# Cardiac-Interventional and Vascular-Interventional Curriculum



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

# Introduction

Advances in interventional techniques and procedures for diagnostic imaging and therapeutic treatment require technologists participating in the studies to possess a battery of specialized knowledge and skills. Technologists gain these skills through a combination of formal education and structured practical experience. Technologists operating within a cardiac-interventional suite and technologists operating in a vascular-interventional setting will have many skills in common. Each also will need to develop a set of additional skills unique to his or her specialty.

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

The professional practice of cardiac-interventional and vascular-interventional procedures requires specific knowledge and skills generally not obtained in basic radiography education programs. This curriculum is intended as a guide to establish criteria for educational programs in cardiac-interventional technology and vascular-interventional technology, recognizing that the components are not static but representative of current practice and trends in the specialties. Educators hold responsibility for incorporating new concepts and trends in the curriculum as they occur.

This curriculum is divided into specific content areas that represent the essential components of an interventional program. The content and objectives should be organized to meet the mission, goals and needs of each program. Faculty members are encouraged to expand and broaden these fundamental objectives as they incorporate them into their curricula. Specific instructional methods were intentionally omitted to allow for programmatic prerogative as well as creativity in instructional delivery.

The curriculum is organized in four sections: Foundations, Common Content, Specialized and Optional Content. The Foundations section represents an inventory of preexisting knowledge and skills gained through an entry-level radiography educational experience and reenforced through professional practice. Foundations section 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.

The Common Content section represents topics found in both cardiac-interventional and vascular-interventional arenas.

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

The Clinical Experience Requirements section is intended to provide information regarding the development of a well-rounded clinical experience. Information regarding the eligibility requirements for a postprimary certification examination in cardiac-interventional technology and vascular-interventional technology is provided in this section.

# Cardiac-Interventional and Vascular-Interventional Curriculum

## Table of Contents

# Foundations

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

**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 radiologic 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 radiologic imaging and total quality management. Levels of competency and outcomes measurement ensure the well-being of the patient preparatory to, during and following the radiologic 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 Structure and Function**
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 radiography are addressed.

**Introduction to Computed Tomography**
Content is designed to provide entry-level radiography 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 radiographer 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 radiographer 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 detailed list of objectives for each content area.

# Common Content

The Common Content section represents topics found in both cardiac-interventional and vascular-interventional arenas.

**Emergency Care Procedures**

**Fundamental Principles of Ultrasound**

**Imaging Equipment, Materials and Enhancement Techniques**

**Interventional Resources and Supplies**

**Mentored Clinical Experience**

**Sample Learning Contract**

**Patient Assessment and Monitoring**

**Physiologic Monitoring and Recording**

**Sterile Technique**

**Vascular Approaches**

**Vascular Correlation and Surgical Intervention**

# Emergency Care Procedures

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

**Description**
Content is designed to provide 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, including early onset.
2. List the medications and corresponding physiologic response produced in counteracting reactions to contrast media or medications.
3. Identify the specific complications related to angiographic procedures, including transient ischemic attack (TIA), stroke, embolism, thrombosis, myocardial infarction, congestive heart failure, cardiac arrhythmia, vasovagal response, anaphylaxis, hypotensive and hypertensive episodes, renal failure, diabetic crisis, pericardial perforation and vascular perforation/dissection.
4. Recognize and respond effectively to patients experiencing a reaction to contrast media.
5. Recognize and respond effectively to common patient emergencies that arise during interventional procedures.
6. Participate in basic life support and advanced cardiac life support activities as needed in the interventional suite.

**Content**

**I. Contrast Media and Medication Reactions**

A. Early symptoms
   1. Histamine reactions
   2. Hemodynamic responses
   3. Nephrotoxicity
   4. CNS reactions

B. Medications
   1. Chemistry
   2. Steroid prep for contrast reaction
   3. Dose

C. Physiologic response

D. Emergency drugs and cash cart

E. Contraindications
   1. Physiologic response

**II. Life-Threatening Complications**

A. Symptoms and emergency treatment
   1. Air embolism
   2. Hemothorax
   3. Pneumothorax
   4. Respiratory arrest
   5. Sepsis
   6. Thrombolytic embolism
   7. Transient ischemic attack (TIA)
   8. Thrombosis
   9. Myocardial infarction (MI)
   10. Congestive heart failure (CHF)
   11. Cardiac arrhythmia
   12. Vasovagal response
   13. Anaphylaxis
   14. Hypotensive episode
   15. Hypertensive episode
   16. Diabetic crisis
   17. Pericardial perforation
   18. Vascular perforation/dissection

B. Renal failure
   1. Symptoms
   2. Complications

## III. Cardiac Life Support

A. Basic life support (BLS)

B. Advanced cardiac life support (ACLS )

C. Pediatric advanced life support (PALS)

# Fundamental Principles of Ultrasound

**Description**
Content is designed to develop an understanding of the basic principles of ultrasonography. Where applicable, ultrasonographic examinations that complement studies performed in an interventional setting will be discussed.

**Objectives**
1. Identify the basic principles of ultrasonographic imaging to include sound wave characteristics, attenuation and echoes.
2. Describe the impact transducer selection has on image resolution.
3. Identify the Doppler effect and how this is used in the examination of vascular structures.
4. Identify the benefits of continuous wave, pulsed wave and color-flow Doppler imaging.
5. Identify basic 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

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. Views

B. 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 and Enhancement Techniques

**Description**
Content is designed to provide 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 will be introduced.

**Objectives**
1. Describe the film-screen speed requirements of various cardiovascular-interventional procedures.
2. Describe and calculate required adjustments in exposure for various film-screen combinations.
3. Describe the principles and steps of radiographic subtraction.
4. List the equipment requirements for magnification radiography.
5. Describe the application of magnification radiographs.
6. Describe the procedures for production of magnified radiographs.
7. List the parameters and essential requirements of generators for serial exposure, including cine, spot films, optical disks and large-format radiographs.
8. List the design characteristics of the tube in relation to the anode, cathode, kilowatt determination, heat storage and cooling characteristics.
9. List the causes of tube malfunctions, including the anode, filament and vacuumized glass envelope.
10. Define primary and secondary switching concepts of cine pulse systems, including grid-controlled x-ray tubes, triodes and tetrodes.
11. Describe various cine-generating equipment.
12. Describe the methods of automatic exposure control (AEC).
13. Explain variable tube potential (kilovolt, or kV, modulation).
14. Explain variable tube current method (mA modulation).
15. Explain pulse side variation (time modulation).
16. Describe the application and use of combination systems for automatic brightness control.
17. Describe the function of the input phosphor, including photon conversion, quantum detection efficiency, contrast and resolution capabilities.
18. Describe the position and function of the photocathode, vacuum tube, electron-focusing lenses, anode, output phosphor and basic lens.
19. List and describe the factors affecting object field size.
20. Identify methods of increasing brightness gain of an image tube.
21. Describe the position and purpose of the basic lens, distributor, beam-splitting mirrors, cine and TV camera lenses.
22. Describe lens aberrations, including direct, oblique, spherical, chromatic, depth of focus and vignetting.
23. Describe the relationship of lens combinations and film image sizes (selection of framing formats).
24. Describe the basic principles of digital image production.
25. Identify procedures for postprocessing of digital images.
26. Identify methods for storing digital image data.

27. Explain the basic operation of digital subtraction angiography (DSA): acquisition, storage, archiving and its integration in the imaging system.
28. Evaluate and make decisions regarding equipment operation and malfunction.
29. Describe the structural and functional differences of angiographic tables.
30. List and describe the primary and optimal components of electromechanical (pressure, flow rate) injectors.
31. Compare the operation, advantages and disadvantages of electromechanical (pressure, flow rate) injectors.
32. List and perform the steps in preventive maintenance of all equipment.
33. Describe the physical principles of image production as they relate to image quality.
34. Evaluate and set exposure factors to provide quality radiographs.
35. Identify the use of 3-D imaging for a diagnostic interventional procedure.
36. Describe C-arm vs. table-step image capture options during lower extremity imaging.
37. Describe the impact of parallax.
38. Identify the basic functions of a postprocessing-type workstation.

**Content**

**I. Film-Screen Systems**

A. Speed

B. Resolution

C. Contrast

D. Uses

**II. Subtraction**

A. Mask

B. First-order subtraction

C. Second-order subtraction

D. Film

E. Equipment

F. Reversal

G. Mapping

**III. Magnification**

A. Equipment requirements

B. Application

C. Procedure

**IV. Specialized Equipment Instrumentation**

A. Generator
   1. Essential requirements
   2. Bid specifications

B. Radiographic tube requirements
   1. Anode characteristics
   2. Cathode characteristics
   3. Kilowatt determinations
   4. Heat storage and cooling
   5. Tube malfunctions

C. Radiographic exposure
   1. Variable kilovolt peak (kVp)

2. Variable milliamperes (mAs)

D. Cine pulsing system

E. Automatic exposure control (AEC)
   1. Methods
   2. kV modulation
   3. mA modulation
   4. Time modulation
   5. Automatic brightness control

F. Image intensification
   1. Input phosphor
   2. Photocathode
   3. Vacuum tube
   4. Electron focusing lenses
   5. Output phosphor
   6. Basic lens
   7. Brightness gain

G. 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. Cost

H. Optics of image intensification
   1. Basic lens
   2. Beam-splitting mirrors
   3. Camera lenses
   4. Lens aberration
      a. Direct
      b. Oblique
      c. Spherical
      d. Chromatic
      e. Depth of focus
      f. Vignetting
   5. Framing formats

I. Digital imaging
   1. Image production

a. Data acquisition
b. Image characteristics
    1) Pixel
    2) Image matrix
    3) Dynamic range
c. Postprocessing
    1) Reconstruction
    2) Enhancement
d. Archiving
e. Quality control

2. Image storage
    a. Methods
        1) Electronic and optical disc
        2) Tape and floppy disc
        3) CD-ROM
        4) Picture archival communication system (PACS)
3. Dry laser imaging vs. darkroom processing

J. Programming devices
1. Types
2. Integration systems

K. Equipment specifications

## V. Ancillary Equipment

A. Digital subtraction angiography (DSA) system
1. Integration with the imaging chain
2. Parts
3. Function
4. Operation
5. Troubleshooting

B. Cardiac and vascular-interventional table
1. Types
2. Operation
3. Cleaning and preventive maintenance

C. Electromechanical (pressure, flow rate) injectors
1. Types
2. Major components
3. Optional components
4. Operation
5. Cleaning and preventive maintenance
6. Accuracy
7. Electrical safety
8. Operation for both manual injections as well as equipment-initiated injections

9. X-ray delay vs. injection delay

D. Recording equipment

E. 3-D imaging
   1. Procedure
   2. Processing
   3. Reconstruction

F. DynaCT imaging
   1. Procedure
   2. Processing
   3. Reconstruction

G. $CO_2$ angiography
   1. Procedure
   2. Image acquisition
   3. Processing

# Interventional Resources and Supplies

**Description**

Content is designed to introduce the resources and supplies required for select 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 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, various dimensions, shapes and gauges of catheters, needles and guidewires.
10. Describe several factors that affect flow rate.
11. Describe the resources used in construction of catheters, guidewires, needles, thrombectomy catheters and 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 $CO_2$ angiography.
21. Review the importance of "isolation cases" (clean and dirty person).

**Content**

**I. Tray**

A. Sterile packs

1. Instruments
2. 4 x 4 gauze
3. Syringes, needles and scalpel
4. Adaptors, stopcocks and manifolds, safety and waste management lines and bags
5. Sterile basins
6. Drapes, towels and tray cover
7. Heparinized saline
8. Sharps container
9. Contaminated waste container
10. Contrast media
11. Introducer sheath
12. Safety products

**II. Surgical Preparations and Scrub Resources**

A. Clippers

B. Antiseptic soap solution

C. Lidocaine

D. Sterile basins

E. Drapes and towels

F. Gloves

**III. Apparel**

A. Sterile gowns

B. Sterile gloves

C. Masks

D. Face shields

E. Goggles

F. Caps

G. Shoe covers

**IV. Radiation Protection**

A. Lead aprons

B. Lead thyroid collar

C. Lead gloves and shields

D. Lead glasses

E. Body shield

F. Time and distance

**V. Guidewires and Catheters**

A. Catheters
   1. Characteristics
      a. Dimensions
      b. Shapes
      c. Side/end holes
      d. Recoil
      e. Coatings (heparin, hydrophilic)
      f. Tractability
      g. Torque
      h. Preparation
      i. Construction
      j. Function
      k. Application
      l. Complications
   2. Types
      a. Angiographic
      b. Occlusion
      c. Angioplasty (percutaneous transluminal angioplasty)
      d. Atherectomy
      e. Directional coronary
      f. Thrombectomy
      g. Extraction (transluminal extraction catheter)
      h. Intravascular ultrasound
      i. Infusion

B. Guidewires
   1. Resources
   2. Physical characteristics
      a. Dimensions
      b. Shapes
      c. Types
      d. Coatings (heparin, hydrophilic)
   3. Specialty guidewires
      a. Diameter sizes

b. Lengths

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

**VI. Therapeutic Devices**

A. 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
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

B. Intraaortic balloon pump

C. Atherectomy

D. Pressure wires (Radi, etc.)

E. Endografts

F. Pericardial tap

G. Chest tubes

H. Laser (endartectomy)

I. Distal protective devices

J. Thrombectomy

K. Brachytherapy

L. Embolic agents

M. Caval filters

N. Retrieval device

**VII. 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
   4. Micropuncture

C. Construction and design

D. Application

E. Special considerations/requirements

**VIII. Miscellaneous Accessory Devices**

A. Dilators

B. Introducer sheaths — vascular and peel-away

C. Adaptors

D. Connectors

E. Stopcocks

F. Manifolds

G. Telfa

H. Torque vise

I. Suture

J. Carbon dioxide setup

K. Fluid line

L. Micropuncture sets

M. Hole punch sets

**IX. Reusable vs. Disposable Products**

**X. Methods of Sterilization**

A. Instruments

B. Catheters

**XI. Patient Assessment Instrumentation**

A. Physiologic monitoring
   1. Hemodynamic
   2. Electrocardiogram (ECG)
   3. Pulse oximeter
   4. Pressure transducer

B. Hemoximeter

C. Activated clotting time (ACT) unit

D. Doppler pulse unit

E. Cardiac output computer

**XII. Cardiac Stimulation Equipment**

A. Defibrillator
   1. Internal
   2. External

B. Temporary pulse generator
   1. Internal
   2. External

C. Electrophysiology stimulation

D. Permanent pacemaker

E. Automatic internal cardiac defibrillator

**XIII. Closure Devices**

**XIV. Permanent Dialysis Access Sites**

A. Life site devices

B. Perma caths

C. Peritoneal dialysis

D. Arteriovenous (AV) fistula or graft

# Mentored Clinical Experience

**Description**

Mentored clinical experience assists technologists in developing a mix of advanced skill levels and knowledge while assisting in the performance of interventional procedures. No two clinical settings will be exactly the same. Working closely with a clinical mentor, technologists will gain the maximum benefit from available learning experiences.

**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/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 select appropriate actions.
8. Demonstrate safe, ethical and legal practices.
9. Assess and evaluate psychological and physical changes in the patient's condition and formulate appropriate actions.
10. Apply principles for transferring, positioning and immobilizing patients.
11. Interact with the patient and family in a manner that provides the desired psychosocial support.
12. Detect and take appropriate action to respond to patient side effects and complications.
13. Document care in the patient's record.
14. Assess, evaluate and 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. Advanced-practice mentors must be afforded the latitude to facilitate student development while engaging students in the learning experience. 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 in the time available. It spells out each person's objectives and responsibilities so both are clear about each party's expectations and responsibilities. It takes the form of a written statement.

Learning contracts focus on the process of learning. This feature is believed to be a key element in the development of advanced-practice technologists. The learning contract helps the advanced-practice mentor and student structure the skill to be learned, how it is 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 and the amount of reward or credit for this 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 an identification of 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 student-mentored clinical experience. Portfolios are purposeful 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.

# Sample Learning Contract

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

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

B: (Second learning objective)

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 |
|---|---|---|
| **Exam Indicators:**<br>Demonstrate knowledge of patient indicators and symptoms consistent with the need for this exam. | Directed Readings and written assessment. | [insert date(s)] |
| **Exam Specifications:**<br>Identify the protocol for patient preparation for this exam.<br><br>Identify the methods and decision points for evaluating the adequacy of patient preparation for this exam. | Directed Readings and written assessment.<br><br>Participate in postexamination debriefing session following patient exams. | [insert date(s)] |
| **Exam Preliminaries:**<br>Identify information gained through an evaluation of the patient's medical history that pertains to this exam.<br><br>Identify information obtained that would contraindicate the exam. | Directed Readings and written assessment.<br><br>Form to record findings from patient's medical history and data obtained from patient interview relative to the exam. | [insert date(s)] |
| **Exam Techniques/General Guidelines:**<br>Prepare resources required to conduct the exam:<br>• Imaging equipment and recording | Directed Readings and written assessment regarding technical | [insert date(s)] |

| | | |
|---|---|---|
| media.<br>• Trays and supplies.<br>• Contrast media and delivery system.<br>• Patient-monitoring and emergency-response equipment.<br>• Notifications and surgical backup. | requirements for performing the exam, followed by assisting in the performance of patient exams leading to performing exams under supervision.<br><br>Departmental form/vehicle for recording clinical observations. | |
| Participate in the procedure. | Directed Readings and written assessment regarding technical requirements for performing the exam, followed by:<br>• Observing peripheral vascular stent placement exams.<br>• Assisting in the performance of patient exams.<br>• Performing exams under supervision. | [insert date(s)] |
| Postprocedural patient care:<br>• Patient education.<br>• Confirmation of patient preparation for dismissal from the specials suite.<br>• Notifications and documentation. | Patient dismissal check-off sheet. | [insert date(s)] |
| Postexam administration:<br>• Room cleanup.<br>• Image postprocessing and archiving.<br>• Documentation. | Evaluator summary and documentation sheet. | [insert date(s)] |
| Postexamination risks/complications:<br>• Identification of possible complications.<br>• Protocol(s) for response. | Evaluator summary and documentation sheet. | [insert date(s)] |

| | | |
|---|---|---|
| • Required documentation.<br>• Risk reduction steps. | | |
| | | |
| Objective B: | Resources Needed | Target Dates |
| (Second learning objective) | | |
| | | |
| | | |

Evaluation Criteria

| |
|---|
| I will have accomplished Objective A when:<br>a) I have observed (*insert number*) peripheral vascular stent placement exams performed on adult patients.<br>b) I have participated in (*insert number*) peripheral vascular stent placement exams performed on adult patients under supervision by my advanced-practice mentor.<br>c) I have performed with mentored guidance (*insert number*) peripheral vascular stent placement exams performed on adult patients.<br>d) 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. |

| |
|---|
| I will have accomplished Objective B when: |

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

*(List radiologist 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

# Patient Assessment and Monitoring

**Description**
Content is designed to provide strategies for patient assessment prior to, during and following the completion of interventional examinations. Patient vital signs, lab values and physiologic monitoring will be presented. Contrast media, common patient medications and techniques for delivery will be discussed. Practices that support aseptic and sterile technique will be reviewed. Recognition and procedures to respond to patient medical emergencies will be presented.

**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. Recognize common medical emergencies, and implement a plan of action to respond to patients' medical needs.
6. Identify the indications and contraindications for contrast media and typical medications used in the interventional suite.
7. Utilize proper techniques in the management of intravenous (IV) therapies.
8. Maintain sterile fields and aseptic technique during the performance of interventional procedures.
9. Perform an adequate, mandatory "timeout" prior to beginning all interventional procedures.
10. Demonstrate knowledge of human diversity to provide quality and safe patient care.
11. Describe required consent documentation and content for select procedures.
12. Explain the reason for a given exam and link to previous patient history.

**Content**

**I. Vital Signs**

A. Temperature

B. Heat rate

C. Respiration

D. Blood pressure

E. Pain

**II. Access Assessment**

A. Peripheral pulses

B. Anatomical location

**III. Lab Values**

A. Chemistry
   1. Bilirubin
   2. Blood urea nitrogen (BUN)
   3. Creatinine
   4. Electrolytes
   5. Enzymes
   6. Glomerular filtration rate (GFR)
   7. Glucose
   8. Potassium

B. Hematology
   1. Hematocrit
   2. Hemoglobin
   3. Platelet count
   4. White blood count (WBC)

C. Coagulation
   1. Prothrombin time (PT)
   2. Partial thromboplastin time (PTT)
   3. International normalized ratio (INR)
   4. Activated clotting time (ACT)

D. Arterial blood gases
   1. pH
   2. $PaCO_2$
   3. $HCO_2$

**IV. Physiologic Monitoring**

A. ECG
   1. Patient preparation
   2. Interpretation

B. Pulse oximetry

C. Capnography
   1. End-tidal $CO_2$ ($etCO_2$)
   2. Normal and abnormal values
   3. Waveform recognition

D. Invasive hemodynamics
   1. Waveform recognition
   2. Normal and abnormal values

E. 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. Pulse oximetry

**V. Contrast Administration**

A. Types and properties of contrast agents
   1. Osmolarity
      a. Ionic
      b. Nonionic
   2. Chemical structure
   3. Gases

B. Indications and contraindications

C. Steroid preparation

**VI. Medications**

A. Types and administration routes
   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. Narcotics
14. Platelet inhibitors
15. Sedatives
16. Thrombolytics
17. Vasoconstrictors
18. Vasodilators

B. Indications and contraindications

C. Preparation and dosage

D. Complications

E. Risks and response
   1. Monitored values indicating a patient at risk
   2. Monitored values requiring an immediate response
      a. Plan(s) for emergency response

F. Conscious sedation
   1. Description
   2. Vitals to be monitored

**VII. IV Therapy**

A. Indications and contraindications

B. Venipuncture

C. Solution preparation

D. Flow rate

E. Complications

**VIII. Asepsis and Sterile Technique**

A. Sterile technique
   1. Types of sterilization
   2. Sterile fields
      a. Patient preparation
      b. Procedural tray
      c. Maintenance of sterile fields
   3. Surgical scrub techniques

a. Waterless solution
b. Betadine/iohexol solutions
c. Other

B. CDC isolation precautions
1. Transmission of infection
a. Contact
b. Airborne
c. Droplet
2. Types of precautions
a. Standard precautions
b. Transmission-based precautions
3. Handling and disposal of biohazardous materials

C. Postprocedural cleaning

**IX. Timeout Procedure**

A. Patient identifiers

B. Procedure consented to be done

C. Correct site/side

D. Equipment/implanted device status

E. Medication

F. Allergies

G. Personnel involved

H. Anticipated blood loss

I. Relevant lab values

J. Use of chemotherapy-type medications for intraarterial procedures
1. Chemo safety-handling
2. Tray setup and disposal
3. Chemo arterial embolization and infusion

K. Therasphere or selective internal radiation (SIR) sphere angiography

# Physiologic Monitoring and Recording

**Description**
Content is designed to provide the student with an overview of the theories and application of patient physiologic monitoring and recording that takes place during an interventional procedure. The student will recognize the difference between atrial, junctional and ventricular arrhythmias as well as interpret them and discuss possible causes.

**Objectives**
1. Describe the procedure for determining 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. Describe electronic calibration and balancing of components.
5. Describe change in ventricular pressure with respect to change in time (dP/dt) and how it is determined.
6. Describe the procedure for performing cardiac output measurements, including the Fick method and thermal dilution.
7. Describe area-length method and computer evaluation techniques for ventricular volume analysis.
8. Explain the function of transducers, amplifiers, oscilloscopes and digital readout modules.
9. Describe the procedure for calibration of the transducer, amplifier, recorder and oscilloscope.
10. Identify valvular gradients and determine valve area.
11. Explain the indications for inserting temporary or permanent pacemaker or internal cardiac defibrillators.
12. Explain the indications for and principles of intraaortic balloon pumping.

**Content**

**I. Physiologic Monitoring**

A. Equipment
   1. Transducers
   2. Amplifiers
   3. Recorders
      a. Digital read-out module
      b. Calibration, balancing
      c. Baseline determination

B. Specialized techniques
   1. dP/dt
   2. Cardiac output measurements
      a. Fick method
      b. Thermal dilution
      c. Manual calculation
   3. Ventricular volume analysis
      a. Area-length method
      b. Computer evaluation
   4. Valvular gradients
   5. Normal valve areas

**II. Cardiac Monitoring**

A. Conduction pathway
   1. Recognition of arrhythmias
   2. Interpretation of arrhythmias

B. Cardiac sinus rhythms

C. Atrial rhythms

D. Heart blocks

E. Junctional rhythms

F. Ventricular rhythms

G. Management of arrhythmias

H. Pacemakers
   1. Temporary
      a. Transcutaneous pacing
      b. Transvenous pacing
   2. Permanent
      a. Transvenous pacing
      b. Transmyocardial pacing

I. Intraaortic balloon pump (IABP)
   1. Indication for IABP
   2. Principle of IABP operation
   3. Physiological basis of IABP
   4. Types
   5. Construction
   6. Function
      a. Pump and electrocardiogram coordination
      b. Triggering
         1) ECG
            a) Peak
            b) R wave
         2) Aortic pressure
   7. Technique for insertion
   8. Monitoring
   9. Complications
   10. Troubleshooting

J. Automated defibrillator

K. Loop recorder

**III. Recording Systems**

A. Equipment

# Sterile Technique

**Description**
Content is designed to provide the student with an overview of sterile technique and isolation procedures that apply to cardiac and vascular-interventional procedures.

**Objectives**
1. Define the types of microorganisms.
2. Describe the body's defense systems.
3. Define the process of infection.
4. List the elements needed to produce infection.
5. Describe the methods of transmitting infectious agents.
6. Define *sterile*, *aseptic* and *disinfectant*.
7. Describe the methods of sterilization, including steam under pressure, gas, chemicals, dry heat and ionizing radiation.
8. Describe the principles of aseptic technique.
9. List various disinfectants.
10. Describe the steps in scrubbing technique for procedural personnel.
11. Describe gowning and gloving to maintain a sterile field.
12. List the steps in scrubbing and patient preparation.
13. Describe proper hand-washing techniques.

**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. Elements Needed To Produce Infection**

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**

A. Steam under pressure

B. Gas

C. Chemical

D. Dry heat

E. Ionizing radiation

**VIII. Asepsis**

A. Betadine

B. Chlorahexadine products

C. Disinfectants

**IX. Sterile Field**

A. Patient preparation

B. Equipment preparation
   1. Image intensification
   2. Control surfaces

C. Cloth-wrapped supplies

D. Steri-peel items

E. Plastic-wrapped supplies

F. Supply transfer to sterile field

## X. Scrubbing, Gowning and Gloving

A. Hand washing

B. Scrubbing techniques
   1. Personnel
   2. Patient

C. Gowning methods
   1. Self
   2. Physician

D. Gloving
   1. Open
   2. Closed

# Vascular Approaches

**Description**

Content is designed to provide the student with a theoretical and practical application 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.
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 reasons for selecting each of the alternative vascular approaches.

**Content**

**I. History of Angiography**

**II. Vessel Construction**

A. Layers
   1. Arteries
   2. Veins

**III. Seldinger Technique**

**IV. Femoral Approach**

A. Left and right approaches
   1. Indications
   2. Contraindications

B. Retrograde
   1. Indications
   2. Contraindications

C. Antegrade
   1. Indications
   2. Contraindications

D. Complications

**V. Axillary Approach**

A. Left and right axillary technique
   1. Indications
   2. Contraindications

B. Complications

**VI. Direct Stick Carotid, Vertebral**

A. Indications

B. Contraindications

C. Technique

D. Complications

**VII. Translumbar**

A. Indications

B. Contraindications

C. Technique

D. Complications

**VIII. Arterial Cutdown**

A. Indications

B. Contraindications

C. Technique

D. Complications

**IX. Retrograde Brachial**

A. Indications

B. Contraindications

C. Technique

D. Complications

**X. Radial Artery**

A. Indications

B. Contraindications

C. Technique

D. Complications

**XI. Femoral Venous Approach**

A. Indications

B. Contraindications

C. Technique

D. Complications

**XII. Venous Cutdown**

A. Indications

B. Contraindications

C. Technique

D. Complications

**XIII. Jugular Approach**

A. Indications

B. Contraindications

C. Technique

D. Complications

**XIV. Brachial Vein**

A. Indications

B. Contraindications

C. Technique

D. Complications

**XV. Subclavian Vein**

A. Indications

B. Contraindications

C. Technique

D. Complications

**XVI. Extremity Vein**

A. Indications

B. Contraindications

C. Technique

D. Complications

**XVII. Vascular Closure**

A. Indications

B. Contraindication

C. Technique

D. Complications

# Vascular Correlation and Surgical Intervention

**Description**

Content is designed to provide the student an overview of vascular correlation and surgical intervention for specific congenital and acquired disease processes.

**Objectives**

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

**Content**

**I. Pathophysiology**

A. Define

1. Atherosclerosis
2. Aneurysms
3. Dissections
4. Renovascular diseases
5. Mesenteric/visceral pathologies
6. Peripheral arterial disease (PAD)
7. Cerebrovascular diseases/accidents
8. Coronary artery diseases
9. Appendicular diseases
10. ST elevation myocardial infarction (STEMI)
11. Non-ST elevation myocardial infarction (NSTEMI)

**II. Clinical Aspects**

**III. Common Sites**

**IV. Origin**

A. Acute

B. Chronic

C. Congenital

D. Trauma

**V. Classification**

# 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.

# Cardiac-Interventional Procedures

**Description**
Content is designed to present 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.
- Exposure technique.
- Image enhancement and processing.
- Closure methods.
- Possible complications.
    - Recognition.
    - Treatment.

**Objectives**

1. Describe the basic operation of image acquisition (cine camera, digital detector, etc.).
2. Describe the procedure of cine operation.
3. Describe the digital image acquisition procedure.
4. Be prepared to play an active role in the performance of select cardiac-interventional procedures.
5. Participate in patient assessment and management prior to and during select cardiac-interventional procedures.
6. Identify the indications and contraindications for given cardiac-interventional procedures.
7. Recognize and respond effectively to patient complications that arise during the performance of cardiac-interventional procedures.
8. Demonstrate and perform various methods of obtaining hemostasis following catheter/sheath removal.
9. Participate in procedural coding for accurate billing of procedures performed (knowledge of supervision and interpretation coding, surgical coding, modifiers and device codes).

**Content**

**I. Imaging Equipment**

A. Basic operation

B. Digital image acquisition

**II. Diagnostic Cardiac Studies**

A. Pulmonary angiography

B. Aortography

C. Coronary angiography

D. Internal mammary angiography

E. Saphenous vein graft angiography

F. Ventriculography

G. Peripheral angiography

H. Renal angiography

I. Cerebral angiography

J. Biopsy

**III. ST Elevation Myocardial Infarction (STEMI) vs. Non-STEMI**

A. Prehospital care

B. Door-to-balloon time

C. Procedures

D. Medications

**IV. Percutaneous Coronary Intervention**

A. Angioplasty

B. Debulking
   1. Directional atherectomy
   2. Rotational atherectomy
   3. Laser atherectomy

C. Stent deployment
   1. Drug eluting

2. Bare metal
3. Covered

D. Thrombolysis
1. Mechanical
2. Pharmacologic

E. Intravascular ultrasound

F. Brachytherapy

G. Fractional flow reserve measurement

H. Optical coherence tomography

**V. Percutaneous Intervention (Other)**

A. Congenital and structural heart diseases
1. Patent foramen ovale closure
2. Atrial spetal defect closure
3. Patent ductus arteriosus closure
4. Coarctation of the aorta
5. Heart and pulmonary valve replacements

B. Valvuloplasty
1. Aortic
2. Mitral

C. Septal Ablation

D. Renal Denervation

E. Inferior vena cava filter placement/retrieval

**VI. Therapy**

A. Pericardiocentesis

B. Intraaortic balloon counterpulsation

C. Removal of foreign bodies

D. Ventricular assist devices

E. Therapeutic hypothermia

**VII. Hemodynamics and Circulations**

A. Ventricular volume measurement

B. Normal valve areas

C. Stenotic valve area (Gorlin method)

D. Shunt detection and calculation

E. Cardiac output calculation and measurement
   1. Fick method
   2. Thermodilution
      a. Angiographic

F. Right and left heart hemodynamics

**VIII. Conduction System Studies**

A. Arrhythmia detection

B. Arrhythmia ablation

C. Cardioversion

D. Implants
   1. Pacemaker, permanent insertion
      a. Single chamber
      b. Dual chamber
   2. Internal cardiac defibrillator (ICD) insertion
      a. Single chamber
      b. Dual chamber
      c. Biventricular
   3. Recorder insertion

E. Pacemaker, temporary insertion

F. Electrophysiology studies

G. Part of lab study/values point-of-care testing (POCT)

**IX. Pediatric Cardiology Interventions**

A. Common anomalies
   1. Atrial septal defect
   2. Ventricular septal defect
   3. Valvular stenosis
   4. Tetralogy of fallot

B. Procedures for correction

C. Shunts

1. Calculations

**X. Postprocedural Homeostasis Methods**

A. Manual

B. Mechanical

C. Suture

D. Collagen placement

**XI. Data Collection**

A. Centers for Medicare and Medicaid Services (CMS)
   1. (ICD Registry)

B. Quality measures
   1. STEMI — CMS and American College of Cardiologists (ACC)
   2. Acurte MI — CMS and ACC
   3. CathPCI Registry — ACC

**XII. Procedural Coding (Supervision and Interpretation Codes, Surgical Codes, Modifiers, Device Codes and Bundling Edits)**

A. Coronary
   1. Diagnostic
   2. Interventions

B. EP Studies
   1. Diagnostic
   2. Interventions

C. Cerebrovascular

D. Neurovascular

E. Peripheral (upper and lower)

F. Pulmonary

G. Abdominal aorta

H. Thoracic aorta

I. Visceral

J. Venous

K. Venous interventional

L. Medical devices

M. Miscellaneous

# Vascular-Interventional Procedures

**Description**

Content is designed to present a systematic approach to the techniques and procedures technologists use in the performance of select 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.
- Possible coding.

**Objectives**

1. Describe the basic operation of image capture.
2. Identify preventive maintenance and cleaning requirements of equipment.
3. Be prepared to play an active role in the performance of select vascular-interventional procedures.
4. Participate in patient assessment and management prior to and during select vascular-interventional procedures.
5. Identify the indications and contraindications for given vascular-interventional procedures.
6. Perform patient assessment before, during and after vascular and nonvascular interventional procedures.
7. Participate in procedural coding for accurate billing of procedures performed (knowledge of supervision and interpretation coding, surgical coding, modifiers and device codes).

**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. Kyphoplasty

I. Vertebroplasty

**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. Angiography of reproductive organs — female

D. Angiography of reproductive organs — male

E. Venous sampling

F. Nephrostomy
   1. Placement
   2. Injection

G. Ureteral stents

H. Ureteral dilation

I. Nephroureterostomy

J. Percutaneous stone extraction

K. Embolizations

L. Renal artery angioplasty

M. Renal artery stent placement

N. Cystostomy

**V. Gastrointestinal (GI) Studies**

A. Selective visceral angiography

B. Pharmacoangiography (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**

A. Abdominal aortography

B. Upper extremity angiography

C. Lower extremity angiography

D. Angioplasty

E. Stent placement

F. Stent (covered) placement

G. Dialysis grafts

H. Thrombolytic therapy (e.g., tissue plasminogen activator (tPA), retavase)

I. Foreign body retrieval

J. Embolization

K. Pharmacoangiography (vasodilator: nitroglycerin, Integrilin)

L. 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. Fibrin sheath removal
   2. Thrombolysis
   3. 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 graft creation, revision and intervention
   1. Thrombolysis
   2. Declot
   3. Percutaneous transluminal angioplasty (PTA)
   4. Stenting
   5. Injection
   6. Types of AV fistulas and grafts

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

**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

**IX. Procedure Coding (Supervision and Interpretation Codes, Surgical Codes, Modifiers, Device Codes and Bundling Edits)**

A. Cerebrovascular

B. Neurovascular

C. Peripheral (upper and lower)

D. Pulmonary

E. Abdominal aorta

F. Thoracic aorta

G. Visceral

H. Venous

I. Venous interventional

J. Gastrointestinal

K. Genitourinary

L. Drainage

M. Biopsy

N. Medical devices

O. Miscellaneous

# Optional Content

This section is intended to decrease the hardship imposed on programs by requiring instructional content that is representative of technologies and technical principles that have been replaced with newer technical systems. It is recognized that traditional technologies are still part of the fabric of many communities. 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.

# 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 with the prognosis, 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 antrium)
    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. Lumbars
   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 is designed to establish a knowledge base in the fundamentals of digital image postprocessing that support guided skill development using clinical-based image workstations.

**Objectives**
1. Describe the benefits of postprocessing of digital images.
2. Describe the requirements of the source data used to create 3-D reformations.
3. Describe fundamentals of image data retrieval stored on Digital Imaging and Communications in Medicine–enabled archive systems (DICOM).
4. Describe techniques and procedures for recording postprocessed images or image sets.
5. Describe how 3-D images are generated.
6. Describe various methods for 3-D image viewing.
7. Describe the principles of correct ergonomics for workstation use.
8. 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.
9. Identify methods of acquiring quantitative data from a normal and temporal volumetric data set.
10. 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
a. 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

The Foundations section represents an inventory of preexisting knowledge and skills gained through an entry-level radiography educational experience and reenforced through professional practice. Foundations section 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.

## 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 radiologic 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 radiologic imaging and total quality management. Levels of competency and outcomes measurement ensure the well-being of the patient preparatory to, during and following the radiologic 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 radiographer'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.
- Critique images for appropriate anatomy, image quality and patient identification.
- Determine corrective measures to improve inadequate images.

## Digital Image Acquisition and Display

**Description**
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.

**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 and dose effectiveness for digital radiography detectors.
- Describe the histogram and the process or histogram analysis as it relates to automatic rescaling and determining an exposure indicator.
- 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 and Moiré effect.
- 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 to digital detectors.
- Evaluate the effect of a given exposure change on histogram shape, data width and image appearance.
- Describe the conditions that cause quantum mottle in a digital image.
- Formulate a procedure or process to minimize histogram analysis and rescaling errors.
- 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.
- 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.

## 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 radiographer.
- Describe the components and implications of informed consent.
- Identify standards for disclosure relative to informed consent.
- 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 Structure and Function

**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 radiography 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 radiography 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 radiographer 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 radiographer.
- Describe the practice standards for the radiographer 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 radiographer.
- Describe the characteristics of each stage of grief.
- Identify methods for determining the correct patient for a given procedure.
- Explain the use of various communication devices and systems.
- Explain specific aspects of a radiographic 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 with various health conditions.
- Describe select 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 radiographer 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.

## 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**
- Distinguish among the chemical, generic and trade names for drugs in general.
- Describe pharmacokinetic and pharmacodynamic principles of drugs.
- Explain the uses and impact of drug categories on the patient.
- Define the categories of contrast agents and give specific examples for each category.
- Explain the pharmacology of contrast agents.
- Describe methods and techniques for administering various types of contrast agents.
- Identify and describe the routes of drug administration.
- Demonstrate appropriate venipuncture technique.
- Differentiate between the two major sites of intravenous drug administration.
- Identify, describe and document complications associated with venipuncture and appropriate actions to resolve these complications.
- Discuss the various elements of initiating and discontinuing intravenous access.
- Differentiate and document dose calculations for adult and pediatric patients.
- Prepare for injection of contrast agents/intravenous medications using aseptic technique.
- Explain the current legal status and professional liability issues of the radiographer's role in contrast and/or drug administration.

## 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 direct and indirect ionizing radiation.
- 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 specific cells from most radiosensitive to least radiosensitive.
- 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 the processes of ionization and excitation.
- Describe charged and uncharged forms of 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 spectra.
- Identify the factors that affect the x-ray emission spectra.
- Discuss various photon interactions with matter by describing the interaction, relation to atomic number, photon energy and part density, and their applications in diagnostic radiology.
- Discuss relationships of wavelength and frequency to beam characteristics.
- Discuss the clinical significance of the photoelectric and modified scattering interactions in diagnostic imaging.

## Radiation Protection

**Description**
Content presents an overview of the principles of radiation protection, including the responsibilities of the radiographer 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.
- Distinguish between somatic and genetic radiation effects.
- Differentiate between the stochastic (probabilistic) and nonstochastic (deterministic) effects of radiation exposure.
- 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 and indicate the potential consequences if the performance standards fail.
- Describe the operation of various interlocking systems for equipment and indicate potential consequences of interlock system failure.
- 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 requirements for 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 anatomical structures that are considered critical for potential late effects of whole body irradiation exposure.
- 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. Information regarding the eligibility requirements for a postprimary certification examination in cardiac-interventional and vascular-interventional is provided in this section.

## 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:

www.arrt.org/pdfs/disciplines/clinical-experience/ci-clinical-experience.pdf and
www.arrt.org/pdfs/disciplines/clinical-experience/vi-clinical-experience.pdf

# Resources

**Textbooks**


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