NMED-1701: NUCLEAR MEDICINE INSTRUMENTATION

Cuyahoga Community College

Viewing: NMED-1701 : Nuclear Medicine Instrumentation

Board of Trustees:

2014-06-19

Academic Term:

Fall 2020

Subject Code

NMED - Nuclear Medicine Technology

Course Number:

1701

Title:

Nuclear Medicine Instrumentation

Catalog Description:

Covers instrumentation use for both non-imaging and imaging including monitoring equipment (surveys), dose calibrators, well counters, uptake probes, laboratory equipment, gamma probe and gamma camera. Reviews imaging components, use, and QC performance and requirements. Explores configuration, function and application of computers and networks used in the reconstruction of images. Includes practical considerations, concepts, data analysis, measurement concerns, and spectroscopy.

Credit Hour(s):

3

Lecture Hour(s):

3

Requisites

Prerequisite and Corequisite

NMED-1501 Radiation Physics, or concurrent enrollment; and NMED-1603 Nuclear Radiopharmacy and Pharmacology.

Outcomes

Course Outcome(s):

Explain and apply the operation and theory of nuclear medicine instrumentation.

Objective(s):

1. Describe and apply the principles and operation of survey meters, dose calibrators, and scintillation detector systems.
2. Review and apply the principles and operation of Magnetic Resonance (MR), SPECT/MR, and PET/MR.
3. Describe and apply the principles and operation of an aerosol delivery system, gas ventilation trap, and gas ventilation/delivery system.
4. Describe and apply the principles and operation of scintillation detectors and multi crystal cameras.
5. Describe the principles and operation of solid state detector systems.
6. Review and apply the principles and operation of SPECT, SPECT/CT, and PET/CT.
7. Describe and apply the principles and operation of laboratory equipment.

Course Outcome(s):

Utilize the different information systems used in the health care environment to manage patient information appropriately.

Objective(s):

1. Describe the configuration, function and application of picture archiving and communications systems (PACS).
2. Describe medical informatics and how to protect patient information.

Course Outcome(s):
Perform quality control procedures and analyze the results.

Objective(s):
1. Explain how to perform quality control procedures including Gamma camera, SPECT camera, PET camera and CT camera new acquisition testing, daily, weekly and monthly imaging quality control processes, and trouble shooting for abnormalities on all systems.
2. Differentiate between normal and abnormal uniformity, spatial resolution, linearity, sensitivity, collimator integrity and energy window calibration on all systems.
3. Assign the correct the schedule for all types of QC procedures (i.e, daily, weekly, monthly, bi-monthly, yearly or only at installation).
4. Troubleshoot, recognize, and repair artifacts.
5. Utilize phantoms and recognize their role in information for quality patient scans.

Methods of Evaluation:
1. Participation
2. Quizzes
3. Assignments
4. Midterm
5. final exam

Course Content Outline:
1. Role of ions and ionization in radiation detection
    a. Exposure and exposure rate
    b. Traditional and SI units
    c. Radiation safety
2. Gas-Filled Detectors
    a. Geiger-Mueller
        i. Varying types
        ii. Dead time
        iii. Quality control
        iv. Calibration
    b. Dose Calibrators
        i. Quality control standards
            1. Constancy
            2. Linearity
            3. Geometry
            4. Accuracy
    c. Miscellaneous other types of gas dectectors
3. Scintillation Detection
    a. Well counter
        i. Operation
        ii. Quality control standards
    b. Uptake probe
        i. Operation
        ii. Quality control
        iii. Flat field collimator
        iv. Isoresponsive curve
        v. Energy resolution
        vi. Full width half maximum (FWHM)
        vii. Calibration importance and methods
4. Gamma Cameras
    a. Special purposes of design characteristics
    b. Crystal
    c. Photomultiplier tube (PMT) array
    d. Pre-amplifier
    e. Amplifier
    f. Pulse height analyzer
    g. Scaler/timer

h. Required positional circuitry
i. Accessory equipment
j. Image Quality Characteristics
    i. Spatial resolution
    ii. Sensitivity
    iii. Field of view
    iv. Image size (magnification/minification)
    v. Image distortion
    vi. Energy characteristics
k. Collimators
    i. Parallel-hole (various types)
    ii. Diverging/converging
    iii. Pinhole
    iv. Slant-hole
    v. Fan-beam
l. Correction circuits
m. Quality control procedures
n. Imaging considerations
    i. Matrix size
    ii. Scaler/timer determination
    iii. Collimation determination
    iv. Static Acquisition
    v. Whole body acquisition
        1. Body contouring
        2. Scan speed
    vi. Dynamic
        1. Time versus counts per frame
        2. Gated

5. Image display and processing considerations for gamma cameras
    a. Color selection and scales
    b. Cine
    c. Sonogram/histogram
    d. Motion correction
    e. 3-dimensional/volumetric
    f. Data recording
    g. Multicrystal Scintillation Cameras
        i. Principles of operation
        ii. Performance characteristics
    h. Solid State Detector Systems
        i. Principles of operation
        ii. Performance characteristics
6. Single Photon Emission Computed Tomography (SPECT)
    a. Basic designs and principles
    b. Orbit selection
    c. Collimator selection
    d. Multi-detector systems
        i. Fixed
        ii. Variable
    e. Acquisition parameters
    f. Factors that limit statistics
    g. Attenuation correction
        i. Attenuation filters
        ii. Sealed/rod source
        iii. X-ray
        iv. Motion correction and linograms/sonograms
7. Positron Emission Tomography (PET)
    a. Basic designs and principles
    b. Scintillation crystals
    c. Time-of-Flight

   d. Coincidence detection
      i. Random coincidences
      ii. Scatter coincidences
      iii. True events
      iv. Coincidence circuitry
   e. Gantry bore
   f. Detector blocks
   g. Timing signals
   h. Pulse height analyzer
   i. Avalanche
   j. Sinograms
   k. Transmission and rod sources
   l. Attenuation correction
      i. Attenuation filters
      ii. Sealed/rod source
      iii. Use on computed tomography
      iv. Motion correction and linograms/sonograms
   m. Normalization
   n. 2D verses 3D modes
   o. Sensitivity
   p. Dynamic versus gated modes
   q. Spatial resolution
   r. Contrast
   s. Count rate
   t. Factors affecting performance
      i. Resolution limits
      ii. Ring geometry
      iii. Dead-time
      iv. Noise
      v. Scatter
   u. Standardized uptake value (SUV)
   v. Quality Control
      i. Acceptance testing
      ii. Normalization scan
      iii. blank scan
      iv. Cross calibration
      v. Uniformity
      vi. Coincidence timing calibration
      vii. Scatter fraction
      viii. Accuracy tests
   w. Artifacts affecting image quality
8. Computed Tomography (CT)
   a. Basic principles of X-ray and CT
   b. Basic computed tomography physics
   c. Instrument generations
   d. Gantry
   e. X-ray tube
   f. X-ray beam
   g. X-ray detectors
   h. Hounsfield unit
   i. Pitch
   j. Image acquisition
   k. Image display
   l. Spiral computed tomography
      i. Development
      ii. Pitch
      iii. Volume imaging
      iv. Advantages and disadvantages of spiral computed tomography

   m. Multi detector array computed tomography systems
      i. Pitch
      ii. Volume imaging
      iii. Advantages and disadvantaes of multi detector array computed tomography
   n. Quality Control
   o. Radiation dosimetry and health concerns
   p. Contrast agents
   q. SPECT/CT Systems
      i. Designs and principles
      ii. Advantages and disadvantages
      iii. System quaility control
      iv. Spatial resolution
      v. Sensitivity
      vi. Attenuation mapping
      vii. Image acquisition and display
      viii. Fusing images
      ix. Advancing technologies
   r. PET/CT systems
      i. Designs and principles
      ii. Advantages and disadvantages
      iii. Quaility control
      iv. Spatial resolution
      v. Sensitivity
      vi. Attenuation mapping
      vii. Image acquisition and display
      viii. Fusing images
      ix. Technical issues
         1. Misregistration
      x. Advancing technologies
9. Magnetic resonance (MR)
   a. Basic principles of magnetic resonance
      i. Electromagnetism and hydrogen atoms
      ii. Precession
      iii. Larmor equation
      iv. Tissue disturbance and differentiation
      v. Radiofrequency Flip Angle (RF Flip)
      vi. T1 relaxation
      vii. T2 relaxation
      viii. The pulse sequence
      ix. Logical notaiton
      x. Data storage
      xi. Slice selection
      xii. Frequency encoding
      xiii. Phase encoding
   b. MR scanner principles
      i. Magnets
      ii. Gradients
      iii. RF coils
      iv. RF pulse characteristics
      v. Reciever coils
      vi. Computer systems
      vii. Proton density weighting
      viii. Image appearance
      ix. Ancillary equipment
   c. MR spectrometry
   d. MRI safety
      i. Safety in magnetic feild
      ii. Bioeffects of static magnetic feilds

iii. Claustrophobia and acoustic noise
iv. MRI contrast
e. Quality control
f. SPECT/MR Systems
i. Eesigns and principles
ii. Advantages and disadvantages
iii. Technical challenges
iv. System quaility control
v. Spatial resolution
vi. Sensitivity
vii. Attenuation mapping
viii. Image acquisition and display
ix. Fusing images
x. Advancing technologies
g. PET/MR systems
i. Designs and principles
ii. Advantages and disadvantages
iii. Technical challenges
iv. System quaility control
v. Spatial resolution
vi. Sensitivity
vii. Attenuation mapping
viii. Image acquisition and display
ix. Fusing images
x. Advancing technologies

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Resources

Bolus, N., & Glasgow, K.W., (Eds.). (2018) *Review of Nuclear Medicine Technology (5th Ed.)*, Reston, VA: Society of Nuclear Medicine and Molecular Imaging.

Lee, K.H. (2015) *Basic Science of Nuclear Medicine: Bare Bone Essentials*, Reston, VA: Society of Nuclear Medicine and Molecular Imaging.

Mettler, F., & Guiberteau, M. (2019) *Essentials of Nuclear Medicine and Molecular Imaging (7th ed.)*, Philadelphia, PA: Elsevier.

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