

Cardiac-Interventional and Vascular-Interventional Curriculum

*Sponsored by the American Society of Radiologic Technologists, 15000 Central Ave. SE,
Albuquerque, NM 87123-3909.*

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Introduction

Modern interventional techniques and procedures for diagnostic imaging and therapeutic treatment require technologists with specialized knowledge and skills. Technologists gain these skills through a combination of formal education and structured practical experience. Though there are many common skills between cardiac- and vascular-interventional practice, each also requires additional skills unique to the specialty.

In recognition of the special nature of the two areas of interventional practice, the American Registry of Radiologic Technologists (ARRT) has created two separate advanced certification examinations for cardiac-interventional radiography and vascular-interventional radiography.

The professional practice of cardiac-interventional and vascular-interventional procedures requires knowledge and skills generally not obtained in basic radiography education programs. This curriculum is intended as a guide to the knowledge and skills required for cardiac-interventional technology and vascular-interventional technology. The components listed here are not comprehensive, but rather representative of current practice and trends in these specialties. Educators will need to incorporate new concepts and trends as they develop.

This curriculum is divided into content areas that represent the essential components of an interventional program. The content and objectives included in the curriculum should be organized to meet the needs of each program. Faculty are encouraged to expand on these fundamental objectives as they incorporate them into their classroom. Specific instructional methods were intentionally omitted to allow for creativity in instructional delivery.

The curriculum includes four sections: Foundations, Common Content, Specialized and Optional Content. The Foundations section is an inventory of preexisting knowledge and skills gained through an entry-level radiography educational experience and reinforced through professional practice. Foundations content is intended to help technologists in career planning, and program managers in developing preassessment tools for candidate selection for their interventional educational program.

The Common Content section covers topics relevant to both cardiac-interventional and vascular-interventional specialties.

The Specialized Content section is the exam-specific component of the curriculum, and is divided into cardiac-interventional studies and vascular-interventional studies.

The Optional Content section includes technical topics, from older equipment to the newest technologies, and is intended to help program planners enhance their curriculum with optional topics that satisfy the mission of their program and the needs of their local employment market.

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Foundations

The Foundations section is an inventory of preexisting knowledge and skills gained through an entry-level radiography educational experience and reinforced through professional practice. Foundations content is intended to help technologists in career planning, and program managers in developing preassessment tools for candidate selection for their educational program.

Clinical Practice

Content and clinical practice experiences should be designed to sequentially develop, apply, critically analyze, integrate, synthesize and evaluate concepts and theories in the performance of medical imaging procedures. Through structured, sequential, competency-based clinical assignments, concepts of team practice, patient-centered clinical practice and professional development are discussed, examined and evaluated.

Clinical practice experiences should be designed to provide patient care and assessment, competent performance of medical imaging procedures and total quality management. Levels of competency and outcomes measurement ensure the well-being of the patient before, during and following the procedure.

Digital Image Acquisition and Display

Content imparts an understanding of the components, principles and operation of digital imaging systems found in diagnostic radiology. Factors that impact image acquisition, display, archiving and retrieval are discussed. Principles of digital system quality assurance and maintenance are presented.

Ethics and Law in the Radiologic Sciences

Content provides a foundation in ethics and law related to the practice of medical imaging. An introduction to terminology, concepts and principles will be presented. Students will examine a variety of ethical and legal issues found in clinical practice.

Human Anatomy and Physiology

Content establishes a knowledge base in anatomy and physiology. Components of the cells, tissues, organs and systems are described and discussed. The fundamentals of sectional anatomy relative to routine imaging are addressed.

Introduction to Computed Tomography

Content is designed to provide entry-level students with an introduction to and basic understanding of the operation of a computed tomography (CT) device. Content is not intended to result in clinical competency.

Patient Care in Radiologic Science

Content provides the concepts of optimal patient care, including consideration for the physical and psychological needs of the patient and family. Routine and emergency patient care procedures will be described, as well as infection control procedures using standard precautions. The role of the technologist in patient education is identified.

Pharmacology and Venipuncture

Content provides basic concepts of pharmacology, venipuncture and administration of diagnostic contrast agents and intravenous medications. The appropriate delivery of patient care during these procedures is emphasized.

Radiation Biology

Content provides an overview of the principles of the interaction of radiation with living systems. Radiation effects on molecules, cells, tissues and the body as a whole are presented. Factors affecting biological response are presented, including acute and chronic effects of radiation.

Radiation Production and Characteristics

Content establishes a basic knowledge of atomic structure and terminology. Also presented are the nature and characteristics of radiation, x-ray production and the fundamentals of photon interactions with matter.

Radiation Protection

Content presents an overview of the principles of radiation protection, including the responsibilities of the technologist for patients, personnel and the public. Radiation health and safety requirements of federal and state regulatory agencies, accreditation agencies and health care organizations are incorporated.

Refer to Appendix A for a list of possible learning objectives for each content area.

Common Content

The Common Content section includes topics relevant to both cardiac-interventional and vascular-interventional practice.

Anatomy and Physiology

Emergency Care Procedures

Fundamental Principles of Ultrasound

Imaging Equipment, Materials, Production and Enhancement Techniques

Interventional Resources and Supplies

Pharmacology and Drug Administration

Patient Care, Assessment and Monitoring

Physiologic Monitoring and Recording

Sterile Technique

Vascular Approaches

Vascular Pathophysiology

Anatomy and Physiology

Description

Content establishes a knowledge base in anatomy and physiology. Components of the cells, tissues, organs and body systems are described.

Objectives

1. Describe the composition and characteristics of blood.
2. List the types of blood cells and their functions.
3. Differentiate between blood plasma and serum.
4. Outline the clotting mechanism.
5. List the blood types.
6. Define the term Rh factor.
7. Explain the relationship of antigens and antibodies, and their use in blood typing.
8. Label the parts of the human heart.
9. Describe the flow of blood through the body and identify the main vessels.
10. Describe the structure and function of arteries, veins and capillaries.
11. Differentiate between arterial blood in systemic circulation and arterial blood in pulmonary circulation.
12. Label the components of the respiratory system.
13. Describe the physiology and regulation of respiration.
14. Identify major sectional anatomical structures found within the head, neck, thorax and abdomen.

Content

I. Blood

- A. Lipoproteins
- B. Hemoglobin (Hb or Hgb)
- C. Oxygen
- D. Clotting
- E. Blood Types
- F. Acid / Base

II. Vasculature

A. Arterial

- 1. Radial
- 2. Brachial
- 3. Axillary
- 4. Subclavian
- 5. Carotid
- 6. Femoral
- 7. Popliteal
- 8. Dorsalis pedis

B. Venous

- 1. Jugular
- 2. Axillary
- 3. Subclavian
- 4. Basilic
- 5. Brachial
- 6. Cephalic
- 7. Femoral

Emergency Care Procedures

Prerequisite

Basic life support (BLS) certification for health care providers, patient care and pharmacology units should be completed prior to this unit. It is strongly recommended that technologists in interventional practice be certified in advanced cardiac life support (ACLS).

Description

Content provides the student with the knowledge and ability to recognize characteristics of life-threatening patient conditions, identify the equipment necessary to handle emergencies and administer emergency care procedures. Content focuses on the technologist's role in managing common emergencies that arise during interventional procedures.

Objectives

1. Describe the physiologic responses to contrast media or medications.
2. Identify complications associated with angiographic procedures.
3. Recognize and respond to common patient emergencies associated with vascular interventional procedures.
4. List complications of vascular interventional procedures.
5. Describe vascular access related injuries sustained during vascular interventional procedures.
6. Apply basic life support and advanced cardiac life support techniques.

Content

I. Airway Management

II. Therapeutic hypothermia

III. Life support medications

IV. Crash cart

V. Cardiac life support

- A. Defibrillation
 - 1. Transcutaneous pacemaker
 - 2. Temporary pacemaker
 - 3. Cardioversion
- B. Basic life support (BLS)
- C. Advanced cardiac life support (ACLS)
- D. Pediatric advanced life support (PALS)
- E. Symptomatic bradycardia
- F. Symptomatic tachycardia
- G. Pericardiocentesis
- H. Left heart assist

VI. Contrast media and medication reactions

- A. Physiologic response
 - 1. Allergic-type
 - a. Minor
 - b. Intermediate
 - c. Severe
 - 1) Anaphylactic shock
 - 2. Adverse reactions
 - a. Hemodynamic responses
 - b. Nephrotoxicity
 - c. CNS reactions
- B. Medications
 - 1. Chemistry
 - 2. Indications
 - a. Premedication for contrast reaction
 - 3. Contraindications
 - 4. Dose
 - 5. Antagonist
- C. Emergency drugs and cash cart

VII. Complications & Emergencies

VIII. Life-Threatening Complications

- A. Acute MI

- B. Arrhythmia
- C. Chest Pain
- D. Shortness of breath
- E. Shock
 - 1. Anaphylaxis
 - 2. Hypovolemic
 - 3. Cardiogenic
 - 4. Septic
- F. Tamponade
- G. Vessel dissection
- H. Cerebrovascular accident
 - I. Pulmonary edema
 - J. Pulmonary embolism
- K. Acute pulmonary hemorrhage
- L. Hypertension and hypotension
- M. Anaphylaxis and allergic reactions
- N. Bronchospasm
- O. Vascular
 - 1. Air embolism
 - 2. Thrombosis
- P. Airway management and oxygen delivery devices
- Q. Stroke
 - 1. transient ischemic attack
 - 2. hemorrhagic
 - 3. non-hemorrhagic
- R. Hemothorax
- S. Pneumothorax
- T. Respiratory arrest
- U. Pulmonary edema
 - 1. Thrombotic embolism, thrombosis
- V. Perforation
 - 1. Pericardial
 - 2. Vascular perforation
- W. Vasovagal response
 - 1. Diabetic crisis
 - 2. hypoglycemia
 - 3. hyperglycemia
 - 4. DKA
- X. Access Site complications
 - 1. bleeding
 - 2. hematoma
 - 3. retroperitoneal bleed
 - 4. infection
- Y. Symptoms and emergency treatment
- Z. Renal failure
 - 1. Symptoms

2. Complications
3. Chronic versus acute

ASRT

Fundamental Principles of Ultrasound

Description

Content imparts an understanding of the basic principles of ultrasonography. Where applicable, ultrasonographic examinations that complement interventional studies will be discussed.

Objectives

1. Identify the basic principles of ultrasonographic imaging, including sound wave characteristics, attenuation and echoes.
2. Describe the effect transducer selection has on image resolution.
3. Explain the Doppler effect and how it is used in the examination of vascular structures.
4. Evaluate the benefits of continuous wave, pulsed wave and color-flow Doppler imaging.
5. List bioeffects and patient safety concerns associated with ultrasonographic imaging.
6. Describe the use of intravascular ultrasound with catheter-based interventions.
7. Identify ultrasound-guided interventional techniques and procedures.

Content

I. Ultrasound Principles

- A. Physics of sound waves
 - 1. Nature of sound waves
 - 2. Frequency, wavelength and propagation speed
 - 3. Properties of sound waves
- B. Production
 - 1. Propagation properties
 - a. Reflection
 - b. Refraction
 - c. Attenuation
 - d. Artifacts

II. Ultrasound Instrumentation Properties

- A. Piezoelectric effect
- B. Construction and operation
 - 1. Depth
 - 2. Long axis
 - 3. Short axis
 - 4. Color flow
 - 5. Flow velocity
 - 6. Dynamic imaging for vascular, structural access
 - 7. Megahertz of devices
 - 8. Probe alignment
- C. Beam focusing
- D. Multihertz frequency
 - 1. Axial resolution
 - 2. Lateral resolution
- E. Types of scan heads
 - 1. Arrays
 - 2. Mechanical

III. Pulsed Echo Instruments

- A. Range equation
- B. Pulse echo characteristics
- C. System controls
 - 1. Power/gain
 - 2. Time-gain control (TGC)/depth-gain compensation (DGC)
 - 3. Calculations
 - 4. Doppler controls
- D. Signal processing
- E. Display modes

IV. Doppler

- A. Physical principles
 - 1. Doppler effect

2. Factors affecting Doppler shift frequency
3. Doppler artifacts
- B. Basic principles of duplex instruments
 1. Pulsed Doppler
 2. Color Doppler
 3. Continuous wave
 4. Spectral analysis
- C. Intravascular (endoluminal) instruments
 1. Display

V. Bioeffects and Safety

VI. Cardiac Imaging With Ultrasound

- A. Transthoracic (TTE)
- B. Transesophageal (TEE)
- C. Intracardiac (ICE)
- D. IVUS
- E. Views
- F. Anatomy and pathophysiology
 1. Diagnosis
 2. Assessment

VII. Interventional Guided Ultrasound Techniques

- A. Vascular access studies
- B. Dialysis graft surveillance
- C. Biopsy
- D. Fluid drainage
- E. Ablations
- F. Intraoperative

Imaging Equipment, Materials, Production and Enhancement Techniques

Description

Content provides the student with an overview of radiographic and ancillary equipment and materials necessary to perform diagnostic and therapeutic interventional procedures. Technique and methods to enhance image quality are introduced.

Objectives

1. List the components and available configurations of fluoroscopy units.
2. Explain the design characteristics of the tube in relation to the anode, cathode, kilowatt determination, heat storage and cooling characteristics.
3. Identify the causes of tube malfunctions, including the anode, filament and glass envelope.
4. Define variable tube potential (kilovolt, or kV, modulation).
5. Define variable tube current method (mA modulation).
6. Define pulse side variation (time modulation).
7. Describe the function of the input phosphor, including photon conversion, quantum detection efficiency, contrast and resolution capabilities.
8. Describe the function of the Image Receptor — Flat Panel Detector (FPD).
9. Explain how C-Arm/table geometry effects dose.
10. Describe the use and effect of anti-scatter grids.
11. Describe the use and effect of spectral shaping filters.
12. Describe the application and effect of magnification modes.
13. List and describe the factors affecting object field size.
14. Describe the position and purpose of the basic lens, distributor, beam-splitting mirrors, cine and TV camera lenses.
15. Describe lens aberrations, including direct, oblique, spherical, chromatic, depth of focus and vignetting.
16. Describe the basic principles of digital image production.
17. Recognize the importance of the as low as reasonably achievable (ALARA) principle and how to use radiation protection features available on fluoroscopy units.
18. Identify procedures for post processing of digital images.
19. Identify methods for storing digital image data.
20. Describe enhanced imaging of vasculature using digital subtraction angiography (DSA).
21. Explain image processing techniques including road mapping, image fade, mask pixel shift and frame summation.
22. Describe the importance of calibration and its effect on anatomic measurements.
23. Describe the systems to adjust the kilovoltage, milliamperage, or exposure time, including automatic exposure control (AEC), automatic dose control (ADC), automatic dose rate control (ADRC) and automatic brightness control (ABC).

Content

I. Image Acquisition and Equipment

- A. Fluoroscopy
 - 1. Dose rate
 - 2. Pulse rate
 - 3. Compensating filters (e.g., wedge, soft)
 - 4. Electronic magnification
 - 5. Geometric magnification
 - 6. Collimation
- B. Cineangiography
 - 1. Roadmapping
 - 2. Digital subtraction
 - 3. 3-D imaging
- C. Automatic exposure quality control
 - 1. General
 - a. kV modulation
 - b. mA modulation
 - 2. Functions
 - a. Automatic exposure control (AEC)
 - b. Automatic dose control (ADC)
 - c. Automatic dose rate control (ADRC)
 - d. Automatic brightness control (ABC)
- D. Projections
 - 1. Nomenclature
 - a. Anteroposterior (AP)
 - b. Right Anterior Oblique (RAO)
 - c. Left Anterior Oblique (LAO)
 - d. Cranial
 - e. Caudal
 - f. Lateral
- E. Digital subtraction angiography (DSA)
 - 1. First-order subtraction
 - 2. Second-order subtraction
 - 3. Equipment
 - 4. Reversal
 - 5. Mapping
- F. Magnification
 - 1. Equipment requirements
 - 2. Application
 - 3. Procedure

II. Specialized Equipment Instrumentation

- A. Radiographic tube requirements
 - 1. Anode characteristics
 - 2. Cathode characteristics
 - 3. Kilowatt determinations

4. Heat storage and cooling
5. Tube malfunctions
- B. Radiographic exposure
 1. Variable kilovolt peak (kVp)
 2. Variable milliamperere seconds (mAs)
- C. Image intensification
 1. Input phosphor
 2. Photocathode
 3. Vacuum tube
 4. Electron focusing lenses
 5. Output phosphor
 6. Basic lens
 7. Brightness gain
- D. Imaging systems
 1. TV tubes
 2. Charge-coupled device (CCD)
 3. Flat panel displays
 4. Benefits/limitations
 - a. Resolution
 - b. Contrast
 - c. Density
 - d. Radiation dose
- E. Digital imaging
 1. Image production
 - a. Data acquisition
 - b. Image characteristics
 - 1) Pixel
 - 2) Image matrix
 - 3) Dynamic range
 - c. Post processing
 - 1) Reconstruction
 - 2) Enhancement
 - d. Quality control
- F. Data archiving systems
 1. Picture archiving and communication system (PACS)
 2. Optical disc
- G. Cardiac and vascular-interventional table
 1. Types
 2. Operation
 - a. Panning
 - b. Step mode
- H. Fluid delivery systems
 1. Manual
 - a. Manifold
 - 1) Assembly
 - 2) Preparation

- 3) Operation
- 2. Electronic
 - a. Automatic pressure injector
 - 1) Assembly
 - 2) Preparation
 - 3) Operation
 - 4) Synchronized injection
- I. 3-D imaging
 - 1. Procedure
 - 2. Processing
 - 3. Reconstruction
 - 4. Rotational angiography
- J. CT imaging capabilities
 - 1. Procedure
 - 2. Processing
 - 3. Reconstruction

III. Radiation Protection

- A. Patients
 - 1. Collimation (e.g., shutters, virtual collimation)
 - 2. Magnification
 - 3. Frame rates
 - 4. Geometry (e.g., SID, OID, tube angle)
 - 5. Pulsed or continuous
 - 6. Shielding
 - 7. Last image hold
 - 8. Dose rate
- B. Personnel (ALARA)
 - 1. Shielding
 - 2. Monitoring devices
 - 3. Occupational exposure reports
 - 4. Promote radiation awareness

IV. Patient Care and Emergency Equipment

- A. Avoximetry
- B. Hemochron
- C. Emergency code cart
- D. Emergency airway equipment

V. Automatic Pressure Injectors

- A. Types (ACIST, Medrad)
 - 1. Parts
 - 2. Function
 - 3. Operation

Interventional Resources and Supplies

Description

Content introduces the resources and supplies required for specific interventional procedures. Discussions will focus on the preparation of materials and supplies prior to beginning a procedure, techniques and uses of materials and devices during a procedure and postprocedural cleanup and care of interventional materials and devices.

Objectives

1. List sterile resources used for interventional procedures.
2. Describe the procedure for setting up a sterile interventional tray.
3. List the sterile apparel to be worn during an interventional procedure.
4. List the resources used to prepare the entry site.
5. List the solutions required for an interventional procedure.
6. List the resources required for emergency situations.
7. List the equipment required for radiation protection.
8. List the equipment available as “safety” products for use on an interventional tray.
9. Describe the physical characteristics, dimensions, shapes and gauges of catheters, needles and guidewires.
10. Describe factors that affect flow rate.
11. Describe the resources used in construction of catheters, guidewires, needles, thrombectomy catheters, vascular stents and drainage catheters.
12. Describe the construction, function and application of angiography, atherectomy, balloon angioplasty, intravascular sonography, retrieval, occluding and infusing catheters.
13. Describe the construction, function and application of regular fixed-core, movable-core, exchange, J-shaped, biliary, axillary, tip-deflecting, high-torque, open-ended, stiff-shaft and coated guidewires.
14. Describe the function of dilators, introducer sheaths and stents (vascular and nonvascular, covered and noncovered, stent grafts).
15. Describe the uses of metal and plastic adaptors, torque devices, connectors, stopcocks and manifolds.
16. Describe the importance of closed-system manifold connections.
17. Describe the types and construction of caval filters and implantable devices.
18. Describe the advantages and disadvantages of reusable and disposable supplies.
19. Describe the advantages and disadvantages of “safety” product supplies.
20. Describe the setup, use and safety precautions to perform CO₂ angiography.
21. Review the importance of “isolation cases” (clean and dirty staff).

Content

I. Sterile Backtable

- A. Instruments
- B. 4 x 4 gauze
- C. Syringes
- D. Sharps
 - 1. Needles
 - 2. Scalpel
 - 3. Count box
- E. Adaptors
 - 1. Stopcocks
 - 2. Manifolds
 - 3. Waste management systems
- F. Sterile basins
- G. Sterile drapes
 - 1. Towels
 - 2. Tray cover
 - 3. Fenestrated drape
- H. Heparinized saline
- I. Contrast media
- J. Introducer sheath

II. Surgical Preparations and Scrub Resources

- A. Clippers
- B. Antiseptic soap solution
- C. Lidocaine
- D. Sterile basins
- E. Drapes and towels
- F. Gloves
- G. Waste receptacles
 - 1. Clean
 - 2. Biohazardous

III. Apparel

- A. Gowns
 - 1. Infection control
 - 2. Sterile
- B. Gloves
 - 1. Infection control
 - 2. Sterile
- C. Masks
- D. Face shields
- E. Goggles
- F. Caps
- G. Shoe covers

IV. Radiation Protection

- A. Aprons
- B. Thyroid collar
- C. Eyewear
- D. Shielding
 - 1. Table skirts
 - 2. Plexiglass
 - 3. Mobile
- E. Gloves

V. Guidewires and Catheters

- A. Catheters
 - 1. Preparation
 - 2. Types
 - a. Diagnostic
 - b. Interventional
 - 3. Characteristics
 - a. Construction
 - b. Function
 - c. Dimensions (French size)
 - d. Shapes
 - e. Side/end holes
 - f. Recoil
 - g. Coatings (heparin, hydrophilic)
 - h. Tractability
 - i. Torque
 - j. Support
- B. Atherectomy
 - 1. Rotational
 - 2. Orbital
 - 3. Directional
- C. Thrombectomy
- D. Transluminal extraction
- E. Intravascular ultrasound
- F. Optical coherence tomography
- G. Infusion
 - 1. Dimensions (French size)
 - 2. Shapes
 - 3. Side/end holes
 - 4. Recoil
 - 5. Coatings (heparin, hydrophilic)
 - 6. Tractability
 - 7. Torque
 - 8. Support
 - 9. Application
 - 10. Complications

11. Types
 - a. Angiographic
 - b. Occlusion
 - c. Angioplasty (percutaneous transluminal angioplasty)
 - d. Atherectomy
 - 1) Rotational
 - 2) Orbital
 - e. Directional coronary
 - f. Thrombectomy
 - g. Extraction (transluminal extraction catheter)
 - h. Intravascular ultrasound
 - i. Optical coherence tomography
 - j. Infusion
- H. Guidewires
 1. Diagnostic
 2. Interventional
 3. Physical characteristics
 - a. Dimensions
 - b. Shapes
 - c. Types
 - d. Coatings (heparin, hydrophilic)
 - e. Components
 - f. Core diameter
 - g. Core taper/grind
 - h. Core material
 - i. Tip style
 - j. Coils & covers
 - k. Coatings
 4. Technical attributes
 - a. Torque response
 - b. Lubricity
 - c. Radiopacity
 - d. Force transmission
 - e. Support
 - f. Length
 5. Performance properties
 - a. Steerability
 - b. Trackability
 - c. Pushability
 - d. Crossability
 - e. Visibility
 - f. Durability
 - g. Tactile feedback
 6. Specialty guidewires
 - a. Diameter sizes
 - b. Lengths

- I. Guide catheters
 1. Types
 2. Preparation
 3. Construction
 4. Function
 5. Application
 6. Complications
 7. Storage

VI. Therapeutic Devices

- A. Angioplasty balloons
 1. Monorail versus over the wire
 2. Compliant
 3. Non-compliant
 4. Cutting balloons
 5. Drug eluting balloons
- B. Stents
 1. Vascular
 - a. Types
 - b. Preparation
 - c. Construction
 - d. Function
 - e. Complications
 2. Coronary
 - a. Types
 - b. Preparation
 - c. Construction
 - d. Function
 - e. Complications
 3. Biliary
 - a. Types (e.g., self-expanding, internal/external)
 - b. Preparation
 - c. Construction
 - d. Function
 - e. Complications
 4. Covered
 - a. Types
 - b. Preparation
 - c. Construction
 - d. Function
 - e. Complications
 5. Drug-eluting
 - a. Types
 - b. Preparation
 - c. Construction

- d. Function
- e. Complications

VII. Invasive circulatory support

- A. Intra-aortic Balloon Pump
 - 1. Indications / Contraindications
 - 2. Equipment
 - 3. Insertion / Removal
 - 4. Physiology
 - 5. Hemodynamics
 - 6. Timing
- B. Percutaneously deployed ventricular assist devices (P-VADs)
 - 1. Indications / Contraindications
 - 2. Equipment
 - 3. Insertion / Removal
 - 4. Physiology
 - 5. Hemodynamics
- C. Atherectomy
 - 1. Indications / Contraindications
 - 2. Equipment
 - 3. Insertion / Removal
- D. Pressure wires
 - 1. Indications / Contraindications
 - 2. Equipment
 - 3. Insertion / Removal
- E. Endografts
 - 1. Indications / Contraindications
 - 2. Equipment
 - 3. Insertion / Removal
- F. Pericardiocentesis
 - 1. Indications / Contraindications
 - 2. Equipment
- G. Chest tubes
 - 1. Indications / Contraindications
 - 2. Equipment
 - 3. Insertion / Removal
- H. Laser (endarterectomy)
 - 1. Indications / Contraindications
 - 2. Equipment
 - 3. Insertion / Removal
- I. Distal protective devices
 - 1. Indications / Contraindications
 - 2. Equipment
 - 3. Insertion / Removal
- J. Thrombectomy
 - 1. Indications / Contraindications

- 2. Equipment
- 3. Insertion / Removal
- K. Brachytherapy
 - 1. Indications / Contraindications
 - 2. Equipment
- L. Embolic agents
 - 1. Indications / Contraindications
 - 2. Equipment
- M. Caval filters
 - 1. Indications / Contraindications
 - 2. Equipment
 - 3. Insertion / Retrieval
- N. Foreign body retrieval device
 - 1. Indications / Contraindications
 - 2. Equipment
- O. Flow diversion devices
 - 1. Indications / Contraindications

VIII. Needles

- A. Types
 - 1. One piece
 - 2. Two piece
 - 3. Doppler-guided needle
- B. Vascular access methods
 - 1. Single wall
 - 2. Double wall
 - 3. Seldinger/ modified Seldinger
 - 4. Micropuncture
- C. Construction and design
- D. Application
- E. Special considerations and requirements

IX. Miscellaneous Accessory Devices

- A. Dilators
- B. Inflation devices (endoflator)
 - 1. Nominal inflation
 - 2. Rated burst pressure
- C. Introducer sheaths (vascular and peel-away)
- D. Adaptors
- E. Connectors
- F. Stopcocks
- G. Tuohy borst
- H. Manifolds
- I. Telfa
- J. Torque device
- K. Suture

- L. Carbon dioxide setup
- M. Fluid line
- N. Micropuncture sets
- O. Hole punch sets

X. Reusable vs. Disposable Products

XI. Methods of Sterilization

- A. Instruments
- B. Catheters

XII. Patient Assessment Instrumentation

- A. Physiologic monitoring
 - 1. Hemodynamic
 - 2. Blood pressure
 - a. Noninvasive
 - b. Invasive (e.g., pressure transducer)
 - 3. Electrocardiogram (ECG)
 - 4. Pulse oximeter
 - 5. Wave form capnography
- B. Hemoximeter
- C. Activated clotting time (ACT) unit
- D. Blood Gas
 - 1. Acidosis
- E. Alkalosis glucose measurement
- F. Doppler pulse unit
- G. Cardiac Stimulation Equipment
 - 1. Internal
 - 2. External
 - 3. Synchronized cardioversion
 - 4. Defibrillation
- H. Temporary cardiac pacing
 - 1. Subcutaneous
 - 2. Transvenous
- I. Electrophysiology stimulation
- J. Permanent pacemaker
- K. Leadless pacemaker
- L. Automatic internal cardiac defibrillator

XIII. Permanent Dialysis Access Sites

- A. Tunneled dialysis catheter
- B. Peritoneal dialysis
- C. Arteriovenous (AV) fistula or graft

Pharmacology and Drug Administration

Description

Content provides basic concepts of pharmacology, venipuncture and administration of diagnostic contrast agents and intravenous medications. The appropriate delivery of patient care during these procedures is emphasized.

Objectives

1. Recognize the chemical, generic and trade names of various drugs.
2. Describe the pharmacokinetic, pharmacodynamic and pharmacogenetic principles of drugs.
3. Explain the uses and effect on the patient of different categories of drugs.
4. Define the categories of contrast agents and give specific examples for each category.
5. Explain the pharmacology of contrast agents.
6. Describe methods and techniques for administering various types of contrast agents.
7. Identify and describe the routes of drug administration.
8. Demonstrate appropriate venipuncture technique.
9. Differentiate between the two major sites of intravenous drug administration.
10. Identify, describe and document complications associated with venipuncture, and appropriate actions to resolve these complications.
11. Discuss the steps of initiating and discontinuing intravenous access.
12. Differentiate and document dose calculations for adult and pediatric patients.
13. Prepare for injection of contrast agents and intravenous medications using aseptic technique.
14. Explain the current legal status and professional liability issues of the technologist's role in contrast and drug administration.
15. Identify common medications and contrast media used in the interventional suite, and the indications and contraindications for each.

Content

I. Drug and IV Infusion Calculations

- A. Basic calculations
- B. IV drips units / hour
- C. IV drips microgram / min
- D. IV medication preparation / correctly mixing solutions

II. Administration routes

- A. Intracoronary (IC)
- B. Intra-arterial (IA)
- C. Intravenous (IV)
- D. Sublingual (SL)
- E. Subcutaneous (SQ)
- F. Oral (PO)
- G. Topical
- H. Indications and contraindications
 - I. Preparation and dosage
 - J. Complications

III. Medications

- A. Types
- B. ACE and ARB inhibitors
 - 1. Analgesics
 - 2. Antiarrhythmics
 - 3. Antibiotics
 - 4. Anticoagulants
 - 5. Antiemetics
 - 6. Antiplatelet medications
 - 7. Anxiolytics
 - 8. Antagonists
 - 9. Beta blockers
 - 10. Calcium channel blockers
 - 11. Diuretics
 - 12. Emergency medications
 - 13. Heparin and lovenox
 - 14. Coumadin (warfarin)
 - 15. Narcotics
 - 16. Platelet inhibitors
 - 17. Sedatives
 - 18. Thrombolytics
 - 19. Vasoconstrictors
 - 20. Vasodilators
 - 21. Local anesthesia
- C. Antagonists (e.g., protamine, vitamin K)
 - 1. Protamine

- 2. Vitamin K
- D. Indications and contraindications
- E. Complications
- F. Risks and response
 - 1. Monitored values indicating a patient at risk
 - 2. Monitored values requiring an immediate response
 - a. Plan(s) for emergency response
- G. Conscious sedation
 - 1. Description
 - 2. Vitals to be monitored

IV. Contrast Administration

- A. Properties of nonionic contrast agents
- B. Premedication/preprocedure preparation
- C. Indications and contraindications
- D. Carbon dioxide angiography

ASRT

Patient Care, Assessment and Monitoring

Description

Content provides strategies for patient assessment prior to, during and following the completion of interventional examinations. Important measures such as vital signs, lab values and physiologic monitoring are described. Contrast media, common patient medications and techniques for delivery will be discussed. Aseptic and sterile technique are explained, as well as procedures to respond to patient medical emergencies.

Objectives

1. Gather and interpret patient vital sign data.
2. Employ proper charting techniques.
3. Evaluate recorded lab values, allergies and precautions from a patient's chart.
4. Critically analyze data created by physiologic monitoring devices used during the course of an interventional examination.
5. Identify common medications and contrast media used in the interventional suite, and the indications and contraindications for each.
6. Apply proper techniques in the management of intravenous (IV) therapies.
7. Maintain sterile fields and aseptic technique during interventional procedures.
8. Perform a mandatory "timeout" prior to beginning all interventional procedures.
9. List required consent documentation and content for select procedures.
10. Explain the reason for a given exam and the link to previous patient history.

Content

I. Patient Interactions and Management

- A. HIPAA requirements
- B. Patient Communication
 - 1. Pre-procedure
 - a. Explanation of procedure
 - b. Informed consent
 - c. Explanation of radiation risk
 - d. Pre-procedure time-out
 - 2. Intra-procedure
 - 3. Post-procedure care instructions
- C. Patient education

II. Vital Signs

- A. Temperature
- B. Heart rate
- C. Respiration
- D. Capnography, pulse oximetry
- E. Blood pressure
 - 1. Invasive and non-invasive
- F. Pain assessment
 - 1. Visual analogue scale (VAS)

III. Respiratory Monitoring

- A. Capnography
- B. Pulse oximetry

IV. Patient Assessment Scales

- A. Aldrete score
- B. Mallampiti score
- C. American Society of Anesthesiologists' (ASA) classification of Physical Health
- D. The New York Heart Association (NYHA) Functional Classification

V. Access Assessment

- A. Vascular patency
- B. Radial artery assessment
 - 1. Allen's test
 - 2. Barbeau test
- C. Pulse assessment for arterial access
 - 1. Palpation of pulses
 - 2. Quantifying pulses
 - 3. Stethoscope assessment
 - 4. Doppler flow assessment
- D. Ultrasound assessment for venous and arterial access
- E. Peripheral pulses (e.g., palpation, Doppler)

- F. Arterial Anatomical location
 - 1. Radial
 - 2. Brachial
 - 3. Axillary
 - 4. Subclavian
 - 5. Carotid
 - 6. Femoral
 - 7. Popliteal
 - 8. Dorsalis pedis
- G. Venous access anatomical location
 - 1. Jugular
 - 2. Axillary
 - 3. Subclavian
 - 4. Basilic, brachial, cephalic
 - 5. Femoral

VI. Lab Values

- A. Chemistry
 - 1. Renal
 - 2. Blood Urea Nitrogen (BUN)
 - a. Glomerular filtration rate (GFR)
 - b. Serum Creatinine (SCr)
 - 3. Bilirubin
 - 4. Blood urea nitrogen (BUN)
 - 5. Creatinine
 - 6. Electrolytes
 - 7. Cardiac markers
 - 8. Glomerular filtration rate (GFR)
 - 9. Glucose
 - 10. Potassium
- B. Hematology
 - 1. Hematocrit
 - 2. Hemoglobin
 - 3. Platelet count
 - 4. White blood count (WBC)
- C. Point-of-care testing
 - 1. Coagulation monitoring
 - 2. Blood oxygenation
- D. Coagulation
 - 1. Prothrombin time (PT)
 - 2. Partial thromboplastin time (PTT)
 - 3. International normalized ratio (INR)
 - 4. Activated clotting time (ACT)
- E. Oxygenation Parameters
 - 1. Normal Ranges
 - a. Partial Pressure of Arterial Oxygen (PaO₂)

- b. Partial Pressure of Arterial CO₂(PaCO₂)
- c. Bicarbonate (HCO₃)
- d. pH
- e. Arterial Oxygen Saturation (SaO₂)
- f. Mixed Venous Saturation (SvO₂)
- 2. Interpretation of Arterial Blood Gasses
 - a. Acidosis
 - b. Alkalosis
- 3. Equations and Normal range
 - a. Arterial oxygen content (CaO₂)
 - b. Venous oxygen content (CvO₂)
 - c. A-V oxygen content difference
 - d. Oxygen consumption (VO₂)

VII. Patient Assessment Scales

- A. Mallampati
- B. Airway evaluation
- C. ASA classification of physical status
- D. NYHA heart failure
- E. CCS angina class
- F. Maintaining accessory medical devices
 - 1. Oxygen delivery systems
 - 2. Chest tubes
 - 3. In-dwelling catheters
 - 4. Drainage bags
 - 5. BP equipment
 - 6. Airway equipment
 - 7. Suction
 - 8. Physiological monitors

VIII. IV Therapy

- A. Indications and contraindications
- B. Venipuncture
- C. Solution preparation
- D. Flow rate
- E. Complications

IX. Infection Control

- A. Transmission of infection
 - 1. Contact
 - 2. Airborne
 - 3. Droplet
- B. Types of precautions
 - 1. CDC Standard Precautions
 - 2. Transmission-based precautions

- C. Handling and disposal of biohazardous materials
- D. Postprocedural cleaning

X. Timeout Procedure

- A. Informed consent
- B. Correct patient (2 identifiers)
- C. Correct side
- D. Correct site
- E. Availability of equipment/implanted devices
- F. Medications
 - 1. Patient-related
 - a. Discontinuation
 - b. Pre-procedure preparation
 - 2. Procedure-related
 - a. Availability
 - 1) Dispensing system (e.g. Pyxis)
 - 2) Backtable
 - b. Chemotherapy-type medications
 - 1) Safety and handling
 - 2) Setup and disposal
 - 3) Embolization and infusion
 - c. Therasphere
 - 1) Safety and handling
 - 2) Setup and disposal
 - 3) Embolization and infusion
 - d. Selective internal radiation (SIR) sphere
 - 1) Safety and handling
 - 2) Setup and disposal
 - 3) Embolization and infusion
- G. Allergies
- H. Personnel involved
- I. Anticipated blood loss
- J. Relevant lab values
- K. H&P performed before consent and procedure

Physiologic Monitoring and Recording

Description

Content introduces the theories of patient physiologic monitoring, and their application during an interventional procedure. The student will recognize the difference between atrial, junctional and ventricular arrhythmias, as well as interpret these conditions and discuss possible causes.

Objectives

1. Measure the patient's baseline physiologic values (ECG, oxygen saturation, pulse, etc.).
2. Identify patterns of cardiac arrhythmias (atrial, ventricular, junctional) as they appear on ECG strips of a physiological oscilloscope.
3. Describe patient management procedures for arrhythmias.
4. Recognize change in ventricular pressure with respect to change in time (dP/dt) and how it is determined.
5. Perform cardiac output measurements, including the Fick method and thermal dilution.
6. Describe area-length method and computer evaluation techniques for ventricular volume analysis.
7. Explain the function of transducers, amplifiers, oscilloscopes and digital readout modules.
8. Calibrate the transducer, amplifier, recorder and oscilloscope.
9. Identify valvular gradients and determine valve area.
10. Explain the indications for inserting a temporary or permanent pacemaker or internal cardiac defibrillators.
11. Explain the indications for and principles of intraaortic balloon pumping.
12. Evaluate cardiac vascular resistance, regurgitant disease, shunts and valve stenosis.

Content

I. Physiologic Monitoring

- A. ECG
 - 1. Lead placement
 - a. 3-lead
 - b. 5-lead
 - c. 12-lead
 - 2. EKG paper/caliper measurements
 - 3. Heart rate calculations
 - 4. Rhythm interpretation
 - 5. Electrical dynamics
 - 6. 12-Lead patterns
 - a. Hypertrophy
 - b. Axis
 - c. Bundle branch
 - d. Infarct
- B. Pulse oximetry
 - 1. Normal and abnormal
 - 2. Waveform recognition
- C. Capnography
 - 1. End-tidal CO₂ (etCO₂)
 - 2. Normal and abnormal values
 - 3. Waveform recognition
- D. Invasive blood pressure
 - 1. Waveform recognition
 - 2. Normal and abnormal values
- E. Equipment
 - 1. Transducer
 - 2. Amplifiers
 - 3. Recorder
 - a. Digital read-out module
 - b. Calibration, balancing
 - c. Baseline determination
- F. Specialized techniques
 - 1. dP/dt
 - 2. Ejection fraction
 - 3. Cardiac output measurements
 - a. Fick method
 - b. Thermal dilution
 - c. Angiographic
 - d. Stroke volume x heart rate (basic formula)
 - 4. Ventricular volume analysis
 - a. Area-length method
 - b. Computer evaluation
 - 5. Valvular gradients
 - 6. Normal valve areas

II. Cardiac Monitoring

- A. Conduction pathway
 - 1. Recognition of arrhythmias
 - 2. Interpretation of arrhythmias
- B. Normal sinus rhythm
- C. Bradycardia
- D. Tachycardia
- E. Atrial rhythms
- F. SVT's (AFib, AFlutter, reentry tachycardia)
- G. Heart blocks (AV blocks [1st, 2nd, 3rd degree])
- H. Junctional rhythms
 - I. Bundle branch blocks
 - J. Ventricular rhythms
- K. Management of arrhythmias
- L. Pacemakers
 - 1. Temporary
 - a. Transcutaneous pacing
 - b. Transvenous pacing
 - 2. Permanent
 - a. Transvenous pacing
 - b. Transmyocardial pacing
- M. Mechanical circulatory support
 - 1. Intraaortic balloon pump (IABP)
 - a. Indication for IABP
 - b. Principle of IABP operation
 - c. Physiological basis of IABP
 - d. Types
 - e. Construction
 - f. Function
 - 1) Pump and electrocardiogram coordination
 - 2) Triggering
 - a) ECG
 - i) Peak
 - ii) R wave
 - b) Aortic pressure
 - g. Technique for insertion
 - h. Monitoring
 - i. Complications
 - j. Troubleshooting
 - 2. Impella
- N. ECMO and other left heart assist devices
- O. Automated defibrillator
- P. Loop recorder

III. Recording Systems

- A. Equipment

Sterile Technique

Description

Content provides the student with an overview of sterile technique and isolation procedures that apply to cardiac- and vascular-interventional procedures.

Objectives

1. List the types of microorganisms.
2. Describe the body's defense systems.
3. Define the process of infection.
4. Identify the causes of infectious disease.
5. Describe the methods of transmitting infectious agents.
6. Define the terms *sterile*, *aseptic* and *disinfectant*.
7. Describe the methods of sterilization.
8. Explain the principles of aseptic technique.
9. List various disinfectants.
10. Demonstrate scrubbing technique for procedural personnel.
11. Use gowning and gloving to maintain a sterile field.
12. List the steps in scrubbing and patient preparation.
13. Describe proper hand-washing techniques.
14. Describe procedural hand antisepsis

Content

I. Types of Microorganisms

- A. Bacteria
- B. Fungi
- C. Viruses
- D. Protozoa
- E. Prions
- F. Helminths

II. Defense Systems of the Body

- A. Nonspecific defense system
- B. Active immunity system
- C. Passive immunity

III. Process of Infection

- A. Incubation period
- B. Prodromal phase
- C. Active stage
- D. Convalescence

IV. Causes of Infectious Disease

- A. Portal of entry
- B. Host defenses
- C. Inflammatory response
- D. Properties of organism

V. Elements Needed To Transmit Infection

- A. Infectious agent
- B. Reservoir
- C. Portal of exit
- D. Portal of entry

VI. Methods of Transmitting Agents

- A. Direct
- B. Indirect
- C. Airborne
- D. Vehicle
- E. Vector

VII. Sterilization Methods

- A. Steam under pressure
- B. Gas
- C. Chemical
- D. Dry heat
- E. Ionizing radiation

VIII. Asepsis

- A. Nosocomial infection
- B. Environmental cleaning
 - 1. Types
 - a. Terminal cleaning
 - b. Damp dusting
 - c. Turnover cleaning
 - 2. Disinfectants
 - a. Germicidal disposable wipes

IX. Skin Preparation

- A. Hair removal
 - 1. Electric shaver
 - 2. Depilatory cream
- B. Antiseptic solutions
 - 1. Application technique
 - 2. Indications and contraindications
 - 3. Solution types
 - a. Betadine combination
 - b. ChloraPrep
 - c. DuraPrep

X. Sterile Field

- A. Patient preparation
 - 1. Positioning
 - a. Femoral approach
 - b. Right and left radial approach
- B. Draping
 - a. Cuffing technique
 - b. Femoral approach
 - c. Right and left radial approach
- C. Procedural tray
 - 1. Supply transfer (equip & fluids) to sterile field
 - a. Package integrity
 - b. Opening technique
 - c. Fluid transfer technique and devices
- D. Equipment preparation
 - 1. Image receptor
 - 2. Control surfaces
- E. Maintenance of Sterile Fields
 - 1. Time of use
 - 2. Movement of fields
 - 3. Monitoring of field
 - 4. Circulator proximity
 - 5. Table cover use

- F. Disposal of procedural equipment
 - 1. Sharps (e.g., needles, scalpel)
 - 2. Biohazard material
- G. Equipment and supply packaging
 - 1. Integrity inspection
 - 2. Types
 - 3. Shelf life
 - a. Woven packaging materials
 - b. Peel pouches
 - c. Rigid sterilization containers
 - d. Plastic-wrapped supplies
 - 4. Sterile Indicators

XI. Scrubbing, Gowning and Gloving

- A. Surgical scrub techniques
- B. Solution types
 - 1. Aqueous
 - a. Chlorhexidine
 - b. Povidone iodine
 - 2. Alcohol
 - a. Ethanol
 - b. Isopropanol
 - c. N-propanol
 - 3. Alcohol rubs w/ additional active ingredients
 - a. Manufacturers' IFU
- C. Gowning
 - 1. Attire
 - a. Caps
 - b. Masks
 - c. Gowns
 - 2. Methods
 - a. Location
 - b. Self
 - c. Physician
- D. Gloving
 - 1. Glove materials
 - 2. Technique
 - a. Open
 - b. Closed
 - c. Double

Vascular Approaches

Description

Content provides the student with a theoretical and practical knowledge of interventional procedures. It will include an overview of the Seldinger technique of vascular access for vascular procedures, and examine the history that led to its development.

Objectives

1. Explain how angiographic procedures were performed prior to the development of the Seldinger technique, including Sones technique for cardiac catheterization.
2. Compare and contrast the vessel construction of arteries and veins.
3. Describe the Seldinger technique.
4. Describe alternative vascular approaches, including axillary, direct carotid, brachial, radial, translumbar, venous and cutdowns.
5. Explain the indications for selecting each of the alternative vascular approaches.

Content

I. History of Angiography

II. Imaging with cine film

III. Vascular Anatomy

- A. Layers
 - 1. Arteries
 - 2. Veins
- B. Access assessment
 - 1. Vascular patency
 - a. Peripheral pulse
 - b. Allen test
 - c. Barbeau test
 - 2. Arterial anatomical location
 - a. Femoral
 - b. Radial
 - c. Brachial
 - d. Axillary
 - e. Dorsalis pedis
 - f. Popliteal
 - 3. Venous anatomical location
 - a. Jugular
 - b. Femoral
 - c. Subclavian
 - d. Axillary
 - e. Basilic
 - f. Brachiocephalic
 - g. Translumbar
 - 4. Imaging
 - a. Ultrasound
 - b. Fluoroscopy

IV. Equipment Selection

V. Local Anesthesia

- A. Procaine
- B. Lidocaine
- C. Bupivacaine
- D. Mepivacaine
- E. Anesthetic cream

VI. Medical Regimen for Radial Catheterization

- A. Heparin
- B. Verapamil

- C. Nitroglycerin
- D. Lidocaine

VII. Identifying Potential Patient Risks

VIII. Local Vascular Complications

- A. Local vascular complications
- B. Hematoma
- C. Retroperitoneal hematoma (RPH)
- D. Pseudoaneurysm.
- E. Arterio-venous (AV) fistula.
- F. Arterial thrombosis

IX. Access Techniques

- A. Seldinger
- B. Modified Seldinger

X. Positioning and Stabilization Equipment

- A. Patient preparation
- B. Armboard

XI. Vascular Access

XII. Femoral Artery and Vein

- A. Left and right approaches
 - 1. Indications
 - 2. Contraindications
- B. Retrograde
 - 1. Indications
 - 2. Contraindications
- C. Antegrade
 - 1. Indications
 - 2. Contraindications
- D. Complications

XIII. Axillary Artery and Vein

- A. Left and right axillary technique
 - 1. Indications
 - 2. Contraindications
- B. Complications

XIV. Radial Artery

- A. Indications
- B. Contraindications
- C. Technique
- D. Complications

- XV. Retrograde Brachial Artery**
 - A. Indications
 - B. Contraindications
 - C. Technique
 - D. Complications

- XVI. Jugular Vein**
 - A. Indications
 - B. Contraindications
 - C. Technique
 - D. Complications

- XVII. Basilic Vein**
 - A. Indications
 - B. Contraindications
 - C. Technique
 - D. Complications

- XVIII. Brachial Vein**
 - A. Indications
 - B. Contraindications
 - C. Technique
 - D. Complications

- XIX. Subclavian Vein**
 - A. Indications
 - B. Contraindications
 - C. Technique
 - D. Complications

- XX. Extremity Vein**
 - A. Indications
 - B. Contraindications
 - C. Technique
 - D. Complications

- XXI. Direct Stick Carotid or Vertebral**
 - A. Indications
 - B. Contraindications
 - C. Technique
 - D. Complications

- XXII. Arterial Cutdown**
 - A. Indications
 - B. Contraindications

- C. Technique
- D. Complications

XXIII. Venous Cutdown

- A. Indications
- B. Contraindications
- C. Technique
- D. Complications

XXIV. Translumbar

- A. Indications
- B. Contraindications
- C. Technique
- D. Complications

XXV. Postprocedural Homeostasis Methods

- A. Vascular closure methods
 - 1. Indications
 - 2. Contraindications
 - 3. Technique
 - 4. Complications
- B. Homeostasis Methods
 - 1. Manual pressure
 - 2. Mechanical compression
 - a. Femoral (e.g., Femo-Stop, ClampEase)
 - b. Transradial
 - 3. Vascular Closure Devices
 - a. Passive
 - 1) Hemostasis pads (e.g., Chito-Seal, Neptune Pad)
 - b. Active
 - 1) Cardiva catalyst (e.g., Boomerang)
 - c. Collagen plug device (e.g., Angio-Seal, Mynx and suture)
 - 1) Polyglycolic acid (PGA) plug device (e.g., ExoSeal)
 - d. Extracellular matrix patch (e.g., FISH device)
 - e. Clip device (e.g., Starclose)
 - f. Suture devices (e.g., Perclose)
 - g. Nitinol clip
 - h. PEG hydrogel plug

Vascular Pathophysiology

Description

Content provides the student with an overview of vascular correlation and surgical/interventional repair for specific congenital and acquired diseases.

Objectives

1. List the process and most common sites of atherosclerosis.
2. Describe the types and most common locations of arterial aneurysms.
3. Explain the clinical aspects of arterial dissections.
4. List the various types of traumatic arterial injuries, including perforations and dissections.
5. Define *renovascular disease* and describe the disease process.
6. Define the various angiographic pathologies of mesenteric vessels.
7. Explain the process and the clinical aspects of peripheral arterial disease.
8. Explain the various disease pathologies in cerebrovascular disease.
9. Describe the differences in the various diseases of the coronary arteries.
10. Define TIMI flow.
11. Explain and define the clinical aspects of portal hypertension.

Content

I. Pathology

- A. Acquired Valvular Disease
 - 1. Murmurs
 - 2. Hemodynamics
 - 3. Pulses
- B. Rheumatic fever
- C. Mitral stenosis
- D. Mitral regurgitation
- E. Aortic stenosis
- F. Aortic insufficiency

II. Pericardial and Myocardial

- A. General
 - 1. Tamponade
 - 2. Constrictive pericarditis
 - 3. restrictive cardiomyopathy
 - 4. Myocarditis
 - 5. Endocarditis
 - 6. Pressure waveforms
- B. Pericardial
 - 1. Etiology
 - 2. Clinical manifestations
 - 3. Assessment
 - 4. Therapy
- C. Myocardial
 - 1. Etiology
 - 2. Clinical manifestations
 - 3. Assessment
 - 4. Therapy
- D. Endocardial
 - 1. Etiology
 - 2. Clinical manifestations
 - 3. Assessment
 - 4. Therapy

III. Coronary Artery Disease and M.I.

- A. General ischemic heart disease
 - 1. Arteriosclerosis
 - 2. Atherosclerosis
 - 3. Ischemia
 - 4. Infarction
 - 5. Etiology
 - 6. Collaterals circulation
 - 7. Stenosis calculations

- B. Acute coronary syndromes
 - 1. ST elevation myocardial infarction (STEMI)
 - 2. Non-ST elevation myocardial infarction (NSTEMI)
 - 3. Unstable angina (Prinzmetal angina)
- C. Coronary angiographic pathology
 - 1. TIMI grade flow
- D. Physiology and mechanisms of CAD.MI
 - 1. Thrombus
 - 2. Spasm
- E. Coronary effect on Left Ventricle
 - 1. Akinetic
 - 2. Hypokinetic
 - 3. Dyskinetic
 - 4. Asynchronous
- F. Complications
- G. Signs and symptoms
 - 1. Stable angina
 - 2. Unstable angina
 - 3. Prinzmetal
 - 4. Risk factors
- H. ECG changes
 - 1. Infarction
 - 2. Injury
 - 3. Ischemia

IV. Heart Failure and Shock

- A. Forms of CHF
- B. Hemodynamics of CHF
- C. Signs and symptoms
- D. Management
- E. Shock pathology
- F. Management and therapy of shock

V. Surgery and Artificial Valves

- A. General surgery
- B. Valve surgery
- C. Coronary bypass surgery

VI. Congenital Heart Disease

- A. General congenital heart disease
- B. Identification of congenital heart disease
- C. Management and therapy

VII. Vascular Disease

- A. Hypertension

- B. Aortic aneurysms
- C. Aortic dissections
- D. Pulmonary embolism
- E. Arterial embolism
- F. Renovascular disease

VIII. Pathophysiology

- A. Define and describe:
 - 1. Atherosclerosis
 - 2. Aneurysm
 - 3. Vessel dissection
 - 4. Embolism
 - 5. Thrombosis
 - 6. Hemothorax
 - 7. Pneumothorax
 - 8. Sepsis
 - 9. Thrombotic embolism
 - 10. Respiratory arrest
 - 11. Myocardial infarction
 - 12. Congestive heart failure
 - 13. Cardiac tamponade
 - 14. Cardiac effusion
 - 15. Systolic heart failure
 - 16. diastolic heart failure
 - 17. Restrictive arrhythmogenic failure
 - 18. Renovascular disease
 - 19. Mesenteric and visceral
 - 20. Peripheral artery disease (PAD)
 - 21. Cerebrovascular disease
 - 22. Transient ischemic attack
 - 23. Abscess
 - 24. Cerebrovascular accident
 - 25. Coronary artery disease
 - 26. Appendicular disease

Specialized Content

The specialized content section serves as the exam-specific component of the curriculum and is divided by cardiac-interventional studies and vascular-interventional studies.

ASRT

Cardiac-Interventional Procedures

Description

Content presents a systematic approach to the techniques and procedures technologists use in the performance of select cardiac-interventional procedures. Common to the discussion of all procedures will be the following:

- Anatomy and physiology.
- Pathology.
- Indications for the procedure.
- Contraindications.
- Patient positioning.
- Access method.
- Patient management during the exam.
- Contrast administration.
- Equipment and devices
- Exposure technique.
- Image enhancement and processing.
- Procedure
- Closure methods.
- Possible complications.
 - Recognition.
 - Treatment.

Objectives

1. Describe the basic principles of image acquisition (cine camera, digital detector, etc.).
2. Describe the procedure of cine operation.
3. Describe the digital image acquisition procedure.
4. Assist in the performance of cardiac-interventional procedures.
5. Recognize normal and abnormal cardiac anatomy.
6. Assess the patient prior to and during cardiac-interventional procedures.
7. Identify the indications and contraindications for cardiac-interventional procedures.
8. Recognize and respond effectively to patient complications that arise during the performance of cardiac-interventional procedures.
9. Demonstrate various methods of achieving hemostasis following catheter/sheath removal.

Content

I. Imaging Equipment

- A. Basic operation
- B. Digital image acquisition

II. Diagnostic Cardiac Studies

- A. Cardiovascular angiography
 - 1. Indications and contraindications
 - 2. Equipment
 - a. Guide wires
 - b. Catheters
 - c. Manifold
 - 3. Vessels and chambers
 - a. Aortography
 - b. Carotid
 - c. Coronary
 - d. Internal mammary
 - e. Pulmonary
 - f. Renal
 - g. Saphenous vein graft
 - h. Ventriculography
- B. Peripheral angiography
 - 1. Femoral
 - 2. Radial
 - 3. Subclavian

III. Right Heart Catheterization

- A. Indications and contraindications
- B. Complications
- C. Procedure
- D. Equipment
 - 1. Catheters
 - 2. Transducers
 - 3. Pressure recording systems
 - 4. System electronics
 - 5. Calibration and recording
 - 6. Recording errors
 - 7. Frequency response
- E. Swan–Ganz insertion techniques

IV. Hemodynamics and Circulations

- A. Normal hemodynamic parameters
 - 1. Arterial blood pressure
 - 2. Mean arterial pressure
 - 3. Pulse pressure variation
 - 4. Stroke volume

5. Right atrial pressure
6. Right ventricular pressure
7. Pulmonary artery pressure
8. Mean pulmonary artery pressure
9. Pulmonary artery wedge pressure
10. Left atrial pressure
11. Left ventricular end diastolic pressure

V. Oxygenation Assessment

- A. Interpretation of arterial blood gasses
- B. Normal range/ equations
 1. Arterial Oxygen Content (CaO_2)
 2. Venous Oxygen Content (CvO_2)
 3. A-V Oxygen Content Difference
 4. Oxygen Consumption (VO_2)

VI. Pressure readings

- A. Venous
- B. Ventricular
- C. Arterial

VII. Pressure Waveform Interpretation

- A. Right heart catheterization
- B. Pullback pressures
- C. Respiratory effects
- D. Gradients
- E. Pressure pathology
 1. Coronary artery monitoring
 2. Valve
 - a. Mitral stenosis
 - b. Mitral regurgitation
 - c. Aortic stenosis
 - d. Aortic regurgitation
 3. Congestive heart failure
 4. Constrictive – restrictive pressures
 5. Myocardial & pericardial
 6. Congenital
- F. Hemodynamic calculations
 1. Units
 2. Poiseuille's law
 3. Cardiac output
 - a. Fick method
 - b. Thermodilution
 - c. Angiographic
 4. A-V difference
 5. Cardiac index

6. Stroke volume
7. Ejection fraction
8. Systemic blood flow
9. Pulmonary blood flow
10. Coronary artery perfusion pressure
11. Fick equation
12. Right ventricular end-diastolic volume
13. Right ventricular end-systolic volume
14. Right ventricular ejection fraction
15. Mean arterial pressure
16. Peak to peak
17. Regurgitant fraction
18. Systolic ejection period
19. Valve area
 - a. Gorlin
 - b. Hakki
20. Vascular resistance
 - a. Ohm's law
 - b. Absolute resistant units
 - c. Systemic resistance
 - d. Pulmonary resistance
21. Shunt detection
 - a. Flow
 - b. Ratio
22. Qualitative LV angiography
23. Cardiovascular ultrasound
 - a. Transthoracic (TTE)
 - b. Trans-esophageal
24. Intracardiac echocardiography (ICE)

VIII. Intravascular Imaging

- A. Optical coherence tomography (OCT)
- B. Intracoronary optical frequency domain imaging (OFDI)
- C. Intravascular ultrasound (IVUS)
- D. Image interpretation

IX. Cardiovascular Ultrasound

- A. Transthoracic (TTE)
- B. Trans-esophageal (TEE)
- C. Intracardiac echocardiography (ICE)

X. Coronary Hemodynamics

- A. Physiology and flow
- B. Hyperemic agents
- C. Assessment
 1. Fractional flow reserve measurement (FFR)

- a. $FFR = Pd/Pa$
- 2. Instantaneous wave-free ratio (iFR)
- D. Door-to-balloon time

XI. Cardiac Biomarkers

- A. Troponin
- B. Creatine kinase (CK-MB)
- C. Lactate dehydrogenase (LDH)
- D. Myoglobin (Mb)

XII. Percutaneous Coronary Intervention

- A. Angioplasty
 - 1. Indications and contraindications
 - 2. Complications
 - 3. Procedure
 - a. Angioplasty
 - b. Mechanisms
 - c. PCI techniques
 - 1) Bifurcation
 - 4. Equipment
 - a. Dilation balloon
 - 1) Configuration
 - a) Monorail
 - b) OTW
 - b. Catheter
 - c. Y-Adapter (Tuohy Borst Adapter)
 - d. Coronary wires
 - 1) Length
 - 2) Diameter
 - 3) Types
 - a) Basic wires
 - b) CTO wires
 - c) Hydrophilic
 - d) Hydrophobic
 - e) Specialty wires
 - (1) rotational atherectomy
 - 4) Characteristics of wires
 - a) Support
 - b) Torqueability
 - c) Steerability
 - d) Pushability
 - e) Trackability
 - 5. PCI Angioplasty
 - 6. PCI Mechanisms
 - 7. PCI Medications
 - 8. PCI Techniques

- B. Embolization protection
 - 1. Equipment
 - a. Proximal
 - b. Distal
 - 1) Filter wire
- C. Debulking
 - 1. Directional atherectomy
 - 2. Rotational atherectomy
 - 3. Laser atherectomy
- D. Stent deployment
 - 1. Drug eluting
 - 2. Bare metal
 - 3. Covered
- E. Thrombolysis
 - 1. Mechanical
 - 2. Aspiration
 - 3. Pharmacologic

XIII. Percutaneous Structural Intervention

- A. Congenital and structural heart diseases
- B. Patent foramen ovale closure
- C. Atrial and ventricular septal defect closure
- D. Patent ductus arteriosus closure
- E. Left atrial appendage occlusion (Mitral clipping)
- F. Transcatheter valve replacement
 - 1. Pulmonic (TPVR)
 - 2. Aortic (TAVR)
- G. Interventions

XIV. Myocardial Biopsy

- A. Indications and contraindications
- B. Complications
- C. Procedure
- D. Equipment
- E. Biotomes
- F. Sheaths
- G. Imaging
- H. Valvuloplasty
 - 1. Atrial
 - 2. Mitral
- I. Myocardial Interventions
 - 1. Septal ablation
 - 2. Transmyocardial revascularization
- J. Pericardiocentesis
- K. Renal denervation

- L. Inferior vena cava filter placement/retrieval
- M. Foreign body retrieval
- N. Percutaneous ventricular restoration (PVR)
- O. Chronic total occlusion

XV. Percutaneous Intervention

- A. Congenital and structural heart diseases
 - 1. Patent foramen ovale closure
 - 2. Atrial and ventricular septal defect closure
 - 3. Patent ductus arteriosus closure
 - 4. Heart and pulmonary valve
- B. Valvuloplasty
 - 1. Aortic
 - 2. Mitral
 - 3. Pulmonic
 - 4. TAVR
- C. Septal Ablation
- D. Indication (for HOCM)
- E. Renal Denervation
- F. Inferior vena cava filter placement/retrieval
- G. Pericardiocentesis
- H. Myocardial biopsy
- I. Foreign body retrieval
- J. Percutaneous ventricular restoration therapy
- K. Brachytherapy

XVI. Therapy

- A. Ventricular assist devices
 - 1. General
 - a. Indications
 - b. Placement
 - c. Therapeutic effect
 - 2. Mechanical circulatory support devices
 - a. Intraaortic balloon counterpulsation
 - b. Impella
 - c. Extracorporeal membrane oxygenation (ECMO)
- B. Intraaortic balloon counterpulsation
 - 1. Impella
- C. Ventricular assist devices ECMO

XVII. Conduction System Studies

- A. Arrhythmia detection
- B. Arrhythmia ablation
 - 1. Atrial fibrillation
 - 2. Atrial flutter
 - 3. Ventricular tachycardia

- C. Cardioversion

XVIII. Subcutaneous Implantable Devices

- A. Electrophysiology
- B. Indications
- C. Types
 1. Pacemaker, permanent insertion
 2. Leads
 - a. Single or multiple
 - b. Unipolar or bipolar
 3. Internal cardiac defibrillator (ICD) insertion
 4. Biventricular pacemaker
 5. Implantable cardiac monitors (ICM)
 6. Epicardial pacing
- D. NASPE/BPEG generic pacemaker codes

XIX. Wireless Transcatheter Pacing System

XX. External Prophylactic Pacemaker

XXI. Paced Beat Recognition

- A. Arrhythmia detection
- B. Arrhythmia ablation
- C. Cardioversion
- D. Implants
 1. Pacemaker, permanent insertion
 - a. Single chamber
 - b. Dual chamber
 - c. His lead placement
 - d. Wireless MICRA
 2. Internal cardiac defibrillator (ICD) insertion
 - a. Single chamber
 - b. Dual chamber
 - c. Biventricular
 - d. Subcutaneous defibrillator
 3. Insertable loop recorder (ILR)
- E. Pacemaker, temporary insertion
- F. Transcutaneous pacemaker
- G. Electrophysiology studies
- H. Loop recorders and implantable recording /monitoring devices

XXII. Pediatric Cardiology Interventions

- A. Common anomalies
 1. Atrial septal defect
 2. Ventricular septal defect
 3. Valvular stenosis

- 4. Tetralogy of fallot
- 5. Aortic arch defects
- B. Corrective procedures
- C. Shunts

XXIII. Data Collection

- A. Centers for Medicare and Medicaid Services (CMS)
- B. Quality measures
 - 1. STEMI — CMS and American College of Cardiologists (ACC)
 - 2. Acute MI — CMS and ACC
 - 3. CathPCI Registry — ACC

ASRT

Vascular-Interventional Procedures

Description

Content presents a systematic approach to the techniques and procedures technologists use in the performance of vascular and nonvascular interventional procedures. Common to the discussion of all procedures will be the following:

- Anatomy and physiology.
- Pathology.
- Indications for the procedure.
- Contraindications.
- Patient positioning.
- Access method.
- Patient management during the exam.
- Contrast administration.
- Equipment.
- Exposure technique.
- Closure methods.

Objectives

1. Describe the basic principles of image capture.
2. Identify preventive maintenance and cleaning requirements of equipment.
3. Assist in the performance of vascular-interventional procedures.
4. Participate in patient assessment and management prior to and during vascular-interventional procedures.
5. Identify the indications and contraindications for vascular-interventional procedures.
6. Assess the patient before, during and after vascular and nonvascular interventional procedures.

Content

I. Image Detector

- A. Acquisition principles
- B. Function
- C. Cleaning and preventive maintenance
- D. Electrical safety

II. Neurologic

- A. Intracranial angiography
- B. Extracranial angiography
- C. Spinal angiography
- D. Embolization
- E. Thrombolysis and thrombectomy
- F. Angioplasty
- G. Stent placement
- H. Discography
- I. Vertebral augmentation
 - 1. Vertebroplasty
 - 2. Kyphoplasty
 - 3. Vertebral body implant

III. Thoracic

- A. Pulmonary angiogram
- B. Thrombolysis and thrombectomy
- C. Thoracic aortography
- D. Bronchial angiogram
- E. Embolization
- F. Thoracentesis
- G. Biopsy
- H. Drainage

IV. Genitourinary (GU) Studies

- A. Renal angiography
- B. Adrenal angiography
- C. Reproductive angiography
 - 1. female
 - 2. male
- D. Venous sampling
- E. Nephrostomy
 - 1. Placement
 - 2. Injection
- F. Ureteral stents
- G. Ureteral dilation
- H. Nephroureterostomy
 - I. Percutaneous stone extraction
- J. Embolizations

- K. Renal artery angioplasty
- L. Renal artery stent placement
- M. Cystostomy

V. Gastrointestinal (GI) Studies

- A. Selective visceral angiography
- B. Pharmacangiography (e.g., pitressin injection)
- C. Embolization
- D. Angioplasty
- E. Stent placement
 - 1. Esophageal
 - 2. Visceral
- F. Stone extraction
- G. Percutaneous transhepatic cholangiogram
- H. Biliary drainage/stenting
- I. Cholecystostomy
- J. Alcohol and radio frequency ablation of the liver
- K. Gastrostomy/gastrojejunostomy
- L. Endoscopic retrograde cholangiopancreatography (ERCP)
- M. Transjugular intrahepatic portosystemic shunt (TIPS)
- N. Chemoembolization
- O. Radioembolization (Yttrium 90)

VI. Peripheral Studies (Arterial and Venous)

- A. Abdominal aortography
- B. Upper extremity angiography
- C. Lower extremity angiography
- D. Angioplasty
- E. Stent/ placement
- F. Thrombolytic therapy (e.g., tissue plasminogen activator (tPA), reteplase)
- G. Foreign body retrieval
- H. Embolization
- I. Pharmacangiography (vasodilator: nitroglycerin, Integrilin)
- J. Endovenous thermal ablation (EVTA) procedures
 - 1. Radiofrequency vs. laser
 - 2. Sclerotherapy
 - 3. Cosmetic and foam
 - 4. Ambulatory phlebectomy

VII. Venous

- A. Central venous access/port placement
 - 1. Types
 - a. Non-tunneled catheter
 - b. Tunneled catheter
 - c. Port placement

- d. Peripheral
 - 1) IV
 - 2) PICC
- 2. Fibrin sheath removal
- 3. Thrombolysis
- 4. Various access sites
 - a. Internal jugular (IJ) vein
 - b. Femoral vein
 - c. Translumbar
 - d. Transhepatic
- B. Dialysis catheter placement
 - 1. Various access sites
 - a. Internal jugular (IJ) vein
 - b. Femoral vein
 - c. Translumbar
 - d. Transhepatic
- C. Dialysis shunt management
 - 1. Types
 - a. AV graft
 - b. AV fistula
 - 2. Thrombolysis
 - 3. Declot
 - 4. Percutaneous transluminal angioplasty (PTA)
 - 5. Stenting
 - 6. Injection
- D. Cavagram
 - 1. Superior vena cava
 - 2. Inferior vena cava
 - 3. Caval filter placement/retrieval
- E. Foreign body retrieval
- F. Stent placement
- G. Thrombolysis
 - 1. Mechanical
 - 2. Pharmacologic
- H. Angioplasty
- I. Venous sampling studies

VIII. Miscellaneous Procedures

- A. Abscess drainage
- B. Pressure measurements
- C. Biopsy
- D. Paracentesis
- E. Radio frequency ablation (RFA)
- F. Microwave ablation
- G. Cryoablation
- H. Chest tube placement

- I. Drain tube injection
- J. Activated clotting time

ASRT

Optional Content

The content in this section is intended to support programs by including content for technologies and technical principles that have been replaced with newer technical systems. Traditional technologies are still part of the fabric of many communities, and this content is still relevant in those areas. Content in this section will assist program planners wishing to enhance the curriculum with select topics of instruction intended to satisfy the mission of a given program or local employment market.

ASRT

Advanced Sectional Anatomy

Description

The ability to locate and identify structures in the axial (transverse), sagittal, coronal and orthogonal (oblique) planes is a necessary skill in many imaging and therapeutic modalities. Volumetric data sets and 3-D reconstruction of the body structures are increasingly important to the critical diagnosis and treatment of diseases. To enhance patient care and assist physicians, radiologic science professionals must understand cross-sectional anatomy.

Objectives

1. Distinguish normal anatomical structures in the transverse or axial, coronal, sagittal and orthogonal (oblique) cross-sectional imaging planes within the:
 - a. Head
 - b. Neck
 - c. Thorax
 - d. Abdomen
 - e. Pelvis
 - f. Body imaging
 - g. Extremities — large joints
2. Distinguish common pathologies recorded on multiplanar images.

Content

I. Head and Brain

- A. Surface anatomy of the brain
 - 1. Fissures (sulci)
 - a. Longitudinal cerebral
 - b. Lateral (Sylvian)
 - c. Central (fissure of Rolando)
 - 2. Convolutions (gyri)
 - a. Precentral
 - b. Postcentral
- B. Sinuses
 - 1. Frontal
 - 2. Maxillary
 - 3. Ethmoid
 - 4. Sphenoid
- C. Facial bones
 - 1. Mandible
 - 2. Maxillae
 - 3. Zygomas
 - 4. Nasal bones
 - 5. Inferior nasal conchae
 - 6. Lacrimal
 - 7. Palatine
 - 8. Vomer
- D. Cranial bones
 - 1. Frontal
 - 2. Ethmoid
 - a. Nasal conchae (turbinates)
 - b. Nasal septum
 - 3. Parietal
 - 4. Sphenoid
 - a. Lesser wings
 - 1) Tuberculum sellae
 - 2) Sella turcica
 - 3) Dorsum sellae
 - 4) Anterior and posterior clinoid process
 - 5) Optic canals
 - b. Greater wings
 - 5. Occipital
 - a. Foramen magnum
 - b. Internal and external occipital protuberance
 - c. Jugular foramen
 - 6. Temporal
 - a. Zygomatic process
 - b. External auditory meatus (EAM)
 - c. Internal auditory canal

- d. Mastoid process
- e. Petrous portion or ridge
- E. Lobes of the brain and midline cerebral hemisphere structures
 - 1. Frontal
 - 2. Parietal
 - 3. Occipital
 - 4. Temporal
 - 5. Insula (island of Reil)
 - 6. Cerebellum
 - 7. Corpus callosum (genu, rostrum, body and splenium)
 - 8. Septum pellucidum
- F. Cranial nerves
 - 1. Olfactory
 - 2. Optic
 - 3. Oculomotor
 - 4. Trochlear
 - 5. Trigeminal
 - 6. Abducens
 - 7. Facial
 - 8. Vestibulocochlear
 - 9. Glossopharyngeal
 - 10. Vagus
 - 11. Accessory
 - 12. Hypoglossal
- G. Brainstem
 - 1. Diencephalon
 - a. Thalamus
 - b. Hypothalamus
 - c. Optic chiasm
 - d. Optic tracts
 - e. Infundibulum (pituitary stalk)
 - f. Pituitary gland
 - g. Mammillary bodies
 - h. Pineal gland
 - 2. Midbrain
 - 3. Pons
 - 4. Medulla oblongata
 - a. Spinal cord
- H. Arteries of the head and neck (Circle of Willis)
 - 1. Vertebral
 - 2. Basilar
 - 3. Internal carotid
 - 4. Anterior and posterior communicating
 - 5. Anterior and posterior cerebral
 - 6. Middle cerebral

- I. Veins
 - 1. Venous sinuses
 - a. Superior sagittal sinus
 - b. Vein of Galen
 - c. Straight sinus
 - d. Confluence of sinuses (torcular herophili)
 - e. Transverse sinus
 - f. Sigmoid sinus
 - 2. Internal jugular
- J. Ventricular system
 - 1. Lateral ventricles (anterior, body, posterior, inferior or temporal and trigone or atrium)
 - 2. Interventricular foramen (foramen of Monro)
 - 3. Third ventricle
 - 4. Cerebral aqueduct (aqueduct of Sylvius)
 - 5. Fourth ventricle
 - 6. Foramen of Luschka
 - 7. Foramen of Magendie
 - 8. Choroid plexus
- K. Meninges
 - 1. Dura mater
 - a. Extensions of the dura mater
 - 1) Falx cerebri
 - 2) Falx cerebelli
 - 3) Tentorium cerebelli
 - 4) Diaphragma sellae
 - b. Spaces
 - 1) Epidural
 - 2) Subdural
 - 3) Subarachnoid
 - 2. Arachnoid
 - 3. Pia mater
- L. Basal ganglia
 - 1. Caudate nucleus
 - 2. Putamen
 - 3. Globus pallidus
 - 4. Claustrum
 - 5. Internal capsule
 - 6. External capsule
 - 7. Extreme capsule
- M. Orbit
 - 1. Globe
 - 2. Lens
 - 3. Optic nerve
 - 4. Lacrimal gland
 - 5. Lateral rectus muscle

6. Medial rectus muscle
 7. Superior rectus muscle
 8. Inferior rectus muscle
 9. Superior oblique muscle
 10. Inferior oblique muscle
 11. Orbital fat
 12. Ophthalmic artery
 13. Retinal vein
- N. Anatomical structures of brain
1. Diploe
 2. Subcutaneous soft tissue
 3. Superior sagittal sinus (anterior and posterior)
 4. Central sulcus
 5. Interhemispheric fissure
 6. Falx cerebri
 7. Centrum semiovale
 8. Corpus callosum (genu, rostrum, body and splenium)
 9. Septum pellucidum
 10. Fornix
 11. Sylvian fissure
 12. Insula
 13. Lentiform nucleus (putamen and globus pallidus)
 14. Caudate nucleus (head)
 15. Internal capsule (anterior, body and posterior sections)
 16. External capsule
 17. Claustrum
 18. Hippocampus
 19. Tentorium cerebelli
 20. Petrous portion or ridge
 21. Cerebellar tonsil
 22. Internal auditory canal (IAC)
 23. Nasal septum
 24. External auditory meatus (EAM)
 25. Clivus
 26. Mastoid air cells

II. Neck

- A. Bones
 1. Cervical vertebrae
 - a. Bony structures
 - b. Intervertebral disks
 - c. Spinal cord and nerves
 - d. Spinal ligaments
- B. Organs
 1. Pharynx
 2. Larynx

3. Esophagus
 4. Trachea
 5. Salivary glands
 6. Thyroid gland
 7. Parathyroid glands
 8. Lymph nodes
- C. Vasculature and neurovasculature
1. Carotid arteries
 2. Vertebral arteries
 3. Jugular veins
 4. Carotid sheath
- D. Musculature
1. Anterior triangle
 2. Posterior triangle

III. Chest and Mediastinum

- A. Bony thorax
1. Thoracic vertebrae
 - a. Bony structures
 - b. Intervertebral disks
 - c. Spinal cord and nerves
 - d. Spinal ligaments
 2. Sternum
 3. Ribs
 4. Costal cartilages
 5. Scapulae
 6. Clavicles
- B. Pulmonary
1. Apices (lung)
 2. Diaphragm
 3. Angles
 4. Hilum
 5. Lobes (lungs)
 6. Trachea
 7. Carina
 8. Primary (mainstem) bronchi
 9. Secondary bronchi
- C. Mediastinum
1. Thymus gland
 2. Heart
 - a. Coronary vessels and valves
 - b. Musculature and septal walls
 - c. Chambers
 - d. Pulmonary vessels
 3. Ascending aorta
 4. Aortic arch

5. Branches of the aortic arch
 6. Descending (thoracic) aorta
 7. Inferior vena cava
 8. Esophagus
 9. Trachea
 10. Thoracic duct
 11. Lymph nodes
 12. Azygos vein
 13. Hemiazygos vein
- D. Breasts
- E. Musculature

IV. Abdomen

- A. Bones
1. Lumbar vertebrae
 - a. Bony structures
 - b. Intervertebral disks
 - c. Spinal cord and nerves
 - d. Spinal ligaments
- B. Diaphragm and openings
- C. Branches of the abdominal aorta
1. Anterior visceral branches
 - a. Celiac axis
 - 1) Left gastric
 - 2) Splenic
 - 3) Hepatic
 2. Superior mesenteric artery
 - a. Jejunal and ileal
 - b. Inferior pancreaticoduodenal
 - c. Middle colic
 - d. Right colic
 - e. Ileocolic
 3. Inferior mesenteric artery
 - a. Left colic
 - b. Sigmoid
 - c. Superior rectal
 4. Lateral visceral branches
 - a. Suprarenal
 - b. Renal
 - c. Testicular or ovarian
 5. Parietal branches
 - a. Inferior phrenics
 - b. Lumbar
 - c. Middle sacral
 6. Terminal branches
 - a. Common iliacs

- D. Tributaries of the vena cava
 - 1. Anterior visceral
 - a. Hepatic veins
 - 2. Lateral visceral
 - a. Right suprarenal
 - b. Renal veins
 - c. Right testicular or ovarian
 - 3. Tributaries of origin
 - a. Common iliacs
 - b. Median sacral
- E. Tributaries of the portal vein
 - 1. Splenic
 - 2. Inferior mesenteric
 - 3. Superior mesenteric
 - a. Left gastric
 - b. Right gastric
 - c. Cystic
- F. Abdominal organs and structures
 - 1. Abdominal cavity
 - a. Peritoneum
 - b. Peritoneal space
 - c. Retroperitoneum
 - d. Retroperitoneal space
 - 2. Liver
 - 3. Gallbladder and biliary system
 - 4. Pancreas and pancreatic ducts
 - 5. Spleen
 - 6. Adrenal glands
 - 7. Urinary system and tract
 - a. Kidneys
 - b. Ureters
 - 8. Stomach
 - 9. Small intestine
 - 10. Colon
 - 11. Musculature

V. Pelvis

- A. Bony structures
 - 1. Proximal femur
 - 2. Ilium
 - 3. Ischium
 - 4. Pubis
 - 5. Sacrum
 - 6. Coccyx

- B. Pelvic vasculature
 - 1. Arterial
 - a. Common iliacs
 - b. Internal iliacs
 - c. External iliacs
 - d. Ovarian/testicular
 - 2. Venous
 - a. External iliacs
 - b. Internal iliacs
 - c. Common iliacs
 - d. Ovarian/testicular
- C. Pelvic organs
 - 1. Urinary bladder
 - a. Ureter
 - b. Urethra
 - 2. Small intestine
 - a. Terminal ilium and ileocecal valve
 - 3. Colon
 - a. Ascending
 - b. Descending
 - c. Sigmoid
 - d. Rectum
 - e. Vermiform appendix
 - 4. Female reproductive organs
 - a. Vagina
 - b. Cervix
 - c. Uterus
 - d. Fallopian tubes
 - e. Ovaries
 - 5. Male reproductive organs
 - a. Testes/scrotum
 - b. Prostate gland
 - c. Seminal vesicles
 - d. External to pelvis
 - 1) Penis

VI. Extremities

- A. Joints and associated soft-tissue structures
 - 1. Shoulder
 - 2. Elbow
 - 3. Wrist
 - 4. Hip
 - 5. Knee
 - 6. Ankle

Image Postprocessing

Description

Content establishes a knowledge base in the fundamentals of digital image postprocessing that supports guided skill development using clinical-based image workstations.

Objectives

1. Describe the benefits of postprocessing digital images.
2. List the requirements of the source data used to create 3-D reformations.
3. Explain the fundamentals of image data retrieval stored on Digital Imaging and Communications in Medicine (DICOM) enabled archive systems.
4. Describe techniques and procedures for recording postprocessed images or image sets.
5. Explain how 3-D images are generated.
6. Implement the principles of correct ergonomics for workstation use.
7. Describe the principles, techniques and applications of:
 - a. Multiplanar and curved reformations.
 - b. Shaded surface displays.
 - c. Volume-rendered images.
 - d. Maximum, minimum and average intensity projections.
 - e. Image segmentation.
 - f. Virtual endoscopy.
 - g. 3-D fusion imaging.
 - h. 4-D imaging.
8. Identify methods of acquiring quantitative data from a normal and temporal volumetric data set.
9. Identify sources of postprocessing image noise and image artifacts, as well as techniques to reduce their presence.

Content

I. Image Postprocessing

- A. Definition
- B. Benefits to the observer
- C. Source data requirements
- D. How 3-D images are generated

II. Retrieval and Exporting Image Data

- A. Communication with configured DICOM devices
 - 1. Query to retrieve study
- B. Preview images as acquired by scanner
 - 1. Identify proper series for postprocessing
- C. Exporting/recording DICOM images

III. Viewing 3-D Images

- A. 2-D screen captures
 - 1. Proper window/level (W/L) display
- B. Cine
 - 1. Maximum intensity projection (MIP)
 - 2. Temporal images
- C. Transmission display
 - 1. Computer monitor
 - 2. Holography
 - 3. Stereoscopic viewing
- D. Workstation ergonomics

IV. Postprocessing Techniques

- A. Multiplanar reformation (MPR)
 - 1. Definition/description
 - 2. Defining the plane of image reformation
 - 3. Thick vs. thin MPR
 - a. Ray-sum projection
 - b. MIP
 - c. Minimum intensity projection (MinIP)
 - d. Average intensity projection (AVE)
 - 4. Curved planar reformation (CPR)
 - a. Manual and automatic vessel tracking
 - 5. MPR and CPR artifacts
 - a. Partial volume
 - b. False stenosis
 - 6. MPR applications
 - a. Anatomically corrected datasets
 - b. Fast anatomical segmentation
 - c. Noise reduction in standard displays
 - d. Improvement in spatial resolution

- B. 3-D surface rendering (shaded surface display [SSD])
 - 1. Principles
 - a. Illumination with virtual light sources(s)
 - b. Shadowing effect
 - c. Color encoding
 - 1) Orthographic vs. perspective rendering
 - d. Threshold selection and size representation
 - e. Image rotation and viewing angle
 - f. Impact of lowering or raising the threshold
 - 1) “Flying pixels”
 - 2) “Pseudostenosis”
 - 2. Applications
 - a. Clarification of complex 3-D relationships
 - b. Virtual endoscopy
- C. Volume rendering techniques
 - 1. Principles
 - a. Opacity curve
 - b. Surface display
 - c. Lighting
 - d. Color coding
 - e. Spatial resolution, voxel and matrix size
 - f. Interactive rendering-movie scripting
 - g. Special techniques
 - 1) Air casts (inverted opacity curves)
 - 2) Orthographic vs. perspective rendering
 - 3) Vessel endoscopic rendering
 - 4) MPR volume rendering
 - 2. Artifacts and pitfalls
 - a. Venetian blind artifacts
 - b. Image noise
 - c. Opacity setting error
 - 3. Applications
 - a. CT/MR angiography
 - b. Skeletal imaging
 - c. Tracheobronchial imaging
 - d. Liver
 - e. Lungs
 - f. Colon
 - g. Pancreas
 - 4. Genitourinary
- D. MIP and MinIP
 - 1. Principles
 - a. Ray tracing
 - b. Defining the volume of interest (VOI)
 - c. Image contrast
 - d. Viewing angle

- e. Cine loop to improve 3-D orientation
- 2. Artifacts and pitfalls
 - a. Depth perception
 - b. Superimposition of structures
 - c. Calcium in vessels
- 3. Applications
 - a. CT/MR angiography
 - b. Central tracheobronchial system
 - c. Intrahepatic bile ducts
 - d. Pancreatic duct
- E. Average/ray sum projection
 - 1. Applications
 - a. Soft-tissue display
 - b. Radiographic projections
- F. Segmentation
 - 1. Principle
 - a. Cutting functions
 - b. Threshold techniques
 - c. Connectivity
 - d. Morphologic operators
 - 1) Erosion
 - 2) Dilation
 - 3) Closing functions (removal of holes)
 - 4) Boolean operators
 - 5) Removal of flying pixels
 - 2. Automated techniques
 - a. Region growing
 - b. Bone removal
 - c. Vessel analysis
 - 3. Applications
 - a. Angiography
 - b. Volume measurement
 - c. Articular surface viewing
- G. Virtual endoscopy
 - 1. Principle
 - a. Perspective rendering along a path
 - b. Viewing angles
 - c. SSD vs. volume rendering
 - 2. Alternative viewing techniques
 - a. Virtual dissection
 - b. Scripting flight paths for movies
 - 3. Artifacts and pitfalls
 - a. Poor patient preparation
 - b. Poor vessel bolus
 - c. Breathing and pulsations
 - 4. Virtual applications

- a. Colonoscopy
 - b. Bronchoscopy
 - c. Cystoscopy
 - d. Angioscopy
- H. Advanced 3-D displays
- 1. 3-D fusion
 - a. PET-CT
 - 2. Computer-assisted diagnosis
 - 3. Tissue perfusion imaging
- I. 4-D imaging
- 1. Cardiac cycles

V. Quantitative Analysis

- A. 2-D measurements
- 1. Angle
 - 2. Centerline length
 - 3. Area
 - 4. Circumference
 - 5. Diameter
 - 6. Histogram
 - 7. Profile
 - 8. Calcium scoring
- B. 3-D measurements
- 1. Volume
 - a. Tumors
 - b. Aneurysms
- C. 4-D measurements
- 1. Ejection fraction
 - 2. Mass analysis
 - 3. CV flow

VI. 3-D Artifacts

- A. Noise
- B. Segmentation misrepresentation
- C. False stenosis
- D. Beam-hardening artifacts (CT)
- E. Wrap artifacts (MR)
- F. Motion
- G. Mirror artifacts (CPR)

Appendix A

This section is an inventory of preexisting knowledge and skills gained through an entry-level educational experience and reinforced through professional practice. Foundations content is intended to aid technologists in career planning and program managers in the development of preassessment tools for candidate selection for an interventional educational program.

ASRT

Clinical Practice

Description

Content and clinical practice experiences should be designed to sequentially develop, apply, critically analyze, integrate, synthesize and evaluate concepts and theories in the performance of medical imaging procedures. Through structured, sequential, competency-based clinical assignments, concepts of team practice, patient-centered clinical practice and professional development are discussed, examined and evaluated.

Clinical practice experiences should be designed to provide patient care and assessment, competent performance of medical imaging procedures and total quality management. Levels of competency and outcomes measurement ensure the well-being of the patient before, during and following the procedure.

Objectives

- Exercise the priorities required in daily clinical practice.
- Execute medical imaging procedures under the appropriate level of supervision.
- Adhere to team practice concepts that focus on organizational theories, roles of team members and conflict resolution.
- Adapt to changes and varying clinical situations.
- Describe the role of health care team members in responding/reacting to a local or national emergency.
- Provide patient-centered, clinically effective care for all patients regardless of age, gender, disability, special needs, ethnicity or culture.
- Integrate the use of appropriate and effective written, oral and nonverbal communication with patients, the public and members of the health care team in the clinical setting.
- Integrate appropriate personal and professional values into clinical practice.
- Recognize the influence of professional values on patient care.
- Explain how a person's cultural beliefs toward illness and health affect his or her health status.
- Use patient and family education strategies appropriate to the comprehension level of the patient/family.
- Provide desired psychosocial support to the patient and family.
- Demonstrate competent assessment skills through effective management of the patient's physical and mental status.
- Respond appropriately to medical emergencies.
- Examine demographic factors that influence patient compliance with medical care.
- Adapt procedures to meet age-specific, disease-specific and cultural needs of patients.
- Assess the patient and record clinical history.
- Demonstrate basic life support procedures.
- Use appropriate charting methods.
- Recognize life-threatening electrocardiogram (ECG) tracing.
- Apply standard and transmission-based precautions.
- Apply the appropriate medical asepsis and sterile technique.

- Demonstrate competency in the principles of radiation protection standards.
- Apply the principles of total quality management.
- Report equipment malfunctions.
- Examine procedure orders for accuracy and make corrective actions when applicable.
- Demonstrate safe, ethical and legal practices.
- Integrate the imaging professional's practice standards into clinical practice setting.
- Maintain patient confidentiality standards and meet HIPAA requirements.
- Demonstrate the principles of transferring, positioning and immobilizing patients.
- Comply with departmental and institutional response to emergencies, disasters and accidents.
- Differentiate between emergency and non-emergency procedures.
- Adhere to national, institutional and departmental standards, policies and procedures regarding care of patients, providing radiologic procedures and reducing medical errors.
- Select technical factors to produce quality diagnostic images with the lowest radiation exposure possible (ALARA).
- Critique images for appropriate anatomy, image quality and patient identification.
- Determine corrective measures to improve inadequate images.

Digital Image Acquisition and Display

Description

Content conveys an understanding of the components, principles and operation of digital imaging systems found in diagnostic radiology. Factors that impact image acquisition, display, archiving and retrieval are discussed. Principles of digital system quality assurance and maintenance are presented.

Objectives

- Define terminology associated with digital imaging systems.
- Describe the various types of digital receptors.
- Describe the response of digital detectors to exposure variations.
- Compare the advantages and limits of each receptor type.
- Evaluate the spatial resolution of a digital imaging system.
- Define sampling frequency.
- Describe the Nyquist-Shannon theorem as it relates to sampling frequency.
- Describe the impact of sampling frequency on spatial resolution.
- Describe the impact of detector element size on spatial resolution.
- Describe detective quantum efficiency (DQE) for digital radiography detectors.
- Describe modulation transfer function (MTF) as it relates to digital radiography detectors.
- Describe the histogram and the process of histogram analysis as it relates to automatic rescaling.
- Describe the calculation of the exposure indicator (AAPM Task Group 116).
- Define region of interest (ROI).
- Relate the location and size of the ROI to the appearance of the image and exposure indicator.
- Relate how the values of interest (VOI) impact image appearance.
- Describe the process of image stitching.
- Relate the receptor exposure indicator values to technical factors, system calibration, part/beam/plate alignment and patient exposure.
- Describe the response of PSP systems to background and scatter radiation.
- Use appropriate means of scatter control.
- Avoid grid use errors associated with grid cutoff.
- Identify common limitations and technical problems encountered when using PSP systems.
- Employ appropriate beam/part/receptor alignment to avoid histogram analysis errors.
- Associate impact of image processing parameters to the image appearance.
- Apply the fundamental principles of radiographic exposure to digital detectors.
- Evaluate the effect of a given exposure change on histogram shape, data width and image appearance.
- Formulate a procedure or process to minimize histogram analysis and rescaling errors.
- Describe continuous quality improvement (CQI).
- Differentiate between quality assurance (QA) and quality control (QC).
- List the benefits of a quality control management to the patient and to the department.

- Examine the potential impact of digital radiographic systems on patient exposure and methods of practicing the as low as reasonably achievable (ALARA) concept with digital systems.
- Discuss the appropriate use of electronic masking.
- Describe picture archival and communications system (PACS) and its function.
- Identify components of a PACS.
- Define digital imaging and communications in medicine (DICOM).
- Describe HIPAA concerns with electronic information.
- Identify common problems associated with retrieving/viewing images within a PACS.
- Compare monitor types (e.g. acquisition, display).
- Describe the components of the various types of display monitors.
- Discuss the impact of viewing angle, luminance, ambient lighting, and pixel size on image display.
- Describe display monitor aspect ratio and its impact on image display.

Ethics and Law in the Radiologic Sciences

Description

Content provides a foundation in ethics and law related to the practice of medical imaging. An introduction to terminology, concepts and principles will be presented. Students will examine a variety of ethical and legal issues found in clinical practice.

Objectives

- Discuss the origins of medical ethics.
- Apply medical/professional ethics in the context of a broader societal ethic.
- Explain the role of ethical behavior in health care delivery.
- Explain concepts of personal honesty, integrity, accountability, competence and compassion as ethical imperatives in health care.
- Identify legal and professional standards and relate each to practice in health professions.
- Identify specific situations and conditions that give rise to ethical dilemmas in health care.
- Explain select concepts embodied in the principles of patients' rights, the doctrine of informed (patient) consent and other issues related to patients' rights.
- Explain the legal implications of professional liability, malpractice, professional negligence and other legal doctrines applicable to professional practice.
- Describe the importance of accurate, complete and correct methods of documentation as a legal/ethical imperative.
- Explore theoretical situations and questions relating to the ethics of care and health care delivery.
- Explain legal terms, principles, doctrines and laws specific to the radiologic sciences.
- Outline the conditions necessary for a valid malpractice claim.
- Describe institutional and professional liability protection typically available to the technologist.
- Describe the components and implications of informed consent.
- Identify standards for informed consent and disclosure of protected health information.
- Describe how consent forms are used relative to specific radiographic procedures.
- Differentiate between civil and criminal liability.
- Define tort and explain the differences between intentional and unintentional torts.

Human Anatomy and Physiology

Description

Content establishes a knowledge base in anatomy and physiology. Components of the cells, tissues, organs and systems are described and discussed. The fundamentals of sectional anatomy relative to routine imaging are addressed.

Objectives

- Discuss the basics of anatomical nomenclature.
- Describe the chemical composition of the human body.
- Identify cell structure and elements of genetic control.
- Explain the essentials of human metabolism.
- Describe the types and functions of human tissues.
- Classify tissue types, describe the functional characteristics of each and give examples of their location within the human body.
- Describe the composition and characteristics of bone.
- Identify and locate the bones of the human skeleton.
- Identify bony processes and depressions found on the human skeleton.
- Describe articulations of the axial and appendicular skeleton.
- Differentiate the primary and secondary curves of the spine.
- Summarize the functions of the skeletal system.
- Label different types of articulations.
- Compare the types, locations and movements permitted by the different types of articulations.
- Examine how muscle is organized at the gross and microscopic levels.
- Differentiate between the structures of each type of muscle tissue.
- State the function of each type of muscle tissue.
- Name and locate the major muscles of the skeleton.
- Differentiate between the structure and function of different types of nerve cells.
- State the structure of the brain and the relationship of its component parts.
- Describe brain functions.
- List the meninges and describe the function of each.
- Outline how cerebrospinal fluid forms, circulates and functions.
- Describe the structure and function of the spinal cord.
- Determine the distribution and function of cranial and spinal nerves.
- Summarize the structure and function of components that comprise the autonomic nervous system.
- Describe the structures and functions of the components that comprise the human eye and ear.
- List the component body parts involved in the senses of smell and taste.
- List the somatic senses.
- Define endocrine.

- Describe the characteristics and functions of the components that comprise the endocrine system.
- Describe the hard and soft palates.
- Describe the structure and function of the tongue.
- Identify the structure, function and locations of the salivary glands.
- Describe the composition and characteristics of the primary organs of the digestive system.
- Describe the function(s) of each primary organ of the digestive system.
- Differentiate between the layers of tissue that comprise the esophagus, stomach, small intestine, large intestine and rectum.
- Differentiate between peritoneum, omentum and mesentery.
- List and label the accessory organs of the digestive system and describe their function.
- Identify the secretions and function of each accessory organ of the digestive system.
- Explain the purpose of digestion.
- List the digestive processes that occur in the body.
- Describe the composition and characteristics of blood.
- List the types of blood cells and state their functions.
- Differentiate between blood plasma and serum.
- Outline the clotting mechanism.
- List the blood types.
- Explain the term Rh factor.
- Explain the antigen/antibody relationship and its use in blood typing.
- Label the parts of the human heart.
- Describe the flow of blood through the body and identify the main vessels.
- Describe the structure and function of arteries, veins and capillaries.
- Differentiate between arterial blood in systemic circulation and arterial blood in pulmonary circulation.
- Outline the major pathways of lymphatic circulation.
- Correlate cardiac electrophysiology to a normal ECG tracing.
- Differentiate between nonspecific defenses and specific immunity.
- Explain antibody production and function.
- List the different types and functions of T- and B-cells and explain their functions.
- Label the components of the respiratory system.
- Describe the physiology and regulation of respiration.
- Label the parts of the kidneys, ureters, bladder and urethra.
- Describe the function of each organ of the urinary system.
- Describe the composition and formation of urine.
- Explain micturition.
- Label the anatomy of the male and female reproductive organs.
- Analyze the function of each of the male and female reproductive organs.
- Identify major sectional anatomical structures found within the head/neck, thorax and abdomen.

Introduction to Computed Tomography

Description

Content is designed to provide entry-level students with an introduction to and basic understanding of the operation of a computed tomography (CT) device. Content is not intended to result in clinical competency.

Objectives

- Describe the components of the CT imaging system.
- Explain the functions of collimators in CT.
- List the CT computer data processing steps.
- Define algorithm and explain its impact on image scan factors and reconstruction.
- Define raw data and image data.
- Describe the following terms in relation to the CT data acquisition process:
 - Pixel.
 - Matrix.
 - Voxel.
 - Linear attenuation coefficient.
 - CT/Hounsfield number.
 - Partial volume averaging.
 - Window width (ww) and window level (wl).
 - Spatial resolution.
 - Contrast resolution.
 - Noise.
 - Annotation.
 - Region of interest (ROI).
- Name the common controls found on CT operator consoles and describe how and why each is used.
- Identify the types and appearance of artifacts most commonly affecting CT images.
- Name the radiation protection devices that can be used to reduce patient dose in CT and describe the correct application of each.
- Describe the general purpose of commonly performed CT studies.
- Discuss general radiation safety and protection practices associated with examinations in CT.

Patient Care in Radiologic Sciences

Description

Content provides the concepts of optimal patient care, including consideration for the physical and psychological needs of the patient and family. Routine and emergency patient care procedures are described, as well as infection control procedures using standard precautions. The role of the technologist in patient education is identified.

Objectives

- Identify the responsibilities of the health care facility and members of the health care team.
- List the general responsibilities of the technologist .
- Describe the practice standards for the technologist as defined by the ASRT and state licensure.
- Differentiate between culture and ethnicity.
- Explain how a person's cultural beliefs toward illness and health affect his or her health status.
- Explain perceptions of dying and death from the viewpoint of both patient and technologist .
- Identify methods for determining the correct patient for a given procedure.
- Explain the use of various communication methods.
- Explain specific aspects of an imaging procedure to the patient.
- Demonstrate correct principles of body mechanics applicable to patient care.
- Demonstrate techniques for specific types of patient transfer.
- Demonstrate select procedures to turn patients who have various health conditions.
- Describe immobilization techniques for various types of procedures and patient conditions.
- Describe specific patient safety measures and concerns.
- Explain the purpose, legal considerations and procedures for incident reporting.
- Describe methods to evaluate patient physical status.
- List the information to be collected prior to a patient examination.
- Describe vital signs and lab values used to assess patient condition, including sites for assessment and normal values.
- Define terms related to infection control.
- Describe the importance of standard precautions and isolation procedures, including sources and modes of transmission of infection and disease and institutional control procedures.
- Identify symptoms related to specific emergency situations.
- Describe the institution's emergency medical code system and the role of the student during a medical emergency.
- Explain the age-specific considerations necessary when performing radiographic procedures.
- Describe appropriate procedures for management of various types of trauma situations.
- Describe the symptoms and medical interventions for a patient with a contrast agent reaction.
- Explain the role of the technologist in patient education.
- Describe the patient preparation for contrast studies.
- Identify specific types of tubes, lines, catheters and collection devices.
- Outline the steps in the operation and maintenance of suction equipment.

- Outline the steps in the operation and maintenance of oxygen equipment and demonstrate proper use.
- Demonstrate competency in basic life support (BLS).
- Describe the steps in performing various mobile procedures.
- Describe the special problems faced in performing procedures on a patient with a tracheotomy and specific tubes, drains and catheters.
- Describe the procedure for producing diagnostic images in the surgical suite.
- Explain the appropriate radiation protection required when performing mobile/surgical radiography.

ASRT

Radiation Biology

Description

Content provides an overview of the principles of the interaction of radiation with living systems. Radiation effects on molecules, cells, tissues and the body as a whole are presented. Factors affecting biological response are presented, including acute and chronic effects of radiation.

Objectives

- Differentiate between ionic and covalent molecular bonds.
- Describe principles of cellular biology.
- Identify sources of electromagnetic and particulate ionizing radiations.
- Discriminate between the direct and indirect effects of radiation.
- Identify sources of radiation exposure.
- Describe radiation-induced chemical reactions and potential biologic damage.
- Evaluate factors influencing radiobiologic/biophysical events at the cellular and subcellular level.
- Identify methods to measure radiation response.
- Describe physical, chemical and biologic factors influencing radiation response of cells and tissues.
- Explain factors influencing radiosensitivity.
- Recognize the clinical significance of lethal dose (LD).
- Identify the radiosensitivity of specific cells.
- Employ dose response curves to study the relationship between radiation dose levels and the degree of biologic response.
- Examine effects of limited vs. total body exposure.
- Relate short-term and long-term effects as a consequence of high and low radiation doses.
- Differentiate between somatic and genetic radiation effects and discuss specific diseases or syndromes associated with them.
- Discuss stochastic (probabilistic) and nonstochastic (deterministic) effects.
- Discuss embryo and fetal effects of radiation exposure.
- Discuss risk estimates for radiation-induced malignancies.
- Discuss acute radiation syndromes.

Radiation Production and Characteristics

Description

Content establishes a basic knowledge of atomic structure and terminology. Also presented are the nature and characteristics of radiation, x-ray production and the fundamentals of photon interactions with matter.

Objectives

- Describe fundamental atomic structure.
- Explain the processes of ionization and excitation.
- Describe the electromagnetic spectrum.
- Describe wavelength and frequency and how they are related to velocity.
- Explain the relationship of energy, wavelength and frequency.
- Explain the wave-particle duality phenomena.
- Identify the properties of x-rays.
- Describe particulate radiation.
- Differentiate between ionizing and nonionizing radiation.
- Describe radioactivity and radioactive decay in terms of alpha, beta and gamma emission.
- Compare the production of bremsstrahlung and characteristic radiations.
- Describe the conditions necessary to produce x-radiation.
- Describe the x-ray emission spectrum.
- Explain the factors that affect the x-ray emission spectrum.
- Discuss various photon interactions with matter.
- Discuss relationships of wavelength and frequency to beam characteristics.
- Discuss the clinical significance of the photoelectric and modified scattering (Compton) interactions in diagnostic imaging.

Radiation Protection

Description

Content presents an overview of the principles of radiation protection, including the responsibilities of the technologist for patients, personnel and the public. Radiation health and safety requirements of federal and state regulatory agencies, accreditation agencies and health care organizations are incorporated.

Objectives

- Identify and justify the need to minimize unnecessary radiation exposure of humans.
- Explain the objectives of a radiation protection program.
- Define radiation and radioactivity units of measurement.
- Identify effective dose limits (EDL) for occupational and nonoccupational radiation exposure.
- Describe the ALARA concept.
- Identify the basis for occupational exposure limits.
- Distinguish between perceived risk and comparable risk.
- Describe the concept of the negligible individual dose (NID).
- Identify ionizing radiation sources from natural and man-made sources.
- Comply with legal and ethical radiation protection responsibilities of radiation workers.
- Describe the relationship between irradiated area and effective dose.
- Describe the theory and operation of radiation detection devices.
- Identify appropriate applications and limitations for each radiation detection device.
- Describe how isoexposure curves are used for radiation protection.
- Identify performance standards for beam-limiting devices.
- Describe procedures used to verify performance standards for equipment.
- Describe the operation of various interlocking systems for equipment.
- Identify conditions and locations evaluated in an area survey for radiation protection.
- Distinguish between controlled and non-controlled areas and list acceptable exposure levels.
- Describe “Radiation Area” signs and identify appropriate placement sites.
- Describe the function of federal, state and local regulations governing radiation protection practices.
- Describe the qualifications and responsibilities of a radiation safety officer.
- Express the need and importance of personnel monitoring for radiation workers.
- Describe personnel monitoring devices, including applications, advantages and limitations for each device.
- Interpret personnel monitoring reports.
- Compare values for individual effective dose limits for occupational radiation exposures (annual and lifetime).
- Identify effective dose limits for the embryo and fetus in occupationally exposed women.
- Distinguish between primary and secondary radiation barriers.
- Demonstrate how the operation of various x-ray and ancillary equipment influences radiation safety and describe the potential consequences of equipment failure.

- Perform calculations of exposure with varying time, distance and shielding.
- Discuss the relationship between workload, energy, half-value layer (HVL), tenth-value layer (TVL), use factor and shielding design.
- Identify emergency procedures to be followed during failures of x-ray equipment.
- Demonstrate how time, distance and shielding can be manipulated to keep radiation exposures to a minimum.
- Explain the relationship of beam-limiting devices to patient radiation protection.
- Discuss added and inherent filtration in terms of the effect on patient dosage.
- Explain the purpose and importance of patient shielding.
- Identify various types of patient shielding and state the advantages and disadvantages of each type.
- Use the appropriate method of shielding for a given radiographic procedure.
- Explain the relationship of exposure factors to patient dosage.
- Explain how patient position affects dose to radiosensitive organs.
- Identify the appropriate image receptor that will result in an optimum diagnostic image with the minimum radiation exposure to the patient.
- Select the immobilization techniques used to eliminate voluntary motion.
- Describe the minimum source-to-tabletop distances for fixed and mobile fluoroscopic devices.
- Apply safety factors for the patient, health care personnel and family members in the room during radiographic procedures.

Appendix B

The Clinical Experience Requirements section is intended to provide information regarding the development of a well-rounded clinical experience.

ASRT

Clinical Experience Requirements

The most current information regarding the eligibility requirements for postprimary certification examination in cardiac-interventional radiography and vascular-interventional radiography can be found at the links below.

The ARRT Clinical Experience Requirements documents are located online at <https://www.arrt.org/earn-arrt-credentials/requirements/education-requirements/education-requirements-postprimary/clinical-experience>.

ARRT

Appendix C

Mentored Clinical Experience

Description

A mentored clinical experience provides technologists with the specific knowledge and psychomotor skills necessary to perform interventional procedures. By working closely with a clinical mentor, the technologist's clinical learning experience will be greatly enhanced.

Objectives

1. Demonstrate competency while participating in interventional procedures under the supervision of an advanced-practice mentor.
2. Establish concepts of team practice that focus on organizational theories of goal setting, establishing priorities, leadership and roles of team members.
3. Establish patient-centered, clinically-effective service-delivery strategies.
4. Participate in diagnostic and therapeutic procedures adhering to acceptable departmental, institutional, governmental and professional standards.
5. Analyze, apply and demonstrate the principles of radiation protection standards.
6. Apply principles of total quality management.
7. Detect equipment malfunctions and respond appropriately.
8. Demonstrate safe, ethical and legal practice.
9. Assess psychological and physical changes in the patient's condition.
10. Transfer, position and immobilize patients.
11. Interact with the patient and family in a manner that provides psychosocial support.
12. Recognize and respond to patient side effects and complications.
13. Document care in the patient's record.
14. Demonstrate life-support procedures.
15. Demonstrate knowledge of the institution's procedures, and respond to emergencies, disasters and accidents.
16. Identify and respond to rapid physiological changes in the patient's condition.
17. Establish strategies that ensure professional development at a level of clinical practice consistent with acceptable standards.
18. Establish values and attitudes congruent with the profession's standards and ethics.

Content

Each patient care setting offers a unique environment for student-mentored clinical experience, and advanced-practice mentors must have the latitude to facilitate student development. Learning contracts, combined with the development of individual student portfolios, facilitate the content and critical assessment of this segment of the planned curriculum.

A learning contract is a practical arrangement between a “mentor” and “student” to enable both to make the most of learning opportunities. It spells out each person’s goals and responsibilities so both are clear in their expectations. A learning contract takes the form of a written statement.

Learning contracts focus on the process of learning and are a key element in the development of advanced-practice technologists. The learning contract helps the clinical mentor and student structure the skills to be learned, how they are to be learned and how learning will be verified. Contracts, though not legally binding, are written agreements or commitments reached between the advanced-practice mentor and student regarding the particular amount of work to be done and the reward or credit awarded for the work.

A typical learning contract specifies the following:

- The knowledge, skills, attitudes and values to be acquired by the learner.
- How these objectives are to be accomplished (through learning resources and strategies.)
- Plans for interim feedback to the learner and self-reflection on progress in accomplishing learning objectives, with the option to modify the learning contract if needed.
- The target date for completion.
- Required evidence to demonstrate that objectives are met.
- How the evidence will be judged or validated.

Student portfolios can be an additional tool for enriching the mentored clinical experience. Portfolios are collections of examples of student work annotated with the student’s reflective commentary. Examples may be drawn from assignments associated with a single clinical event or from curricular and cocurricular activities spanning a broad period of time.

Portfolio development consists of five stages:

- Collection: Students learn to save artifacts that represent the successes and “growth opportunities” in their day-to-day learning.
- Selection: Students review and evaluate the artifacts they have saved and identify those that demonstrate achievement of specific objectives and goals.
- Reflection: Students become reflective practitioners, evaluating their growth over time and their clinical achievements, as well as gaps in their development.
- Direction: Mentors and students compare their reflections to performance indicators and set learning goals for the future. This portion of individual professional development supports key elements of lifelong learning.
- Presentation: Students share their portfolios with their peers. This stage helps to encourage collaboration and commitment to professional development and lifelong learning.

Student portfolios offer another bridge that deepens the student-mentor relationship. They also provide insights for tailoring learning contracts as individual students progress through the clinical experience.

ASRT

Sample Learning Contract

Learning Objective(s): Describe the skills, knowledge or experiences you will accomplish.

(Example)

A: Demonstrate clinical competency in peripheral vascular stent placement exams performed on adult patients.

List the steps needed to accomplish each objective. Then list the resources needed to complete the steps and the proposed completion dates for each step.

Objective A:	Resources Needed	Target Dates
<p>Exam Indicators: Demonstrate knowledge of patient indicators and symptoms consistent with the need for this exam.</p>	Directed Readings and written assessment.	[insert date(s)]
<p>Exam Specifications: Identify the protocol for patient preparation for this exam.</p> <p>Identify the methods and decision points for evaluating the adequacy of patient preparation for this exam.</p>	<p>Directed Readings and written assessment.</p> <p>Participate in postexamination debriefing session following patient exams.</p>	[insert date(s)]
<p>Exam Preliminaries: Identify information gained through an evaluation of the patient's medical history that pertains to this exam.</p> <p>Identify information obtained that would contraindicate the exam.</p>	<p>Directed Readings and written assessment.</p> <p>Form to record findings from patient's medical history and data obtained from patient interview relative to the exam.</p>	[insert date(s)]
<p>Exam Techniques/General Guidelines: Prepare resources required to conduct the exam:</p> <ul style="list-style-type: none"> • Imaging equipment and recording media. 	Directed Readings and written assessment regarding technical	[insert date(s)]

<ul style="list-style-type: none"> • Trays and supplies. • Contrast media and delivery system. • Patient-monitoring and emergency-response equipment. • Notifications and surgical backup. 	<p>requirements for performing the exam, followed by assisting in the performance of patient exams leading to performing exams under supervision.</p> <p>Departmental form/vehicle for recording clinical observations.</p>	
<p>Participate in the procedure.</p>	<p>Directed Readings and written assessment regarding technical requirements for performing the exam, followed by:</p> <ul style="list-style-type: none"> • Observing peripheral vascular stent placement exams. • Assisting in the performance of patient exams. • Performing exams under supervision. 	<p>[insert date(s)]</p>
<p>Postprocedural patient care:</p> <ul style="list-style-type: none"> • Patient education. • Confirmation of patient preparation for dismissal from the specials suite. • Notifications and documentation. 	<p>Patient dismissal check-off sheet.</p>	<p>[insert date(s)]</p>
<p>Postexam administration:</p> <ul style="list-style-type: none"> • Room cleanup. • Image postprocessing and archiving. • Documentation. 	<p>Evaluator summary and documentation sheet.</p>	<p>[insert date(s)]</p>
<p>Postexamination risks/complications:</p> <ul style="list-style-type: none"> • Identification of possible complications. • Protocol(s) for response. 	<p>Evaluator summary and documentation sheet.</p>	<p>[insert date(s)]</p>

<ul style="list-style-type: none"> • Required documentation. • Risk reduction steps. 		
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Evaluation Criteria

I will have accomplished Objective A when:

- I have observed (*insert number*) peripheral vascular stent placement exams performed on adult patients.
- I have participated in (*insert number*) peripheral vascular stent placement exams performed on adult patients under supervision by my advanced-practice mentor.
- I have performed with mentored guidance (*insert number*) peripheral vascular stent placement exams on adult patients.
- I have participated in weekly performance summaries/reflections with my advanced-practice mentor and have been successful in satisfying the identified evaluation goals for my performance.

Support resources: With whom will you share your learning plan and approach for feedback and motivation?

(List mentor and any designate.)

Additional learning plan impacts *(list strategies, resources, potential barriers, prior knowledge or experience that may affect the plan, etc.):*

- Student is required to document the successful completion of a fluoroscopic unit operation and safety training module prior to beginning this clinical sequence.
- Student must successfully complete preclinical orientation to the interventional suite.
- Student must hold current ACLS certification.

Your signature and date

Mentor's signature and date

Appendix D

Curriculum Revision Workgroup

We would like to extend special recognition to the outstanding professionals who volunteered their time as members of the curriculum revision project:

Courtney Akvan, B.S., R.T.(R)(VI)
Filipe Fernandes, B.A.T., R.T.(R)(CI)
Joshua Kramer, A.A.S., R.T.(R)(VI)
Richard Merschen, Ed.S., R.T.(R)(CV), RCIS
Sean Puckett, B.S., R.T.(R)(VI), CIIP
Christopher Steelman, M.S., R.T.(R)(CI), RCIS
Richard Wall, M.S.R.S., R.T.(R)(CT)(CI), RCIS
Serena Winham, B.S., R.T.(R)(VI)
Eric Zdrojowski, M.R.S., R.R.A., R.T.(R)

We also wish to express our sincere appreciation for the many contributions and suggestions from the professional community over the course of this project.

Resources

This list of resources will assist educators in sampling the pool of references and study materials that pertain to medical imaging. The resources list should be viewed as a snapshot of available materials. Omission of any one title is not intentional. Because the creation of literature and media related to the field is dynamic, educators are encouraged to search additional sources for recent updates, revisions and additions to this collection of titles.

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