Cardiac-Interventional and Vascular-Interventional Curriculum

Sponsored by the American Society of Radiologic Technologists, 15000 Central Ave. SE, Albuquerque, NM 87123-3917.

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 their 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 three sections: foundations, common content and specialized content. The foundations section represents an inventory of pre-existing knowledge and skills gained through an entry level radiography educational experience and reinforced 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 competencies section is intended as a guide to the development of a well-rounded clinical experience. Information to aid in meeting the eligibility requirements for a postprimary certification examination in cardiac-interventional and vascular-interventional technology also is included in Appendix B.

Cardiac-Interventional and Vascular Interventional Curriculum

Table of Contents

Foundations

Foundations represent an inventory of pre-existing knowledge and skills gained through an entry-level radiography educational experience and reinforced through professional practice.

Computers in Radiologic Sciences
Content is designed to introduce knowledge in computing and information processing. Computer applications in the radiologic sciences related to image capture, display, storage and distribution are presented.

Ethics and Law in the Radiologic Sciences
Content design provides a fundamental background in ethics. The historical and philosophical basis of ethics, as well as the elements of ethical behavior, will be discussed. The student will examine a variety of ethical issues and dilemmas found in clinical practice.

An introduction to legal terminology, concepts and principles also will be presented. Topics include misconduct, malpractice, legal and professional standards. Content emphasizes the importance of proper documentation and informed consent.

Human Diversity
Content is designed to promote better understanding of patients, patients' families and professional peers through comparison of diverse populations based on value systems, cultural and ethnic influences, communication styles, socioeconomic influences, health risks and life stages. Content will include the study of factors that influence relationships with patients and professional peers. Understanding human diversity assists the student in providing better patient care.

Human Structure and Function
Content design establishes a knowledge base in anatomy and physiology. Components of the cells, tissues, organs and systems will be described and discussed.

Imaging and Processing
Content is designed to establish a knowledge base in factors that govern and influence the production and recording of radiologic images. Film and electronic imaging with related accessories will be emphasized. Class demonstrations and labs are used to demonstrate application of theory.

Patient Assessment, Management and Education
Content introduces a model for clinical thinking to aid in patient assessment. Content includes a focus on the application of normal anatomy and physiological phenomena to ill and injured individuals. Interviewing skills and assessment techniques with a clinical focus will be discussed. This foundation introduces an emphasis on the analysis and interpretation of physiological data to assist in patient assessment and management.

Patient Care in Radiologic Science
The basic concepts of patient care, including consideration for the physical and psychological needs of the patient and family make up the design of this foundation's content. Routine and emergency patient care procedures will be described, as well as infection control procedures utilizing standard precautions. The role of the radiographer in patient education will be identified.

Patient Information Management
Content is designed to provide the basic concepts of patient information management. Medical records management including privacy and regulatory issues will be examined. The role of the bachelor of science in radiologic science (B.S.R.S.) technologist will be identified and discussed.

Pharmacology
Content design aims to broaden the technologist's knowledge of pharmacology. Topics include consumer safety and drug regulation, sources and bodily effects of drugs and safe dose preparation. Types of drug preparations, principles of responsible drug administration including routes and techniques are included. An introduction to clinical drug trials and a classification of drugs related to body systems are included as topics for presentation.

Quality Management
Content is designed to impart an understanding of quality management activities of a typical radiology department. Benefits of a quality management program to the patient and department will be presented. Tools, procedures and evaluation criteria used in the performance assessment of imaging modalities and image processing will be discussed.

Radiation Protection
Content is designed to present 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

Emergency Care Procedures

Fundamental Principles of Ultrasound

Imaging Equipment, Materials and Enhancement Techniques

Interventional Materials and Supplies

Mentored Clinical Experience

Patient Assessment and Monitoring

Physiologic Monitoring and Recording

Sterile Technique

Vascular Approaches

Vascular Correlation and Surgical Interventions

Emergency Care Procedures

Prerequisite
Cardiopulmonary resuscitation (CPR) 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 and pericardial perforation.
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. 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

B. Renal failure
   1. Symptoms
   2. Complications

III. Cardiac Life Support

A. Basic life support (BLS)

B. Advanced cardiac life support (ACLS)

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 color-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.

Content

I. Ultrasound Principles

A. Physics of sound waves
   1. Nature of sound waves
   2. Frequency, wavelength, propagation speed
   3. Properties of sound waves

B. Propagation of sound through soft tissue
   1. Propagation speed of sound
   2. Reflection
   3. Refraction
   4. Attenuation
   5. Frequency

II. Transducers

A. Piezoelectric effect

B. Construction and operation

C. Beams and focusing

D. Detail resolution

E. Transducer configurations

III. Pulsed Echo Instruments

A. Range equation

B. Pulse echo characteristics

C. Gain

D. Signal processing

E. Display modes

IV. Doppler

A. Physical principles
   1. Doppler effect
   2. Factors affecting Doppler shift frequency

B. Instrumentation
   1. Pulsed Doppler
   2. Continuous wave
   3. Basic principles of duplex instruments
   4. Spectral analysis

5. Color flow imaging
    a. Spectral color Doppler
    b. Amplitude Doppler

C. Intravascular instruments
1. Instruments
2. Display

V. Artifacts

A. Propagation

B. Attenuation

C. Spectral Doppler

D. Color Doppler

VI. Bioeffects and Safety

VII. Cardiac Imaging With Ultrasound

A. Long axis views

B. Short axis views

C. Apical or subxiphoid views

D. Substernal views

E. Introduction to M-mode and 2-D echo

F. Diseases of the aorta

G. Assessment of the mitral valve

H. Cardiomyopathies

I. Principles of Doppler echocardiography

J. Coronary artery disease

K. Assessment of the aortic valve

L. Cardiac masses, tumors and thrombi

VIII. Peripheral Vascular Examination With Ultrasound

A. Carotid Doppler

B. Upper and lower extremity venous studies

C. Upper and lower extremity arterial studies

D. Dialysis graft evaluation

E. Abdominal Doppler

IX. Intravascular Examination With Ultrasound

A. Cross section examination of vessels

B. Vessel evaluation for balloon/stent selection

C. Vessel evaluation for restenosis

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 the 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.

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

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
      a. Photon conversion
      b. Quantum detection
      c. Contrast
      d. Resolution
   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. Post processing
         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 Archiving and 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

D. Recording equipment

Interventional Materials and Supplies

Description

Content is designed to introduce the materials 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 clean up and care of interventional materials and devices.

Objectives

1. List the sterile materials included on an interventional tray.
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 materials used to prepare the entry site.
5. List the solutions required for an interventional procedure.
6. List materials required for emergency situations.
7. List the equipment required for radiation protection.
8. Describe the physical characteristics, various dimensions, shapes and gauges of catheters, needles and guidewires.
9. Describe several factors that affect flow rate.
10. Describe the materials used in construction of catheters, guidewires, needles, thrombectomy catheters and vascular stents and drainage catheters.
11. Describe the construction, function and application of angiography, atherectomy, balloon angioplasty, intravascular sonography, retrieval, occluding and infusing catheters.
12. Describe the construction, function and application of regular fixed-core, movable-core, exchange, J-shaped, biliary, axillary, tip-deflecting, high-torque and open-ended, stiff-shaft and coated guidewires.
13. Describe the function of dilators, introducer sheaths and stents (vascular and nonvascular).
14. Describe the uses of metal and plastic adaptors, connectors, stopcocks and manifolds.
15. Describe the types and construction of caval filters and implantable devices.
16. Describe the advantages and disadvantages of reusable and disposable supplies.

Content

I. Tray

A. Sterile packs

1. Instruments
2. 4 x 4 gauze
3. Syringes, needles and scalpel
4. Adaptors, stopcocks and manifolds
5. Sterile basins
6. Drapes, towels and tray cover
7. Heparinized saline
8. Guidewires
9. Catheters
10. Sharps container
11. Contaminated waste container
12. Contrast media

II. Solutions

A. Preparation of solutions

1. Systemic heparinization
2. Surgical preparation and scrub materials
   a. Razors
   b. Antiseptic soap solution
   c. Sterile basins
   d. Drapes and towels
   e. Gloves
3. Contrast media
4. Emergency drugs and crash cart

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 gloves and shields

C. Body shield

D. Time and distance

V. Guidewires and Catheters

A. Angiographic catheters
   1. Materials' physical characteristics
      a. Types
      b. Dimensions
      c. Shapes
      d. Side holes
      e. Factors affecting flow rate
   2. Reusable vs. disposable products
   3. Methods of sterilization

B. Occlusion and dilatation balloon catheters
   1. Types
   2. Preparation
   3. Construction
   4. Function
   5. Application
   6. Complications

C. Atherectomy catheters
   1. Types
   2. Preparation and setup
   3. Construction
   4. Function
   5. Application
   6. Complications

D. Directional coronary catheter
   1. Types
   2. Preparation
   3. Construction
   4. Function
   5. Application
   6. Complications

E. Thrombectomy catheters
   1. Types
   2. Preparation
   3. Construction
   4. Function

5. Application
6. Complications

F. Transluminal extraction catheters (TEC)
1. Types
2. Preparation
3. Construction
4. Function
5. Application
6. Complications

G. Intravascular ultrasound catheters
1. Types
2. Preparation
3. Construction
4. Function
5. Application
6. Complications

H. Guidewires
1. Materials
2. Physical characteristics
a. Dimensions
b. Shapes
c. Types
3. Special guidewires

I. Cleaning and storage

VI. Therapeutic Devices

A. Balloons

B. Stents
1. Vascular
2. Biliary

C. Intra-aortic balloon pump

D. Atherectomy

E. Pressure Wires (Radi, etc.)

F. Endografts

G. Pericardial tap

H. Chest tubes

I. Laser

J. Distal protective devices

K. Thrombectomy

L. Brachytherapy

VII. Needles

A. Percutaneous arterial puncture
   1. Construction and design
   2. Application

B. Cubital vein puncture
   1. Construction and design
   2. Application

C. Nonvascular interventional procedures
   1. Construction and design
   2. Application

D. Pediatric
   1. Special requirements
   2. Application

VIII. Miscellaneous Accessory Devices

A. Dilators

B. Introducer sheaths

C. Stents
   1. Coronary
   2. Vascular
   3. Drug-eluting stents

D. Caval filters

E. Adaptors

F. Connectors

G. Stopcocks

H. Manifolds

IX. Reusable Vs. Disposable Products

X. Methods of Sterilization

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

XIII. Implantable Devices

A. Cava Filters

B. Central venous catheters
   1. Peripherally inserted central catheter (PICC) line
   2. Ports

C. Embolic materials

D. Stents
   1. Vascular
   2. Nonvascular

E. Stent grafts

1. Endografts

F. Closure devices

G. Permanent pacemakers

H. Implantable cardiac defibrillator

I. Permanent dialysis access sites
   1. Life site devices
   2. Perma caths

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. Encompass strategies that assure 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 along with engaging students in the leaning experience. Leaning 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 the objectives and responsibilities of each person so that 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 on one hand and the amount of reward or credit for this work on the other.

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 student reflective commentary. Examples may be drawn from assignments associated with a single clinical event, or from curricular and co-curricular 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: Demonstrate knowledge of patient indicators and symptoms consistent with the need for this exam.	Directed readings and written assessment.	[insert date(s)]
Exam Specifications: Identify the protocol for patient preparation for this exam. Identify the methods and decision points for evaluating the adequacy of patient preparation for this exam.	Directed readings and written assessment. Participate in postexamination debriefing session following patient exams.	[insert date(s)]
Exam Preliminaries: Identify information gained through an evaluation of the patient's medical history that pertains to this exam. Identify information obtained that would contraindicate the exam.	Directed readings and written assessment. 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: Prepare resources required to conduct the exam: • Imaging equipment	Directed readings and written assessment regarding technical	[insert date(s)]

and recording media. • Trays and supplies. • Contrast media and delivery system. • Patient monitoring and emergency response equipment. • Notifications and surgical backup.	requirements for performing the exam, followed by assisting in the performance of patient exams leading to performing exams under supervision. 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: • Observing peripheral vascular stent placement exams. • Next, assisting in the performance of patient exams. • Leads to performing exams under supervision.	[insert date(s)]
Postprocedural Patient Care: • Patient education. • Confirmation of patient preparation for dismissal from the specials suite. • Notifications and documentation.	Patient dismissal check-off sheet.	[insert date(s)]
Postexam Administration • Room cleanup. • Image postprocessing and archiving. • Documentation.	Evaluator summary and documentation sheet.	[insert date(s)]
Postexamination Risks/Complications: • Identification of possible complications.	Evaluator summary and documentation sheet.	[insert date(s)]

• Protocol(s) for response. • Required documentation. • Risk reduction steps.		
Objective B:	Resources Needed	Target Dates
(Second learning Objective)		

Evaluation Criteria

I will have accomplished Objective A when: a) I have observed (*insert number*) peripheral vascular stent placement exams performed on adult patients. b) I have participated in (*insert number*) peripheral vascular stent placement exams performed on adult patients under supervision by my advanced practice mentor. c) I have performed with mentored guidance (*insert number*) peripheral vascular stent placement exams performed on adult patients. 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: Who will you share your learning plan with and go to 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. Evaluate recorded lab values from a patient's chart.
3. Critically analyze data created by physiologic monitoring devices used during the course of an interventional examination.
4. Recognize common medical emergencies and implement a plan of action to respond to patients' medical needs.
5. Identify the indications and contraindications for contrast media and typical medications used in the interventional suite.
6. Utilize proper techniques in the management of intravenous (IV) therapies.
7. Maintain sterile fields and aseptic technique during the performance of interventional procedures.

Content

I. Vital Signs

A. Temperature

B. Heat rate

C. Respiration

D. Blood pressure

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. Glucose
7. 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 normalization 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. Invasive hemodynamics
   1. Waveform recognition
   2. Normal and abnormal values

D. Maintaining accessory medical devices
   1. Oxygen delivery systems
   2. Chest tubes
   3. In-dwelling catheters
   4. Drainage bags

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

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. Beta blockers
   9. Calcium channel blockers
   10. Diuretics
   11. Emergency medications
   12. Narcotics
   13. Platelet inhibitors
   14. Sedatives

15. Thrombolytics
16. Vasoconstrictors
17. Vasodilators

B. Indications and contraindications

C. Preparation and dosage

D. Complications

E. 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

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

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, green dye and thermal dilution.
7. Describe area-length method and computer evaluation techniques for ventricular volume analysis.
8. Explain the function of transducers, amplifiers, recorders (hot stylus, optical, spray link), 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 pacemakers.
12. Explain the indications for and principles of intra-aortic balloon pumping.

Content

I. Physiologic Monitoring

A. Equipment
   1. Transducers
   2. Amplifiers
   3. Recorders
      a. Hot stylus
      b. Optical
      c. Spray link
      d. Oscilloscopes
      e. Digital read out module
      f. Calibration, balancing
      g. Base line determination

B. Specialized techniques
   1. dp/dt
   2. Cardiac output measurements
      a. Fick method
      b. Green dye
      c. Thermal dilution
      d. 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
   1. AV blocks
   2. Bundle 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. Intra-aortic balloon pump (IABP)
    1. Implication for IABP
    2. Principle of IABP operation
    3. Construction
        a. Function
            1) Pump and electrocardiogram coordination
            2) Triggering
                a) ECG
                    i) Peak
                    ii) R wave
                b) Aortic pressure
    4. Technique for insertion
    5. Monitoring
    6. Complications
    7. Troubleshooting

J. Automated defibrillator

III. Recording Systems

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.

Content

I. Types of Microorganisms

A. Bacteria

B. Fungi

C. Viruses

D. Protozoa

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

V. Methods of Transmitting Agents

A. Direct

B. Indirect

C. Airborne

D. Vehicle

E. Vector

VI. Sterilization

A. Steam under pressure

B. Gas

C. Chemical

D. Dry heat

E. Ionizing radiation

VII. Asepsis

A. Betadine

B. Alcohol

C. Disinfectants

VIII. 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

IX. Scrubbing, Gowning and Gloving

A. Scrubbing techniques
   1. Personnel
   2. Patient

B. Gowning methods
   1. Self
   2. Physician

C. 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 venipuncture for vascular procedures and examine the history that lead 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 or Venous 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

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. Describes 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.

Content

I. Atherosclerosis

A. Definition

B. Clinical aspects

C. Common occlusion sites

II. Arterial Aneurysms

A. Definition

B. Types

C. Clinical aspects

D. Common aneurysm sites

III. Arterial Dissections

A. Definition

B. Types

C. Clinical aspects

D. Classifications

IV. Types of Arterial Trauma

V. Renovascular Disease

A. Stenosis

B. Aneurysms

C. Fibromuscular dysplasia

D. Trauma

VI. Mesenteric Vessel Pathologies

A. Atherosclerosis

B. Aneurysms

C. Embolism

D. Angiodysplasia

E. GI bleeding

F. Trauma

VII. Peripheral Arterial Disease

A. Atherosclerosis

B. Aneurysms

C. Embolism

D. Trauma

E. Dissection

VIII. Cerebrovascular Disease

A. Types of pathologies
   1. Tumor
   2. Arterial venous malformations
   3. Infarctions
   4. Intracranial bleeds
   5. Aneurysms
   6. Fibromuscular dysplasia
   7. Dissection

B. Clinical aspects

IX. Coronary Artery Disease

A. Stenosis

B. Total and subtotal occlusions

C. Thrombosis formation and atherosclerosis

D. Calcified lesions

Specialized Content

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 devices: manual and mechanical compression.
- Possible complications.
    - Recognition.
    - Treatment.

Objectives

1. Describe the basic operation of the cine camera.
2. Describe the procedure of cine film transport, loading technique, film perforation and pitch, troubleshooting, cleaning and preventive maintenance.
3. Be prepared to play an active role in the performance of select cardiac-interventional procedures.
4. Participate in patient assessment and management prior to and during select cardiac-interventional procedures.
5. Identify the indications and contraindications for given cardiac-interventional procedures.
6. Recognize and respond effectively to patient complications that arise during the performance of cardiac-interventional procedures.
7. Demonstrate and perform various methods of obtaining hemostasis following catheter/sheath removal.

Content

I. Cine Camera

A. Basic operation

B. Film transport

C. Loading

D. Film perforation

E. Pitch

F. Troubleshooting

G. Processing

II. Diagnostic Cardiac Studies

A. Pulmonary angiography

B. Aortography

C. Coronary angiography

D. Internal mammary angiography

E. Saphenous vein graft angiography

F. Ventriculography

G. Biopsy

III. Percutaneous Coronary Intervention

A. Angioplasty

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

C. Stent placement
   1. Drug eluting stents

D. Thrombolysis
   1. Mechanical
   2. Pharmacologic

E. Intravascular ultrasound

F. Brachytherapy

IV. Therapy

A. Pericardiocentesis

B. Intra-aortic balloon counterpulsation

C. Removal of foreign bodies

V. 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
   2. Thermodilution
      a. Angiographic

F. Right and left heart hemodynamics

G. Intravascular ultrasound

VI. Conduction System Studies

A. Arrhythmia detection

B. Arrhythmia ablation

C. Cardioversion

D. Implants
   1. Pacemaker, permanent insertion
   2. Internal cardiac defibrillator (ICD) insertion

E. Pacemaker, temporary insertion

F. Biventricular pacemaker implantation

G. Electrophysiology studies

H. Miscellaneous
    1. Activated clotting time

VII. 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

VIII. Postprocedural Homeostasis Methods

A. Manual
B. Mechanical

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.
- Image enhancement and processing.
    - Application of compensating filtration.
- Closure devices.
- Possible complications.
    - Recognition.
    - Treatment.

Objectives

1. Describe the basic operation of select rapid serial film changers.
2. Describe the operational and technical considerations of single and biplane serial filming.
3. Describe the function of the program selector.
4. Describe and list the functioning parts of cut-film, cassette and roll-film rapid serial film changers, including the advantages and disadvantage of each.
5. Describe what is meant by linear and area magnification.
6. Identify preventive maintenance and cleaning requirements of select rapid film changers.
7. Be prepared to play an active role in the performance of select vascular-interventional procedures.
8. Participate in patient assessment and management prior to and during select vascular-interventional procedures.
9. Identify the indications and contraindications for given vascular-interventional procedures.
10. Perform patient assessment before, during and after vascular/nonvascular interventional procedures.

Content

I. Rapid Serial Film Changers

A. Operation
   1. Program selector

B. Function

C. Types
   1. Cut-film
   2. Cassette
   3. Roll-film
   4. Single plane
   5. Biplane

D. Magnification radiography requirements

E. Cleaning and preventive maintenance

F. Electrical safety

II. Neurologic Studies

A. Intracranial angiography

B. Extracranial angiography

C. Neurologic embolization

D. Neurologic thrombolysis

E. Neurologic angioplasty

F. Neurological stent placement

G. Vertebroplasty

III. Pulmonary Studies

A. Pulmonary embolization

B. Pulmonary angiogram

C. Thoracentesis

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

G. Ureteral stents

H. Percutaneous stone extraction

I. Embolizations

J. Renal artery angioplasty

K. Renal artery stent placement

L. Dialysis graft creation, revision and intervention
   1. Fibrin sheath stripping
   2. Thrombolysis
   3. PTA
   4. Stenting

M. Cystostomy

V. Gastrointestinal (GI) Studies

A. Selective visceral angiography

B. Pharmacoangiography (e.g. pitressin injection)

C. Embolization

D. Angioplasty

E. Stent placement
   1. Esophageal stents

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

VI. Peripheral Studies

A. Abdominal aortography

B. Thoracic aortography

C. Upper extremity angiography

D. Lower extremity angiography

E. Inferior vena cava venography (cavagram)

F. Superior vena cave venography (cavagram)

G. Angioplasty

H. Stent placement

I. Stent graft placement

J. Dialysis grafts

K. Thrombolytic therapy (e.g., streptokinase, urokinase, TPA)

L. Caval filter placement

M. Foreign body retrieval

N. Peripheral vascular embolization

O. Central venous access/port placement

VII. Miscellaneous Procedures

A. Abscess drainage

B. Pressure measurements

C. Biopsy

D. Paracentesis

E. Vertebroplasty

F. Radio frequency ablation (RFA)

G. Chest tube placement

Appendix A

Computers in Radiologic Sciences

Description
Content is designed to introduce knowledge in computing and information processing. Computer applications in the radiologic sciences related to image capture, display, storage and distribution are presented.

Objectives
1. Identify various types of computers.
2. Define analog to digital conversion and digital signal processor.
3. Identify various terms related to computer fundamentals and components.
4. Describe major functions of the central processing unit (CPU).
5. Differentiate the various input and output devices.
6. Give examples of various types of memory.
7. Describe computer care and preventive maintenance.
8. Explain computer operation.
9. Distinguish between analog computers and digital computers.
10. Discuss application of various types of software.
11. Explain the following computing applications as they relate to radiology: radiologic information systems (RIS), hospital information systems (HIS) and picture archiving and communication systems (PACS).
12. Define digital imaging and communications in medicine (DICOM).
13. Discuss the impact the Internet has on the distribution of health information.

Ethics and Law in the Radiologic Sciences

Description
Content is designed to provide a fundamental background in ethics. The historical and philosophical basis of ethics, as well as the elements of ethical behavior, will be discussed. The student will examine a variety of ethical issues and dilemmas found in clinical practice.

An introduction to legal terminology, concepts and principles also will be presented. Topics include misconduct, malpractice, legal and professional standards. The importance of proper documentation and informed consent is emphasized.

Objectives
1. Describe specialized standards of behavior for the healing arts as a continuum, with historical and philosophical roots in the earliest periods of human history.
2. List the major milestones in the development of codes of behavior and ethical standards in the healing arts.
3. Explain ethics as a branch of philosophy and the moral, social and cultural basis of the development of an ethic.
4. Describe the moral, social and cultural basis of ethics.
5. Apply medical/professional ethics in the context of a broader societal ethic.
6. Explain the role of ethical behavior in health care delivery.
7. Differentiate between empathetic rapport and sympathetic involvement in relationships with patients and relate these to ethical conduct.
8. Explain concepts of personal honesty, integrity, accountability, competence and compassion as ethical imperatives in health care.
9. List legal/professional standards and their relationship to practice in health professions.
10. Identify specific situations and conditions that give rise to ethical dilemmas in health care.
11. Discuss the *US Genome Project* relative to the cause of genetically induced disease.
12. Explore the ethical issues of genetic screening.
13. Explain the genetic counseling responsibility of health care providers.
14. Employ a basic system of examination, clarification, determination of alternatives and decision-making in addressing ethical questions.
15. Explain select concepts embodied in principles of patients' rights, the doctrine of informed (patient) consent and other issues related to patients' rights.
16. Explain the legal implications of professional liability, malpractice, professional negligence/carelessness and other legal doctrines applicable to professional practice.
17. Describe the importance of accurate, complete, correct methods of documentation as a legal/ethical imperative.
18. Explore theoretical situations and questions relating to the ethics of care and health care delivery.
19. Explain specific legal terms, principles and laws.
20. Outline the elements necessary for a valid malpractice claim.
21. Define specific legal doctrines to include vicarious liability, respondeat superior, and res ipsa loquitur.

22. Describe the scope of practice for radiography, the elements that comprise it and responsibilities of the radiographer.
23. Differentiate between professional and legal standards and describe how each relates to the radiography profession.
24. Describe institutional and professional liability protection typically available to the radiographer.
25. Describe the elements and implications of informed consent.
26. Identify standards for disclosure relative to informed consent.
27. Describe how consent forms are utilized relative to specific radiographic procedures.

Human Diversity

Description
Content is designed to promote better understanding of patients, patients' families and professional peers through comparison of diverse populations based on their value systems, cultural and ethnic influences, communication styles, socioeconomic influences, health risks and life stages. Content will include the study of factors that influence relationships with patients and professional peers. Understanding human diversity assists the student in providing better patient care.

Objectives
1. Explain the development of a personal value system.
2. Discuss the interrelationship between personal, community and societal values.
3. Explain the influence a person's value system has on his or her behavior.
4. Discuss the development of personal and professional values.
5. Describe how professional values influence patient care.
6. Examine Kohlberg's theory on how an individual's morality influences his or her behavior.
7. Differentiate between culture and ethnicity.
8. Explain how a person's cultural beliefs toward illness affect his or her recovery.
9. Explain the origins of medical ethnocentrism.
10. Discuss the societal factors that influence the quality of health care.
11. Compare alternative/complementary medicine to the traditional Western model.
12. Describe the culture of poverty and its effect on health care.
13. Discuss family dynamics in a cultural, social, ethnic and lifestyle context.

Human Structure and Function

Description
Content is designed to establish a knowledge base in anatomy and physiology. Components of the cells, tissues, organs and systems will be described and discussed.

Objectives
1. Identify the location of structures using directional and orientation terms.
2. Indicate where various planes lie in relation to the body.
3. Identify the structural limits, functions and contents of each of the body cavities.
4. Explain the terms atom, ion, atomic number and atomic weight.
5. Describe the nature of chemical bonds and compare the different types of chemical bonds.
6. Apply the pH scale to differentiate between acid and base substances.
7. Differentiate between polar and nonpolar compounds, and relate these to water solubility.
8. List different types of carbohydrates and give examples of each type.
9. Differentiate between the different types of lipids and determine common characteristics.
10. Describe the structure and functions of proteins.
11. Describe the structure of deoxyribonucleic acid (DNA) and the law of complementary base pairing.
12. Describe the structure of ribonucleic acid (RNA) and name the different types of RNA.
13. Characterize the structure of the cell membrane and the cytoskeleton.
14. Compare endocytosis and exocytosis.
15. Identify the structure and function of cilia and flagella.
16. Diagram the replication of DNA.
17. Diagram the phases of the cell cycle.
18. Describe genetic transcription and the post-transcriptional modifications that change pre-mRNA into mRNA.
19. List the functions of mRNA, tRNA and rRNA.
20. List the functions of the rough endoplasmic reticulum and Golgi apparatus in post-transitional modifications of secretory proteins.
21. Outline the sequence of events that occurs in the synthesis packaging and exocytosis of secretory proteins.
22. Differentiate between the stages of meiosis and mitosis and identify the stages of each reproductive process.
23. Define the following: anabolism, catabolism and metabolism.
24. Characterize the role of enzymes in metabolism.
25. Describe carbohydrate metabolism.
26. Describe lipid metabolism.
27. Describe the Krebs cycle in general terms and its functional significance.
28. Express the significance of ketone.
29. List the factors that affect the basal metabolic rate.
30. Diagram the germinal layers of the embryo.
31. Classify tissue types, describe the functional characteristics of each and give examples of their locations within the human body.
32. Identify and locate the bones of the human skeleton.

33. Identify bony processes and depressions found on the human skeleton.
34. Describe articulations of the axial and appendicular skeleton.
35. Differentiate the primary and secondary curves of the spine.
36. Describe sesamoid bones and locate examples on radiographs.
37. Summarize the functions of the skeletal system.
38. Label different types of articulations.
39. Compare the types, locations and movements permitted by the different types of articulations.
40. Examine the organization of muscle at the gross and microscopic levels.
41. Differentiate between the structures of each type of muscle tissue.
42. State the function of each type of muscle tissue.
43. Name and locate the major muscles of the skeleton.
44. Differentiate between the structure and function of different types of nerve cells.
45. State the structure of the brain and the relationship of its component parts.
46. Describe the brain functions.
47. List the meninges and describe the function of each.
48. Outline the formation, circulation and function of cerebrospinal fluid.
49. Describe the structure and function of the spinal cord.
50. Determine the distribution and function of cranial and spinal nerves.
51. Summarize the structure and function of components making up the autonomic nervous system.
52. Describe the structures and functions of the components making up the human eye and ear.
53. List the component body parts involved in the senses of smell and taste.
54. List the somatic senses.
55. Define endocrine.
56. Describe the characteristics and functions of the components making up the endocrine system.
57. Identify the location and describe the structure of each component of the endocrine system.
58. Identify the major hormone(s) secreted by each component of the endocrine system.
59. Describe the hard and soft palates.
60. Differentiate between deciduous and permanent teeth in terms of age for eruption and number.
61. Differentiate between the types of teeth in terms of number and location within the jaws and their functions.
62. Label the component parts of a tooth.
63. Describe the structure and function of the tongue.
64. Identify the structure, function and locations of the salivary glands.
65. Recite and label the primary organs of the digestive system.
66. Describe the function(s) of each primary organ of the digestive system.
67. Differentiate between the layers of tissue that comprise the esophagus, stomach, small intestine, large intestine and rectum.
68. Differentiate between peritoneum, omentum and mesentery.
69. List and label the accessory organs of the digestive system, and describe their function.
70. Identify the secretions of accessory organs of the digestive system and the function of each.
71. Explain the purpose of digestion.
72. List the digestive processes that occur in the body.

73. Describe the composition and characteristics of blood.
74. List the types of blood cells and state their functions.
75. Differentiate between blood plasma and serum.
76. Outline the clotting mechanism.
77. List the blood types.
78. Explain the term Rh factor.
79. Explain the antigen/antibody relationship and its use in blood typing.
80. Label the parts of the human heart.
81. Describe the flow of blood through the body and identify the main vessels.
82. Describe the structure and function of arteries, veins and capillaries.
83. Differentiate between arterial blood in systemic circulation and arterial blood in pulmonary circulation.
84. Differentiate between normal and common abnormal electrocardiogram (ECG) tracings.
85. Summarize the structure, distribution and function of lymphatic vessels.
86. Outline the major pathways of lymphatic circulation.
87. Identify the location of major lymph node clusters.
88. Differentiate between nonspecific defenses and specific immunity.
89. Explain antibody production and function.
90. List the different types and functions of T- and B-cells and explain their functions.
91. Label the components of the respiratory system.
92. Describe the physiology and regulation of respiration.
93. Label the parts of the kidneys, ureters, bladder and urethra.
94. Describe the function of each organ of the urinary system.
95. Describe the composition and formation of urine.
96. Explain micturition.
97. Label the anatomy of the male and female reproductive organs.
98. Analyze the function of each of the male and female reproductive organs.
99. Demonstrate the use of topographical landmarks to locate internal structures.
100. Identify major anatomical structures found within sectional images.

Imaging and Processing

Description
Content is designed to establish a knowledge base in factors that govern and influence the production and recording of radiologic images. Film and electronic imaging with related accessories will be emphasized. Class demonstrations/labs are used to demonstrate application of theory.

Objectives
1. Discuss practical considerations in setting standards for acceptable image quality.
2. Assess radiographic density on radiographic images.
3. Distinguish between acceptable and unacceptable image densities.
4. Analyze the relationships of factors that control and affect image density.
5. Critique the radiographic contrast within various radiographic images.
6. Differentiate between subject contrast and image receptor contrast.
7. Distinguish between acceptable and unacceptable contrast scales.
8. Compare long-scale and short-scale contrast images.
9. Analyze the relationships of factors that control and affect radiographic contrast.
10. Critique recorded detail on various radiographic images.
11. Differentiate between umbra and focal spot blur.
12. Analyze the relationships of factors affecting recorded detail.
13. Define distortion.
14. Differentiate between shape and size distortion.
15. Perform calculations to determine image magnification and percent magnification.
16. Differentiate between magnification as distortion and macro-radiography.
17. Summarize the relationships of factors affecting distortion.
18. Formulate a plan of action to decrease image distortion.
19. Summarize the relationships of factors affecting exposure latitude.
20. Describe the operation and applications for different types of beam-limiting devices.
21. Evaluate beam-limiting devices.
22. Select the most appropriate beam-limiting device to be used for a given clinical situation.
23. Explain beam filtration.
24. Describe the change in the half value layer (HVL) when additional filtration is added to the beam.
25. Summarize the relationships of factors affecting scattered and secondary radiation.
26. Evaluate the effects of scattered radiation on the image.
27. Compare types of grid.
28. Articulate the advantages and disadvantages of grid use.
29. Describe grid maintenance.
30. Select the most appropriate grid for a given clinical situation.
31. Interpret grid efficiency in terms of grid ratio and frequency.
32. Define grid cutoff.
33. Summarize the factors influencing grid cutoff.
34. Evaluate grid artifacts.
35. Formulate a set of rules for grid use to prevent grid cutoff and artifacts.

36. Explain the use of standardized radiographic technique charts.
37. Explain exposure factor considerations involved in technique selection.
38. Compare fixed kilovolt peak (kVp) and variable kVp systems.
39. Formulate a technique chart using either a fixed kVp or variable kVp system.
40. Calculate the photographic effect when exposure factors are given.
41. Apply mAs reciprocity to clinical simulations.
42. Describe the function of each component of radiographic film.
43. Explain latent image formation.
44. Discuss photostimulable phosphor plates as image receptors.
45. Discuss how an image is retrieved from a photostimulable phosphor.
46. Describe the features of the characteristic curve and explain its purpose.
47. Compare the characteristic curve for differing types of image receptors, both film and photostimulable phosphor plates.
48. Select the most appropriate image receptor to be used for given clinical situations.
49. Describe various types of image receptor holders.
50. Describe the function of each component of an intensifying screen.
51. Select the most appropriate intensifying screen for given clinical situations.
52. Explain the classifications of intensifying screens and the applications of each.
53. Identify procedures that ensure a long screen life devoid of artifacts and distortion.
54. Employ a quality control program for intensifying screens.
55. Differentiate between traditional intensifying screens and photostimulable phosphors.
56. Discuss darkroom-related OSHA standards for health and safety.
57. Discuss safelight illumination appropriate for specific image receptor systems.
58. Discuss the possible causes and health implications of "darkroom chemical sensitivity."
59. Describe the effects of storage on image quality.
60. List image archiving options.
61. Describe the operation and utilization of wet and dry processing.
62. Analyze the effects of processing on image quality.
63. Identify key components of an automatic film processor.
64. Demonstrate how various film sizes are fed into the film processor.
65. Analyze the steps of the processing cycle providing the specific action and duration of time for each step.
66. Identify the purpose of a daily quality control program for processors.
67. Discuss digital image processing and postprocessing.
68. Identify types of image artifacts and analyze the artifacts to determine the cause.
69. Compare methods of silver recovery.
70. Evaluate silver recovery security in terms of control, theft and misappropriation.

Patient Assessment, Management and Education

Description
Content is designed to introduce a model for clinical thinking to aid in patient assessment. Content includes a focus on the application of normal anatomy and physiological phenomena to ill and injured individuals. Interviewing skills and assessment techniques with clinical focus will be discussed. An emphasis on the analysis and interpretation of physiological data to assist in patient assessment and management will be introduced.

Objectives
1. Develop clinical thinking skills applied to the patient care setting.
2. Develop skills in conducting patient interviews to document a patient's medical history.
3. Apply the techniques and procedures for conducting a patient physical assessment and procedures to document findings.
4. Obtain and critically analyze a patient's vital signs.
5. Compose a plan for managing the patient based upon patient needs.
6. Participate in patient education.
7. Foster relationship-centered patient care.
8. Adapt communications techniques to address patient needs.

Patient Care in Radiologic Sciences

Description
Content is designed to provide the basic concepts of 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 utilizing standard precautions. The role of the radiographer in patient education will be identified.

Objectives
1. Identify the responsibilities of the health care facility and members of the health care team.
2. List the general responsibilities of the radiographer.
3. Describe the scope of practice for the radiographer as defined by the ASRT and state licensure.
4. Explain select perceptions of death and dying from patient and technologist viewpoints.
5. Describe ethical, emotional, personal and physical aspects of death.
6. List the stages of dying and describe the characteristics of each stage.
7. Identify the support mechanisms available to the terminally ill.
8. Identify methods for determining the correct patient for a given procedure.
9. Explain the use of various communication devices and systems.
10. Explain specific aspects of a radiographic procedure to the patient.
11. Demonstrate correct principles of body mechanics applicable to patient care.
12. Demonstrate techniques for specific types of patient transfer.
13. Demonstrate select procedures for turning patients with various health conditions.
14. Describe select immobilization techniques for various types of procedures and patient conditions.
15. Describe specific patient safety measures and concerns.
16. Explain the purpose, legal considerations and procedures for reporting an accident or incident.
17. Describe methods for evaluation of patient status.
18. List the information to be collected prior to patient examination.
19. Describe vital signs used to assess patient condition.
20. Convert a Fahrenheit measurement to the Celsius equivalent.
21. State the normal temperature values for the oral and rectal routes of measurement.
22. Describe the method of monitoring respiration and state the normal values expected.
23. Identify the normal values for blood pressure for males and females.
24. Identify the seven major sites for monitoring the pulse and indicate the normal values.
25. Assess patient vital signs.
26. List the normal ranges for specific laboratory studies.
27. Define terms related to infection control.
28. Describe the importance of Standard Precautions and Isolation Procedures.
29. Explain sources and modes of transmission of infection and disease.
30. List institutional/departmental procedures for infection control.
31. Describe methods for the prevention of infection to the health worker and patient.
32. Identify symptoms related to specific emergency situations.

33. Describe the emergency medical code system for the institution and the role of the student during a medical emergency.
34. Explain the special considerations necessary when performing radiographic procedures on an infant or a child.
35. Explain the special considerations necessary when performing radiographic procedures on a geriatric patient.
36. Describe the symptoms and precautions taken for a patient with a head injury.
37. Describe the symptoms and precautions taken for a patient with a spinal injury.
38. Explain the types, immobilization devices and positioning for upper and lower extremity fractures.
39. Describe the symptoms and precautions taken for a patient with massive wounds.
40. Describe the classifications and medical interventions for burns.
41. Describe the symptoms and medical interventions for a patient having a contrast agent reaction.
42. Explain the role of the technologist in patient education.
43. Describe the patient preparation for various barium studies.
44. Describe the procedure to properly prepare a patient for a barium study.
45. Identify specific types of tubes, lines, catheters and collection devices.
46. Explain the purpose, precautions and care of tubes, lines, catheters and collection devices.
47. Outline the steps in the operation and maintenance of suction and oxygen equipment and demonstrate their use.
48. Demonstrate competency in CPR.
49. Demonstrate the use of specific medical emergency equipment and supplies.
50. Demonstrate select first aid techniques.
51. Describe the monitoring, pre- and post-procedure care, drug administration and special precautions for a patient undergoing myelography and urography.
52. Demonstrate the appropriate procedure for gathering information prior to performing a mobile radiographic examination.
53. Describe the initial steps in performing a mobile procedure.
54. Explain the procedure for placing an image receptor under a patient in an orthopedic bed frame.
55. Describe the special problems faced in performing procedures on a patient with tracheotomy and specific tubes, drains and catheters.
56. Describe the procedure for producing diagnostic images in the surgical suite.
57. Explain the appropriate radiation protection required when performing mobile/surgical radiography.

Patient Information Management

Description
Content is designed to provide the basic concepts of patient information management. Medical records management including privacy and regulatory issues will be examined. The role of the technologist will be identified and discussed.

Objectives
1. Discuss the Joint Commission on the Accreditation of Healthcare Organizations (JCAHO) standards regarding the accountability and protection of patient information.
2. List the requirements of a patient consent document.
3. Identify challenges to the protection of patient information.
4. Distinguish between various types of patient records.
5. Explain the contents of the medical record.
6. Demonstrate proper protocols for charting patient information.
7. Explain the procedures for document administration.
8. Discuss privacy and regulatory issues related to patient information.
9. Assess the application of the Health Insurance Portability and Accountability Act (HIPAA) to patient information systems.
10. Define medical informatics and describe examples of informatics systems found in today's patient care setting.
11. Identify potential abuses for the use of confidential patient information.

Pharmacology

Description
Content is designed to broaden the technologist's knowledge of pharmacology. Topics include consumer safety and drug regulation, sources and bodily effects of drugs and safe dose preparation. Types of drug preparations, principles of responsible drug administration, including routes and techniques are included. An introduction to clinical drug trials and a classification of drugs related to body systems are included as topics for presentation.

Objectives
1. Identify key drug laws impacting consumer safety.
2. Identify the five schedules of controlled substances and cite a drug example of each.
3. Identify the role of the U.S. Food and Drug Administration (FDA) and Drug Enforcement Administration (DEA) in the regulation and control of consumer drugs.
4. Implement strategies for health care workers involved in dispensing medications to comply with the restrictions of drug laws.
5. Interpret common abbreviations and symbols used for medication orders.
6. Translate drug measurements across measurement systems.
7. Differentiate among drug names (generic, chemical, trade, official).
8. Explain the restrictions of drug sales implied by the designation of: over the counter, legend drug and controlled substance.
9. List common material sources from which drugs are developed.
10. Describe the biological processing of drugs in the body.
11. List common variables affecting drug action within the body.
12. Describe common unexpected responses to drugs.
13. Accurately perform calculations for drug dose delivery.
14. Describe dose modifiers for pediatric and geriatric patients.
15. Describe various forms of drug preparations and supplies.
16. Incorporate the principles of responsible drug administration in the patient care setting to prevent medication error.
17. Describe administration routes and techniques for select medications.
18. Describe the principles associated with a controlled clinical drug trial.
19. Distinguish between single-blind and double-blind drug trials.
20. Organize drugs according to body system.

Quality Management

Description
Content is designed to impart an understanding of the tasks and protocols making up the quality management activities of a typical radiology department. The roles and responsibilities of all parties contributing to the quality management effort will be presented. Tools, procedures and evaluation criteria used in the performance assessment of imaging modalities and image processing will be discussed.

Objectives
1. Discuss practical considerations in setting standards for acceptable image quality.
2. Employ a quality control program for intensifying screens.
3. Describe the effects of storage on image quality.
4. Analyze the effects of processing on image quality.
5. Identify the purpose of a daily quality control program for processors.
6. Differentiate between quality improvement/management, quality assurance and quality control.
7. List the benefits of a quality management program to the patient and to the department.
8. List elements of a quality management program and discuss how each is related to the quality management program.
9. Identify common equipment malfunctions that affect image quality.
10. Apply the principles of total quality management.
11. Ensure that performance reflects professional competence in selecting technical factors to produce quality diagnostic images with the lowest possible radiation exposure.
12. Critique images for appropriate clinical information, image quality and patient documentation.

Radiation Protection

Description
Content is designed to present 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
1. Identify and justify the need to minimize unproductive radiation exposure of humans.
2. Distinguish between somatic and genetic radiation effects.
3. Differentiate between the stochastic and nonstochastic (deterministic) effects of radiation exposure.
4. Explain the objectives of a radiation protection program.
5. Define radiation and radioactivity units of measurement.
6. Identify dose equivalent limits (DEL) for occupational and nonoccupational radiation exposure.
7. Describe the as low as reasonably achievable (ALARA) concept.
8. Identify the basis for occupational exposure limits.
9. Distinguish between perceived risk and comparable risk.
10. Describe the concept of negligible individual risk level (NIRL).
11. Identify ionizing radiation sources from natural and man-made sources.
12. Comply with legal and ethical radiation protection responsibilities of radiation workers.
13. Calculate DEL with reference to the latest National Council on Radiation Protection and Measurements (NCRP) reports.
14. Describe the theory and operation of radiation detection devices.
15. Identify appropriate applications and limitations for each radiation detection device.
16. Describe how isoexposure curves are used for radiation protection.
17. Identify performance standards for beam-directing, -defining and -limiting devices.
18. Describe procedures used to verify performance standards for equipment and indicate potential consequences of performance standards failure.
19. Describe the operation of various interlocking systems for equipment and indicate potential consequences of interlock system failure.
20. Identify conditions and locations evaluated in an area survey for radiation protection.
21. Distinguish between controlled and noncontrolled areas and list acceptable exposure levels.
22. Describe “Radiation Area” signs and identify appropriate placement sites.
23. Describe the function of federal, state and local regulations governing radiation protection practices.
24. Describe the requirements for and responsibilities of a radiation safety officer.
25. Express the need and importance of personnel monitoring for radiation workers.
26. Describe personnel monitoring devices, including applications, advantages and limitations for each device.
27. Interpret personnel monitoring reports.
28. Compare values for dose equivalent limits for occupational radiation exposures (annual and lifetime).

29. Identify anatomical structures that are considered critical for potential late effects of whole body irradiation exposure.
30. Identify dose equivalent limits for the embryo and fetus in occupationally exposed women.
31. Distinguish between primary and secondary radiation barriers.
32. Demonstrate how the operation of various x-ray and ancillary equipment influences radiation safety and describe the potential consequences of equipment failure.
33. Perform calculations of exposure with varying time, distance and shielding.
34. Discuss the relationship between HVL and shielding design.
35. Identify emergency procedures to be followed during failures of x-ray equipment.
36. Demonstrate how time, distance and shielding can be manipulated to keep radiation exposures to a minimum.
37. Explain the relationship of beam-limiting devices to patient radiation protection.
38. Discuss added and inherent filtration in terms of the effect on patient dosage.
39. Explain the purpose and importance of patient shielding.
40. Use the appropriate method of shielding for a given radiographic procedure.
41. Explain the relationship of exposure factors to patient dosage.
42. Identify the appropriate image receptor that will result in an optimum diagnostic image with the minimum radiation exposure to the patient.
43. Select the immobilization techniques used to eliminate voluntary motion.
44. Describe the minimum source-to-tabletop distances for fixed and mobile fluoroscopic devices.
45. Apply safety factors for the patient (and others) in the room during mobile radiographic procedures.

Appendix B

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Cardiac-Interventional Technology
Clinical Experience Requirements

Eligibility Requirements Effective
For Examinations Beginning January 2003

All applicants for the Examination in Cardiac-Interventional Technology are required to perform certain clinical procedures to establish eligibility for certification. This document identifies the minimum core clinical experience requirements for certification. The ARRT encourages individuals to obtain education and experience beyond these minimum requirements.

Directions

1. **Perform the Procedures**: Applicants must perform the required number of repetitions for each clinical procedure identified in this document. Repetitions must be performed within the 24 month period immediately before submitting the application for examination. Repetitions may be completed in less than 24 months.
2. **Document Performance**: Applicants must use the attached *Clinical Experience Documentation Form* to record the performance of each repetition of the procedures. The procedures must be organized in a manner similar to those on the following pages (e.g., all left heart catheterizations grouped together). The documentation must include: name of procedure, patient identification, date of performance, facility where performed, and the initials of person verifying performance. The "Verified By" column on the form must be initialed by the department supervisor or the procedural physician. The name and address corresponding to each set of initials also must be provided on the form.
3. **Apply for the Examination**: When applying for the examination, applicants must complete the *verification section* of the exam application to attest to the completion of the experience requirements. Mail only the application for examination to the ARRT; do not send the *Clinical Experience Document Form* to ARRT with the application. Submitting false documentation to ARRT as part of the application process is a violation of the ARRT Standards of Ethics and may result in sanctions up to and including revocation.
4. **Maintain Your Records**: Applicants must keep the *Clinical Experience Documentation Form* for at least 24 months after the application for examination is submitted. The ARRT conducts **audits** of some applications for examination. Applicants who are audited will be required to send the *Clinical Experience Documentation Form* to ARRT. Additional documentation may be required from individuals who are audited.

Clinical Experience Requirements

Requirements

The next page identifies 17 cardiac-interventional procedures that form the basis of the clinical experience requirements. Some of the procedures are mandatory and others are elective. Applicants must actively participate in, and document their repetitions of, a subset of these 17 procedures according to the following rules:

1. Applicants must complete a total of 150 repetitions across all of the mandatory and elective procedures.

    a. **Mandatory Procedures**. At least 20 right heart and 60 left heart catheterizations must be documented, for a total of 80 repetitions. Applicants must perform the specified studies listed under each catheterization procedure on the following page.

    b. **Elective Procedures**. At least 70 repetitions of the elective procedures must be documented. The maximum number of repetitions allowed for each elective is specified on the following page. Electives can be satisfied by: (a) completing any of the 15 electives that appear on the list; or (b) completing additional repetitions of the mandatory procedures (i.e., the cardiac catheterizations).

2. Multiple procedures can be documented for each patient. However, each individual procedure (e.g., thrombolysis) can be documented only once for each patient.

    Example. A patient has a left heart catheterization with intervention to follow. Two vessels need stenting with atherectomy and mechanical thrombolysis of both vessels. The procedures should be documented as:

    1 angioplasty / stent placement
    1 atherectomy
    1 thrombolysis
    Counts as one left heart catheterization
    1 coronary angiogram
    1 left ventriculogram Counts as one left heart catheterization
    1 hemodynamic measurement

Examples

The hypothetical applicants below illustrate three ways of satisfying the clinical experience requirements. Numerous other combinations are possible.

Applicant A: This person participated in 20 right heart catheterizations, 60 left heart catheterizations, 20 angioplasties, 20 intravascular ultrasounds, 10 thrombolyses, 5 cardio-versions, 5 pericardiocenteses, 5 biopsies, and 5 foreign body removals.

Applicant B: This person participated in 35 right heart catheterizations, 100 left heart catheterizations 10 thrombolyses, and 5 coronary angioplasties.

Applicant C: This person participated in 20 right heart catheterizations and 130 left heart catheterizations.

Cardiac-Interventional Procedures

Mandatory Procedures (can also be used as electives)

1. Right heart catheterization

   Applicants **must complete 20** right heart catheterizations, and each procedure must include at least 2 studies from the following list. Up to 70 additional right heart catheterizations may be performed as elective procedures.

   - cardiac output calculations (e.g., Fick, thermodilution)
   - hemoximetry hemodynamics
   - shunt detection
   - pulmonary angiography
   - valve measurement
   - ventriculography

2. Left heart catheterization

   Applicants must complete 60 left heart catheterizations, and each procedure must include at least 3 studies from the following list. Up to 70 additional left heart catheterizations may be performed as elective procedures.

   - Coronary angiography.
   - Coronary artery bypass graft angiography.
   - Aortography hemodynamics.
   - Left ventriculography.
   - Ventricular volume measurement (EF).

Elective Procedures

3. coronary angioplasty/stent placement
4. debulking (atherectomy)
5. Thrombolysis — No limit to repetitions
6. intravascular ultrasound

7. intra-aortic balloon counterpulsation
8. arrhythmia ablation
9. Cardioversion
10. Electrophysiology study
11. pacemaker, temporary insertion
12. pacemaker, permanent implantation — Up to 5 repetitions
13. Pericardiocentesis
14. automatic defibrillator implantation
15. endomyocardial biopsy
16. removal of foreign body
17. vascular closure devices

Vascular-Interventional Clinical Experience Requirements

Eligibility Requirements Effective For Examinations Beginning January 2003

All applicants for the Examination in Vascular-Interventional Technology are required to perform certain clinical procedures to establish eligibility for certification. This document identifies the minimum core clinical experience requirements for certification. The ARRT encourages individuals to obtain education and experience beyond these minimum requirements.

Directions

1. **Perform the Procedures**: Applicants are required to perform the required number of repetitions for each clinical procedure identified in this document. Repetitions must be performed within the 24 month period immediately before submitting the application for examination. Repetitions may be completed in less than 24 months.
2. **Document Performance**: Applicants must use the attached *Clinical Experience Documentation Form* to record the performance of each repetition of the procedures. The procedures must be organized in a manner similar to the Experience Requirements on the following pages (i.e., same procedures grouped together). The documentation must include: name of procedure, patient identification, date of performance, facility where performed, and the initials of person verifying performance. The "Verified By" column on the form must be initialed by a Registered Technologist or a licensed physician. The name and address corresponding to each set of initials must also be provided on the form.
3. **Apply for the Examination**: When applying for the examination, applicants must complete the *verification section* of the exam application to attest to the completion of the experience requirements. Mail only the application for examination to the ARRT; do not send the *Clinical Experience Document Form* to ARRT with the application. Submitting false documentation to ARRT as part of the application process is a violation of the ARRT Standards of Ethics and may result in sanctions up to and including revocation.
4. **Maintain Your Records**: Applicants must keep the *Clinical Experience Documentation Form* for at least 24 months after the application for examination is submitted. The ARRT conducts **audits** of some applications for examination. Applicants who are audited will be required to send the *Clinical Experience Documentation Form* to ARRT. Additional documentation may be required from individuals who are audited.

Clinical Experience Requirements

Specific Procedural Requirements

The next page identifies 50 vascular-interventional procedures that form the basis of the clinical experience requirements. Applicants must complete and document the performance of a subset of these 50 procedures according to the following rules:

- Applicants must complete a minimum of 10 of the 50 procedures; more than 10 procedures may be selected for completion.
- Each selected procedure must be performed a minimum of 5 times (repetitions) in order for the applicant to receive credit for that procedure.
- Each procedure may be counted a maximum of 20 times.
- Each applicant must complete a total of 200 repetitions across all procedures selected for performance.

*Example*s. The following hypothetical applicants illustrate three ways of satisfying the clinical experience requirements. Numerous other combinations are possible.

Applicant A: This person identified 10 different procedures from the list on the following page and performed each of those procedures 20 times (10 x 20 = 200).

Applicant B: This person identified 25 different procedures from the list on the following page. This applicant performed 15 of those procedures 10 times (15 x 10 = 150), and the other 10 procedures 5 times (10 x 5 = 50).

Applicant C: This person identified 40 different procedures from the list on the following page and performed each of those procedures 5 times (40 x 5 = 200).

General Requirements

In completing the specific clinical procedures listed on the following page, applicants must demonstrate appropriate:

- Preparation of supplies and maintenance of equipment.
- Evaluation of requisition and patient, patient preparation, administration of medications as required.
- Patient monitoring during procedure.
- Follow-up patient care.
- Image processing, including evaluation of images to ensure they demonstrate correct anatomy, radiographic techniques, and identification/labeling.

Vascular-Interventional Studies that Satisfy the Clinical Experience Requirements

A. Neurological

1. Intracranial angiography
2. Extracranial angiography
3. Neurologic embolization
4. Thrombolysis
5. Angioplasty
6. Stent placement
7. Spinal arteriography

B. Thoracic

1. Pulmonary arteriograms
2. Pulmonary embolization
3. Thoracic aortography
4. Superior vena cava venography (cavagram)

C. Genitourinary

1. Renal angiography
2. Adrenal angiography
3. Angiography of reproductive… female
4. Angiography of reproductive…male
5. Venous sampling
6. Nephrostomy
7. Ureteral stents
8. Percutaneous stone extraction
9. Embolizations
10. Renal artery angioplasty
11. Renal artery stent placement

D. Gastrointestinal

1. Selective visceral angiography
2. Pharmacoangiography
3. Embolization
4. Angioplasty
5. Stent placement
6. Stone extraction
7. Percutaneous transhepatic cholangiogram
8. Biliary drainage/stenting
9. Cholecystostomy
10. Gastrostomy/gastrojejunostomy
11. TIPS

12. Chemoembolization

E. Peripheral

1. Abdominal aortography
2. Upper extremity angiography
3. Lower extremity angiography
4. Inferior vena cava venography (cavagram)
5. Angioplasty
6. Stent placement
7. Stent graft placement
8. Thrombolytic therapy
9. Caval filter placement
10. Foreign body retrieval
11. Peripheral vascular embolization
12. Central venous access/port placement
13. Dialysis graft/extremity venography

F. Miscellaneous

1. Biopsies
2. Abscess drainage
3. Removal of foreign body

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