RADT-2401: IMAGING SYSTEMS

Cuyahoga Community College

Viewing: RADT-2401 : Imaging Systems

Board of Trustees:
May 2023

Academic Term:
Fall 2023

Subject Code
RADT - Radiography

Course Number:
2401

Title:
Imaging Systems

Catalog Description:
Presentation of imaging systems and imaging modalities. Topics include conventional and digital fluoroscopy, image intensification, computerized tomography, magnetic resonance imaging, mammography, bone densitometry, sonography, nuclear medicine, radiation therapy and cross-sectional anatomy.

Credit Hour(s):
2

Lecture Hour(s):
2

Requisites

Prerequisite and Corequisite
RADT-1351 Image Acquisition and Evaluation or concurrent enrollment; or departmental approval.

Outcomes

Course Outcome(s):
Explain the principles and application of Conventional and Digital Fluoroscopy/Recording Systems.

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. Differentiate fluoroscopic examinations from static diagnostic radiographic examinations.
b. Summarize the uses of dynamic and static fluoroscopic recording systems.
c. Explain the general purpose and functioning of image-intensified and digital fluoroscopy.
d. Explain the advantages of a digital flouroscopy system and flat panel image receptors (FPIR).
e. Explain pixel size in digital flouroscopy.
f. Calculate flux gain, minification gain and brightness gain as they relate to image intensification.
g. Identify basic anatomy and structures seen on fluoroscopic images.
h. Describe human vision anatomy and physiology and its significance to fluoroscopy.
i. Recognize appropriate approximate kVp and mA techniques for fluoroscopic examinations.
j. Identify reasoning for using contrast media.
k. Apply general radiation safety and protection practices associated with radiographic and fluoroscopic examinations.
l. Describe a typical basic fluoroscopic image chain.
m. Apply various methods of reducing radiation dose to the patient, radiographer and radiologist during fluoroscopic examinations.
n. Explain how the TV monitor can affect the spatial resolution and image display.
o. Identify the minimum source-to-tabletop distances for fixed and mobile fluoroscopic devices.

p. Describe different post-processing fluoroscopic techniques such as digital subtraction, masking and road mapping.
q. Explain the difference between the operation of a fluoroscopic and a diagnostic x-ray tube.
r. Describe the advantages of image intensified fluoroscopy over conventional fluoroscopy.
s. Analyze the functions of the image intensification tube including the input phosphor, photocathode, electrostatic focusing lenses anode and output phosphor.
t. Summarize the operation of a multifield magnification image intensification tube.
u. Explain the basic function of a fluoroscopic automatic brightness control (ABC) or automatic exposure control (AEC).
v. Discuss the factors that affect fluoroscopic image contrast, resolution, distortion, veiling glare and quantum mottle.
w. Indicate the function of Charged Coupling Devices (CCD), lens coupling, fiber optics, video camera, photospot and the TV monitor.

Course Outcome(s):

Explain the principles and application of Computerized Tomography (CT).

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. Name the individual who first demonstrated the process of CT.
b. Describe the components and functions of a CT imaging system.
c. List the CT computer data processing steps.
d. Identify the types and appearances of artifacts most commonly affecting CT images.
e. Explain the types and function of collimators in CT.
f. Describe the differences between conventional CT and helical (spiral) CT.
g. Analyze the changes seen between CT generations and state their advantages.
h. Explain CT system components and their functions including the gantry, table, computer and image detectors.
i. Define algorithm and explain its impact on scan factors and reconstruction.
j. Describe characteristics that detectors must have including stability, dynamic range and response time.
k. Define CT-based terminology including pixel, voxel, matrix, CT Hounsfield, widow width (ww), window level (wl), spatial resolution, contrast resolution, noise, pitch, slip ring technology, region of interest (ROI), raw data, image data, linear attenuation coefficient, partial volume averaging and annotation.
l. Explain the difference between reconstructing and reformatting an image and define array processing used for image reconstruction.
m. Discuss detector configurations and functions.
n. Describe and explain the common controls on the CT operator console.
o. Discuss radiation protection principles for CT to include technical factor selection and adjustment, immobilization devices and dose measurement units (CTDI, MSAD and DLP).
p. Discuss image quality as it relates to spatial resolution, contrast resolution, system noise, linearity and spatial uniformity.
q. Describe the general purpose of commonly performed CT studies and the importance of patient preparation for the administration of contrast media and understanding of possible risk factors.
r. Explain how artifacts can be reduced or eliminated.
s. Discuss general radiation safety and protection practices associated with CT examinations.
t. Identify basic anatomy and structures seen on a CT image.
u. Explain how a CT scanner generates and displays images in different imaging planes.
v. Summarize CT image characteristics and CT numeric values.
w. Describe how typical CT mA and kVp techniques affect estimated patient dose measured in Computed Tomographic Dose Index (CTDI) and Multiple Scan Average Dose (MSAD).
x. Identify different CT grids and their effect on the image.
y. Explain the diagnostic advantages of CT over diagnostic radiography and summarize advantages and disadvantages of CT imaging.

Course Outcome(s):

Explain the principles and application of Magnetic Resonance Imaging (MRI).

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 the source of the magnetic fields within the body that are used during MRI.
b. Describe the properties of proton precession as used in MRI.
c. Describe how magnetic resonance imaging (MRI) is a complement to diagnostic radiography and its advantages over routine radiography.
d. Describe the use of radio frequency (RF) pulses in the various MRI pulse sequence.
e. Describe the components of an MRI unit, including the stationary magnet, gradient and Radio Frequency (RF) coils, table and computer consoles.
f. Explain how MRI image contrast is controlled.
g. Describe the use of paramagnetic contrast agents.
h. Summarize the history of the creation of MRI.
i. Discuss methods of reducing MRI image noise.
j. Discuss safety measures for protection of all persons who approach the MRI unit magnetic field.
k. Discuss patient safety while in the magnet.
l. Discuss the importance of patient screening for MRI.
m. Distinguish how MRI is a unique imaging modality.
n. Explain the process hydrogen takes when introduced to the magnetic field and the subsequent imaging fields.
o. Explain how an MRI unit's magnetic field strength is measured.
p. Define superconductor, solenoid, quenching and surface coils.
q. Explain the different types of MRI units including permanent, resistive and super conductive.
r. Distinguish between extrinsic and intrinsic parameters.
s. Explain how different MRI sequences and parameters are used to create different images and gray scales.
t. Explain the importance of patient and room shielding in MRI including the Faraday cage.

Course Outcome(s):

Explain the principles and application of Bone Densitometry.

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):

1. Define osteoporosis.
2. Describe the basic components of a bone densitometry unit.
3. Demonstrate basic positioning protocols for bone density studies.
4. Describe how bone density is measured including T and Z scores.
5. Identify reasons for bone loss.
6. Differentiate between different bone densitometry units.

Course Outcome(s):

Explain the principles and application of Ultrasonography.

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 the basic concepts of ultrasonography.
b. Summarize the different procedures performed using ultrasonography.
c. Explain proper patient preparation techniques for different ultrasonographic exams.
d. Justify the advantages and disadvantages of ultrasonography compared to other imaging modalities.
e. Identify basic anatomy viewed on ultrasonographic images.
f. Describe the equipment used in ultrasonography including the transducer.

g. Define Doppler ultrasound.
h. Explain how attenuation affects ultrasonographic images.
i. Define the conservation of energy law and how it pertains to ultrasonography.
j. Discuss different sound wave parameters including frequency, period, wavelength and amplitude.
k. Describe how different sound wave variables including pressure, tissue density, particle vibrations and temperature affect the ultrasonographic image.
l. Define a longitudinal sine wave.
m. Identify the compression and rarefaction on an ultrasonographic wave.

Course Outcome(s):

Explain of the principles and application of 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. Discuss the history of mammography.
b. Discuss appropriate patient contact techniques/skills relative to patient assessment and education.
c. List National Council on Radiation Protection and Measures (NCRP) regulations concerning radiation exposure.
d. Identify anatomical structures of the breast.
e. Describe changes in breast tissue as they relate to hormones, pregnancy, lactation, and menopause.
f. Describe the staging process and treatment options for breast cancer.
g. Explain basic and special mammography positioning protocols.
h. Define medical terms associated with mammography and breast imaging position.
i. Summarize basic Mammography physics principles.
j. Discuss how automatic exposure control (AEC), compression, grids, object-to-image distance (OID), source-to-image distance (SID), and focal spot size relate to image quality for mammograms.
k. Contrasts the difference between screening mammograms and diagnostic mammograms.
l. Explain the components and design characteristics of digital mammography units.
m. Justify how important quality assurance control tests are in Mammography.
n. Summarize some of the Food and Drug Administration (FDA) and Occupational Safety and Health Administration (OSHA) regulations in regards to mammography.
o. Identify some of the risk factors for the development breast cancer.
p. Describe specialized mammography procedures such as biopsies, localization procedures utilizing ultrasonography, ductography, scintimammograph, and other stereotactic procedures.

Course Outcome(s):

Explain the principles and application of Nuclear Medicine.

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. Explain the basic concepts of Nuclear Medicine.
b. Summarize the history of Nuclear Medicine.
c. Summarize the basic physics behind Positron Emission Tomography (PET).
d. Explain PET’s significance to diagnostic radiography.
e. Explain radiation safety used in Nuclear Medicine as it relates to the patient, technologist and lab.
f. Distinguish the different types of imaging studies seen in Nuclear Medicine and their purpose.
g. Describe the relationship between radiopharmaceuticals, radioactive isotopes, half life and hot spots and how they affect imaging in Nuclear Medicine.
h. Compare different imaging techniques used in Nuclear Medicine including gamma cameras, CT, PET, SPECT and hybrid fusion studies.

i. Describe Nuclear Medicine lab radiation detecting devices including Geiger-Mueller counter, scintillation detectors, dose calibrator and survey meters.

Course Outcome(s):

Explain the principles and application of Radiation Therapy.

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 radiation therapy.
b. Explain the uses of radiation therapy.
c. Identify the equipment used in radiation therapy.
d. Explain how radiation is administered for radiation therapy.
e. Describe the benefits of radiation therapy.
f. Describe the disadvantages and side effects of radiation therapy.
g. Summarize radiation safety techniques used in radiation therapy for the patient and therapist.
h. Explain the radiation therapy workflow and those who are involved in creating a radiation therapy treatment plan.
i. Define the unit of measurement that radiation therapy utilizes.
j. Explain proton therapy and Braggs peak.
k. Define simulation and why it is used in radiation therapy.
l. Differentiate between PET and SPECT imaging seen in radiation therapy.
m. Explain the difference between fusion imaging and structural imagining used in radiation therapy.

Course Outcome(s):

Explain the education and certification required for technologists to practice in Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Mammography, Bone Densitometry, Sonography, Nuclear Medicine and Radiation Therapy.

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. Explain the educational requirements for all specialized imaging modalities and radiation therapy.
b. Explain the certification and licensure requirements for all specialized imaging modalities and radiation therapy.

Course Outcome(s):

Identify anatomical planes and basic anatomy on cross-sectional 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. Explain the advantages of a cross-sectional image compared to a diagnostic two-dimensional image.
b. Identify the body regions and cavities.
c. Describe anatomy using proper directional terms.
d. Identify the imaging planes used on different CT, MR and sonographic images.
e. Differentiate images produced by various modalities.
f. Identify major sectional anatomical structures found within the head/neck, thorax and abdomen/pelvis.
g. Name and describe the function of select anatomical structures located in the head/neck, thorax and abdomen/pelvis.
h. Locate select anatomical structures of the head/neck, thorax and abdomen/pelvis on CT, MR and sonographic images in the transverse axial, coronal, sagittal and orthogonal (oblique) cross-sectional imaging planes.

Methods of Evaluation:

a. Take-home assignments
b. Tests/quizzes
c. Midterm/final exam
d. Class presentations
e. Written reports

Course Content Outline:

a. Fluoroscopy
    i. Conventional Fluoroscopy
        1. Origin
        2. Equipment
        3. Radiation safety concerns
        4. Image intensified fluoroscopy
            a. Image intensification
                i. Origin
                ii. Development
                iii. Equipment
                iv. Multifield image intensification
                v. Uses in Radiography
                vi. Radiation safety and measurements
                    1. Techniques
            b. Viewing Systems
                i. Film
                ii. Optical mirror system
                iii. Thermionic TV camera tube
                iv. Video monitor
                    1. Frames
                    2. Interlacing
                    3. 525 line system
                v. Cineradiographic camera
                vi. Coupling
            c. Recording systems
                i. Cassette-loaded spot film
                ii. Photospot camera
    ii. Digital Flouroscopy
        1. Digital imaging process in fluoroscopy
            a. Origin
            b. Development
            c. Equipment
            d. Image acquisition
            e. Uses in Fluoroscopy
            f. Radiation safety and measurement
        2. Viewing systems
            a. Digital camera
            b. Digital monitor
                i. 1024 line system
                ii. Spatial resolution
                iii. Pixel size
            c. Cineradiographic camera
            d. Charged coupled device
            e. Flat Panel Image Receptor
            f. Digital Subtraction
                i. Mask mode
                ii. Road mapping
                iii. Subtraction
        3. Recording systems

        - a. Digital Image recording Systems
            - i. ADC and DAC storage systems
        - b. Digital Image Storage Systems
            - i. Types of storage and review media
- b. Computerized Tomography
    - i. Origin
    - ii. Development
        - 1. Generations
    - iii. Equipment
        - 1. Table
        - 2. Gantry
        - 3. X-ray tube
        - 4. Image detectors
        - 5. Operator console
        - 6. Image storage
        - 7. Immobilization devices
            - a. Straps
            - b. Head holders
            - c. IV arm boards
        - 8. Uses in radiography
            - a. Contrast
    - iv. Radiation safety and measurements
        - 1. Techniques
        - 2. Dose
        - 3. Reducing exposure to scatter radiation
    - v. Image creation
        - 1. Hounsfield units
        - 2. Windowing
        - 3. Leveling
        - 4. Matrix
        - 5. Pixel vs Voxel
        - 6. Artifacts
        - 7. Recons
    - vi. Basic computed tomography physics
    - vii. Spiral computed tomography
        - 1. Slip ring technology
    - viii. Multi detector array computed tomography systems
        - 1. Development
        - 2. Pitch
        - 3. Volume imaging
        - 4. Detector dose efficiency
        - 5. Grids
    - ix. Digital Imaging Modality
        - 1. Recons
    - x. Current Trends
        - 1. Research
        - 2. Health Concerns
- c. Magnetic Resonance Imaging
    - i. Origin
    - ii. Development
    - iii. Equipment
        - 1. Main magnet
        - 2. RF subsystem
            - a. Transmitter
            - b. Receiver coils
        - 3. Gradient Coils
        - 4. Couch
        - 5. Operator console
        - 6. Computer

        7. Faraday cage
        8. Shim system
    iv. Basic Magnetic Resonance Physics
        1. Hydrogen
        2. Magnetic movement
        3. Precession
        4. B0 and B1 fields
        5. Resonance
        6. Larmor frequency
    v. Digital Imaging Modality
        1. See M. Digital Image Processing
    vi. 3 Plane Direct Imaging
        1. Cartesian Coordinates
        2. Parameters
            a. Intrinsic
            b. Extrinsic
        3. Sequences
        4. Protocols
        5. Advantages provided by Magnetic Resonance Imaging
    vii. MRI Safety
        1. Patient
        2. Public
        3. Personnel
    viii. Current Trends
        1. Research
        2. High field magnets
        3. Health concerns
d. Bone Densitometry
    i. Origin
    ii. Development
    iii. Equipment
        1. DEXA
    iv. Image acquisition
        1. Hip
        2. Lumbar Spine
        3. Forearm
        4. Heel
    v. Bone anatomy
        1. Cortical bone
        2. Trabecular bone
    vi. How used in radiology
        1. World Health Organization
        2. T Score
        3. Z Score
        4. Osteoporosis
            a. Risk factors
            b. Indicators
    vii. Radiation safety
        1. Dose to patient
        2. Dose to personnel
e. Ultrasonography
    i. Origin
    ii. Development
        1. History of ultrasonography
        2. Accreditation
    iii. Equipment
        1. Transducers
        2. Crystal

        3. Computer system
        4. Operator console
    iv. Image acquisition
        1. Sound waves
            a. Compression
            b. Rarefaction
            c. Variables
            d. Types
            e. Parameters
        2. Law of conservation of energy
        3. Attenuation
    v. How used in Radiology
        1. Doppler ultrasound
        2. Types of exams
    vi. Ultrasonographic safety
f. Mammography
    i. Origin
    ii. Breast anatomy
    iii. Breast Cancer
        1. Types
        2. Statistics
        3. Risks
        4. Treatment options
    iv. Development
    v. Equipment
        1. Digital equipment for Mammography
        2. Digital storage systems for Mammography
        3. Digital viewing systems for Mammography
            a. Image manipulation
            b. Exam enhancements for diagnosis
    vi. Protocols
        1. Techniques
        2. Positioning
        3. Compression
        4. Magnification
    vii. Uses of Mammography in Radiology
        1. Current trends in Mammography
            a. Ultrasound
            b. Surgical alternatives
            c. Positioning techniques
    viii. Radiation safety in Mammography
        1. FDA Guidelines
            a. BSE- Breast Self Exam
            b. CBE- Clinical Breast Exam
        2. OSHA Guidelines
g. Nuclear Medicine
    i. Origin
    ii. Development
    iii. Equipment
        1. Gamma camera
            a. Hot spots
        2. SPECT
        3. PET
        4. Hybrid scanners
    iv. Image acquisition
        1. Radiopharmaceuticals
            a. Tc-99m
            b. Half life
            c. Uptake
                i. Vehicles

                d. Nuclear decay
                e. Radioactive isotopes
                    i. Positrons
        v. How used in Radiology
            1. Common exams
        vi. Radiation safety
            1. Patient
            2. Technician
            3. Lab
                a. Radiation detectors
h. Radiation Therapy
    i. Origin
    ii. Development
        1. Workflow
        2. Prescription
        3. Treatment plan
    iii. Equipment
        1. Linear Accelerator
    iv. Image acquisition
        1. Simulation
        2. Image fusion
            a. PET
            b. SPECT
            c. CT
            d. MRI
        3. Image Guided Radiation Therapy (IGRT)
            a. Side effects
        4. Proton Therapy
            a. Braggs peak
    v. How used in Radiology
    vi. Radiation safety
i. Educational and Certification Requirements
    i. Computed tomography
    ii. Magnetic resonance imaging
    iii. Mammography
    iv. Bone Densitometry
    v. Ultrasonography
    vi. Nuclear Medicine
    vii. Radiation Therapy
j. Cross-Sectional Anatomy
    i. Anatomy Nomenclature
        1. Terms of direction
        2. Body planes
        3. Body cavities
        4. Body quadrants
        5. Body regions
    ii. Cross-sectional anatomy of structures and their locations
        1. Head/Cranium
            a. Surface anatomy of the brain
            b. Sinuses
            c. Bones/Cranium
            d. Lobes of brain
            e. Head/face muscles
            f. Cranial nerves
            g. Brain stem
            h. Circle of Willis
            i. Veins
        2. Thorax

a. Neck/Chest
    i. Bones
    ii. Respiratory organs
    iii. Circulatory organs
    iv. Vasculature
    v. Musculature

3. Abdomen
    a. Surface landmarks
    b. Main Arteries/Veins
    c. Bony structures
    d. Abdominal/GI organs
4. Pelvis
    a. Reproductive organs
    b. Bony structures
    c. Pelvic vasculature

Resources

Bushong, S. C. *Radiologic Science for Technologists*. 12th ed. St. Louis, MO: Elsevier Mosby, 2021.

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Pope, T. L. Jr. *Aunt Minnie's Atlas Imaging- Specific Diagnosis*. 4th ed. Philadelphia, PA: Lippincott Williams & Wilkins, 2014.

Madden, M. E. *Introduction to Sectional Anatomy*. 3rd ed. Baltimore, MD: Lippincott Williams & Wilkins, 2012.

Seeram, E. *Computed Tomography: Physical Principles, Clinical Applications, and Quality Control*. 4th ed. Elsevier Health Sciences, 2016.

Westbrook, C., Roth, C. K. & Talbot, J. *MRI in Practice*. 5th ed. Chichester, West Sussex: Blackwell Publishing, 2018.

Long, B. W., Hall Rollins, J. & Smith, B. J. *Merrill's Atlas of Radiographic Positioning & Procedures*. 15th ed. St. Louis, MO: Elsevier Mosby, 2022.

Carter, C. & Veale, B. *Digital Radiography and PACS*. 3rd ed. Maryland Heights, MO: Elsevier Mosby, 2019.

Resources Other

1. American Society of Radiologic Technologists Radiography Curriculum www.asrt.org (http://www.asrt.org)
2. American Registry of Radiologic Technologists Radiography Examination Content Specifications www.arrt.org (http://www.arrt.org)

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