact. We can clean the printer head of the printer which may has some dusts in the printer head.
Agfa dry Laser Printer

There has a side door (arrow) to open the printer.
Handling method

After open the door, we can see some rollers and the printer head (red arrow) in the lower portion of the printer. When there has printing artifact in the film. We can use a alcohol swab to clean the printer head. After cleaning reset the printer again.


