Learn to identify and remedy artifacts in Computed Radiography
Identify the sources of various types of artifacts in Computed Radiography images.

Orient on how they can be remediated.

MAH = Mount Auburn Hospital, Cambridge, MA
First, let’s see an example of an artifact: index patient 1.
Easy to tell – the opacity is outside of the patient.

Wait, what is this?

Easy to tell – the opacity is outside of the patient.
The patient was sent to the fluoroscopy room for evaluation and extraction of a possible foreign body located in the soft tissue anterior to the distal left tibia.
Fluoroscopy
There’s no foreign body. It was an artifact.
New x-ray taken after the fluoroscopy, with a different x-ray cassette.
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There’s no foreign body. It was an artifact.
Now let’s see another patient with a more serious case.
52 year-old woman who had just underwent a pelvic surgery.

After the surgery, there was a needle missing (incorrect needle count).

An x-ray was performed to check whether the needle had been forgotten inside the patient.

All information provided to the radiologist was: “Pelvic surgery. Incorrect needle count.”
The linear opacities in the previous slide do not have exactly the density we would expect from a metal object, but their shape and location (specially the pelvic opacity) raise enough suspicion.

If the opacity could not be confirmed to be an artifact, the patient would need to be re-operated, exposing her to more risk, and exposing the hospital and staff to malpractice litigation.
The attending radiologist then ordered **two new x-rays**, one of the abdomen, one of the pelvis, to re-evaluate for both linear opacities.
The linear opacity between the 11th and 10th rib has dissapeared. It was an artifact.
The linear opacity at the pelvis is still there. This greatly increases the likelihood of it being an actual needle.
Before telling you the end of this case, let’s talk about the technology called “Computed Radiography”.
Computed vs Digital
Computed VS Digital

**COMPUTED**
- Uses the same equipment used for film x-rays, except for the film, which is replaced by an imaging plate that can be erased and reused for several years.
- Has technical advantages over film radiography, as well as some extra possible pitfalls which must be properly watched for.

**DIGITAL**
- Fully digital: the x-rays are directly sensed by an electronic sensor.
- Technically, it is superior technology, achieving better images at lower radiation levels and with less dependency on the skills of the radiographer.
Computed VS Digital

**COMPUTED**

- The majority of hospitals do not have a portable digital x-ray, so computed radiography is the choice for whenever it is not possible to bring the patient into the x-ray room:
  - Patients unable to move or be moved.
  - Patients in the emergency room.

**DIGITAL**

- There is instant feedback from the sensors to the x-ray generator, so the machine is able to analyse the image and optimize the imaging parameters in real time. Because of this, better radiographs are obtained while exposing the patient to lower radiation levels.
Computed VS Digital

**COMPUTED**
- The image is delivered to the PACS after being read by the CR scanner.
- Is cheaper than digital radiography and its results are already good enough and better than conventional film.

**DIGITAL**
- The image is delivered to the PACS instantly.
- Is more expensive and its better results, in practice, are only of marginal benefit to either patients or radiologists.
Let’s learn how an image is obtained through Computed Radiography.
Computed Radiography workflow

1. **Image Acquisition**
   - X-Ray source
   - Patient

2. **CR Image Reader**
   - IP Cassette
   - Digitizer

3. **Image Display**
   - Display Monitor

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The cassette is the box which contains an imaging plate instead of a conventional film.

The imaging plate absorbs the x-rays and acquires a latent image. If you just look at the imaging plate, you won’t see anything.
After exposure to the x-rays, the operator brings the cassette to the CR scanner machine. Before doing that, it chooses the proper settings in the CR scanner for each image. Different body parts require different scanning settings.

The CR scanner machine opens the cassette and releases the imaging plate, which is rolled inside the machine by the rollers.
Inside the CR scanner (plate reader)
Inside the CR scanner

- The imaging plate is exposed to a laser beam, causing the plate’s electrons to release photons which the photomultiplier tube is capable of sensing.

- The light guide is similar in technology to an optic fiber cable and leads the photons from the imaging plate to the photomultiplier tube.
The photomultiplier tube is the actual sensor which produces an electric signal corresponding to the photons it receives. It can be imagined as a camera with only one pixel (do not confuse with “1 megapixel”).

In order to read millions of pixels from the imaging plate, a mirror redirects the laser beam in scan lines while the plate moves perpendicularly to those scan lines.
Inside the CR scanner

- The electric signals generated by the photomultiplier tube are electronically processed to a digital signal, which is then sent to the PACS – picture archiving and communications system.
Inside the CR scanner

- After the scanning is done, the CR scanner exposes the imaging plate to the light of an halogen lamp. This causes it to be erased.
  - Different types of x-rays require different exposures to the halogen lamp to ensure the image is completely erased. This is one of the reasons why the operator must configure the CR scanner according to what body part was x-rayed before inserting the cassette.
Inside the CR scanner

- Finally, the imaging plate is inserted back into the cassette and it CR scanner releases it for reuse.
Now let’s see some examples of artifacts in Computed Radiography and how they can be addressed.
Sources of artifacts

- The imaging plate
- The CR scanner (plate reader)
- Electronic processing of the image
- Operator errors
Perfectly straight linear opacity extending all through the image.

Perfectly straight linear opacity extending all through the image. – Dirt in the light guide.

Missing part of the image, but notice that the missing part does interact with the image itself (the dragged black shadow below). – Malfunctioning of the rollers.

Remedy:
Professionally service the CR reader.
Patterned opacities extending through most or all of the image – they are the imprinting of the shape of the back of the cassette, which was exposed to the x-rays from the back and not from the front.

Remedy: Ensure proper education of the radiographers.

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Delayed scanning

Remedy: Ensure plates are scanned as soon as possible after exposure.

In 8 hours, 25% of signals stored in the imaging plate are lost, but this does not mean that the image will be 25% less visible. In this example, the cassette was inserted in the CR scanner 48 hours after having been exposed to the x-rays.

Fading of the periphery of the image while the center seems adequately exposed.

The imaging plate is very sensible and will be affected by scattered radiation even if it is not directly under the source of x-rays. This image was taken from a cassette that was forgotten inside a room where x-rays were being performed. There was a pen over the cassette and its shape got imprinted on the imaging plate.

Scatter radiation

Remedy:
Erase the cassette and protect it from radiation.

Any cassette found to be lying unattended in an x-ray room should be erased before being used.

Two double-J stents are seen in the left kidney, because the imaging plate was exposed two times -- one during inspiration, another during expiration, making the kidney be at different heights at each exposure.

Confusing opacities are seen around the image. The imaging plate wasn’t properly erased between two uses. The problem can be easily identified by noticing there are two identification stamps in the image, one in the upper right corner, another in the lower middle.

**Improper erasure**

**Remedy:**
Correctly select the imaged body part before inserting the cassette in the CR reader, or replace the halogen bulb in the plate reader.

Damage to the imaging plate caused by the rollers

Remedy: Clean the rollers and replace the imaging plate.

Damaged areas on the imaging plate become opaque in the image. The alignment of the linear opacities allow you to identify the rollers as the cause of that damage to the imaging plate.

Dust on the rollers

Remedy:
Clean the rollers.

The scattered opacities easily mimic real findings and can be difficult to identify as artifacts. The opacity pointed by the black arrow could be a gallstone. A new x-ray, with a different cassette (and thus different imaging plate), should help identify the findings as artifacts.

Again, the scattered opacities might mimic real findings and can be difficult to identify as artifacts. A new x-ray, with a different cassette (and thus different imaging plate), should help identify the findings as artifacts.
Improper use of grid

Remedy:
Use grids with no less than 60 lines per cm, and positioned perpendicular to the plate reader’s scan lines.

Special grids are used to cover the cassette during exposure to increase the image sharpness by filtering scattered rays while allowing collimated rays to pass to the imaging plate. However, if the grid lines are parallel to the scan lines in the plate reader, and of lower density than the scan lines of the reader, the artifacts shown here can appear.

Damage to the lead foil in the back of the cassette

Remedy: Replace the cassette.

The back of the cassette is covered in lead foil to prevent scattered radiation from hitting the imaging plate from the back. If there is damage to that lead foil, the scattered radiation will enter and produce lucencies in the image.

In this example it is easy to tell the lucent lines are artifacts, but in other cases they might get misdiagnosed as fractures.

Inadequate image processing

Remedy:
Select special processing settings for images with wide dynamic ranges. Re-imaging might be necessary.

The prosthesis’ (metal) density is too high, making it difficult to see the interface between the prosthesis and the bones. Special processing settings may be able to compensate for that and provide visible detail in both prosthesis’ and bones’ density ranges.

Memory or transmission problems

Remedy: Professionally service the electronic equipments.

Notice that the artifacts seem to hold no relation to the image itself: the black stripes over the dark background are as black as the ones over the whiteness of the bones. This allows the identification of the electronic nature of the problem.
These are the most difficult to identify. The opacity over the scapula could be mistaken as a parasitic calcification. A new x-ray, with a different cassette and thus different imaging plate, should help identify the findings as artifacts.

Damage to the imaging plate

Remedy: Replace the imaging plate.

This time, the location of the artifact incidentally makes it easier to suspect it is an artifact. However, a new x-ray, with a different cassette and thus a different imaging plate, should be ordered for proper confirmation.

Can be misdiagnosed as extravasation of contrast at the right renal pelvis.

A new radiograph, using a different cassette and thus a different imaging plate, will help identify the opacities as artifacts. Physical buckles in the imaging plate are unrecoverable – the plate will need to be discarded.

Damage to the imaging plate

Remedy: Replace the imaging plate.
Now let’s go back to our index case.
“52 year old woman, pelvic surgery, incorrect needle count.”
This is already the second x-ray and the opacity is still there, in the same place.
The attending radiologist then ordered a third x-ray, but with the following requests:

1. Remove the cushioning from under the pelvis of the patient.
2. Use a new cassette that wasn’t used before.
3. Do not use any grid to cover the cassette.
The linear opacity has disappeared from the pelvis. It was an artifact. No re-operation is needed.
Thank you for your attention!

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Flamengo Park and Sugarloaf Mountain, Rio de Janeiro, Brazil
Image source: http://www.flickr.com/photos/luliweb/2362204197/
References


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Thanks to