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

“Conventional Imaging”

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## Content

- X-ray Film
- Film Construction
- Types of Film Based on Their Application
- Film Artifacts
- Film Handling and Storage
- Intensifying Screen
- Factors Affecting Image Quality
- Film Cassette
- Film Processing
- Limitations
Film – Screen Radiography

• In film-screen radiography, a sheet of film with a light-sensitive emulsion on both sides is **sandwiched** between two intensifying screens

• In order to overcome the thicker screen, sandwiching the double-sided film between two screens serves to add the optical densities of the two emulsions together

Reference: John Ball, Tony Price, Chesney’s Radiographic
X-ray Film

Reference: John Ball, Tony Price, Chesney’s Radiographic
X-ray Film

• A media that makes a permanent record of the image
• To record the image on the film
• Images are stored as a latent image

Reference: John Ball, Tony Price, Chesney’s Radiographic
Film Construction

Reference: John Ball, Tony Price, Chesney’s Radiographic
Film Construction

1) Polyester plastic base:

- Support layer for fragile emulsion
- Must be clear, strong and consistent thickness (0.18 mm)
- Tinted pale blue or blue-gray (reduces eye strain)
- Coated on one or two sides with emulsion
  * single emulsion film (better detail)
  * double emulsion film (less detail)

Reference: John Ball, Tony Price, Chesney’s Radiographic
Film Construction – Cont.

2) Adhesive Layer

• To provide uniform surface over which the emulsion can be coated uniformly

3) Substratum layer

• To keep emulsion layer and base adhering to each other during the coating stage and processing

Reference: John Ball, Tony Price, Chesney’s Radiographic
4) Emulsion layer:

- Acts as photographic active layer
  * activated by light and radiation to create image
- Consists of a mixture of gelatin solution and silver halide crystal
  * typical emulsion consists of silver bromide (98%) and silver iodide (2%)
  * crystal size – 1.0 to 1.5 μ in diameter

Reference: John Ball, Tony Price, Chesney’s Radiographic Film Construction – Cont.
Film Construction – Cont.

Reference: John Ball, Tony Price, Chesney’s Radiographic
Film Construction – Cont.

“Latent Image Formation”

• Exposure of silver – iodo – bromide grains to light photons emitted by the screen

• Affects of grain size and distribution:
  • The bigger the average grain size, the higher the speed of the film
  • The more grain distribution, the lower the contrast
  • The bigger the crystal, the higher the graininess (clumping of the crystal)
  • Latent image is made visible by chemical processing

Reference: John Ball, Tony Price, Chesney’s Radiographic
Film Construction – Cont.

“White and Dark Appearance on Film”

• **Dark** – silver halide crystals exposed to photons
  *after processing, it turns to black metallic silver

• **White** – no crystals exposed
  *silver halide is wash away by processing

Reference: John Ball, Tony Price, Chesney’s Radiographic
Film Construction – Cont.

5) Supercoat

• To protect the layer of *gelatin*
• To reduce damage from scratches and pressure

**Gelatin**

• Used as a suspending medium and binding agent for the silver halide particles
• Can be easily spread on the film base when warm
• Firmly exists on the base as a gel when cool
• Flexible and does not crack easily on bending

Reference: John Ball, Tony Price, Chesney’s Radiographic
Types of Film based on their Application

Reference: John Ball, Tony Price, Chesney’s Radiographic
Types of Film based on their application

1) Screen Films:
   • Most commonly used
   • Sensitive to blue light emitted by intensifying screens and direct actions of x-rays
   • Used in cassettes with intensifying screens
   • High speed

Reference: John Ball, Tony Price, Chesney’s Radiographic
Types of Film based on their application – Cont.

2) Non-screen / Direct exposure films:
   • Has thicker coat of emulsion used without an intensifying screen
   • Depends mainly on action of x-ray
   • Four times faster than that of screen films
   • Must be manually processed because of thick emulsion
   • Uses:
     a) To detect intra-ocular foreign bodies
     b) In dental with intra-oral cardboard
Types of Film based on their application – Cont.

3) Mammography film:

- Single coated
- Designed to be used with single intensifying screen
- Combination must be fast to deliver minimum dose to the glandular tissue

Reference: John Ball, Tony Price, Chesney’s Radiographic
Types of Film based on their application – Cont.

4) Duplicating Film:

- Used to copy radiograph
- Original cassette to be copied is inserted into a cassette whose opaque front has been replaced by a pane of clear glass
- Special duplicating film is placed with emulsion side down onto the radiograph

Reference: John Ball, Tony Price, Chesney’s Radiographic
## Types of Film based on their application – Cont.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Single side</th>
<th>Double coated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation dose</td>
<td>Increased</td>
<td>Decreased</td>
</tr>
<tr>
<td>Detail</td>
<td>Increased</td>
<td>Decreased</td>
</tr>
<tr>
<td>Parallex effect</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Contrast</td>
<td>Decreased</td>
<td>Increased</td>
</tr>
</tbody>
</table>

Reference: John Ball, Tony Price, Chesney's Radiographic Types of Film based on their application – Cont.
Film Artifacts

Reference: John Ball, Tony Price, Chesney’s Radiographic
# I. Technical artifacts (caused by X-rays tube)

<table>
<thead>
<tr>
<th>No</th>
<th>Artifacts</th>
<th>Causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Over exposure</td>
<td>- High exposure factors</td>
<td>- Use optimum factors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- High exposure on fast speed screens</td>
<td>- Use film – screen combination</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Under exposure</td>
<td>- Low exposure factors</td>
<td>- Use optimum factors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Low exposure on slow speed screens</td>
<td>- Use film – screen combination</td>
</tr>
</tbody>
</table>

Reference: John Ball, Tony Price, Chesney’s Radiographic
## I. Technical artifacts (caused by X-rays tube) – Cont.

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<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Double exposure</td>
<td>- Single film is exposed twice</td>
<td>- Always separate exposed and unexposed cassettes</td>
</tr>
<tr>
<td>4</td>
<td>Film fog / noise</td>
<td>- Use of damaged cracked cassette</td>
<td>- Carefully use the cassette</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Replace the damaged cassette on time</td>
</tr>
</tbody>
</table>

Reference: John Ball, Tony Price, Chesney’s Radiographic
## I. Technical artifacts (caused by X-rays tube) – Cont.

<table>
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<th>No</th>
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<th>Causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Grid cut off effect</td>
<td>- Due to inaccurate position of patient on the table</td>
<td>- The patient’s midsagittal plane should be aligned with the mid axis of the table</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Grid is not completely inserted into the table</td>
<td>- Grid should be completely inserted into the table</td>
</tr>
</tbody>
</table>

Reference: John Ball, Tony Price, Chesney’s Radiographic
2. Positioning artifacts (caused by position of patient, cassette and tube)

<table>
<thead>
<tr>
<th>No</th>
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<th>Causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Image blurring</td>
<td>- Due to improper respiration</td>
<td>- Ask patient to practice inspiration, expiration and holding of breath</td>
</tr>
<tr>
<td>2</td>
<td>Marker effect</td>
<td>- Due to the use of wrong marker or side placement</td>
<td>- Use accurate markers and on the proper side</td>
</tr>
</tbody>
</table>

Reference: John Ball, Tony Price, Chesney’s Radiographic
2. Positioning artifacts (caused by position of patient, cassette and tube) – Cont.

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<tr>
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<th>Causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Movement unsharpness</td>
<td>- Due to patient movement during exposure</td>
<td>- Explain the procedure to the patient</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Use immobilization devices</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Reduce exposure</td>
</tr>
<tr>
<td>4</td>
<td>Metallic Artifact</td>
<td>- Presence of metallic object between tube and film</td>
<td>- Ask the patient to remove the radiopaque objects</td>
</tr>
</tbody>
</table>

Reference: John Ball, Tony Price, Chesney's Radiographic
### 3. Processing artifacts

<table>
<thead>
<tr>
<th>No</th>
<th>Artifacts</th>
<th>Causes</th>
<th>Remedy</th>
</tr>
</thead>
</table>
| 1  | Film fog    | - Damaged safe light  
- Accidental exposure of white light or any general light | - Check safe light periodically or within 15 days  
- Cassette should be closed  
- Door interlocked |
| 2  | Age fog     | - Use of expired film                                                  | - Always use film before the expiry date and check the date regularly                      |

Reference: John Ball, Tony Price, Chesney’s Radiographic
3. Processing artifacts – Cont.

<table>
<thead>
<tr>
<th>No</th>
<th>Artifacts</th>
<th>Causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age fog</td>
<td>- Storing of film in high temperature and high humidity conditions</td>
<td>- Air conditioner should be installed and check properly</td>
</tr>
<tr>
<td>3</td>
<td>Cresenteric effect</td>
<td>- Due to image of finger on film during handling</td>
<td>- Always handle the film carefully with the help of two fingers during loading and unloading</td>
</tr>
</tbody>
</table>

Reference: John Ball, Tony Price, Chesney’s Radiographic
### 3. Processing artifacts – Cont.

<table>
<thead>
<tr>
<th>No</th>
<th>Artifacts</th>
<th>Causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Stain effect (various colours may appear on film during processing</td>
<td>- Improper fixing</td>
<td>- Proper fixing</td>
</tr>
<tr>
<td></td>
<td>Brown colour stain</td>
<td>- Exhausted fixer</td>
<td>- Change fixer on time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Improper washing</td>
<td>- Proper washing</td>
</tr>
</tbody>
</table>

Reference: John Ball, Tony Price, Chesney’s Radiographic
### 3. Processing artifacts – Cont.

<table>
<thead>
<tr>
<th>Artifacts</th>
<th>Causes</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow colour stain</td>
<td>- Oxidized developer</td>
<td>- Developer tank should be covered and preservative added</td>
</tr>
<tr>
<td></td>
<td>- Use of old developer</td>
<td>- Change developer solution on time</td>
</tr>
<tr>
<td>Static elastic effect (stripe)</td>
<td>- Due to friction between two films</td>
<td>- Film should be handled properly and film box should be placed vertically</td>
</tr>
</tbody>
</table>

Reference: John Ball, Tony Price, Chesney’s Radiographic
Film Handling & Storage

Reference: John Ball, Tony Price, Chesney’s Radiographic
Film Handling

1. Do not flex
2. Hands must be clean
3. Film is sensitive to pressure, scratches, light, x-rays, heat, moisture, electricity and age

Reference: John Ball, Tony Price, Chesney's Radiographic Film Handling
Film Storage

1. Proper film storage is required for high quality and long-lasting images.

2. The location must be clean, dry and light tighten.

3. 40-60% humidity and 69°F or 10 – 24 °C temperature.

4. Avoid storing near chemical fumes which can fog the film.

5. Safe from radiation exposure.

Reference: John Ball, Tony Price, Chesney’s Radiographic
Film Storage

6. Expiration date clearly visible

7. Should be stored on edge (like books in a library)

8. Do not stack the film boxes horizontally because film in the bottom may show pressure artifacts

9. Always used older film first

Reference: John Ball, Tony Price, Chesney’s Radiographic Film Storage
Intensifying Screen

Reference: John Ball, Tony Price, Chesney's Radiographic
Intensifying Screen

• An image amplifier **converting the aerial image** which is relatively made of a few x-rays photons into many thousand times of light photons

• Converts incident **x-ray photons to visible light** which then exposes the silver halide emulsion on the film

• The image is formed **by processing the latent image** using dark room procedures

Reference: John Ball, Tony Price, Chesney's Radiographic
Intensifying Screen Construction

• Polyester plastic base – support layer
• Phosphor layer – active layer (X-rays photons converted to light photons) *Photoelectric effect
• Reflective layer – increases screen efficiency
• Protective coating

Reference: John Ball, Tony Price, Chesney’s Radiographic
Intensifying Screen Construction – Cont.

*Intensifying Screen Phosphor;*

1. Rare Earth phosphor (emits green light) *Standard*
   • most efficient and commonly used

2. Calcium Tungstate (emits blue light)
   • not efficient

Reference: John Ball, Tony Price, Chesney’s Radiographic
Intensifying Screen Construction – Cont.

1. Rare Earth Screen:

   - Higher DQE (detective quantum efficiency)
   - Higher x-rays absorption abilities
   - Higher CE (Conversion efficiency)
   - More light emitted per x-rays absorbed by the screen

*the percentage of x-rays absorbed by the screen
*the amount of light emitted for each x-rays absorbed

Reference: John Ball, Tony Price, Chesney’s Radiographic
Types of Intensifying Screen with different speed

<table>
<thead>
<tr>
<th>Screen</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>High resolution</td>
<td>Slow</td>
</tr>
<tr>
<td>Regular or Standard</td>
<td>Medium</td>
</tr>
<tr>
<td>Fast</td>
<td>Fast</td>
</tr>
</tbody>
</table>

Reference: John Ball, Tony Price, Chesney’s Radiographic
Types of Intensifying Screen with different speed

• Screen speed is defined as a relative number to demonstrate how efficiently x-rays are converted into useable light
  • Screen speed ranges from 100 (slow) to 1200 (fast)
  • Routine - 200 to 800, high detail – 50 to 100

Faster screen speed - reduces patient exposure
  Quantum mottle
  Image detail ↓
  Image noise (speckled background on the image)

Reference: John Ball, Tony Price, Chesney’s Radiographic
# Advantages and Disadvantages of Intensifying Screen

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>A screen can absorb 20 – 40 times more x-rays than film alone</td>
<td>Less detail than direct exposure</td>
</tr>
<tr>
<td>Reduced exposure</td>
<td>Formation of quantum mottle and unsharpness</td>
</tr>
<tr>
<td>Reduced patient dose</td>
<td>Reduced detail</td>
</tr>
<tr>
<td>Increased x – ray tube life</td>
<td>Maintenance of screen</td>
</tr>
</tbody>
</table>

Reference: John Ball, Tony Price, Chesney’s Radiographic
## Advantages and Disadvantages of Intensifying Screen – Cont.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contrast good</td>
<td>Screen artifact</td>
</tr>
<tr>
<td>Prevent motional lack of sharpness</td>
<td>-</td>
</tr>
<tr>
<td>Suitable for pediatric, geriatric and large body parts</td>
<td>-</td>
</tr>
<tr>
<td>Short developing time</td>
<td>-</td>
</tr>
</tbody>
</table>

Reference: John Ball, Tony Price, Chesney’s Radiographic
Factors Affecting Image Quality

Reference: John Ball, Tony Price, Chesney’s Radiographic
Factors affecting image quality

• Rare Earth screen should be used to be a good image quality.

• The use of intensifying screens lowers spatial resolution (good differentiation between two nearby objects) compared with direct-exposure radiographs

Reference: John Ball, Tony Price, Chesney’s Radiographic
Factors affecting image quality – Cont.

• Spatial Resolution:
  
  • The higher the lp/mm the smaller the object that can be imaged
    
    Very fast screens - 7 lp/mm
    
    Fine-detail screens - 10 lp/mm
    
    Direct-exposure screens - 50 lp/mm

  *Spatial resolution is expressed by the number of line pairs per millimeter (lp/mm)*

Reference: John Ball, Tony Price, Chesney’s Radiographic
Factors affecting image quality – Cont.

• Noise reduces the image contrast
  *caused by high kvp and fast screens used
• Artifacts (unwanted information in the image) reduces the image quality
  - Small scratches and dirty screen

Screens should be cleaned once each month with manufacturer’s cleaner with antistatic compounds

Reference: John Ball, Tony Price, Chesney’s Radiographic
Film Cassette

Reference: John Ball, Tony Price, Chesney's Radiographic
What is a Film Cassette?

“A film cassette is a container for exposed or unexposed film.”

Functions:

• To hold intensifying screen and protect them from damage
• To exclude all light from entering the cassette and fogging the film
• To maintain a close and uniform contact between the film and screens
• To exclude dust and dirt from the sensitive screens

Reference: John Ball, Tony Price, Chesney’s Radiographic
Care of cassette

- Do not scratch the surface
- Keep clean (use mild soap and water on a regular basis)
- Do not allow the screen to become wet
- Record the date of cleaning

Reference: John Ball, Tony Price, Chesney’s Radiographic
Care of cassette – Cont.

• Hold it gently and store in a standing position

• Do not store cassette near sources of heat

• Do not leave the cassette open

• Ensure the screen is fully dry before reloading the cassette
Cassette storage

- Upright and away from radiation
- Do not stack
- Should always be loaded and ready to use
- Avoid humidity and dust

*Number the cassettes so repeat problems can be easily identified*
Cassette

Front side

Back side
Film Processing

Reference: John Ball, Tony Price, Chesney’s Radiographic
Manual Film Processing:

• Involves the processing of the film by chemicals with the help of a person
• Latent image is converted into visible image in this process

• This process contains (5) steps:
  1) Developing  4) Washing
  2) Rinsing      5) Drying
  3) Fixing

Reference: John Ball, Tony Price, Chesney’s Radiographic
I. Developing

**Developing**

Is a chemical process in which the latent image is converted into a visible image.

To convert metallic silver into black metallic silver by reduction process.

Reference: John Ball, Tony Price, Chesney’s Radiographic
I. Developing – Cont.

• A developer solution contains:
  
  i. Solvent
  
  ii. Developing agent
  
  iii. Activator
  
  iv. Preservative
  
  v. Restrainer

Reference: John Ball, Tony Price, Chesney’s Radiographic
I. Developing – Cont.

i. Solvent

- Commonly used solvent is water
- The solvent dissolves chemicals and also aids ionization

ii. Developing agent

- Hydroquinone, phenidone and metol
- The purpose of developing agent is to convert exposed AgBr crystals to black metallic silver
- Hydroquinone is responsible for high contrast
- Metol responsible for grey shades

Reference: John Ball, Tony Price, Chesney’s Radiographic
I. Developing – Cont.

- Hydroquinone is always used in combination with metol to shorten the developing time
- Works more efficiently when the solution temperature is less than 20 degree Celsius

iii. Activator

- Commonly used hydroxide, sodium carbonate and sodium metaborate
- Used to open the pores of the film and allow the developing agent to do their work
- Optimum pH is range from 10 to 11

Reference: John Ball, Tony Price, Chesney’s Radiographic
I. Developing – Cont.

iv. Preservative

- Use sodium sulphate or potassium metabisulphite
- Decrease the rate of oxidation of hydroquinone (developing agent)
- Increases the life of the developer solution

v. Restrainer

- Use potassium bromide solution
- It is also called the anti fogging agent

Reference: John Ball, Tony Price, Chesney’s Radiographic
2. **Rinsing**

- When the x-ray film is removed from the developer, some chemicals remain on the film
- The film should be rinsed to remove these chemicals
- To stop the reaction of development of the developer and neutralization the basicity of the residual developer solution
- In a water bath, rinsing the film for **30 seconds**

Reference: John Ball, Tony Price, Chesney’s Radiographic
3. Fixing

• Is the process of removing the unexposed AgBr without damaging the image formed by metallic silver

• It also hardens the gelatin emulsion

• The optimum temperature is 18-24 degree Celsius

• Fixing time is one to four minutes

Reference: John Ball, Tony Price, Chesney's Radiographic
The fixing solution contains:

i. Solvent

ii. Acidifier

iii. Clearing agents

iv. Hardening agent

v. Preservative
3. Fixing – Cont.

i. Solvent
   • Water is normally used as solvent
   • Used to dissolve the chemicals

ii. Acidifier
   • Commonly use sulphuric or acetic acid
   • Neutralize the basicity of the residual developer which remains on the film
   • It also provides the suitable medium for the fixer and hardener to act

Reference: John Ball, Tony Price, Chesney’s Radiographic
3. Fixing – Cont.

iii. Clearing agents

• Commonly use sodium or ammonium thiosulphate salt
• Also acts as fixing agent

iv. Hardening agent

• Commonly used chemical is potassium Alum
• To hard the gelatin emulsion
• Decrease the physical injury of the film

Reference: John Ball, Tony Price, Chesney’s Radiographic
3. Fixing – Cont.

v. **Preservative**

- Commonly use chemical sodium sulphite
- Increase the life of the fixer solution
- **Protects** the fixing agent from *decomposition* (damage)
4. Washing

**Washing:**

- After fixing the film, the film must be washed with water.
- Washing *removes the residual* processing solution and fixing chemicals.
- If these chemicals are *not removed* the image will *discolor* and fade.
- Normally, x-ray film should be washed with *distilled water or tap water*.
- Washing time is normally about *20 min* at 20 degree Celsius.

Reference: John Ball, Tony Price, Chesney's Radiographic
Limitations

Reference: John Ball, Tony Price, Chesney’s Radiographic
Limitations in Conventional Radiography

- The radiographic speed is fixed and not possible to adjust patient dose
- Narrow exposure latitude (low visualization of soft tissue and bone)
- Fixed brightness and grey-scale that cannot be adjusted
- Many toxic chemicals are used

Reference: John Ball, Tony Price, Chesney’s Radiographic
Limitations in Conventional Radiography – Cont.

- High repeat exposure rate
- Imaging archiving is difficult
- Time intensive
- Increased radiation dose

Reference: John Ball, Tony Price, Chesney’s Radiographic
THANK YOU!