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# Chest X-ray Taking Procedures Training for X-ray Technicians/ Radiographer

# "Computed Radiography"

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# Content

# Advantages of Digital Imaging Systems

| | | | |
|---|---|---|---|
| Fast image acquisition | Wide exposure latitude (better visualization of soft tissue and bone) | Fixed brightness and grey-scale that can't be adjusted | Short exposure time |
| Easy image storage | Ability to correct under or over exposure of film without having to repeat radiographs | Decreased radiation dose | Transmit images over an electronic network for remote consultation |

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# Digital Imaging

- Digital image is produced when the analog signal is sent through an analog-to-digital converter to convert information into numerical data.

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# "Two types of digital x-ray techniques"

1

**Computed Radiography (CR)**

2

Digital Radiography (DR)

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# Computed Radiography (PSP-based digital imaging system )

**"Computed Radiography"** is a digital image acquisition process that produces images that have much better contrast than a conventional film-screen system.

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# Components of Computed Radiography

## Photostimulable Storage Phosphor (PSP) Plate

- To acquire the x-ray projection image

## CR Reader

- To extract the electronic latent image

## Digital electronics

- To convert the signals to digital form

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# Components of Computed Radiography – Cont.

## CR Cassette

- Same conventional Radiography cassette
- Made of durable light weight plastic material
- Backed by a thin sheet of Aluminium that absorbs the x-ray
- Instead of Intensifying Screen inside, there is antistatic material that protects against static electricity build up, dust collection and mechanical damage to the plate

## The Reader

- No chemicals and dark room necessary
- Cassette is fed into reader
- Removes IP (imaging plate) and scans plate with the laser to release the stored energy

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# Components of Computed Radiography – Cont.

**PSP cassette and reader**

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# Imaging plate (IP) or storage phosphor plate

## It has several layers:

| | |
|---|---|
| 1. Protective layer | • Protects the phosphor layer |
| 2. Phosphor/ Active layer | • "Traps" electrons during exposure<br>• Made of Barium Fluorohalides with Eu (BaFBR 85%, BaFI - 15%) : Eu – europium |
| 3. Reflective layer | • Sends light in a forward direction when released in the cassette reader<br>• Is black to reduce the spread of stimulating light and the escape of emitted light |

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# Imaging plate (IP) or storage phosphor plate – Cont.

| | |
|---|---|
| 4. Conductive layer | • Absorbs and reduces static electricity |
| 5. Color layer | • Contains a color layer<br>• Located between the active layer and the support layer and absorbs the stimulating light but reflects emitted light |
| 6. Support layer | • Semi rigid material that gives the imaging sheet some strength |

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# Imaging plate (IP) or storage phosphor plate – Cont.

7.

Backing layer

- Is a soft polymer that protects the back of the cassette

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# Image Producing Steps

1

- Radiographer selects exposure factors

2

- After exposure of the CR plate, incident x-rays exposed onto the image receptor (storage phosphor plate - imaging plate (IP))

**IP plate coated with phosphor such as europium activated barium fluorohalide*

3

- The x-ray intensities are absorbed by the phosphor and the divalent europium atoms gets oxidised into trivalent atoms with release of electron in the valance band by the photoelectric effect

****electrons → >100 electrons released per x-ray photon***

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# Image Producing Steps – Cont.

4

band and then the radiation traps the electrons in the higher state at the F centers in the forbidden zone

** F center (also known as color or phosphor center)*

** The **trapped signal** will **remain** for **an hour** or even for one day*

***25% of the stored signal will be lost between 10 min and 8 hrs** after exposure resulting in the loss of energy through spontaneous*

5

- Higher state forms the latent image

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# Image Producing Steps – Cont.

6. • CR cassette is loaded into the reader

7. • Reader unit accepts the cassette and removes the IP so that it may be scanned with a helium neon laser beam (λ~700 nm)

8. • When Laser beam scans multiple times across the PSP using a rotational multifaceted mirror, F centre absorbs energy and transfers into the electrons

9. • The electrons in the conduction band move to the valance band and the electrons join with the trivalent erupium and are converted into the divalent europium

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# Image Producing Steps – Cont.

10

- The laser releases the electrons trapped in higher energy states and fall to lower energy states

11

- Electrons give up the blue green light (λ~300-500 nm)

**the emitted light intensity is proportional to the original incident X-ray intensity*

12

- Blue green light energy is detected by the fiber optic guide and amplified by a photomultiplier tube that collects the light energy and gives an electronic signal

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# Image Producing Steps – Cont.

13

- Electronic signal is digitized and stored in the memory

14

- The image is displayed onto the computer

15

- The image can be manipulated through various postprocessing steps: *Subtraction, Contrast enhancement, Edge enhancement, Black/white reversal*

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# "Various postprocessing steps"

i. *Subtraction:*
   - *Removal of superimposed or unwanted structures from the image*

ii. *Contrast enhancement:*
   - *Altering of image to display varying brightness*

iii. *Edge enhancement:*
   - *Improves visibility of small, high contrast areas*

iv. *Black/white reversal:*
   - *Reversal of the grey scale in the image*

**Postprocessing can compensate for overexposures or underexposures of considerable degree (−100% to +500%)*

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# Image Producing Steps – Cont.

16

- Image may be printed onto film using a laser camera

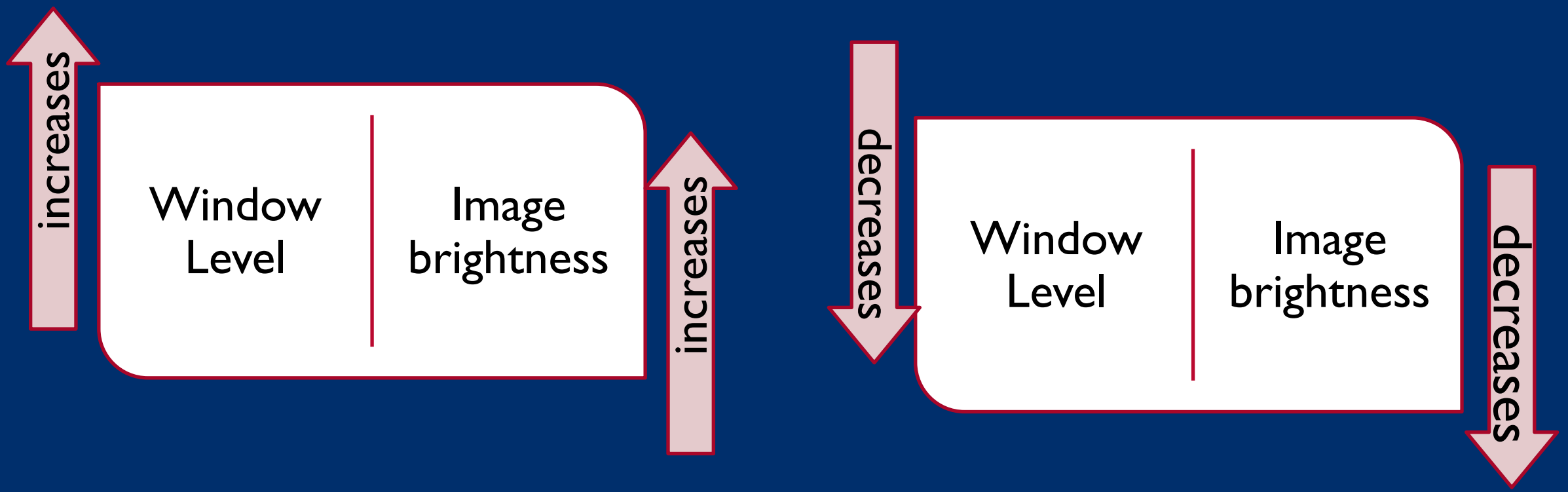
17

- The residual image is erased from the plate by an intense light source (white light) to return all electrons to their original state because the phosphor will not give up all trapped electrons in the first stage of laser light and some amount of trapped electrons may remain which may cause the ghost artefact

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# Post processing modes

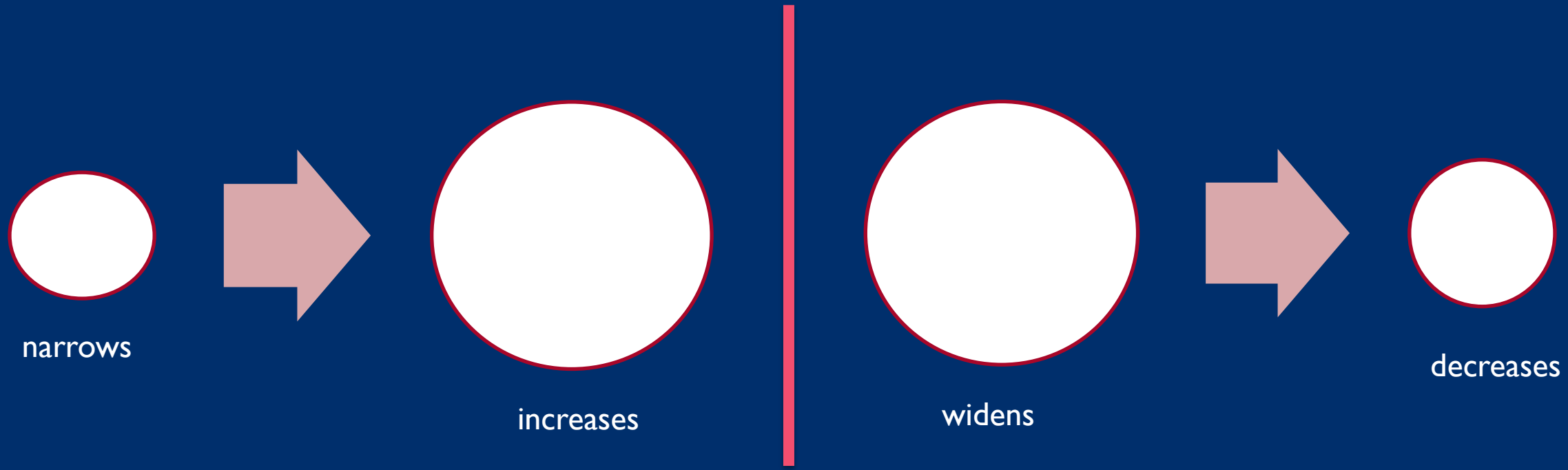
- Changing the window level (midpoint of densities) adjusts the image brightness (lighter or darker):




Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# Post processing modes – Cont.

- Changing the window width adjusts the radiographic contrast:




Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# Post processing modes – Cont.

Spatial frequency resolution:

- Level of detail or sharpness on the CR image
- Look-up table (LUT)
  - Histogram of pixel values from image acquisition that can be used to correct or enhance luminance values

**histogram (graphic display) is constructed to show the radiographer the distribution of pixel values (indicating low, proper, or high exposure)*

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# Factors Affecting Image Quality

## 1. Exposure Index (speed)

- The Exposure Index (EI) is a measure of the amount of exposure on the image receptor
- In screen-film radiography, if the image is under or overexposed it will be too bright or too dark
- In computed or digital radiography the image brightness is altered digitally

## 2. Latitude (dynamic range)

- Wide exposure latitude; range of exposure techniques that will result in an acceptable image
- Exhibit good visualization of soft tissue and bone

# Factors Affecting Image Quality – Cont.

## 3. Spatial resolution

Improved by

- Smaller diameter of readout laser beam (thinner line of image plate "read out“)
- Smaller pixel
- Smaller size of phosphor crystals
- Thinner phosphor layer
- No light reflection / absorption backing layer (as this produces scatter despite improving efficiency by using more of the photons for image production)
- Spatial resolution is best described by the modulation transfer function (MTF)

## 4. Detective Quantum Efficiency (DQE)

- The higher the DQE the more efficiently the detector can record information
  - 0.25 for a standard IP
  - 0.12 for high resolution IP

# Standard & High Resolution IP

| | Standard IP | High Resolution IP |
|---|---|---|
| **Layer of phosphor crystal** | Thicker layer | Thinner layer |
| **Crystal size** | Larger | Smaller |
| **Light reflection layer** | Yes | No |
| **Uses** | General radiographic examinations | High spatial resolution |
| **Fractional x-ray absorption efficiency** | 40% (good) | Lower i.e. need larger x-ray dose |

Reference: Christi E. Carter, Beth L.Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# Artifacts

| | Causes |
|---|---|
| Vertical or horizontal lines across the image | • Malfunctioning rollers in the CR plate reader |
| Wavy lines across the image | • A CR imaging plate that "stutters" or pauses while in the reader |
| Moiré pattern on the image | • Incorrectly oriented grids |

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# Artifacts – Cont.

| | Causes |
|---|---|
| "Ghosting" or "Image lag" (the appearance of anatomy image on the previous exposure) | • Inadequate erasure of an image receptor or incorrect erasure settings |
| Loss of information of the image (Artifacts related to software) | • Overprocessing the digital image<br>• Over compression of the image |
| Too light, too dark, or too noisy (Artifacts related to technical errors) | • Improper collimation<br>• Misalignment of the exposure field |

Reference: Christi E. Carter, Beth L. Vealé, Digital Radiography and PACS, 2nd Edition, 2014

# THANK YOU !