SAWA UNIVERSITY

CONVENTIONAL RADIOLOGICAL EQUIPMENT TECHNIQUES

Computed Radiography (CR) and Digital Radiography (DR)

جامعة ساوة

كلية التقنيات الصحية والطبية

قسم تقنيات الأشعة والسونار

المرحلة الثانية

اسم المحاضر: م. م. احمد عكاب شراد

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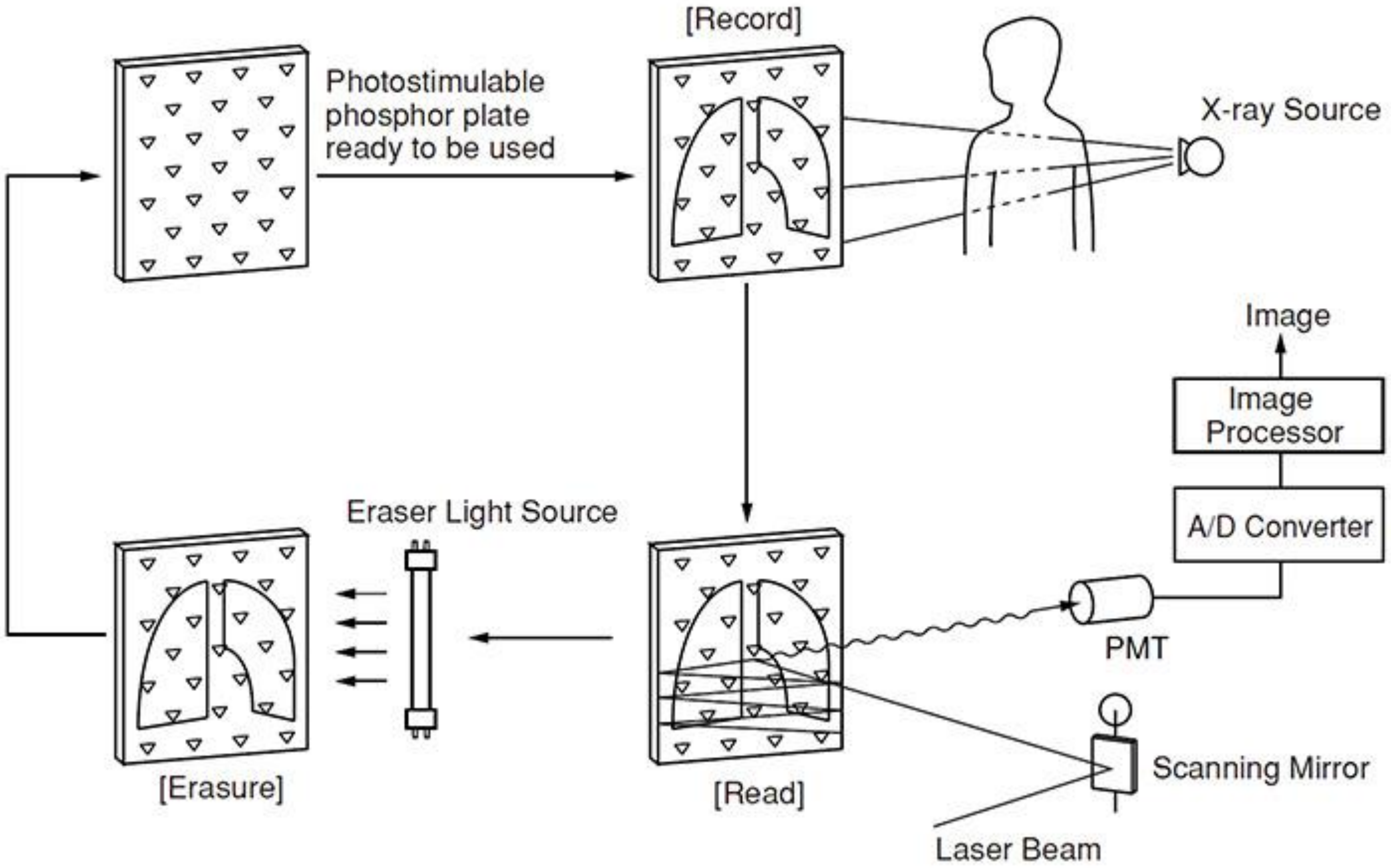
Computed Radiography (CR)

Computed radiography (CR) is a digital imaging technology used in medical radiology to capture and store X-ray images. It serves as a transition between traditional film-based radiography and fully digital systems. CR uses special imaging plates coated with photostimulable phosphors instead of conventional X-ray film.



System Apparatus

The system apparatus of computed radiography (CR) consists of several key components that work together to capture, process, and display X-ray images in digital form. The apparatus is designed to function as an integrated system, allowing for efficient and high-quality imaging without the use of traditional X-ray film.

1. X-ray Source (Input)

Purpose: Generates X-rays that penetrate the patient's body, allowing the internal structures to be imaged.

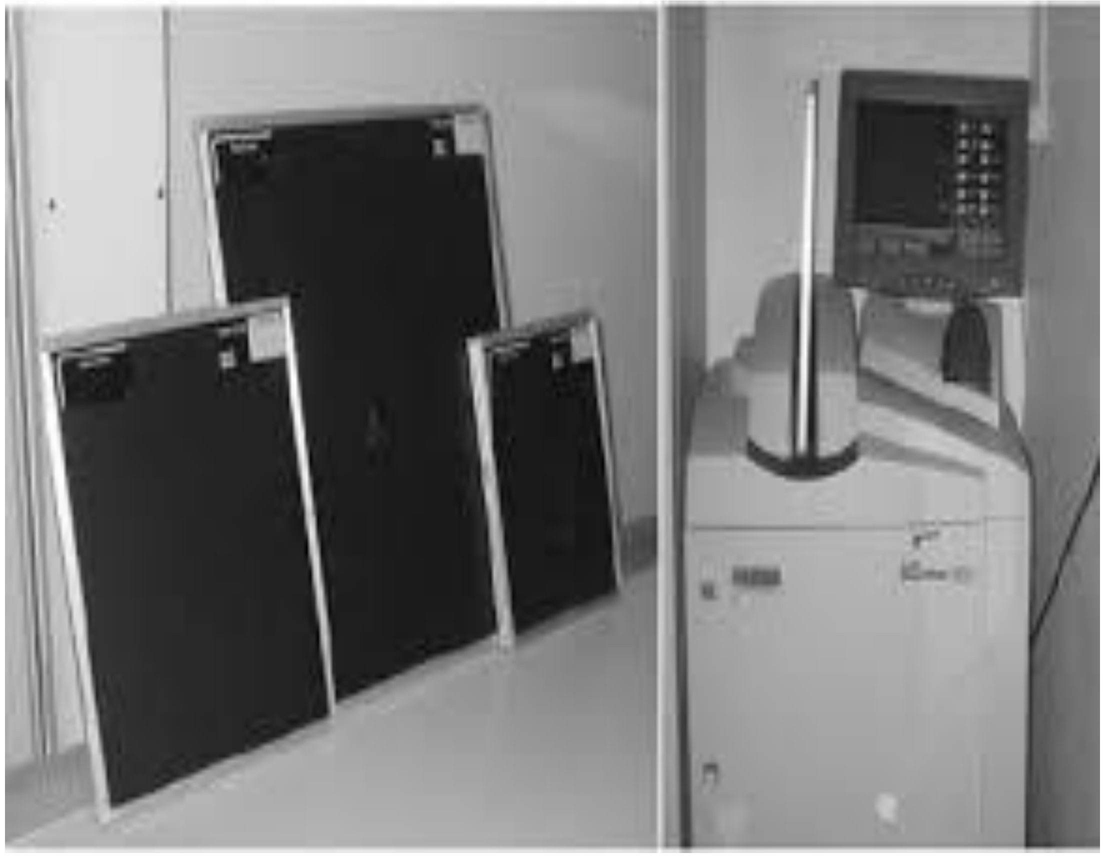
Operation: The X-rays pass through the patient's body and are absorbed by different tissues at varying rates, creating an image based on the absorption pattern.

2. Imaging Plate (Input Sensor)

Structure: A reusable plate coated with photostimulable phosphors (commonly barium fluorohalide compounds).

Function: The imaging plate is placed where traditional X-ray film would be used. It captures and stores the X-ray energy that passes through the patient as latent images.

Key Feature: Unlike traditional film, the imaging plate can be reused after it is "erased" by exposure to bright light.



3. Plate Reader (Processing Unit)

Laser Scanner: After the X-ray exposure, the imaging plate is inserted into the plate reader, where it is scanned by a laser beam.

Light Emission: The laser stimulates the phosphors on the plate, causing them to release the stored energy in the form of visible light.

Photodetector: This emitted light is captured by a photomultiplier tube (PMT) or a charged-coupled device (CCD), which converts the light into an electrical signal.

Analog-to-Digital Converter (ADC): The electrical signal is then digitized, transforming the analog image information into a digital format for further processing and manipulation.

4. Image Processing Software (Control Unit and Processing)

Image Enhancement: Once digitized, the image is processed using specialized software that adjusts parameters such as contrast, brightness, and sharpness for optimal diagnostic quality.

Noise Reduction and Filtering: The software can apply various algorithms to remove noise and artifacts that may obscure important details.

Measurement Tools: The software often includes measurement and annotation tools that assist radiologists in analyzing the image.

5. Digital Image Storage and Archiving (Output & Feedback)

Storage: The processed digital images are stored in a Picture Archiving and Communication System (PACS) or another digital storage system, where they can be accessed by radiologists and other healthcare providers.

Transmission: The images can be transmitted across networks for remote diagnosis or consultation (teleradiology).

Feedback: The radiologist or technician can review and adjust the image, if necessary, before final storage or printing.

6. Monitor or Display System (Output)

Display: The digital images are typically displayed on high-resolution medical-grade monitors, which allow radiologists to view and interpret the images with high accuracy.

Key Feature: These monitors often have features like grayscale calibration and high brightness levels to ensure image quality.

7. Printer (Optional Output)

Film Printing: Some systems are equipped with dry or laser printers that can produce hard copies of the digital images on film or paper for situations where a physical image is needed.

8. Erasure Unit (Recycling)

Purpose: After the image is captured and processed, the imaging plate is exposed to bright light to erase the stored image, making it ready for reuse.

Key Feature: The imaging plate can typically be reused thousands of times, reducing material costs and waste.

9. Power Supply (Support Unit)

Function: Provides the necessary electrical power to run the X-ray generator, plate reader, computer systems, and display units.

Key Feature: Reliable and consistent power is essential for maintaining image quality and system performance.

10. User Interface (Control and Feedback)

Control Panel or Workstation: Radiology technicians operate the system via a control interface, often located in a shielded room to avoid X-ray exposure.

Parameter Adjustment: This interface allows the technician to set exposure parameters (kVp, mAs), monitor system status, and review the images immediately after processing.

Summary of System Apparatus:

1. **Input:** X-ray source, patient positioning, imaging plate.
2. **Processing:** Plate reader with a laser scanner, photodetector, and ADC.
3. **Control:** Image processing software that enhances, stores, and transmits images.
4. **Output:** Digital display monitors or printers for viewing and interpreting images.
5. **Feedback:** Radiologist reviews and adjusts images, and the system recycles the imaging plate for future use.

Summary of Work Mechanism:

1. **X-ray Exposure:** X-rays pass through the patient and are absorbed by the imaging plate.
2. **Latent Image Formation:** Photostimulable phosphors in the plate store the energy from the X-rays.
3. **Laser Scanning:** The plate is scanned by a laser, releasing the stored energy as visible light.
4. **Light Detection:** A photodetector captures the emitted light and converts it to an electrical signal.
5. **ADC Conversion:** The analog signal is digitized into a digital image.
6. **Image Processing:** The digital image is enhanced for optimal viewing.
7. **Image Display:** The image is displayed on a monitor for analysis.
8. **Plate Erasure:** The imaging plate is erased for reuse.
9. **Image Storage/Transmission:** The digital image is stored in a PACS or transmitted for remote diagnosis.

Advantages of Computed Radiography

1. **Cost Efficiency:** CR systems are typically less expensive than DR systems and can be integrated with existing X-ray equipment.
2. **Reusability:** The PSP plates are reusable, reducing the cost of consumables.
3. **Better Workflow:** Digital images are easier to store, retrieve, and share compared to film-based systems.
4. **Improved Image Quality:** The ability to enhance images digitally allows for better diagnostic precision.

Disadvantages of Computed Radiography

1. **Slower Process:** CR requires the extra step of scanning the imaging plate, making it slower than DDR (Digital Radiography), where images are generated instantly.
2. **Lower Spatial Resolution:** CR typically provides lower spatial resolution compared to DR systems.
3. **Plate Handling:** The PSP plate must be manually transported to the plate reader after exposure, adding complexity and time to the imaging process.

Titles only

Direct to Digital Radiography (DDR)

also known as Digital Radiography (DR), is an advanced form of X-ray imaging where detectors directly capture data and convert it into digital images, bypassing the need for intermediate steps like those used in Computed Radiography (CR). Unlike CR, which uses an imaging plate and requires a plate reader to digitize the image, DDR captures the X-ray image directly on a flat-panel detector, allowing for immediate image processing and display.

How DDR Works:

1- X-ray Exposure (Input)

Process: Similar to other X-ray systems, the patient is positioned between the X-ray source and the DDR detector. The X-ray generator produces a controlled X-ray beam that passes through the patient, where different tissues absorb the X-rays at different rates, depending on their density (e.g., bone, soft tissue, air).

2- Flat-Panel Detector (Direct Capture)

Process: The X-ray photons are captured directly by a flat-panel detector.

Types of Detectors

1. Direct Detectors:

These detectors use materials like amorphous selenium (a-Se) to directly convert X-ray photons into electrical charges.The electrical charges are then collected and converted into a digital image without the need for intermediate steps like light emission.

2. Indirect Detectors:

In indirect detectors, the X-rays first interact with a scintillator layer (made from materials like cesium iodide or gadolinium oxysulfide), which converts the X-ray photons into visible light.The light is then captured by a photodiode or CCD (charged-coupled device), and the light signal is converted into electrical charges and further processed into a digital image.

3. Analog-to-Digital Conversion (ADC)

Process: The flat-panel detector converts the electrical charges generated by the captured X-rays (either directly or indirectly) into a digital signal.

Mechanism: This conversion is done by an analog-to-digital converter (ADC), which transforms the analog electrical signals into digital pixel values. Each pixel represents a specific level of X-ray exposure, resulting in a detailed image of the internal structures.

4. Real-Time Image Processing (Control Unit)

Process: The digital image is immediately processed by software, optimizing the image quality for diagnostic purposes.

Mechanism:

Automatic Optimization: The software adjusts brightness, contrast, sharpness, and noise reduction in real-time.

Custom Adjustments: Radiologists or technicians can manually enhance the image using the system interface, allowing for fine-tuning of specific areas of interest (e.g., improving visibility of bones or soft tissue).

5- Instant Display of Images (Output)Process:

The digital image is displayed instantly on a medical-grade monitor for immediate interpretation.

Mechanism: This instantaneous feedback allows for quick verification of the quality of the X-ray, reducing the need for repeat exposures and improving patient throughput.

6- Image Storage and Transmission

Process: Once captured and processed, the image is stored digitally in a Picture Archiving and Communication System (PACS).

Mechanism: The images can be transmitted across networks for teleradiology (remote diagnosis), stored for future reference, or sent directly to radiologists for immediate diagnosis.

Summary of Work Mechanism of DDR

1. **X-ray exposure** is directly captured by a flat-panel detector.
2. **Direct or indirect conversion** turns X-ray photons into electrical charges.
3. **ADC** digitizes the electrical charges into pixel values.
4. **Image processing** optimizes the image in real-time.
5. **Instant display** of the digital image allows immediate analysis.
6. **Images are stored** in PACS for future access or transmitted for remote consultation.

Advantages of Direct Digital Radiography (DDR)

1. **Faster Image Acquisition:** Since the image is captured directly and processed in real-time, DDR provides almost instantaneous images, significantly reducing the time between exposure and diagnosis.
2. **Higher Image Quality:** DDR offers superior spatial resolution and contrast compared to traditional CR, as it eliminates intermediate steps like laser scanning and light conversion. This improves diagnostic accuracy, especially for detailed anatomy like small bones and soft tissue.

3. Lower Radiation Dose: DDR systems are often more sensitive to X-rays, meaning they require a lower dose of radiation to produce high-quality images. This reduces the patient's exposure to ionizing radiation.

4. Increased Efficiency: Instant image availability reduces the need for retakes and improves the workflow, leading to higher patient throughput in clinical settings.

Disadvantages of DDR

1. **Higher Initial Cost:** DDR systems are typically more expensive to install compared to CR systems, as they require specialized flat-panel detectors and associated equipment.
2. **Limited Detector Lifespan:** Over time, the flat-panel detectors may degrade, leading to increased maintenance and potential replacement costs.
3. **Immobile Detectors:** While CR systems allow more portability due to the use of imaging plates, DDR detectors are often built into fixed systems, limiting their flexibility in certain clinical settings (e.g., mobile or bedside imaging).

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