RADT-2640: PHYSICS OF MAMMOGRAPHY

Cuyahoga Community College

Viewing: RADT-2640 : Physics of Mammography

Board of Trustees:
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Academic Term:
Fall 2023

Subject Code
RADT - Radiography

Course Number:
2640

Title:
Physics of Mammography

Catalog Description:
Study of physics of mammography, including instrumentation equipment, digital mammography, and the factors affecting the images and picture archiving and communications system (PACS).

Credit Hour(s):
1

Lecture Hour(s):
1

Requisites

Prerequisite and Corequisite
Departmental approval: admission to Mammography program.

Outcomes

Course Outcome(s):
Describe the components, specification and use of various mammographic units.

Essential Learning Outcome Mapping:
Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

a. Label the components of the mammographic unit.
b. Properly operate mammography equipment including the demonstration of the correct use of compression devices, filtration devices, the magnification setup, use of grids and automatic exposure controls.
c. Label the components of the dedicated mammography tube.
d. State the specifications of the various components in a mammography unit (half-value layer, focal spot size, source-to-image distance and the minimum requirements based on MQSA guidelines).
e. Explain the significance of target/filter combinations.
f. Define heel effect.
g. Describe the geometry and purpose of the mammography primary beam.
h. Define reciprocity law failure.
i. Differentiate between the various types of x-ray generators used in mammography.

Course Outcome(s):
Explore digital mammography.

Essential Learning Outcome Mapping:

Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

a. Define digital mammography to include digital breast tomosynthesis (DBT).
b. Discuss image processing and the effect it has on digital mammography images.
c. Explain the additional functions available with digital imaging: measuring the area of interest, filtration of image, magnification, contrast, density and subtraction of image.
d. Define compression, its usefulness and minimum and maximum requirements based on MQSA guidelines.
e. State the purpose of magnification.
f. Accessorize equipment according to the procedure being performed.
g. Set appropriate kilovoltage peak (kVp), milliamperage (mA) and time or automatic exposure control (AEC) and the correct position of the photosensor.
h. Process digital images if available.

Course Outcome(s):

Discuss the importance of the picture archiving and communications system (PACS).

Essential Learning Outcome Mapping:

Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

a. Describe a picture archiving and communications system (PACS) and its function.
b. Identify components of a PACS.
c. Identify modality types that may be incorporated into a PACS.
d. Define accession number.
e. Describe worklist and correct use.
f. Define digital imaging and communications in medicine (DICOM).
g. Describe data flow for a DICOM image from an imaging modality to a PACS.
h. Identify common problems associated with retrieving/viewing images within a PACS.
i. Identify the primary uses of the diagnostic display workstation.
j. Produce hard copies of digital images if available.
k. Discuss the image storage and viewing capabilities related to digital mammography.

Course Outcome(s):

Recognize factors that govern and influence the production and recording of mammographic images.

Essential Learning Outcome Mapping:

Not Applicable: No Essential Learning Outcomes mapped. This course does not require application-level assignments that demonstrate mastery in any of the Essential Learning Outcomes.

Objective(s):

a. Perceive the purpose for AEC and relate it to an automatic kVp system.
b. Describe how kVp, mA, time and compression affect the mammographic image.
c. Identify the maximum permissible dose per mammography exam based on MQSA standards.
d. Identify the average dose per mammographic exposure.
e. Describe how kVp, mA, time and compression affect the radiation dose to the patient.
f. Select the correct technical variable based on variations in breast anatomy.
g. Identify imaging artifacts on digital mammography images.

Methods of Evaluation:

a. Participation and discussion
b. Written assignments
c. Case studies
d. Exams
e. Quizzes
f. Other methods deemed appropriate by department

Course Content Outline:

a. Dedicated Mammography Equipment
    i. C-arm x-ray tube stand
    ii. Mammography tube
        1. Rotating vs. stationary anodes
        2. Tube design
            a. Tube configuration
            b. Anode configuration
            c. Biangular targets
        3. Focal spot
            a. Standard sizes
            b. Magnification size
            c. Effective target angle
            d. Reference axis target angle
            e. Bias focusing
        4. Target materials
            a. Molybdenum
            b. Specialized tungsten
            c. Rhodium
            d. Dual targets (e.g. tungsten, rhodium, molybdenum choice)
    iii. Filtration
        1. Exit window filtration
            a. Glass
            b. Beryllium
        2. Tube filtration
            a. Molybdenum
            b. Rhodium
            c. Aluminum
            d. Silver
    iv. Beam geometry
        1. Primary beam
            a. Central ray geometry
            b. Reference axis
            c. Photon energies
        2. Heel effect
            a. Effects on intensity
            b. Effects on apparent focal spot size
        3. Beam limiting devices
            a. Purpose
            b. Collimation
                i. Three-sided
        4. Source-to-image distance (SID)
        5. Object-to-image distance (OID)
            a. Effects on dose
            b. Effects on contrast
    v. Generator
        1. Types
            a. Three-phase
            b. High-frequency
            c. Constant potential
        2. Homogenous x-ray beam

3. Ripple factor
4. Tube capacity (mA output)

vi. Automatic exposure control (AEC)
1. Purpose
2. Types
a. Ionization chamber
b. Solid state
c. Functions
d. Design
e. Placement in system

vii. Grids
1. Types
a. Reciprocating
b. Stationary
2. Ratio
3. Design
a. Conventional
b. Honeycomb

viii. Magnification
1. Purpose
2. Focal spot size
3. Air gap technique
4. Effect of dose
5. Magnification factor

b. Digital Mammography
i. Type of detectors
1. Photostimulable phosphor (PSP) technology
2. Flat panel detectors
a. Direct
b. Indirect
3. Photon counting technology

ii. Digital technology
1. Charged coupled device (CCD)
2. Matrix/pixels
3. Field sizes
4. Resolution
5. Optical density vs. noise ratio-signal to noise ratio (SNR)
6. Contrast to noise ratio (CNR)

iii. Approaches of digital mammography
1. Single-exposure approach
2. Multiple-exposure approach

iv. Pre- and post-processing of the digital image

v. Advantages
1. Radiation dose reductions
2. Image enhancement
3. Time
4. Telemammography
5. Productivity

vi. Other aspects of digital technology
1. Expense
2. Additional equipment
a. Review workstation
b. PACS
c. Laser printer
d. Computer-aided detection (CAD)
3. Connectivity
4. Compatibility
5. Computer literacy of the technologist

c. PACS

i. Terminology
ii. System components and function
iii. Digital communications
    1. Digital imaging and communications in medicine (DICOM)
        a. Components of a DICOM record
        b. DICOM conformance statements
        c. DICOM coded terminology pertinent to digital mammography
    2. HIS, RIS, EMR and HL7
iv. Telemammography
v. Lossy and lossless compression
vi. Mammographer
    1. Access work order (worklist)
    2. Postprocessing-image manipulation
    3. Annotation issues
    4. Transmitting images to PACS
    5. Health Insurance Portability and Accountability Act (HIPAA)
    6. Workflow
    7. Processing other vendor (OV) images
vii. Image output
    1. Retention
    2. Transfer of images
        a. Final interpretation quality
            i. Laser images
            ii. CD

d. Technical Variables
i. Density
ii. Contrast
iii. kVp
    1. Range
    2. Rationale
    3. Effect on image quality
    4. Relationship to exposure time/reciprocity law failure and optimum optical density
    5. Effect on contrast
    6. Effect on digital images
iv. Milliamperage-Seconds (mAs)
    1. Range
    2. Relationship to mR
    3. Relationship to exposure time/reciprocity law failure
    4. Effect on density
    5. Effect on digital images
v. Compression
    1. Density
    2. Contrast
    3. Detail
    4. Radiation dose
vi. Automatic exposure control (AEC)
    1. Definition
    2. Effect of kVp
    3. Effect of consistent image quality
    4. Backup timing
    5. Photocell placement
    6. Tracking
    7. Reproducibility
    8. MQSA requirements
vii. Manual technique
    1. Uses
viii. Density setting
ix. Tube/filter combination
x. Half-value layer (HVL)

1. Heterogeneous and homogeneous radiation
2. MQSA requirments

xi. Reciprocity law failure
1. Definition
2. Correlation to generator type and mR/mAs
3. Correlation to exposure time
4. Correlation to digital imaging

e. Exposure Range -Standard Deviation
i. Collimation
1. Purpose and importance
2. Field size
3. MQSA requirements

ii. Artifacts
iii. Laser imaging systems

f. Introduction to Digital Breast Tomosynthesis
i. Physics principles trade offs
ii. Design features
1. Tube motion
2. Target material

iii. What is DBT
1. Images acquired
2. Single DBT view
3. Combo mode
4. Dose
5. Reconstructions
6. Projections
7. Slices

Resources

American College of Radiology (ACR). ACR Mammography Manual. Reston, VA.

American Registry of Radiologic Technologists (ARRT). (Current) Content Specifications for Mammography. St. Paul, MN. https://www.arrt.org/docs/default-source/discipline-documents/mammography/mammography-content-specifications.pdf?sfvrsn=8a6303fc_8

American Society of Radiologic Technologists (ASRT). (Current) *Mammography Curriculum*, Albuquerque, NM. https://www.asrt.org/docs/default-source/educators/curriculum/mammography/2018-adopted-mammography-curriculum.pdf

Cardenosa, Gilda. (2017) *Breast Imaging Companion*, Philadelphia: Wolters-Kluwer.

Lille, Shelly. Marshall, Wendy. (2019) *Mammographic Imaging--A Practical Guide*, Philadelphia: Wolters-Kluwer.

Peart, Olive. (2022) *Lange Q and A: Mammography Imaging-A Practical Guide*, New York: McGraw Hill.

Peart, Olive. (2022) *Mammography and Imaging Prep: Program Review and Exam Prep*, New York: McGraw-Hill.

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